Towards Technologies for Promoting Nutritional Health in Older People with Dementia Living in Their Own Home

THE UNIVERSITY of ADELAIDE

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I would like to dedicate this thesis to my beloved family, teachers, and mentors who have helped me to become the person I am today.

Declaration

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Abstract

Dementia compromises older people's ability to maintain good nutrition, which in turn hinders their capacity to live in their homes for longer. Thus, they need significant support to maintain their nutritional health, often through care workers, especially when living with limited or no family support. However, with the rapid growth of the older population, the burden on care workers continues to increase, resulting in an urgent need to consider ways to assist people with dementia to maintain their nutritional health as well as their care workers to provide better support for their clients. Through a cross-disciplinary study, this thesis investigates how technologies can be used to promote nutritional health in older people with dementia living in their own homes. This involves an in-depth qualitative descriptive study and two technology development demonstrations.

Understanding needs prior to technology development is crucial for technologies to be effective, accepted by users and able to reach their desired maturity; however, this necessitates greater research investment. This thesis presents, for the first time to the best of the researcher's knowledge, a qualitative descriptive study with the aim of obtaining an holistic perspective of needs for technologies promoting nutritional health in older people with dementia living in their own home, involving focus groups with 27 care workers who provide care to older people with dementia, recruited from four leading aged care providers. Eight categories emerged from synthesising the care workers' voices. These categories provide deep, reliable insights useful for designing nutritional health-promoting technologies. In particular, nutritional health challenges faced by older people with dementia and challenges faced by care workers when providing nutritional health assistance to their clients demonstrate the demand and need for technological assistance and opportunities for developing technologies to promote nutritional health for the target cohort. Furthermore, this thesis proposes important elements need to be considered in technology development in the form of eleven technology design considerations.

Based on the formulated design considerations, two technology development demonstrations are presented. Firstly, poor fluid intake is identified as a significant problem and therefore, recognising fluid intake related primitive human motions using

batteryless Radio Frequency Identification (RFID) technology is investigated. To this end, a *smart cup* to collect fluid intake data is designed and experiments are conducted with young (30.7 ± 1.6 years) and old (69.0 ± 4.6 years) participants. The promising results demonstrate the feasibility and efficacy of recognising short distance, short duration natural fluid intake gestures using batteryless RFID technology for the first time to the best of researcher's knowledge. Secondly, a study that focuses on an architecture, Home of Things for Ambient Assisted Living—HoTAAL, suitable for facilitating the development of a collaborative environment, having heterogeneous technologies that can have seamless integration with each other as well as humans is conducted. It is expected that such an infrastructure would allow the development of a broad range of innovative technological applications to promote the nutritional health of older people with dementia. A demonstration of providing meal preparation assistance employing HoTAAL with three kitchen appliances was conducted. Additionally, possible technological applications based on HoTAAL architecture are described for several scenarios extracted from the focus group findings.

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Acknowledgement of material arising from this thesis

Manuscripts published

- A. Jayatilaka and D.C. Ranasinghe, "Real-time fluid intake gesture recognition based on batteryless UHF RFID technology", Pervasive Mobile Computing, vol. 34, pp. 146-156, 2017.
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- A. Jayatilaka and D.C. Ranasinghe, "Towards unobstrusive real-time fluid intake monitoring using passive UHF RFID", in the IEEE international conference on RFID, USA, 2016, pp. 1-4.
- A. Jayatilaka, D.C. Ranasinghe, K. Falkner, R. Visvanathan, A. Wilson, "Caregivers' voices in designing assistive technologies for preventing malnutrition in older people with dementia: Innovative Practice", Dementia (Accepted).

Manuscripts in preparation

- A. Jayatilaka, D.C. Ranasinghe, K. Falkner, R. Visvanathan, A. Wilson, "Challenges that affect the nutritional health of older people with dementia: Technology directions from caregiver perspectives".
- A. Jayatilaka, D.C. Ranasinghe, K. Falkner, R. Visvanathan, A. Wilson, "Technological opportunities for assisting care workers to provide improved nutritional health support to clients with dementia living at home".

Presentations

- A. Jayatilaka, "Towards technology development to support nutritional health in older people living in their own homes with dementia", Research Seminar, Adelaide Geriatrics Training and Research with Aged Care Centre, Adelaide, 2014.
- A. Jayatilaka, "Real-time fluid intake monitoring system based on passive UHF RFID", Adelaide Geriatrics Training and Research with Aged Care Centre research showcase, Adelaide, 2015.
- A. Jayatilaka, "Towards unobtrusive real-time fluid intake monitoring using passive UHF RFID", in IEEE international conference on RFID", IEEE RFID Conference, Orlando, USA, 2016.
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Section I

Overview and background

Chapter 1

Introduction

Dementia, an umbrella term for the decline in cognitive ability, is a major cause of disability and dependency among older people [5, 6]. It affects a person's memory, ability to think and the ability to perform day to day activities. With the unprecedented growth rate in older people in the population, the proportion of people with dementia continues to increase [5, 6]. In fact, by 2050, the world population of older people is expected to reach nearly 2.1 billion, which is double the amount compared with 2015 [7]. It is estimated that at least one in nine people aged 65 and older worldwide will have dementia [8]. In Australia, there are more than 353,800 older people living with dementia and, if the current trends continue, it is expected that the number of people with dementia will be almost 900,000 by the year 2050 [9].

In Australia, 70% of people with dementia are community-dwelling (i.e. live in private homes) and it is estimated up to one-third of those people may live alone [10]. Most older people with dementia prefer to stay in their own home for as long as possible and government policies currently favour what is referred to as 'Ageing in Place'; supporting older people to remain in their home in order to reduce the heavy financial burden on the health care system [5]. The evidence suggests that people with dementia generally have a longer length of stay in hospitals and need more care than others, thus the average cost of hospital care for older people with dementia is higher than for people without dementia [11]. However, despite government policies to delay the admission of older people with dementia into hospitals or residential care and the desire of older people to live in their own home as long as possible, often people with dementia have to be moved out of their home earlier, compared with other older people [12].

Poor nutritional health is a major problem for many older people. Older people with dementia living with limited or no family support are at an increased risk of having poor nutritional health [5, 12–14]. It is estimated that approximately 50%

of older people living in the community are malnourished or at risk of developing malnutrition [15]. Unfortunately, even people at early stages of dementia can be malnourished due to their poor food intake [16]. Reduced nutritional health in older people, in general, results in sarcopenia (loss of muscle mass and strength), increased frailty, reduced wound healing, recurrent hospitalisation and increased mortality [16–19]. In particular, poor nutrition in older people with dementia living in their own home is critical as it can further complicate and exacerbate the issue of dementia, threatening their ability to live independently in their home for a longer period of time [20].

People with dementia who are living in their own home require significant support to maintain good nutrition and successfully live independently [21, 12]. Often, care workers, particularly care coordinators and home support workers, working in the community are employed by aged care organisations to provide care support for older people who are living independently in their own home with limited or no family support. Home care services related to nutrition and mealtimes generally include assistance with household tasks, such as shopping and cleaning, as well as assistance in basic personal care related to eating and drinking. A care worker is typically responsible for multiple clients, and the duration of support provided for a client can range from a few hours per week to several times per day [21]. Caring for an older person with dementia is often more challenging than caring for others without dementia [22, 23]. It has been identified that there is a higher possibility for care workers of older people with dementia to suffer from stress and tiredness [22]. With the rapid growth of dementia, the burden on the care workers continues to increase [23].

To promote the nutritional health of older people with dementia, there is an urgent need to provide careful attention to ways which can assist older people with dementia living in their own home to maintain their nutritional health, as well as for their care workers to provide better support to the clients. Unfortunately, as highlighted in previous research, nutrition and mealtime situations of older people with dementia living at home are often overlooked compared with hospitalised older people or those who are in nursing homes [24, 21, 25]. It has been identified that the inability to perform mealtime tasks may cause feelings of loss of independence among older people with dementia [12, 26]. The limited studies in this space mostly looked at the perspectives of families living with or managing nutrition and mealtimes of their loved ones with dementia [27–29]. On the other hand, the ways for care workers to provide a better service with respect to their clients' nutritional health is rarely explored [21].

There is an increased interest in developing technologies to assist older people with dementia living at home to achieve better health outcomes and assisting care workers in providing improved care for their clients as a result of the rapid growth

of the ageing population [23, 30, 31]. It has been identified that technology has the potential to promote independence in older people with dementia and delay the need for admission into nursing homes or hospitals [32]. Most technology development studies, centred around older people with dementia living at home, are primarily developed as interventions to support their memory related issues and to improve their health and safety [33–35]. Some progress has been made in the development of technologies for supporting older people with dementia living at home to carry on mealtime activities, particularly meal preparation activities. Unfortunately, most research is small scale pilot studies evaluating technology prototypes and hence still in its infancy [36, 31, 37, 38].

For technologies to reach their desired maturity and to obtain user acceptance for the end product, it is crucial to take into account the user needs and preferences [33]. Nevertheless, it has become common to design and develop assistive technologies based on designers' experiences and assumptions on user behaviours and needs [39–41]. This is mainly due to the greater initial research investment required to identify user needs. Evidence indicates that technology solutions built without properly understanding user behaviours and demands can be ineffective or short-lived when deployed in the real world [42, 33]. This is particularly important for an older population with dementia as it is extremely difficult to seamlessly integrate technology into their lives without making them confused and scared [43]. A recent review of 58 technology applications that focused on assisting older people diagnosed with dementia highlighted that only three devices have undergone clinical trials and none had undertaken real-world evaluation [42]. Identifying user needs properly can help technologies being developed to address actual needs rather than be forced into irrelevant areas [43, 23, 44]. Interestingly, there have not been studies that focus on obtaining needs for technological solutions geared towards promoting the nutritional health of older people with dementia. In particular, no studies have considered the needs of both care workers and the older people together. Gaining an holistic view of these technological needs is important to design useful and practical technologies which can collectively be employed for promoting the nutritional health of this cohort.

The aim of this thesis was to investigate, through a cross-disciplinary research study, how technologies could be used to promote nutritional health in older people with dementia living in their own home. To this end, the thesis reports an in-depth qualitative descriptive study investigating the holistic technological needs for supporting older people to maintain their nutritional health and for facilitating their care workers to provide improved nutritional health support to their clients. In addition, two research studies demonstrate possible technology developments for promoting the nutritional

health in older people with dementia based on several technology design considerations resulting from the qualitative study.

1.1 Contributions of the thesis

To begin this section lists the main contributions of the thesis and later describes them in detail.

1.1.1 List of contributions

- Obtaining an holistic perspective of needs for technologies geared towards promoting nutritional health of older people with dementia living in their own home
  - Designing and conducting a qualitative descriptive study aimed at obtaining an holistic perspective of needs for technologies assisting older people to maintain their nutritional health and for facilitating their care workers to provide improved nutritional health support to their clients (see Chapter 3).
  - Synthesising care workers' perceptions and identifying eight categories that describe the nutritional health support received by older people with dementia, challenges faced by older people with dementia to maintain good nutritional health, challenges faced by care workers when providing nutritional health support to the clients, care workers' information needs, and care workers' technological wishes and concerns (see Chapter 4 to Chapter 7).
  - Reviewing new knowledge gathered and formulating design considerations for technology development to promote nutritional heath in older people with dementia living in their own home (see Chapter 8).
- Demonstrating possible technology developments for promoting the nutritional health in older people with dementia living in their own home
  - Demonstrating the feasibility and efficacy of using commercially available passive (batteryless) Ultra High Frequency (UHF) Radio Frequency Identification (RFID) tags for monitoring human motions related to fluid intake (see Chapter 9).
  - Demonstrating a possible architecture for intelligent interconnected things for ambient assisted living, focusing on the nutritional health of older people with dementia (see Chapter 10).

1.1.2 Description of the contributions

- *Designing and conducting a qualitative descriptive study aimed at obtaining an holistic perspective of needs for technologies assisting older people to maintain their nutritional health and for facilitating their care workers to provide improved nutritional health support to their clients:*

  To identify the potential for assistive technologies to collectively support older people with dementia to maintain good nutrition, and for their care workers to better assist their clients, a broad understanding of challenges faced by them is essential. These identified challenges demonstrate the demand and need for technological assistance and opportunities for developing technologies to promote the nutritional health of the target cohort. Furthermore, it is expected that based on a broad understanding of the nutrition and mealtime situations of older people with dementia, design considerations for effective technology development in this space can be formulated. This approach would allow the developed technologies to be usable, acceptable, easily translated into practice and assimilated only where required, rather than applied to areas that do not need them.

  In this thesis, for the first time to the best of the researcher's knowledge, a study rooted in qualitative descriptive design was conducted with the aim of obtaining an holistic perspective of technologies geared towards promoting the nutritional health in older people with dementia living in their own home. This study involved focus groups with 27 care workers who provide care support to older people with dementia recruited from four leading aged care providers in South Australia.

  The main objectives of this qualitative descriptive study are to identify the challenges older people with dementia living in their own home face that may prevent them from maintaining good nutrition, the challenges care workers face when trying to ensure good nutrition among their clients, and considerations for the development of technologies that may be effective for assisting older people with dementia to maintain their nutritional health and for their care workers to provide improved care support to their clients. While identified challenges suggest technological needs, the formulated design considerations suggest important aspects that need to be taken into account by technology designers and developers when designing and developing technologies to address the identified challenges.

- *Synthesising care workers' perceptions and identifying eight categories that describe the nutritional health support received by older people with dementia, challenges faced by older people with dementia to maintain good nutritional health, challenges faced by care workers when providing nutritional health support to the clients, care workers' information needs, and care workers' technological wishes and concerns:*

  The focus group participants' comments were synthesised into findings using qualitative content analysis [45]. Eight categories emerged from the focus group data based on the research methods employed. These categories are: i) *Care worker support*; ii) *Family Support*; iii) *Older people's nutritional health challenges as perceived by care workers*; iv) *Care workers' challenges in supporting their clients' nutritional health*; v) *Care workers' information needs related to clients' nutritional health*; vi) *Care workers' wishes for technologies designed to support their clients*; vii) *Care workers' wishes for technologies designed to support them*; and viii) *Care workers' technological concerns*. Each category was formulated by one or more related concepts. Each concept consisted of one or more related nodes. These categories provide useful information for identifying how technology can be used effectively to promote the nutritional health in older people with dementia living in their home.

- *Reviewing new knowledge gathered and formulating design considerations for technology development to promote nutritional heath in older people with dementia living in their own home:*

  The findings of the focus groups involving care workers shows that there are opportunities and benefits in designing supportive technologies not only for assisting older people but also for their care workers. Discussions are carried out to illustrate how the new knowledge, mainly related to challenges faced by older people with dementia in maintaining their nutritional health and the challenges faced by care workers when aiding their clients, add to the current literature. As explained previously, identification of these challenges is important as they form a demand for support and hence could be turned into technological needs to support older people with dementia and their care workers.

  More importantly, based on the study findings, six design considerations to guide the overall development of technologies to support older people with dementia living in their own home to maintain their nutritional health and five design considerations to guide the development of technologies to facilitate care workers to better assist their clients' nutritional health are formulated. Additionally,

several potential avenues for technology development by considering the existing technology development research and the findings of this study are presented.

- *Demonstrating the feasibility and efficacy of using commercially available passive UHF RFID tags for monitoring human motions related to fluid intake:*

  Careful monitoring of primitive human motions is identified as one of the key technology design considerations. This is important for technologies to make reliable estimates about the activities performed by older people with dementia and thereby provide assistance when required. Furthermore, poor fluid intake is identified as a significant problem for older with dementia through the qualitative descriptive study and findings suggest that simply monitoring the initiation of fluid intake or water levels alone may not be a reliable estimate of fluid consumption. Therefore, monitoring human motions related to drinking is warranted without creating any additional burden to older people with dementia or stress to their care workers, which are also proposed as design considerations.

  In this thesis, for the first time to the best of the researcher's knowledge, the use of passive UHF RFID technology for automatic monitoring of human motions related to drinking is investigated. This includes a simple drinking container design (henceforth referred to as *smart cup*) with sensing and unique identification capability. The design enables the *smart cup* to be used for recognising natural drinking episodes based on streaming RFID information without the need for any body-worn devices or cameras. Data was collected from: i) ten young volunteers (age: 30.7 ± 1.6 years) based on broadly scripted activity routines; and ii) five older volunteers (age: 69.0 ± 4.6 years) in an unscripted setting. Anonymised and annotated datasets are made publicly available to support other researchers as well as to serve as a baseline for future research[1]. A machine learning based approach capable of recognising natural drinking episodes embedded in the underlying patterns in RSSI and phase data variations was employed. During the evaluation, firstly, the efficacy of the proposed system to recognise natural drinking episodes based on the data collected from young participants was evaluated. Secondly, based on the machine learning models trained from data collected from young participants, the performance of the system to recognise drinking episodes for data collected from older participants was evaluated. The promising results demonstrate the efficacy of the proposed approach to recognise natural drinking episodes for both young and older participants.

[1] http://autoidlab.cs.adelaide.edu.au/research/inutricare

- *Demonstrating a possible architecture for intelligent interconnected things for ambient assisted living, focusing on the nutritional health of older people with dementia:*

  Making intelligent appliances and objects at home inter-connected with each other as well as humans is one of the technology design considerations identified based on the qualitative descriptive study. This creates increased opportunities for developing diverse, innovative technological applications targeted towards promoting nutritional health of older people with dementia. However, it is important that technologies do not create an additional burden on older people with dementia or cause additional stress for their care workers. Avoiding such burdens have been proposed as design considerations.

  In this thesis, HoTAAL (Home of Things for Ambient Assisted Living), is presented as a possible architecture for combining the ubiquity of Internet connectivity in homes with pervasive and intelligent sensors to exploit user interactions with everyday home appliances and objects. Embedding sensors into appliances and objects at home provides the opportunity for unobtrusive in-home monitoring of activities performed by older people with dementia. The proposed architecture creates the possibility for physical sensors to exhibit seamless social interactions with each other as well as humans in a naturalistic manner, facilitating the development of technological applications for older people with dementia and their care workers. A demonstration of the possibility of employing the social kitchen appliances for providing meal preparation assistance was conducted [2]. Additionally, possible technological applications based on HoTAAL architecture to address three scenarios devised from the focus group findings are described.

1.2 A guide to the thesis

The thesis is presented mainly as four sections. The first section (Section I) of the thesis presents the overview and the background for the thesis. The second section (Section II) of the thesis presents the methodological framework, the findings and a discussion related to the qualitative descriptive study conducted to understand holistic technological needs for promoting the nutritional health in older people with dementia living in their own home. The third section (Section III) of the thesis presents the two technology development demonstrations. The fourth section (Section IV) presents the conclusions drawn from this thesis.

[2] http://autoidlab.cs.adelaide.edu.au/HoTAAL

Section I: Overview and background

Chapter 1: Introduction Chapter 1 presents the motivation behind this thesis, the aim of the thesis, main contributions of the thesis, thesis organisation, researcher position and definition of main terms used in the thesis.

Chapter 2: Related work Chapter 2 presents a review of published work related to the topic of this thesis. The chapter, firstly, provides a review of non-technology research related to the nutritional health of older people with dementia living at home to understand what is generally known regarding nutrition and mealtimes of older people with dementia living in their own home. Secondly, a review of the literature on studies that focus on identification of the needs for technologies for supporting older people with dementia living in their own home and care workers is presented. Thirdly, a review of the literature on technology development for both older people with dementia and their care workers is presented with an emphasis on technologies centred around nutrition and mealtime activities. Finally, the gaps in existing knowledge and research are discussed as a motivation for this thesis.

Section II: Investigation of technological needs

Chapter 3: Theoretical framework Chapter 3 provides an explanation and justification of the theoretical underpinnings of the study aimed at obtaining an holistic view on the needs for technologies geared towards promoting nutritional health in older people with dementia living in their own home. The chapter provides a detailed description of the research paradigm, the research design and the research methods chosen for the study. The description of research methods include participant selection and recruitment, data collection and data analysis procedures. Furthermore, the chapter provides a detailed description of the methodological techniques employed to enhance the rigour of the study.

Chapter 4: Findings I - Support received by older people with dementia living in their own home to maintain their nutritional health Chapter 4 describes the characteristics of the participants who were involved in this study and presents the findings related to the *Care worker support* and *Family Support* categories. *Care worker support* describes the types of care support currently provided by care workers to their clients to maintain their nutritional health. The findings of this study reveal a number of ways families may support older people with dementia to maintain their nutritional health which are discussed in the *Family Support* category.

Chapter 5: Findings II - Older people's nutritional health challenges as perceived by care workers Chapter 5 presents the findings related to *Older people's nutritional health challenges as perceived by care workers* category. This category describes challenges faced by older people with dementia living in their own home, which may threaten their nutritional health, based on care workers' perspectives.

Chapter 6: Findings III - Care workers' challenges in supporting their clients' nutritional health and their information needs Chapter 6 presents findings related to the two categories: i) *Care workers' challenges in supporting their clients' nutritional health*; and ii) *Care workers' information needs related to clients' nutritional health. Care workers' challenges in supporting their clients' nutritional health* describes challenges faced by care workers when trying to assist their clients with dementia living in their own home to maintain good nutrition. The *Care workers' information needs related to clients' nutritional health* category describes the types of nutrition and mealtime related information that care workers believe would assist them to provide a better service to their clients.

Chapter 7: Findings IV - Care workers' wishes and concerns about technologies Chapter 7 presents the findings related to the three categories: i) *Care workers' wishes for technologies designed to support their clients*; ii) *Care workers' wishes for technologies designed to support them*; and iii) *Care workers' technological concerns*. *Care workers' wishes for technologies designed to support their clients* describes participants' wishes on types of technological assistance that could be offered to their clients to promote good nutrition. *Care workers' wishes for technologies designed to support them* describes participants' wishes for the types of technological assistance that they think could be useful for them to provide improved care services to their clients with respect to their nutritional health. *Care workers' technological concerns* describes care workers' concerns for translating technologies into practice.

Chapter 8: Discussion on the findings of the technological needs investigation Chapter 8 provides a detailed discussion of the main findings of the qualitative descriptive study. In particular, a discussion on the challenges faced by older people with dementia living in their own home and care workers is conducted, in relation to the existing knowledge in the field, around the concepts identified through the qualitative descriptive study. Then the chapter presents a description of the design considerations formulated to guide the overall design of technologies geared towards assisting older people with dementia to maintain good nutrition and assisting care workers to provide better support to their clients. Additionally, several avenues for

technology development by considering the existing technology development research and findings of this study are presented. A description of the strengths and weaknesses of the study considering the research methodology employed is also presented at the end of the chapter.

Section III: Technology development demonstrations

Chapter 9: Real-time fluid intake gesture recognition based on passive UHF RFID technology Chapter 9 presents the design and development of a passive UHF RFID based fluid intake monitoring system. This chapter first explains the realisation of the *smart cup*, followed by a description of the data collection procedures for both young and older people, and the proposed machine learning based approach to recognise natural drinking episodes embedded in the RFID data stream. Finally, statistical analysis and the evaluation results are presented.

Chapter 10: Home of Things for Ambient Assisted Living (HoTAAL) Chapter 10 presents a possible architecture, HOTAAL, which enables physical sensors to exhibit social interactions with each other as well as humans in a naturalistic manner. The chapter first describes the high-level architecture of HOTAAL. Then a proof of concept implementation and a demonstration of three social kitchen appliances is described. Finally, several possible technological applications geared towards promoting the nutritional health of older people with dementia living in their own home which can benefit from HoTAAL are described. These application scenarios are devised based on focus group findings.

Chapter 11: Discussion on the findings of the technology development demonstrations Chapter 11 presents a brief discussion of the technology development demonstrations presented in the thesis.

Section IV: Revisiting the purpose

Chapter 12: Conclusion Chapter 12 summarises the thesis's main contributions to the discipline and includes a description of future work stemming from this thesis.

1.3 Researcher position

Having experience as a business analyst in the software industry, the researcher has identified the significance of requirement elicitation prior to technology development

which subsequently leads to cost reduction and shorter time period to product maturity. However, the researcher has experienced that the importance of requirement elicitation and efforts required for it, is often un-recognised or under-appreciated by management teams and software developers. Furthermore, the researcher has observed, through the literature, that a similar trend exists in the domain of assistive technologies, particularly in relation to older people with dementia. Therefore, with experience and passion in conducting multi-disciplinary research, and experience in requirement elicitation, the researcher began this thesis with the intention of addressing the current deficits in the research and facilitating effective technology developments in the future.

1.4 Definition of terms used in this thesis

The following section describes the non-technological and technological terms useful for this thesis.

Assistive technologies: Devices or systems that increase the physical and/or mental capabilities of people with disabilities.

Care coordinator: Care coordinator is a type of care worker who is mainly responsible for assessing the needs of clients, build strong relationships with clients and family members, developing appropriate care plans based on assessed needs, coordinating, monitoring and reviewing the provision of services to individual clients, and supervising home support workers.

Care worker: Staff employed by aged care organisations to provide care support for older people with dementia who are living independently in their own home with limited or no family support.

Community-dwelling: Living in a private home (i.e. not in a nursing home or residential care).

Formal care: Care provided by care workers involved in the aged care industry.

Home support worker: A home support worker is a type of care worker who will deliver different services by visiting clients at home, based on a client specific care plan. The services provided generally include domestic assistance, shopping, meal preparation and personal care assistance.

Informal care: Care provided by family or friends.

Machine learning: Allowing computers to learn patterns or trends from existing data.

Passive sensor: Passive sensors do not employ any batteries. They gather data through the detection of different changes occurring in the environment such as vibrations, radiation or heat.

RFID: Radio Frequency Identification technology is commonly used to identify objects uniquely. The modern RFID tags typically contain a non-volatile memory that can store its ID and other information specified by the tag user.

Smart home: A home where multiple types of sensors and devices are employed to monitor the resident's daily functioning and to provide them with assistance when needed.

UHF: Ultra High Frequency describes the radio frequencies in the range 300 MHz to 3 GHz, as defined by the International Telecommunication Union.

Chapter 2

Related work

Dementia compromises older people's ability to maintain a good nutritional status while demanding increased care and support services. Care workers, recruited by aged care organisations, often assist older people with dementia living in their own home with limited or no family support to live independently. Therefore, to facilitate the overall goal of promoting the nutritional health in older people with dementia living in their own home, it is important to design and develop technologies for assisting them to maintain their nutritional health and for facilitating care workers to provide better support to their clients.

This chapter reviews what is known in the contemporary literature related to the topic of this thesis. The discussion first considers non-technology research with the aim of exploring what is generally known about the broader problem of maintaining good nutrition among older people with dementia living in their own home. Then there is a review of the literature on technology needs identification and technology development focusing on older people with dementia living in their home and their care workers is presented, with a special emphasis on nutrition and mealtime-related support.

The chapter is organised as follows. Section 2.1 presents the non-technology research related to the nutritional health of older people with dementia living in the community. Section 2.2 presents a review of studies that identify needs for technologies supporting older people with dementia living in their own home and their care workers. Section 2.3 presents a review of technologies developed to be used by both older people with dementia living in their home and their care workers, with an emphasis on technologies centered around nutrition and mealtime activities. A summary of this chapter is presented in Section 2.4.

2.1 Nutrition and mealtime situations of older people with dementia

Although, a significant amount of non-technology focused research has been conducted on nutrition and mealtime situations of older people with dementia in hospital and nursing home settings, such research exploring the nutritional health of community-dwelling older people with dementia is limited. This has also been pointed out in several previous publications [24, 46–49].

Existing research on nutritional health related aspects of older people with dementia living in home mostly relies upon information obtained from families who are living with or supporting older people with dementia [50, 29, 27, 46, 51]. Most such studies focused on exploring the experiences of the families, social changes, emotional changes and gender-related role changes related to mealtimes. Furthermore, some of these studies have identified certain nutrition and mealtime-related issues of older people with dementia as a part of the process [46, 50, 27]. For example, eating experiences within families living with older people diagnosed with dementia were explored through interviews conducted with informal caregivers who were mostly residing with and taking care of their loved ones [27, 28, 51]. Their findings revealed three themes related to the experiences of families having meals with older people diagnosed with dementia [28, 51]. These themes are: being connected, honouring identity and adapting to an evolving life. Furthermore, in another study, a number of strategies used by families to change eating behaviours to overcome those changes were highlighted [27]. For instance, to overcome the changes in eating styles, families have trialled a number of adaptations such as providing softer food, making food that takes longer to eat and cutting food into pieces.

A number of studies have been conducted to understand how couples manage mealtime situations at home when a partner is suffering from dementia [26, 29, 51]. It was revealed that couples adopted new routines to cope with the changes in mealtime situations. For example, gender-related role-shifts were visible with dementia progression among couples.

Nutrition education needs and resources used in dementia care in the community have been identified through two user studies [46]. The first study was conducted with families and formal care providers of persons with dementia to identify several nutritional health related issues, which may indicate their educational needs. Content analysis of the data collected through interviews revealed a number of nutritional health related issues. These issues were mostly related to eating. For example, eating related issues identified included changes in preferences for food and changes in eating styles. Apart from that, it was highlighted that older people may have issues with meal

preparation mainly due to difficulties in operating appliances. A second study, through a questionnaire, focused on evaluating nutrition questions generally asked by families and the print resources currently provided to them.

In another closely related study, families who are looking after people with dementia at home and who manage their shopping, meal preparation, and eating activities, were interviewed to explore the impact of dementia progression on shopping, food preparation and eating [50]. Data analysis was performed using thematic analysis and the findings revealed behavioural changes within the family or friends, and issues older people face when performing mealtime-related activities. When considering the shopping related issues, it was highlighted that older people with dementia experience a rapid decline in shopping capability, particularly, the inability to travel, managing finances, and selecting and paying for food. Furthermore, a number of eating related issues which included mealtime behaviour changes and diet related issues were described. Furthermore, with respect to cooking, issues in cooking their own meals and operating appliances were highlighted. The identified issues are mostly consistent with the findings reported by other studies [27, 46].

On the other hand, researchers investigated self-descriptions of older people with dementia living in their own home regarding their mealtime situations [12]. Fifteen older people with dementia living in their own home were interviewed and the focus of the study was to understand how they managed their cooking, eating, and shopping activities. The study findings revealed a number of themes, namely, being able to manage, using familiar habits, changing and accepting the situation, being satisfied with the present, being supported and using strategies to manage to live with memory loss. The study concluded that although the need for supporting older people with dementia living in their own homes in mealtime situations may exist, older people may not express those needs due to the fear of others thinking that they cannot take care of themselves any more.

In a seminal study by Johansson et al. [21], focus groups were conducted with staff involved in the care of older people with dementia living in their home. The goal of this study was to identify strategies that care workers can utilise to improve mealtime experiences of their clients with dementia. Proposed strategies included knowledge-based planning, enabling meals at home, taking over meal preparation and moving meals outside of the home. The findings of this study implicitly suggest several challenges relating to mealtimes for older people with dementia, such as the inability to prepare their own meals and forgetting to eat.

2.2 Identification of technology needs

In this thesis, two main user groups: i) older people with dementia living in their own home; and ii) their care workers are considered. These groups have different interests and hence have different technological needs. Therefore, the literature on identifying needs for technologies to support these user groups are discussed separately in the following sections.

2.2.1 Technological needs of older people with dementia

A limited number of studies have identified technological needs for supporting older people with dementia living in their own home [44, 52, 39, 53]. Such research has predominantly focused on the identification of the types of general activities of daily living with which older people with dementia may need assistance [44, 39]. Furthermore, research has been carried out to explore the need for technologies to support specific aspects of the lives of older people with dementia such as autonomy and independence [54–56, 53]. However, studies that focus on technology needs specifically related to nutrition and mealtimes of older people with dementia are not common [57]. In this section, firstly, there is a brief overview of general technology needs identification studies related to older people with dementia living in their own home to offer an examination of such technologies. Secondly, studies related to identifying needs for technologies to support nutrition and mealtime activities of older people with dementia are presented.

Needs related to general support

Several studies have looked at identifying types of activities of daily living where technological support can be provided for older people with dementia living in their own home. For instance, previous researchers have conducted focus groups with care workers, and interviews with older people with dementia and their family members to explore the types of daily activities with which older people with dementia may need assistance [44]. The analysis of the data collected revealed a number of areas in which older people with dementia may need support, such as taking medication, personal hygiene and preparing food. Instead of interviews, another study had distributed questionnaires among family members for the same purpose [39]. Analysis of the questionnaire responses revealed that older people with dementia are often able to complete fundamental activities of daily living such as getting dressed, going to the bathroom, eating and drinking but have difficulties in completing advanced daily tasks such as cleaning the house and preparing meals.

Apart from the studies that focused on identifying high-level overview of different areas of daily living activities where technological support is needed, there are studies which explored the technology needed to support specific aspects of the lives of older people with dementia [54–56, 53, 58, 59]. These research studies mostly looked at technological needs in areas such as autonomy and independence of older people with dementia. For example, in a pioneering study in this field, the needs for possible technology solutions to help people with early dementia to experience greater autonomy, feelings of empowerment, and to enjoy an enhanced quality of life have been identified using data collected through two workshops and one group interview with older people with dementia and their family members [55, 60]. This study was conducted in three cities in the Netherlands, Northern Ireland and Sweden with a maximum of six people from each city. Their findings revealed the importance of providing technological support in the areas of memory and remembering, social contacts, daily activities, and feelings of safety. In another study, focus groups were conducted with older people with dementia and their care workers to identify the role of technology in promoting independence among older people [56]. Furthermore, researchers have conducted interviews with older people with dementia in order to compile a 'wish-list' of suitable technology applications to enhance their quality of life [53]. The findings of the study revealed a long list of technological needs that can form the basis for many technological developments in the future.

Although the above-described research studies are conducted on the assumption that technological assistance delivery mechanisms can be selected after assessing user needs, a parallel line of research that focuses on determining the technological needs for assisting older people with dementia living at home, based on pre-selected technology delivery mechanisms or devices exists [61–63]. For example, focus groups have been conducted with older people with dementia and their family members to identify what features are useful for a Global Positioning System (GPS) device to support safe walking [62]. The study findings revealed the recommended characteristics of such a GPS device related to multiple themes such as style, size, battery, and weight.

Needs related to nutrition and mealtime activity support

Although previous studies on technology needs for supporting activities of daily living have not specifically considered nutrition and mealtime activities, their findings revealed that meal preparation is a key area where older people with dementia may need assistance [44, 39]. Wherton and Monk [57] have selected technological prompting as the information delivery mechanism and have conducted a study to identify how this can be used to support with meal preparation scenarios of older people with dementia.

Using a small sample of older people with dementia, Wherton and Monk [57] video recorded older people performing one of the pre-selected meal preparation tasks such as preparing a cup of tea, making a bowl of music. During the recording, an instructor provided assistance in performing these activities using verbal prompts whenever required. Their findings, based on the subsequent analysis of the video recordings, revealed that older people with dementia can benefit from prompting for sequencing, finding things, the operation of appliances, and dealing with incoherence.

2.2.2 Technological needs of care workers

Despite the number of studies that aim to identify the technological needs of informal carers of older people with dementia, the technological needs of care workers have rarely been looked at [64, 30, 65–67]. A possible reason for this may be the difficulties in recruiting care workers for research studies due to their limited availability, as a result of their workloads, as has been highlighted in previous research [68].

The limited studies that identify the needs of care workers of older people with dementia living in their own home have focused on technologies facilitating communication and decision-making. For instance, a recent study has highlighted the need for technologies to strengthen communication among care workers [69]. In this study, care workers were requested to describe their ideas in areas such as communication, uniformity in work processes, and knowledge and expertise through focus groups. It was concluded that most care workers required access to information about dementia, treatment options and the care needs of their clients. In another study, care workers' needs related to an interactive web tool for shared decision-making in care networks of people with dementia were explored through semi-structured interviews [70]. Content analysis of the data collected revealed a list of topics that needed to be considered when developing such a technological tool to be used by older people, family members, and care workers. The identified topics included daily activities, mobility, safety, finances and social contacts. Unfortunately, no studies focusing on the technological needs of care workers to assist them to provide improved nutrition and mealtime care support to their clients have been conducted.

2.3 Development of technologies

In this section, a review the of literature that focuses on technology development for supporting older people with dementia living at home and their care workers is presented separately.

2.3.1 Technologies to support older people with dementia

In this section, firstly, a brief overview of technologies that have been developed for supporting older people with dementia living in their own home without a focus on mealtime activities is presented. Here the primary goal is not to provide the most comprehensive review of such assistive technologies but to offer a summary of the range of technologies that are available. Secondly, a discussion on technologies specifically developed for supporting older people with dementia with nutrition and mealtime activities is carried out with a note as to whether or not those studies were based on user needs identification research.

General support

Assistive technologies for older people with dementia living in their home are primarily developed as interventions to support their memory related issues, and to improve their health and safety [33–35, 71]. These technologies typically range from simple non-intelligent systems such as calendar clocks to more complex, intelligent and automatic systems [72]. Intelligent systems require monitoring of the home environment to understand the current situation as the first step. Then based on the identified context, relevant assistance is provided.

Smart homes for older people with dementia: A smart home is where multiple types of sensors and devices are employed at home to monitor residents' daily functioning and to provide them with assistance when needed [73, 74, 42, 75–77]. The sensors in a smart home usually operate in a network and connect to a remote server where data is collected and analysed through different types of algorithms and methods. This facilitates the development of intelligent technological applications that can identify the current situation at home and provide assistance where required [78–80, 79].

Some of the commonly used sensors and devices employed for monitoring and assisting older people with dementia can be found in the review of smart homes conducted by Alam et al. [74]. These sensors include light sensors, passive Infra-red (PIR) sensors, pressure sensors, cameras, and microphones. In smart homes, these sensors are usually attached to doors, objects, hallways, and floors to monitor residents' locations and object usages. Speakers, headsets and Liquid Crystal Displays (LCD) are commonly used for providing prompts. In addition to the environmental sensors deployed at home, a parallel line of research using body-worn sensors exists [42]. Furthermore, hybrid smart home technologies which use both environmental and body-worn devices are also proposed [81, 82]. Diverse intelligent technological applications

have been developed to monitor as well as assist older people with dementia, based on data collected from sensors in smart homes [74, 83].

Safety and security: Tracking the movements of older people with dementia inside and outside the house facilitates the generation of alarms in emergency situations, such as when falls occur or when abnormal events are detected [84–89]. For example, researchers have proposed identification and prediction of the abnormal behaviour of older people with dementia in the home environment using data collected from sensors attached to the environment [86] and sensors attached to the body [90]. Mobile phone-based GPS tracking of older people with dementia has been developed [87]. The developed phone has three buttons to switch the phone on and off, send an alarm and dial a pre-programmed number in emergency situations.

Activity reminders: A number of simple task and time-based activity reminders that assist older people to carry out their day-to-day activities are commercially available such as dementia-friendly calendars, pill box reminders and automatic medication dispensers [91]. Furthermore, sensory and therapeutic interventions to allow older people to be as mentally active as possible are currently available. Examples of such technologies are activity and sensory boxes, and robotic pets. Zanjal and Talmale [92] have conducted a review on medicine reminder and monitoring systems for older people with dementia.

The ENABLE project, considered as a pioneering technology development project, has focused on memory aids for older people with dementia living in their own home [93]. The project places a greater emphasis on physiological impact and user acceptance than technology development. The project focused on a series of useful devices for people with dementia. This included a night-and-day calendar, a medicine reminder, a pre-programmable telephone and a remote day planner. This project is among the few projects which have formally evaluated the technologies with older people with dementia for a longer period of time across different countries. With the lack of user-acceptance identified based on the study drop-out rates, it is suggested that better understanding of the user's needs is important when developing technology for people with dementia [33].

Completion of activities for daily living: A number of technologies assisting older people with dementia to complete their activities for daily living have been developed [35]. One of the noteworthy systems in this field is the COACH system that has been developed with the aim of increasing the personal hygiene of older people with dementia [94]. The COACH system was initiated a few decades ago with non-

intelligent devices. However, the system was developed into one that incorporates diverse sensor networks and artificial intelligence to sense and perform complex human activity recognition. The current COACH system can assist older adults with dementia through handwashing with audio and audio-video prompts where necessary, based on three levels of assistance. The different versions of the COACH system have used different tracking devices such as pattern wristbands worn by the users and video cameras [95, 94]. Furthermore, research on robots to aid older people with dementia living at their own home is becoming popular [96, 97]. Apart from assisting older people with dementia in carrying out daytime activities, technologies have been designed to assist older people with dementia during the night time. A review on such technologies useful in the night time has been conducted by Carswell et al. [98].

Nutrition and mealtime activity support

Although several research groups have developed technologies for providing assistance in meal preparation [99, 100], food intake [101, 102] and shopping [103, 104], most of these are not focused on the population of people with dementia living at home. The limited research that focuses on assisting mealtime related activities of older people with dementia is predominantly based on technologies for providing assistance with cooking [105, 31].

Remote assistance when cooking: A number of studies that facilitate older people with dementia to get remote assistance from others during cooking exists [105, 106, 75, 107]. For example, a system that allows the remote supporters to provide verbal and visual prompts to older people with dementia has been proposed [105]. In addition to the verbal and visual prompts, an intelligent method that can automatically switch to multiple modes for displaying the visual prompts has been proposed [105]. There were two proposed modes of providing visual prompts. If the target object is on a surface such as a countertop, it is highlighted by circular mark around the object. Otherwise, the visual prompts are displayed on a wall by projectors or embedded monitors. Which mode to switch is decided based on images acquired by five cameras. The system requires feedback from the remote supporter on whether or not the older person completed the task that was prompted.

Similarly, researchers proposed kitchen environments that allow care workers to monitor the cooking processes of older people with dementia remotely and provide verbal instructions to them with the aid of a visual cooking assistance system [107]. This approach employed cameras placed around the kitchen to monitor different areas and objects in the kitchen. Apart from allowing others to remotely observe what is

happening in the kitchens, the systems are also capable of providing guidance to older people with dementia using projectors and speakers installed in the smart kitchen environment, based on the information obtained from the cameras [107].

Among these studies, only one study has indicted that the design and development of the technology was motivated by a needs identification study [105]. In fact this study was based on the findings of the user study conducted by Wherton and Monk [57]. However, most of these studies have performed a qualitative or qualitative user evaluation of developed technology prototypes with only one or two people having dementia in a coffee preparation scenario.

Automatic prompting when cooking: Research towards intelligent and fully automatic prompting for older people with dementia to complete meal preparation activities can be found [36, 31, 37, 38]. Among these, only a few were based on user studies [31, 108, 109]. In fact, those studies were also based on the research study conducted by Wherton and Monk [57]. Common practice was to develop such prompting systems without a proper need analysis and only evaluate the technical performance of the system after technology development [81, 82, 110].

In order to develop intelligent prompting systems for cooking activities, it is important to monitor kitchen environments. The Ambient Kitchen is such a lab based on a prototyping environment situated in the New Castle University [111, 31, 112]. The Ambient Kitchen was implemented to facilitate technology development towards assisting older people with dementia with meal preparation. It utilises a number of sensors which include extensively deployed RFID readers, six cameras integrated into the walls of the kitchen, accelerometers attached to kitchen objects and cupboard doors, and a pressure sensitive floor. Furthermore, projectors and speakers are embedded in the environment to provide assistance to older people. The Ambient Kitchen has multiple display screens in the kitchen to show: i) the menu from which a user can select a recipe; ii) the selected recipe's ingredients and nutritional information; and iii) meal preparation instructions. A number of other similar systems that focus on monitoring cooking activity purely based on the sensors attached to kitchen objects are available [81, 82].

Based on the sensors deployed at the Ambient Kitchen, Hoey et al. [109] proposed a knowledge-driven method for automatic activity recognition and context-sensitive verbal prompting for meal preparation tasks. They have used making a cup of tea as the case study to illustrate their method. The reliability of sensors was demonstrated by asking 12 participants to perform actions related to making a cup of tea. User evaluation of the appropriateness of the prompts were evaluated with two volunteers who were asked to prepare a cup of tea.

Apart from knowledge-driven methods, machine learning based methods for automatically detecting the prompting situations for older people with dementia exists [38, 37, 108]. Das et al. [38] proposed a method that was modelled considering various aspects related to the activity such as duration of the step, the number of unique sensors involved with the step, number of sensor events associated with the step, previous step ID, next step ID and the time elapsed since the beginning of the activity. Noodle soup preparation was selected as the cooking activity for the evaluation. The data for the performance evaluation was collected in a smart home prototype in Washington State University campus which employs a grid of sensors on the ceiling, doors, refrigerator doors, microwave oven doors and on containers in the cabinets [110]. Sarni and Pulli [108] developed a prototype that is capable of transforming cooking activities into process models optimised for people suffering from dementia. This was achieved by splitting cooking activities into different stages such as gathering required items, mixing ingredients, cooking and cleaning. Markov Decision Process was used to model the decision-making process. During the evaluation, a part of the system's technical performance was assessed based on the *gather ingredients stage* and two *get items tasks*.

Previous researchers have attached or embedded sensors in kitchen appliances (i.e. smart ranges) to closely monitor the cooking activity and identify where prompting is needed [113, 76]. For instance, Bouchard et al. [113] used load cells, heat sensors and electromagnetic contacts embedded in the cooker to identify the current state of an on-going activity. An Android tablet was embedded to replace the frontal control panel of the smart range. This tablet allows users to select one or more recipes that they want to perform using a touch screen menu. Error detection accuracy of the system was evaluated by young adults cooking a chicken while simulating errors.

Safety in kitchen: Technologies towards ensuring safety in kitchen environments is another area where some progress has been made with respect to older people with dementia [114, 115]. For instance, cookers with time-based automatic gas or power shut-off is now commercially available [115]. These cookers typically have a motion sensor to detect the presence or absence of the resident in the kitchen area and turns off the cooker once the specified time is exceeded. As a part of the ENABLE project, a cooking monitor system was developed that can automatically turn off the cooker based on the information obtained from the heat sensors installed. Although the usability of the proposed cooking monitor was expected to be evaluated among older people with dementia, all except one participant dropped out during the evaluation due to dissatisfaction with the product [33].

Assistance for eating and drinking: There are studies focusing on providing technological assistance to older people with dementia with eating and drinking activities. These studies have not based their technology design and development on user studies. However, they have evaluated the technical efficacy of the developed prototypes by conducting experiments, mostly in lab environments, employing activity scripts [116, 117].

Reminder systems that notify older people with dementia about their eating and drinking times exist. The simplest form of such reminders are the time-based reminders [118]. Furthermore, there is a growing research interest in alerting older people with dementia to eat and drink by monitoring and recognising deviations in their behavioural patterns. However, current research has mostly focused on the monitoring aspect of the food and fluid intake alone as it is the first step towards any such intelligent system [116, 117].

Food and fluid intake monitoring research often identifies the location of the person inside the house, using motion and pressure sensors, and assumes that a person has taken the meals based on their presence in the kitchen or dining area [119]. However, the location itself does not provide adequate information of food and fluid intake [120]. Some research has utilised vision based techniques to recognise the food and fluid intake of older people with dementia by employing video cameras [117, 121]. For example, researchers have developed methods to automatically recognise food types and portions using images [117]. They evaluated the recognition performance of the proposed method based on images of different food items acquired using a Webcam. Attaching one or more battery-powered device to the body has also been explored as an option to monitor food and fluid intake related human movements of older people with dementia [116].

Assistance for meal planning and shopping: Limited studies have considered providing assistance to older people with dementia with meal planning and shopping. For example, a simple system based on a touch screen was designed to plan the cooking and eating activities of older people with dementia [122]. The system facilitates menu planning for a week based on user defined food preferences and health conditions. The system also allows the users to select the recipe that they like and instruct the oven to set the relevant temperature for the selected recipe. A preliminary user evaluation of the system's usability was conducted by employing healthy older people. However, the design details of the system or the details of the user evaluation have not been adequately explained. In another study, researchers have focused on developing mobile applications which could assist older people to find their way back home, possibly after shopping [123]. They developed a compass based application that points to one's

home location to support exploratory way finding and a landmark-based application to assist older people to find their way. None of these studies have based technology on a needs identification study but have mostly evaluated the usability of the developed prototypes to identify how they can be improved.

2.3.2 Technologies to support care workers

Previous reviews have highlighted that most technologies for staff involved in dementia care have been developed with a focus on hospital and nursing home settings [22]. On the other hand, in terms of technologies for community-based care, significant amounts of research have been carried out to assist informal carers of older people with dementia, such as family members [22, 124, 125]. However, as also highlighted in previous research, technologies for assisting care workers who are providing their services to older people with dementia living at home are not properly examined [22]. In this section, first, a brief overview of general technologies that are developed for supporting care workers of older people living in their own home is presented. Here the primary goal is to offer a summary of the range of technologies that are available. Then, a discussion on technologies that can be used for supporting care workers when carrying out their clients' nutrition and mealtime activities is presented with a note on whether those studies were based on user needs identification research.

General support

Technologies developed for care workers assisting older people with dementia living in their own home are generally centred around providing education and training, and remote monitoring of the clients. For example, a multilingual e-learning web portal was developed to provide dementia care training to both care workers and families [126]. The courses offered in the e-learning portal include the medical model of dementia with information on types of dementia, symptoms, and diagnostics, the perspective of functional consequences in daily life and the perspectives of dealing with the psychosocial consequences for the person with dementia and their family. In another study, care workers were given the opportunity to record their success stories as to how they handle their clients, and to view other care workers' stories through a mobile application [127]. User evaluations of the system, suggested that care workers were not satisfied with the system, mainly because of the perceived security threat in video recordings.

Several studies have looked at providing access for care workers to the data obtained from sensors attached to home environments or to the bodies of their clients in order to remotely monitor their behaviours [128, 129, 83, 83]. Nijhof et al. [128]

developed a tool which provides a visual representation of activity levels in different parts of the house, based on the collected sensor data. For example, the system included a bar chart that shows the number of times the sensors in the hallway had been activated during a given time period [128]. It is expected that such a visual representation would allow the care workers to identify the activity level of their clients and detect problems as early as possible. Similarly, data collected from a smart watch worn by older people with dementia was visualised to provide information to care workers on their clients' behaviours [129]. A number of sensors, which included an optical blood flow sensor, 3D accelerometer and body temperature sensors were in-built in the smart watch. Data collected from these sensors were used to illustrate the activity levels and sleeping patterns of the older person with dementia to their care workers.

Previous research has proposed systems that allow the care workers to remotely monitor their clients through video cameras. For example, video cameras were deployed around the house for care workers to remotely watch their clients [129]. The proposed video monitoring system enabled care workers to optimise their work. However, some care workers expressed concerns about privacy due to the possibility of their activities being watched by other care workers through the camera.

Nutrition and mealtime activity support

As explained previously, research that allows care workers to remotely monitor older people's cooking activities in kitchen and provide them instructions where necessary has been conducted [105, 106, 130]. Although the focus of such studies is to assist the older people with dementia, care workers have also benefited as they are able to remotely monitor multiple clients simultaneously without visiting their homes.

Previous researchers have developed kitchen simulations to provide opportunities for care workers and family members of older people with dementia to experience a day in the life of someone with dementia and learn about the difficulties they may face [131]. Inside the living kitchen, sensors and projectors simulate the limitations of having dementia. Although the path taken to developing the simulation environment is not clearly mentioned, the study has carefully evaluated the usefulness and effectiveness of the developed prototypes using semi-structured interviews and a survey administered among care workers and family members.

2.4 Discussion

This chapter discusses the related literature with respect to the topic of this thesis. Firstly, a discussion of non-technology research related to the nutritional health of older

people with dementia living at home was presented to understand what is generally known regarding their nutrition and mealtimes. Secondly, a description of studies that investigated the technology needs of older people with dementia living in their home and their care workers was presented. Thirdly, a review of the types of technologies developed for assisting older people with dementia living at home and their care workers was conducted, with a special emphasis on technologies supporting nutrition and mealtime activities and a note on whether those studies were based on user studies.

Despite the significant amount of research that focuses on residential care and hospital settings, previous studies have clearly highlighted that technologies to support older people with dementia living in their home have been not explored properly [132, 22]. Furthermore, care workers assisting older people with dementia living in their own home is a user group that is often excluded from technology development research [22]. On the other hand, existing technology development studies centred around older people with dementia living in their own home are in their infancy [42, 33]. Among these, there are only limited studies that have focused on supporting older people with dementia living in their own home when carrying out nutrition and mealtime related tasks. These studies have mostly conducted experiments in scripted settings with very small samples. This may well be explained by the fact that the studies are at a very early stage of development and are mostly evaluating technology prototypes. Important considerations related to such technologies are that only a few have based their design on user studies [37, 111, 31, 123].

There are no studies that focus on understanding the holistic technological needs for supporting older people with dementia to maintain good nutrition and for supporting care workers to promote the nutritional health of their clients. It is important that technology needs are identified without having any particular technology or technology delivery mechanism in mind, as opposed to pre-selecting technology or delivery mechanisms and investigating how they could be used, as done by Wherton and Monk [57]. Some interesting insights into issues faced by older people with dementia can be obtained through non-technology research studies. However, to date most of the understanding about nutrition and mealtime situations of older people with dementia comes from the families or friends who are mostly residing with or managing the nutrition and mealtime tasks of their loved ones [24, 46, 48, 50]. Furthermore, nutritional health issues identified through the previous studies were mostly related to eating, as most studies were centred around behavioural, social and emotional changes related to having meals [27, 46]. Therefore, much is still unknown especially about people living with limited or no family support. Given the possibility of older people with dementia having issues in differentiating between the present and past, normalising or not accepting their difficulties [133, 134], it is important that reliable methods are

employed for identifying their technology needs. Support from care workers is often arranged for older people with dementia living in their home, especially in situations where there is limited or no family support. However, the care workers' voices about their clients nutrition and mealtime situations are rarely heard [21]. A possible reason for this could be the difficulty in recruiting care workers for research studies due to their limited availability as a result of their workloads [68]. In particular, the challenges faced by care workers when assisting their clients to maintain good nutrition are still not properly identified.

The following conclusions can be drawn from the literature reviewed in this chapter:

- While some progress has been made in developing assistive technologies for supporting different aspects related to the nutritional health of older people with dementia living at home, challenges remain to reach the desired maturity for such technologies.

- The successful development of technologies for promoting the nutritional health of older people with dementia can benefit from proper identification of user needs [135, 42]. This includes identifying technological needs for supporting older people with dementia to maintain nutritional health and for their care workers to provide better support to their clients. Unfortunately, there is no research that focuses on obtaining an holistic view of the technological needs for supporting both older people with dementia living in their home and their care workers.

- Identifying user needs requires greater research investment initially. In particular for an older population with dementia this poses extra challenges. As a result, technology developers tend to design and develop technologies based on their assumptions and experiences, without conducting proper needs assessments, and later evaluating the effectiveness or user acceptance of the system [42, 33].

- Previous reviews have clearly highlighted the urgent need to co-design technologies with users, in order to increase user acceptance and to allow those technologies to reach the desired level of maturity in the longer run [42, 33].

- Even though obtaining an understanding of user needs before developing technology is a time consuming and costly task initially, it ultimately reduces product development costs by increasing the end-user satisfaction and acceptance for the developed technologies [42].

Section II

Investigation of technological needs

Section II of this thesis presents a study rooted in qualitative descriptive research design, which aims to obtain an holistic perspective of the needs for technologies geared towards promoting the nutritional health of older people with dementia living in their own home. This involves focus groups with twenty seven care workers recruited from four leading aged care organisations in South Australia.

Chapter 3 reports the methodological underpinning of the qualitative descriptive study, including research methodology, research design and research methods. Furthermore, research techniques employed to enhance study rigour are described in Chapter 3. Chapters 4 through to 7 report the findings of the qualitative descriptive study based on the research methods employed. Chapter 8 provides a detailed discussion of the findings of the qualitative descriptive study.

Chapter 3

Theoretical framework

Developing technologies geared towards promoting nutritional health among older people with dementia living in their own home is important to support effective independent living. In this context, it is useful to design technologies to support older people with dementia to maintain good nutrition and their care workers to better assist their clients. Although a more straightforward approach to developing technologies is to rely on technology designers' perceptions, technologies built without properly understanding user behaviours and demands can be ineffective or short-lived when deployed in the real world [42, 33]. Therefore, there is an urgent need to conduct user studies before technology development [42, 33].

Gaining an holistic view of the nutrition and mealtime situations related to older people with dementia living in their own home is important to design useful and practical technologies which can collectively work towards promoting nutritional health in this cohort. As highlighted in Chapter 2, although there are limited studies that investigate co-designing technologies with users [136, 137, 56, 44], none focus on the holistic needs for technologies that promote nutritional health in older people with dementia living in their own home. Furthermore, previous studies highlight that much remains unknown about nutrition and mealtime situations of older people with dementia especially living in their own home [24, 21]. Limited non-technology research in this space mainly relies upon information obtained from families who are living with and supporting older people with dementia [27, 46, 39, 138, 139].

Support from care workers employed by aged care organisations is often arranged for older people with dementia living in their own home, especially in situations where there is limited or no family support. As a result, care workers typically have extensive experience in providing care support to multiple older people with dementia. In the light of previous research highlighting older people with dementia's issues in differentiating between the present and the past, normalising or not accepting their

difficulties [133, 134], relying on care workers' descriptions about the challenges that their clients have, creates the opportunity to obtain reliable information. However, as highlighted in Chapter 2, existing research rarely pays attention to care workers' voices with respect to nutrition and mealtimes of their clients [21].

It was anticipated that care workers' voices will allow the researcher to obtain an holistic perspective of the technological needs for promoting nutritional health in older people with dementia living in their own home, including identifying:

(i) the challenges older people with dementia living in their own home face that may prevent them from maintaining good nutrition

(ii) the challenges care workers face when trying to ensure good nutrition amongst their clients

(iii) the considerations for developing technologies that may be effective for assisting older people with dementia to maintain their nutritional health and for facilitating care workers to provide improved care support to their clients

To envision a comprehensive technological platform consisting of interoperable technologies geared towards promoting nutritional health in the target cohort, as an initial step, broad understanding of the challenges faced by older people with dementia and their care workers is essential. Care workers' experiences in supporting many older people with dementia living in their own home is invaluable to obtain deeper and more reliable insights about such challenges. These challenges will demonstrate a demand for support for assisting older people with dementia and their care workers; and hence suggest technological needs for promoting nutritional health of older people with dementia living in their home. Furthermore, the holistic perspective of the nutrition and mealtime situations obtained from the care workers will allow the researcher to formulate design considerations to guide the technology development in this space.

This chapter reports the details of the theoretical framework that underpins the qualitative study which is grounded in the interpretivist/constructivist research paradigm and the qualitative descriptive research design. The chapter is organised as follows. Section 3.1 provides an explanation and justification of the research methodology and Section 3.2 describes the research methods used in this study. This includes: i) participants selection and recruitment (Section 3.2.1); ii) data collection (Section 3.2.2); and iii) data analysis (Section 3.2.3). Methodological techniques employed to enhance the rigour of the study are further discussed in Section 3.3. Finally, the chapter ends with a summary in Section 3.4. Ethical approval (ethical approval number: H-2014-246) for the study has been received from the Human Research Ethics Committee, The University of Adelaide (See Appendix A). The theoretical framework presented in this

chapter has been submitted to Dementia (Innovative Practice), the international journal of social research and practice and has received minor corrections.

3.1 Explanation and justification of the research methodology

Theoretical underpinnings of the study were carefully taken into consideration when deciding on the research methods. Therefore, this section provides details of the research paradigm and the research design chosen for the study.

3.1.1 The research paradigm selection

According to Bogdan and Biklen [140], a research paradigm is defined as:

> "a loose collection of logically related assumptions, concepts, or propositions that orient thinking and research" (p. 22).

Paradigms influence the way phenomena are studied and interpreted and there are a number of such theoretical paradigms discussed in the literature [141, 142]: i) the positivist paradigm; ii) the interpretivist/constructivist paradigm; iii) the transformative paradigm; and iv) the pragmatic paradigm. We first review these research paradigms before selecting the most suitable research paradigm for this study.

The positivist paradigm employs a scientific approach to research where a hypothesis is tested based on knowledge extracted from data analysis and synthesis [141]. This paradigm assumes that any research is influenced by one or more existing theories and usually emphasizes multiple viewpoints from participants [143]. In studies that follow a positivist paradigm, the researcher's role is limited to data collection. The interpretation is usually done following an objective approach and the findings of the research are observable and measurable. The positivist paradigm was replaced by post-positivism which argues that we cannot guarantee claims of knowledge when studying about humans, as all observations can be imperfect and can have errors [141]. Quantitative methods of data collection and analysis are naturally associated with both positivist and post-positivist research.

The interpretivist/constructivist paradigm intends to understand "the world of human experience" [144] by studying participants' views and experiences of the situation being studied [141]. Unlike research following the post-positivist paradigm,

constructivist research is not likely to start off with a theory, but rather to try to explore and discover theory or patterns of meaning through observations [141]. Therefore, the researcher is involved in understanding and interpreting what others say about the situation. This type of research predominantly uses qualitative data collection methods such as interviews, focus groups and observations and qualitative data analysis methods. However, a combination of both qualitative and quantitative methods can also be used.

The transformative paradigm is power and justice oriented and places importance on the study of the experiences of people who are normally disregarded [144, 145]. In particular, discrimination based on gender, race, disability and sexual orientation are studied under the transformative paradigm, while focusing on political and social actions drawing from these discriminations. The transformative paradigm usually employs qualitative, quantitative and also mixed methods in data collection and analysis.

The pragmatic paradigm is problem centred and the focus is on the 'what' and 'how' of a research problem [141, 145]. Researchers can choose the methods and techniques that best suit their problem and do not have to be committed to any one system of beliefs. Furthermore, pragmatic paradigms might include data collection and data analysis techniques from both positivist and interpretivist paradigms, as the researcher's goal is to select what is best for the given moment. Therefore, it is common to combine qualitative and quantitative data collection and analysis methods in the pragmatic paradigm.

Selection of the research paradigm for the study. This study focuses on exploring care workers' perceptions regarding nutrition and mealtimes of older people diagnosed with dementia living in their own home. Therefore, an interpretivist/constructivist paradigm is best suited for this research as it allows the researcher to explore participant's perceptions without being committed to any theories or assumptions in advance. In particular, the interpretivist/constructivist paradigm provides a context that allows the researcher to: i) explore the care workers' meal-time experiences; ii) explore the issues faced older people and care workers during mealtimes; and iii) understand care workers' views and expectations of technologies geared towards preventing malnutrition.

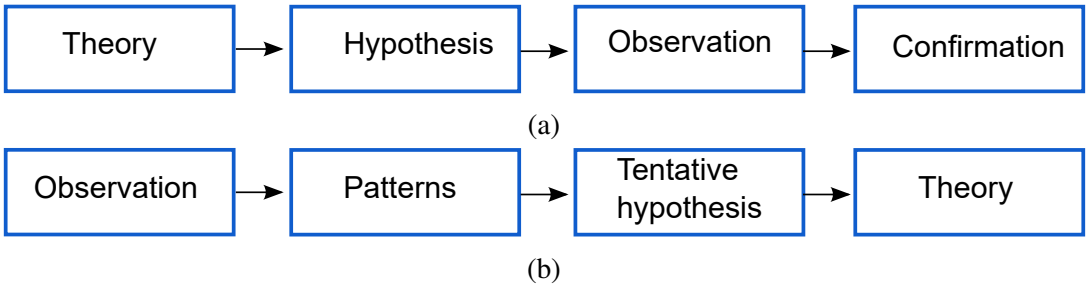


Fig. 3.1 Deductive process vs inductive process: (a) deductive process; and (b) inductive process

3.1.2 The research design selection

When using the interpretivist/constructivist paradigm, qualitative design is a natural choice [146]. The following section describes the characteristics of qualitative research and the relevance of qualitative descriptive design for this study.

Qualitative research

Qualitative research is a type of social inquiry which relies on words or stories, compared with quantitative research which focuses on numbers and measurement [147]. According to the 'Handbook of Qualitative Research' [148] qualitative research is much more flexible than quantitative research and is defined as:

> "Qualitative research is multimethod in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret phenomena in terms of the meanings people bring to them" (p. 2).

As a result of the flexibility involved in qualitative research, it is more suited for understanding experiences and feelings of individuals than quantitative approaches [148, 149]. Key characteristics of qualitative research are described below [140, 142]. However, it is important to note that not all qualitative research designs exhibit the following characteristics to the same degree.

- Naturalistic enquiry: Qualitative research focuses on studying situations as they unfold in a naturalistic manner where data collected will not be controlled or manipulated [142]. Without having any pre-determined constraints on the findings, the knowledge is allowed to emerge from its natural setting.
- Descriptive data: The data collected in qualitative research are descriptive [142]. For example, data collected can take the form of words instead of

numbers and reports often contain quotations from the collected data to facilitate understanding and deepen meaning. Qualitative research demands that the research needs to be conducted without making any prior assumptions about the importance of data being collected. All pieces of data gathered may help to provide useful descriptions and clear understanding of the situation being studied.

- Inductive process: Usually qualitative studies are carried out due to the non-existence of a theory or due to existing theory failing to sufficiently explain what is being studied [142]. Qualitative research usually employs an inductive approach for research. Unlike deductive approaches which focus on testing a theory, inductive approaches begin with specific observations and then identify patterns and regularities, and finally develop some general conclusions or theories. The inductive approaches are usually considered to be bottom up (see Figure 3.1). Inductive reasoning is more open-ended and exploratory by its nature [142].

- Focus on meaning and understanding: The focus of qualitative research is on understanding how participants interpret their experiences [142]. Therefore, qualitative researchers set up plans and measures that enable them to uncover the experiences from participant viewpoints. Patton [150] describes that qualitative research is:

  > "... an effort to understand situations in their uniqueness as a part of a particular context and the interactions there. This understanding is an end in itself, so that is no attempting to predict what may happen in the future necessarily, but to understand the nature of that setting – what it means for the participants to be in that setting, what their lives like, what is going on for them, what their meaning are, what the world looks like in that particular setting." (p. 1).

- The researcher is the primary instrument: In qualitative research, as the emphasis is on exploring and interpreting participant experiences, the researcher primarily gets involved in data collection and analysis [142]. Researcher (human) involvement creates the possibility of being responsive, adaptive to what participants have to say, and able to clarify, summarise material and explore unanticipated responses.

Before selecting the research design for the study, six prominent qualitative research designs were reviewed: i) phenomenology; ii) ethnography; iii) grounded

theory; iv) narrative; v) case study and vi) qualitative descriptive. However, it is important to note that, even though these qualitative designs have distinct characteristics, they all can have similarities with each other up to a certain extent [151, 152].

Phenomenology is rooted in the concepts of inquiry coming from philosophy and psychology, and focuses on understanding a situation as seen through the eyes of those who have actually experienced it [153]. In simple terms, a phenomenological research study tries to provide interpretative meaning of an experience and tries to answer the question 'what is it like to experience ...?'. In depth interviews are a common form of data collection in phenomenological research. Sometimes researchers may even interview the same individual several times to get a full understanding of their experiences of the situation that is being studied.

Ethnography is drawn from anthropology and sociology. The researchers following an ethnographic approach immerse themselves within the participants' environment to understand their culture [154]. Culture can be described as the beliefs, values, practices, language, rituals, and material that are common to the participants [155]. The goal of ethnographic research is to provide a deep and comprehensive description of the culture of the group under study. A common ethnographic approach is participant observation where the researcher lives with them to experience their way of life.

Grounded theory is drawn from sociology and the goal is to develop a theory that explains an activity or event that has occurred [152]. Grounded theory research usually has a complex iterative process that involves multiple stages of data collection and refinement with continuing data collection and analysis throughout the study.

Narrative is rooted in the concepts of inquiry coming from humanities and focuses on exploring the life of one or more individual [156]. The selected participant or participants are requested to share stories about their lives. In-depth interviews are a common data collection method, although observation, documents and images are also used to understand the participant's lives. These experiences are chronologically ordered and reported by the researchers as stories.

Case studies are drawn from psychology, law and political science and focus on developing in-depth descriptions and analysis about a case or multiple cases. A case is considered as a bounded system due to multiple reasons such as time and place, and usually involves multiple types of data sources [143].

Qualitative description design The focus of qualitative description research is on providing rich descriptions, in everyday terms, of specific events experienced by a person or groups of people [157, 151]. Qualitative descriptive studies do not influence the phenomenon in any way and present the findings in everyday language [157, 151]. For example, qualitative description is different from theory development as in grounded theory or providing rich description as in ethnography or providing interpretative meaning of an experience as in phenomenology [157, 151].

Even though some researchers view qualitative descriptive design as a qualitative alternative to other qualitative research designs, such as grounded theory, phenomenology, and ethnography, researchers have argued that qualitative descriptive design should be viewed as another category in the qualitative research tradition rather than a non-categorical alternative [157].

In contrast to other research designs, such as grounded theory and ethnography, which are based on specific methodological frameworks, qualitative descriptive design does not have a specific discipline or philosophical commitments and tends be built on the concepts of naturalistic inquiry [158]. Naturalistic inquiry focuses on studying the target problem or situation in its natural state without prior selection of variables for the study. Furthermore, in qualitative descriptive design, the data collected will not be manipulated and there will be no commitment to any theoretical view of what is being studied.

The researcher's own interpretation of the findings is limited when following a qualitative descriptive design compared with other qualitative designs such as ethnography and phenomenology [157]. Furthermore, the descriptions in qualitative descriptive studies require the presentation of the findings in everyday language, where as other research designs such as phenomenology, ethnography, or narrative inquiry require that the descriptions are re-presented in other terms (e.g. a 'conditional/consequential matrix' in grounded theory studies or 'life world existential' such as corporeality and temporality in certain phenomenological studies).

Selection of the research design for the study The qualitative descriptive design is well-suited when descriptions of complex human experiences are needed [151]. The focus of this study is on describing and understanding care workers' perceptions in everyday terms rather than trying to develop new theories. As there is no definitive description about the problem being studied in the literature, qualitative descriptive design allows us to explore, describe and understand care workers' perceptions on nutrition and mealtimes of older people with dementia living in their own home. This knowledge can subsequently be used to identify need and design considerations for

technology development focusing on promoting the nutritional health of older people with dementia living in their own home.

3.2 Research methods

The research methods employed for the study are described below.

3.2.1 Participant selection and recruitment

Purposeful sampling is best suited to obtain rich information for qualitative descriptive studies [151, 159]. Therefore, this sampling technique was utilised in this study to recruit care workers employed by four aged care organisations, who provide care support to older people with dementia living in their own home.

There are two types of care workers employed by aged care organisations for in-home support services targeting older people: i) care coordinators; and ii) home support workers (also referred to as home care assistants). Care coordinators hold a range of responsibilities that typically include: i) assessing the personal and social needs of clients; ii) developing appropriate care plans based on assessed needs; iii) coordinating, monitoring and reviewing the provision of services to individual clients; iv) assisting with coordination and day-to-day running of the aged care centre based activities; v) assisting the managers with rosters and supervision of staff involved in the provision of direct client services (i.e. home support workers); and vi) assisting the managers with the reviews and periodic evaluations of the program in terms of outcomes for clients, unmet needs and financial performance. Home support workers are typically required to work at various locations and within private homes, providing services for individual clients. They generally assist their clients with activities relating to personal well-being, household management and lifestyle. Usually multiple home support workers are allocated for a specific client, depending on the client's needs. Therefore, in order to increase the variation in sampling, both types of care workers, who had clients with dementia living in their own home, were included in the study.

In order to recruit care workers for the study, senior officers/managers of four prominent aged care organizations in South Australia were initially contacted and were invited to participate in the study. They were requested to identify suitable care workers in their respective organisations. The senior officers/managers were also requested to email the consent form (see Appendix B), the contacts for information on the project, and independent complaints procedure (see Appendix C) and the participant information sheet (see Appendix D), to the selected participants at least two weeks prior to the study. The participants were remunerated as a part of their employment.

Additionally, the participants were awarded a certificate of participation with which they could apply for Continuous Professional Development points.

3.2.2 Data collection

The main purposes of collecting data from the care workers was to allow them to describe: i) their perspectives on challenges faced by their clients in relation to nutrition and mealtime activities; and ii) challenges faced by them when providing nutritional health support to their clients. A broad understanding of these issues is essential for technology development. In addition, care workers' wishes for technologies to facilitate them to provide improved nutritional health support to their clients and to assist their clients to maintain good nutritional health, were obtained. As care workers cannot be expected to provide detailed descriptions of the role of technologies, it was anticipated that their wishes on technological assistance may provide useful hints, and serve as entry points to identifying potential technology applications. Overall, it was expected that the data collected from care workers will allow the researcher to formulate design considerations for technology development in this space.

Explanation and justification of the data collection method

The method of data collection for this study was chosen following a review of data collection methods suitable for a qualitative descriptive study [151]. The reviewed data collection methods were: i) individual interviews; and ii) focus groups interviews.

Three types of individual interviewing techniques exists [159]: i) informal conversational interview; ii) semi-structured interview; and iii) structured interview. Informal conversation is commonly utilised in ethnographic research due to the relatively high flexibility compared with other interviewing techniques. Structured interview ensures that similar questions are asked of all the participants, hence, least flexible among the three approaches. Semi-structured interviews utilise an interview guide, which allows flexibility for the researcher when interviewing compared to structured interviews.

Focus groups have been identified as a useful method to obtain information on perceptions, attitudes, experiences and beliefs of a group of individuals [160]. As a result, focus groups was selected as the method of data collection in this study. Interactions among members of a focus group are considered the unique feature that differentiates focus groups from individual interviews [161]. Focus group originated from group theory and is a very popular data collection technique in qualitative descriptive studies [162]. Focus groups are based on the assumption that people who share common experiences are more prepared to discuss them in a group than during an individual interview and hence provides richer information.

Focus groups allow conversations, agreement and disagreement among participants hence ideas are brainstormed and the interactions between the participants can stimulate ideas that will be useful for the discussion. Furthermore, focus groups encourage participants to explore the reasons behind their thoughts and allow the issues to be explored in-depth with more data to be collected within a given amount of time [160]. According to [162], the data generated in focus group interviews are:

> "... richer and deeper than data elicited in the one-to-one interview" (p119).

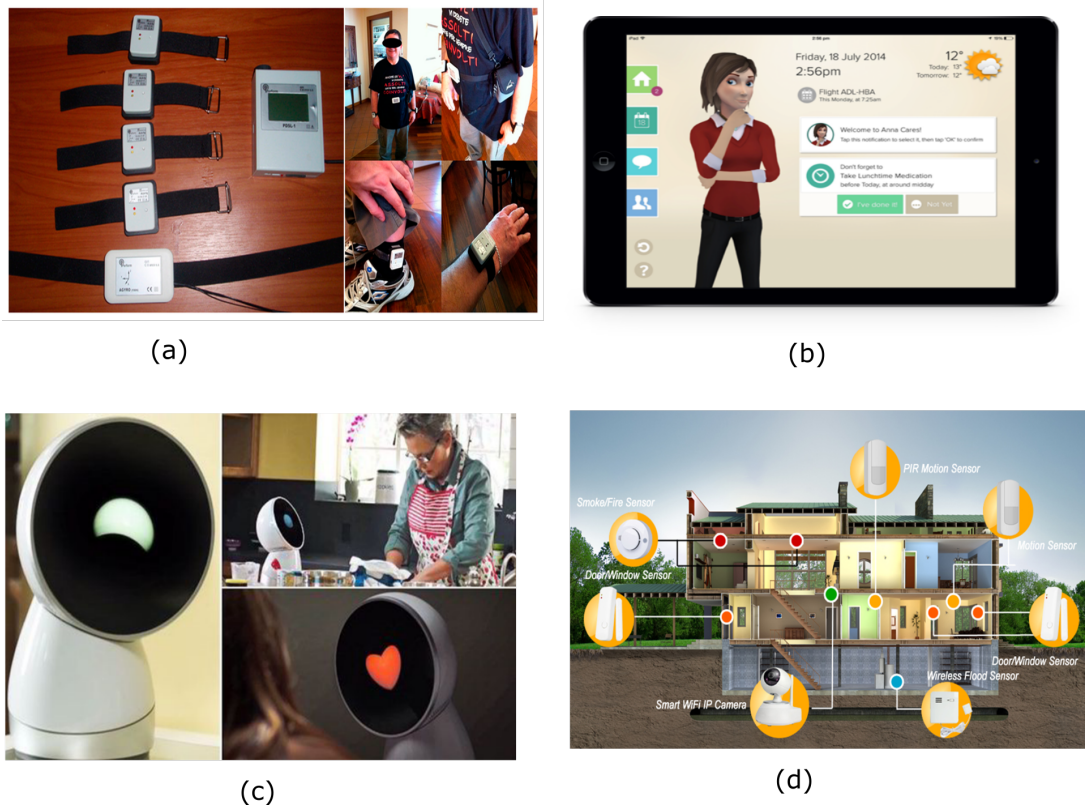
However, researchers have pointed out that focus groups can be intimidating for some individuals [161]. On the other hand, other researchers have argued that group conversations can be less threatening compared with individual interviews as the presence of peers offers support and encouragement even to individuals with less self-confidence [162, 163].

Focus group procedure

Separate group meetings with each type of care worker were conducted. It is beneficial to have separate focus groups because: i) having care workers with similar roles in a single focus group allows them to relate to each other's experiences; and ii) the participants may more freely express their ideas when their supervisors or subordinates are not present. All meetings were held in each respective aged care organisation and were conducted at a time most suitable for the participants.

Each focus group lasted for approximately 90 minutes and included a moderator (the researcher) and note taker (a supervisor who is a expert in qualitative research). The moderator led the focus group meeting. At the start of the meeting, everyone introduced themselves and a full explanation of the purpose and ground rules regarding confidentiality was provided to the participants by the moderator. Participants were assured of anonymity in the findings. Participants completed a brief information sheet (Appendix E). All focus group discussions were conducted in English and audio recorded. Participants provided informed consent before the meeting. During the meeting, the moderator tried to ensure all the participants were included in the discussion and asked follow up questions to explore on the matters that were discussed further. Focus group discussions were conversational and guided by a semi-structured focus group guide (see Appendix F). The details of the focus group guide are given below.

Focus group guide The researcher decided on the types and order of questions in the focus group guide after several rounds of brainstorming and refinement with her



(a) (b)

(c) (d)

Fig. 3.2 Examples of technologies for in-home monitoring or assistance included in the presentation conducted by the moderator during the focus groups: a) wearable sensors [1]; b) hand held tools [2]; c) robots [3]; and iv) smart home [4]. ((a) is licensed under CC BY 4.0.)

supervisors. The focus group guide has been also reviewed by an external geriatrics specialist involved in dementia care. Before the start of the meeting the moderator clearly explained to the care workers who participated in the study that the focus group is centred around their clients with dementia living in their own home with or without support from families.

The guide includes an opening question, several transition questions and an ending question. The opening question is mainly used as an ice-breaker for the focus group meeting and also to obtain background information. Although the general duties of each type of care worker was described in Section 3.2.1, it is expected that care worker' responses for the opening question may provide further insights into the sorts of care support older people with dementia living in their own home generally receive, related to their nutritional health.

The second question sought to obtain participants' perceptions on challenges that their clients face when trying to maintain good nutrition. The third question asked participants about the challenges they face when trying to promote nutritional health

in their clients. Understanding these challenges is important as they can be translated into technological needs for supporting older people with dementia living in their own home to maintain their nutritional health and for facilitating care workers to better manage their clients' nutritional health.

Although the challenges care workers face when trying to assist their clients in maintaining good nutrition may implicitly suggest some of their information needs, it is interesting to understand the sorts of information care workers themselves consider valuable to support their clients' nutritional health. Therefore, the fourth question was designed to obtain the information that care workers think will be valuable for them to provide a better support to their clients in terms of their nutritional health. Any insights obtained from this question were expected to be useful when designing assistive technologies to support care workers in providing a better service to their clients.

The closing question allowed participants to think 'out-of-the-box' and express their wishes regarding the role of technologies in assisting them and their clients to maintain good nutrition. Prior to the final question, the moderator conducted a 5-10 minute presentation about commonly used technologies designed to monitor or assist general activities of daily living in home environments. This included showing photos of such technologies (see Figure 3.2) and a video of JIBO [164], a social robot for the home. The goal of the presentation was to provide knowledge about existing monitoring and assistance systems and stimulate ideas in the participants. As explained previously, although care workers were not expected to provide detailed descriptions of the types of technologies, it was anticipated that their ideas may provide suggestions on potential technology application areas and serve as an entry point to designing technologies.

Probes were used to stimulate the discussion. While there were some pre-defined probes, the moderator also used appropriate probes based on how the discussion was flowing to obtain more information from the participants. After each focus group, both the moderator and the note taker listened to respective audio recordings to identify any required improvements to the focus group guide, especially the probes used.

3.2.3 Data analysis

Qualitative content analysis is best suited for qualitative descriptive studies [151]. The main aim of qualitative content analysis is to obtain a comprehensive description of the situation being studied through the development of concepts or categories describing that situation [45, 165]. Detailed description of the data analysis framework used in this study is given below.

Fig. 3.3 Stages of the organisation stage of the qualitative content analysis

Qualitative inductive content analysis reported by Elo and Kyngäs [45] was performed. According to Elo and Kyngäs [45], there are two types of content analysis approaches: i) inductive; and ii) deductive. In the inductive approach, categories are derived from data and this approach is well suited when there is not much theory in the situation that is being studied. On the other hand, deductive content analysis is based on established theory and is best suited when the goal is to verify an existing theory based on the collected data.

Qualitative inductive content analysis involves three main stages: preparation, organizing and reporting. In the preparation stage, researches can choose to analyse either the manifest content alone or the latent content as well. Manifest content is considered as the primary content and focuses on main ideas of the text and on the other hand contextual information such as silence, posture are considered as latent content [166]. We chose the conventional manifest content for this study.

Selection of the unit of analysis is another consideration under preparation stage of qualitative inductive content analysis. The unit of analysis is sometimes referred to as the meaning unit. According to [167], the meaning unit is a:

> "... collection of words or statements that relate to the same central meaning" (p. 2).

Therefore, categories derived from the data were considered as the unit of analysis for this study. Figure 3.3 presents the main steps of the organisation stage of the inductive content analysis [165]. The purpose of creating categories is to systematically organise data for retrieval and analysis. When data are analysed inductively, the researchers group data that present a similar meaning into a single category. Such an abstraction allows for a general description of the situation being studied to be constructed. The abstraction process can continue as long as the generated categories are meaningful.

Data analysis procedure Data collected from focus groups were transcribed by the researcher and analysed using the NVivo^{TM} software. The transcriptions were read multiple times to obtain a sense of the whole. Notes taken by the note taker were read to clarify discussion points in the recordings. The data analysis was performed by the same moderator (the researcher) and the note taker (a supervisor who is a qualitative study expert) who were involved in the data collection.

Open coding was performed where focus group data were marked and labelled with a code describing their content. Once the initial codes were generated, they were independently analysed by the researcher and her supervisor. Discussions were carried out until agreement reached about how the codes should be labelled. It was decided to refer the lowest level of codes as the 'nodes'. Next the 'nodes' relating to each other were freely grouped together, forming 'concepts'. Later 'concepts' that had similar meaning, were merged together forming the 'categories'. The main questions used in the interview guide were used to label the main categories as this allows to report participants' responses to individual questions separately. Additionally, separate categories were created for the coded content which didn't fall under the main questions. The supervisor reviewed all the categories, concepts and nodes that were identified by the researcher, iteratively improved the grouping of data and naming of the groups until an agreement was reached. It is important to note that the researcher's own interpretation of the findings is limited when following a qualitative descriptive design (see Section 3.1.2). Therefore, the categories, concepts and nodes were derived from the data based only on what the care workers had to say.

3.3 Study rigour

The nature of qualitative descriptive studies creates the possibility for the researcher to stay close to what care workers have to say. The rigour in the qualitative descriptive research can be improved with a well-considered use of research methods and techniques based on the selected research design [168, 169]. The following section discusses in detail how the rigour in this research has been achieved through careful selection of research methods and techniques based on qualitative descriptive design.

Purposefully selecting the participants, who can provide in-depth information about the topic being discussed could increase the variation of the study sample, and is an important aspect for authenticity and credibility of the research [168]. However, data collection in a setting where participants have a hierarchical organisational structure can be challenging. It is believed that in such a setting, it is judicious to make sure participants in a single focus group belong to the same or similar role in the organisation in order to create an inviting environment for them to express their ideas freely while relating to each other's experiences.

Having a flexible focus group guide plays an important role when considering the authenticity and credibility of the research [168]. The guide should be carefully designed to allow participants to develop trust and partnership with the researchers as well as others in the meeting. This is an important aspect in ensuring the authenticity

of data collected [168]. The opening question of the focus group guide was designed to allow participants to describe their current work. This created an inviting environment for them to engage freely in the discussions. Furthermore, phrases such as “According to your experience ..." were used to allow participants to share their stories with the members in the focus group.

It is also important to note that the presentation on assistive technologies was done with caution so to minimise bias in the collected data. In particular, the presentation was strategically conducted immediately prior to the ending question as opposed to conducting it at the start. This is because, if the focus of the group meeting is diverted from personal experiences towards technology from the outset, there is a higher tendency for participants to trying to relate their experiences with their understanding of technologies and subsequently unknowingly fail to express other valuable information.

In qualitative research, the researcher becomes the primary instrument for data collection and analysis. As qualitative descriptive design does not have a prior commitment to any theory. Using this design provides the opportunity for the researchers to stay very close to the data during data analysis and reporting [169]. However, the influence of the researcher on data collection and analysis can result in research bias. Rather than trying to eliminate the bias, a key aspect of a study’s integrity is on identifying it and understanding how it forms part of the data collection and analysis procedures [142].

When considering the data collection in this study, researcher subjectivity involved in the data collection was reduced by developing the focus group guide in consultation with all members of the supervisory panel and also an external expert in geriatrics who has experience in dementia care. By having a geriatrics expert in dementia care any negative impact of the researcher’s limited knowledge on dementia on the questions and initial probes of the focus group was minimised. Furthermore, the researcher having limited knowledge in dementia care meant that follow-up questions are asked without having any preconceptions compared with what someone who is familiar with dementia would ask and therefore, may have facilitated uncovering unanticipated information. Additionally, the moderator and the note taker iteratively improved the probes used during the focus groups by listening to the audio recordings after each group meeting.

Data analysis was conducted by the moderator (primary researcher) and note taker (supervisor) involved in the collection of data. This strengthened the study’s rigour. The effects of subjectivity during data analysis were reduced by the primary researcher closely working with her supervisor during the data analysis process. The supervisor’s independent view improved the coding consistency and the reliability in data analysis.

3.4 Summary

Obtaining deeper insights into nutrition and mealtime situations of older people with dementia living in their own home is important to obtain an holistic needs for technologies to support older people with dementia living in their own home to maintain good nutrition and to facilitate their care workers to provide improved care support to their clients. In this chapter, the design of such a study using care workers (n = 27) as the information source was described. Care workers for the study were recruited through four leading aged care organisations in South Australia. By involving care workers in the design process, it is anticipated that the developed technologies are likely to be usable, acceptable, easily translated into practice and assimilated where required rather than be forced into irrelevant areas.

It was anticipated that care workers' voices will allow the researcher to obtain an holistic perspective of needs for technologies geared towards promoting nutritional health in older people with dementia living in their own home, including identifying the: i) challenges older people with dementia, living in their own home, face that may prevent them from maintaining good nutrition; ii) challenges care workers face when trying to ensure good nutrition among their clients; and iii) considerations for developing technologies that may be effective for assisting older people with dementia to maintain their nutritional health and for care workers to provide improved care support to their clients.

Research design and the inherent methodological framework influences the way phenomena is studied and interpreted into new knowledge. Therefore, theoretical underpinnings of the study should be taken into consideration carefully when deciding about the data collection, data analysis and reporting procedures. This chapter provided details on the research methodology, research methods, and how research rigour was achieved in the study.

By means of an interpretivist/constructivist paradigm, a qualitative descriptive research design was chosen for this study. The research methods were selected to suit a qualitative descriptive design. Focus groups were chosen as the method of data collection from care workers. For all the focus groups, the researcher and the supervisor participated as the moderator and the note taker respectively. The main purposes of conducting focus groups with care workers was to allow them to describe challenges faced by them when providing nutritional health support to their clients and challenges faced by their clients related to nutrition and mealtime situations. These identified challenges suggest needs for technology development to support older people and their care workers. In addition, to obtain further insights into technology development, care workers' wishes for technologies, to facilitate them to provide

improved nutritional health support to their clients and to assist their clients to maintain good nutritional health, were obtained. Although care workers were not expected to provide detailed descriptions of the role of technologies, it was anticipated that their wishes on technological assistance may provide useful hints, and serve as entry points to identifying potential technology applications. Overall, the data collected from care workers will allow the researcher to formulate considerations for designing and developing effective technologies in this space.

Qualitative content analysis was selected as the method of data analysis. Data analysis was performed by the researcher and supervisor who were also involved in the collection of data, which helps to strengthen the study's rigour. During the data analysis, based on the concepts of qualitative descriptive design, the categories, concepts and nodes were derived from the data based only on what the care workers had to say. The eight categories determined by analysis of the focus group data are discussed in Chapters 4 to 7. Finally, a detailed discussion of the findings is presented in Chapter 8. This included a review of new knowledge gathered and a description of design considerations formulated based on the focus group findings.

Chapter 4

Findings I - Support received by older people with dementia living in their own home to maintain their nutritional health

The qualitative descriptive study described in this thesis seeks to inform technological design and development geared towards promoting nutritional health in older people with dementia living in their own home. As such, exploring care workers' perceptions regarding nutrition and mealtimes of older people diagnosed with dementia living in their own home is important. Focus groups were conducted with care workers employed by leading aged care organisations in South Australia. The characteristics of the participants who were involved in this study are presented in Section 4.1.

Eight categories emerged from the focus group data, based on the methods described in Chapter 3. Rooted in the concepts of qualitative descriptive research, these categories were derived only from what care workers had to say. These categories are: i) *Care worker support*; ii) *Family Support*; iii) *Older people's nutritional health challenges as perceived by care workers*; iv) *Care workers' challenges in supporting their clients' nutritional health*; v) *Care workers' information needs related to clients' nutritional health*; vi) *Care workers' wishes for technologies designed to support their clients*; vii) *Care workers' wishes for technologies designed to support them*; and viii) *Care workers' technological concerns*. The findings are presented in both figures and text. The quotations presented when reporting the findings are verbatim and G1, G2, G3 and G4 are the focus group numbers.

This chapter presents the findings related to: i) *Care worker support*; and ii) *Family Support* categories. Understanding the ways in which older people with dementia cur-

rently receive nutritional health support forms the basis for analysing and interpreting other findings reported in this study. *Care worker support* (see Section 4.2) describes the types of care support currently provided by care workers to the clients to maintain their nutritional health. Although the participants of the focus group meetings were not explicitly requested to explain the support provided by the families, the findings of this study reveal several ways families may support older people with dementia to maintain their nutritional status. *Family Support* (see Section 4.3) describes such family support as described by the care workers. Finally, a summary of this chapter is presented in Section 4.4.

4.1 Participant characteristics

The usual duties performed by care workers were described in Section 3.2.1. In this section, additional information specific to 27 care workers recruited for the study are described. The 27 participants included 15 home support workers and 12 care coordinators. They were employed by four aged care organisations named as G1, G2, G3 and G4 in this thesis (see Table 4.1). Most care workers were female (n=25); the mean age was 48.4 years; the mean work experience in the aged care industry was 9.8 years; and the mean work experience working with older people with dementia living in their homes was 6.0 years. Both types of care workers had one or more professional or academic qualifications related to their occupation. Most of the care coordinators had a Bachelor in Nursing or Dementia Care, or a Diploma in Nursing. Most home support workers had a certificate in Aged Care or Home and Community. Two participants in G3 were located in remote sites and found it difficult to attend the focus group meeting in-person, hence they were linked in by telephone.

Home support workers often interact directly with the clients and communicate details of the provision of services with respect to each client to responsible care coordinator(s). Care coordinators reported that they interact directly with clients in the initial visit. Later they interact directly with the clients as and when required and when home support workers are not available. All care workers, except home support workers in G2, managed client data manually as well as electronically. The home support workers in G2 only used written records. Most care workers use email and phone alerts. The general nutritional health information that care workers record about their clients include the amount of food and fluids consumed, types of food and fluids consumed, and clients' weight.

Table 4.1 Participant characteristics

Group number	Type	No of participants	Average age (years)	No of working days per week	Average experience (years)		Average no of clients handled per month	
					Aged care industry	With older people dementia living in their homes	In general	Older people with dementia living in their own homes
G1	Home support worker	9	47.3	5.3	11.8	5.6	49.6	4.8
G2	Home support worker	6	51.3	4.8	4.7	5.2	49.5	15
G3	Care coordinator	8	51.8	4.9	13.2	7.5	35.6	13
G4	Care coordinator	4	40	5.3	5.9	5.4	47.3	22.7

4.2 Category: *Care worker support*

The audit trail for *Care worker support* is presented in Figure 4.1. This category is comprised of eight concepts which describe services generally received by older people with dementia living in their own home from care workers with respect to their nutritional health. These concepts are: i) *Plans* (see Section 4.2.1); ii) *Documentation* (see Section 4.2.2); iii) *Dental care* (see Section 4.2.3); iv) *Shopping* (see Section 4.2.4); v) *Meal preparation* (see Section 4.2.5); vi) *Food consumption* (see Section 4.2.6); vii) *Fluid consumption* (see Section 4.2.7); and viii) *Food quality* (see Section 4.2.8), which are formulated from 25 nodes.

4.2.1 Concept: *Plans*

Plans describes the assistance provided by the care workers in making care plans related to food and nutrition for their clients. This involves a comprehensive assessment of the needs of each individual and then setting up care plans based on the needs identified. The three nodes related to *Plans* include: i) *Comprehensive assessments of needs*; ii) *Setting up initial plans*; and iii) *Setting up on-going plans*, and are described below.

4.2.1.1 Node: *Comprehensive assessments of needs*

Participants reported that for all new clients a comprehensive assessment of needs is carried out in conjunction with their families and the medical practitioners. This includes obtaining information about clients' likes, dislikes, medical issues, dental issues, health issues and personal issues.

> G3: *Robust assessment to determine a client who has dementia's previous experiences with food and whether there are any speech pathology issues that need to be referred to, dentures, whether there is taste sensation that is missing now. Yeah, the assessment is important.*

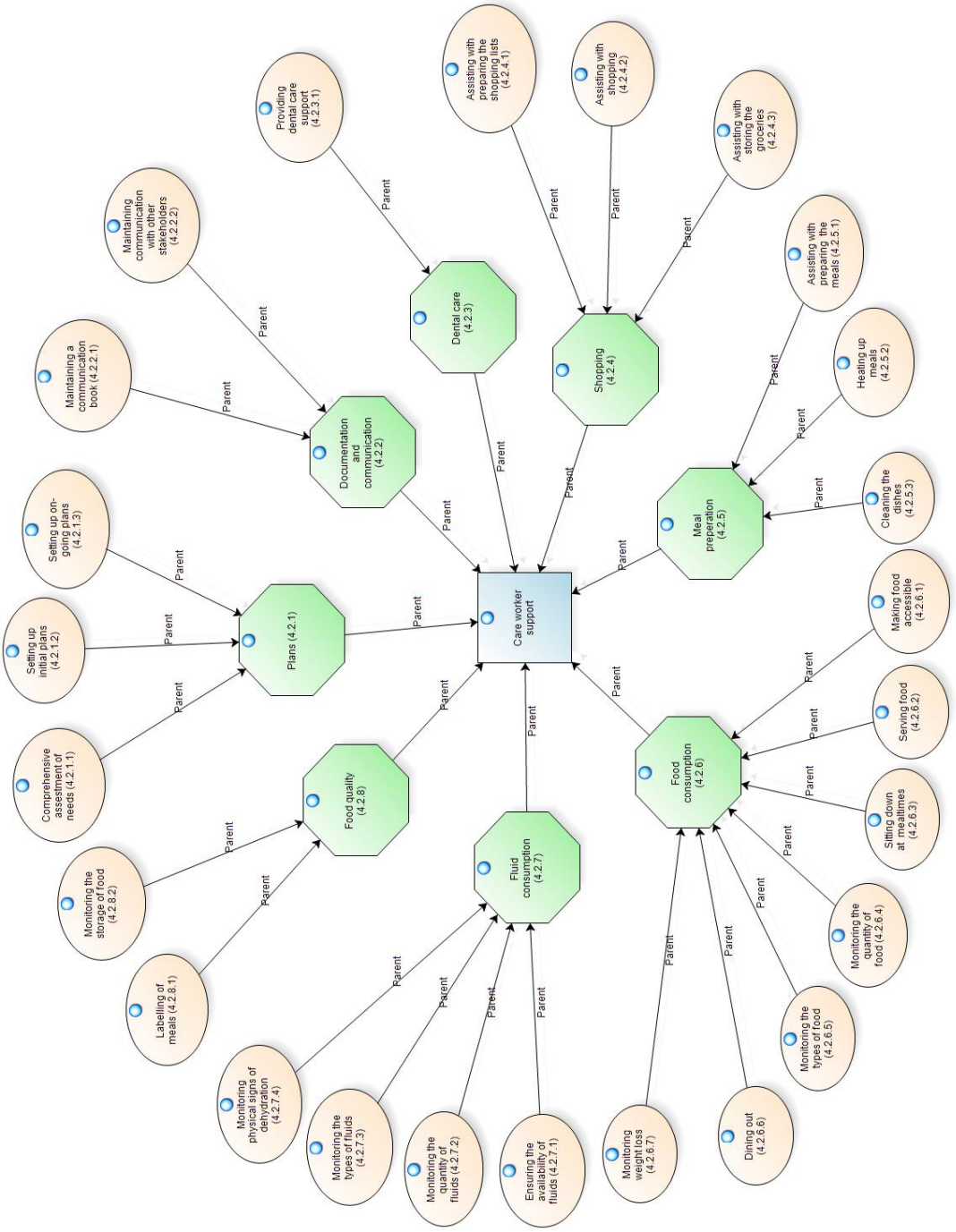


Fig. 4.1 Audit trail for the category: *Care worker support*

4.2.1.2 Node: *Setting up initial plans*

Participants stated that after a comprehensive assessment of needs, it is important to prioritise those needs and identify the types of assistance that can be provided by the care workers based on the allocated budget. Family input was regarded as highly valuable when prioritising the needs. After the priorities are identified, the plans are set, the goals are identified and documented.

> G3: *One of the main things is that we have packages that we are delivering and they are all allocated under a budget and in that budget, there is a whole lot of negotiations to go through to work out what is the most important care that client and family want. So it's being able to fulfil at least three times a day isn't it, and in between that service among their other needs. Especially when you are talking about dementia, so there is a competition of needs and within a budget.*

4.2.1.3 Node: *Setting up on-going plans*

Participants stated that at times they set up weekly menu plans. However, more often menu plans were decided daily. The participants emphasised the importance of incorporating their clients as much as possible in the decision-making process when setting up menu plans.

> G3: *Meal planning with the family and the client.*

> G3: *Involving them in the planning of the meals as well, what would you like for lunch today, do you like to eat fish or chicken, you know, just giving them few choices.*

4.2.2 Concept: *Documentation and communication*

Documentation describes the record keeping carried out by care workers on a day to day basis with respect to their clients. The nodes related to the concept *Documentation and communication* is described below.

4.2.2.1 Node: *Maintaining a communication book*

Participants reported that communication books are maintained with respect to each client. The communication books are used as a way to share information, such as the services provided, nature of meals prepared and issues encountered, with multiple care workers. It is expected that even if a new care worker comes in, they can read

and understand the usual practices and the nature of a particular client through the communication books.

> G2: *There might be a support worker that goes in the morning, there might be one at lunch and there might be one at tea. I know one lady who got three visits a day and then we all got our own notes that we write down and keep in contact with each other, what she had to eat and so forth.*

4.2.2.2 Node: *Maintaining communication with other stakeholders*

The care workers explained that they often communicate clients' nutritional health status and needs to various parties including families.

> G4: *The amount of documentation and communication that you have to do is huge, with all the key players that are involved in this one process.*

4.2.3 Concept: *Dental care*

Participants emphasised that dental care has a direct impact on food consumption. *Dental care* describes the dental support provided by the care workers to their clients. The node related to the concept *Dental care* is described below.

4.2.3.1 Node: *Providing dental care support*

Participants reported that they support their clients to maintain their dentures and clean their teeth. The denture related support included training their clients to clean the dentures and negotiate with families to get the clients to dentists when they have poorly fitting dentures.

> G3: *We ask our support worker to assist them with their dental care. How to clean their teeth, how to maintain their dentures, how to support them, negotiate with families to get them to the dentist if they have poor fitting dentures.*

> G3: *Strategies to actually get the teeth out to clean.*

4.2.4 Concept: *Shopping*

Shopping describes different types of assistance provided by the care workers to their clients in the process of shopping. The three nodes related to *Shopping* include: i) *Assisting with preparing the shopping lists*; ii) *Assisting with shopping*; and iii) *Assisting with storing the groceries*, and are described below.

4.2.4.1 Node: *Assisting with preparing the shopping lists*

Participants reported that they assist their clients to prepare shopping lists. Creating the shopping lists can be a lengthy process as it involves working out what is in the fridge and pantry, and then identifying what food items are running out. Some older people have standing shopping lists, however, care workers are still required to add items to those shopping lists, based on what is running out in the fridge and pantry. The following comments highlight this situation:

> G3: *I'm supposed to go in there and check her fridge, work through a shopping list.*

> G4: *A lot of the time they [clients] actually have a standing shopping list, which has bread and milk and kind of like a check list. They know that they are the essentials that they need to get each week and then the home care staff will add to that list when things run out.*

Care workers' knowledge and experience about clients' likes and dislikes are also useful in creating the shopping lists.

> G4: *Because those [home support] workers are going in there regularly. So they get used to the routine and they know usually what clients like to eat and generally what they make for the clients meals and they get their own routine going.*

However, the participants did not agree with completely taking over the shopping tasks and emphasised the importance of incorporating their clients as much as possible, depending on their capabilities.

> G3: *We try to make [them] maintain independence ... There is someone who prompts that independence and encourages that let's do it together, not that they will come and do that for you and take they will control. Let's do it together and they do have challenging behaviour, so it takes a long time and patience and strategies from the home support worker not to put the agenda for the client that we are going shopping.*

G4: *You could check, you know, with the client as well what they like this week so we can add on to that list.*

4.2.4.2 Node: *Assisting with shopping*

Participants described that assistance is often offered to older people to do their food shopping. During the shopping visits, the care workers usually accompany the clients to the shopping centres, and assist them to buy the food items they want. The participants emphasised that they try to engage the older people in the shopping activity as much as possible.

G1: *Mostly if we need to take them shopping we will get them to help us.*

G2: *I used to take her shopping as well.*

It was also highlighted that there are some clients who do the shopping independently, without any support from care workers. However, they usually received some sort of external supply of food delivered to their home. Hence, if they missed buying any essential items, it could be managed with the external supplies. Care workers explained that shopping is a social activity for most older people. Therefore, older people tend to like the experience of going out of the house and socialising with others when shopping.

G2: *They like that actual going out and doing shopping. It is the adventure rather than the actual task.*

Even though the care workers emphasised the importance of enabling clients to do their own shopping, they also highlighted that there are situations where the care workers cannot take their clients for shopping based of the their level of dementia. In these situations, it was necessary for the care worker to take over shopping completely.

G1: *Again getting back to the different stages or the different diseases like of dementia, I mean my two ladies with dementia you would not be even able to take them shopping. They have got no idea. They are at that really bad late stage of dementia.*

G2: *They do not always come shopping with us. We are sent off to do the shopping for them.*

4.2.4.3 Node: *Assisting with storing the groceries*

Participants stated that their clients often need support after shopping to store groceries in appropriate places. For example, a care worker explained a situation where the family did on-line shopping and the care workers were requested to arrive at the house when goods were delivered so that the care worker can assist the client to store the groceries in the proper places.

> G3: *The family was doing on-line shopping and we were arriving when the shopping was arriving, so that was sort of synchronised and we are unpacking and doing things.*

4.2.5 Concept: *Meal preparation*

Meal preparation describes the meal preparation assistance provided by care workers to their clients. The three nodes related to *Meal preparation* include: i) *Assisting with preparing the meals*; ii) *Heating up meals*; and iii) *Cleaning the dishes*, and are described below.

4.2.5.1 Node: *Assisting with preparing the meals*

Participants reported that they often prepare meals for their clients. This ensured that the clients had enough food at home to consume.

> G2: *We all come in and do the meal prep for her.*

Participants highlighted that the smell coming from the food, when they prepare meals at clients' homes, is often useful in creating a desire for them to eat.

> G2: *I will cook her a bacon sandwich for breakfast. You know which got eggs whatever. But just the smell and you know she loves mushrooms, so I buy mushrooms. She likes butter ... You know just the smell. 'Ah I will try some of those now'.*

On the other hand, other external sources of food such as meals on wheels, frozen meals, food prepared by family and canned food are also employed, especially at times when care workers do not visit. However, a participant from the countryside explained that in her area the only source of external meals is Meals on Wheels, therefore, most times care workers have to go in and prepare meals for their clients.

> G2: *We find that really in the country basically the only service is Meals on Wheels as a outside source of food. So we do have a lot of clients where we are actually going in and prepare the meals for them.*

However, taking over the meal preparation process is not something that the participants encouraged. The participants stressed they take an effort to incorporate older people in the meal preparation process. The care workers request older people to carry out small tasks such as washing lettuce during meal preparation. The participants further stated that older people are more inclined to eat meals that they were involved in preparing.

> G1: *Mostly with meal preparation, I have tended to work with the customers and have them assist me in preparing their meals to encourage them to eat what we prepare afterwards.*

> G1: *I have got one [client] that I can encourage to help me if I have to do meal prep with them. But it depends on how they are on the day. Whether they feel inclined to get involved or not. It is about trying to encourage them. If they do not want to you cannot [force] and they just won't.*

4.2.5.2 Node: *Heating up meals*

Participants stated that they assist their clients to heat up meals using the microwave or the oven. These meals are usually pre-packaged meals or meals prepared by the family which are stored in the fridge or freezer. Furthermore, participants stated that even the Meals on Wheels food sometimes needed to be heated up.

> G4: *We might go in there and heat it up [frozen meals]. Even the Meals on Wheels might need heating up again.*

4.2.5.3 Node: *Cleaning the dishes*

The participants stated that cleaning of dishes was a regular task carried out by them especially after preparing the meals for their clients.

> G1: *You can be doing the dishes and letting them eat.*

> G1: *We [care workers] come in and start preparing the meals and cleaning and doing the dishes.*

4.2.6 Concept: *Food consumption*

Most older people with dementia who are living in their home may not be eating properly. Therefore, care workers take efforts to ensure that their clients are eating properly and having enough nutrition. *Food consumption* describes such efforts taken by care workers. The seven nodes related to *Food consumption* include: i) *Making food accessible*; ii) *Serving the food*; iii) *Sitting down at mealtimes*; iv) *Monitoring the quantity of food*; v) *Monitoring the types of food*; vi) *Dining out*; and vii) *Monitoring the weight loss*, and are described below.

4.2.6.1 Node: *Making food accessible*

Participants stated that they try to make sure that nutritious meals are easily accessible for the older people when they are living alone. For example, having nutritious food in the fridge is important, so older people can easily have access to such meals.

> G2: *This client yet again, you know, you cut cucumber, cut the cheese up and put it on a plate, so she can open this fridge ... 'oh here is this, easy, bang'. It is still nutritious.*

4.2.6.2 Node: *Serving the food*

Participants stated that sometimes they serve the food to the table for their clients. Having a plate of food served to the table can be helpful to make the older person sit and eat.

> G2: *Sometimes if you plate it up and put it on a plate and present it, you know, set the table, that helps.*

Care workers highlighted the importance of presentation when serving food. Older people often prefer to eat food when placed on a dinner plate and served in an appealing manner. Care worker stated that even the colour of the plate can make an impact when creating a desire to eat. The same food can also be presented in different ways to make it look interesting. Therefore, participants stated that when serving food they make an effort to make the presentation interesting and appealing to their clients.

> G1: *Over the years I sort have found with a lot of my customers if I'm preparing the meals, whether they are dementia or not, I make it look interesting as I would like to see when I'm eating it and they can see the effort you have put into it.*

Older people can be overwhelmed if large quantities of food are served. Therefore, the participants stated that they are careful to serve only small quantities of food on the plate first. Then quantity is increased after the served food is fully eaten.

> G2: *I tend to start off small cause I got one particular lady that if I give her what her daughter asks me to give her, all on one plate, straight away she just goes 'no that's too much' and she won't touch any of it. Where if I give her say half of what her daughter mentioned, she eats all of it, then I will say 'you enjoyed that would you like some more', 'yes', and then I will go and put the rest of it and she tends to eat the whole meal.*

4.2.6.3 Node: *Sitting down at mealtimes*

Most participants found it is important to sit with their clients during mealtimes whenever possible. In this setting, participants indicated that they can prompt their clients to continue eating and provide them encouragement to complete their meals.

> G1: *When you got the time just sitting there with them and getting them. Prompt them.*

Participants emphasised that having a meal is a social activity, so simply sitting together with the client, even without prompting them to eat, can often encourage older people with dementia to eat more.

> G1: *You are not saying to them, 'come on eat up', but you are sitting there and interacting with them and they are quite happy to eat while you are doing that.*

However, participants highlighted the importance of bringing their own food, if they are sitting with the older person for the meals. Otherwise, the older people can try to share their meals with the care workers, which is not what is intended.

> G1: *So we will put the service in over the lunch time. The support worker can take their lunch. We can say well you can take your lunch, if it is in their own home and sit down and eat with the person. If the worker does not take their lunch, there is sometimes clients who want to share their lunch and that does not achieve anything.*

4.2.6.4 Node: *Monitoring the quantity of food*

Participants stated they monitor the quantity of food consumed by their clients. As the care workers cannot stay in their clients' homes continuously, they generally get an idea about the quantity of food consumed by their clients by observing he food leftovers and wrappings.

> G3: *There is half a loaf of bread gone and there is packet of lollies all over the place and three bars of chocolate, a bag of snacks, a loaf of bread.*

4.2.6.5 Node: *Monitoring the types of food*

Monitoring the types of food consumed is considered important by the participants in order to make sure that older people with dementia obtain adequate nutrition from their diets. Furthermore, knowing the types of the food consumed by older people with dementia is useful for care workers to provide shopping assistance to their clients. The participants mentioned that as a strategy to keep a track of the types of food older people with dementia are having when they live alone at home, the care workers usually keep an eye on the leftovers and rubbish. Furthermore, the care workers some times sit down with clients during mealtimes, so that they can physically observe the types of food their clients consume.

> G1: *But there are some who expect you to sit there at the table with them and make sure that they eat their meal and eat it properly and actually get the nutrition as a part of the meal and not just the stuff they want to eat.*

4.2.6.6 Node: *Dining out*

Care workers reported that they assist their clients to have meals outside the home. This means accompanying the clients to restaurants or cafes to have meals or snacks. Participants emphasised that providing a social environment during mealtimes generally helps older people with dementia to eat more.

> G3: *It could be a social outing where they go out for lunch to a cafe or restaurant and they all eat together. It turns into a social event which means people do eat when they are socialising.*

4.2.6.7 Node: *Monitoring the weight loss*

Participants reported that they monitor the weight loss of their clients in order to ensure that they maintain an adequate amount of nutrition.

> G1: *If you look at weight loss, you know once they starting that way, you are going to notice it so record it in and that is the only thing you can do when you are not there.*

4.2.7 Concept: *Fluid consumption*

Monitoring fluid consumption of older people with dementia living in their own homes was considered highly desirable by the participants. Most older people with dementia could be poorly hydrated when living in their own homes and care workers undertake a series of tasks to ensure that their clients are adequately hydrated. *Fluid consumption* describes the different types of such support provided by care workers. The four nodes related to *Fluid consumption*: i) *Ensuring the availability of fluids*; ii) *Monitoring the quantity of fluids*; iii) *Monitoring the types of fluids*; and iv) *Monitoring physical signs of dehydration*, are described below.

4.2.7.1 Node: *Ensuring the availability of fluids*

Participants stated that making sure fluids are available at home is more important than just asking their clients to have a drink and having a jug of water available could create a desire to drink in an older person. Therefore, the participants stated that they try to make sure that there are enough fluids available for their clients.

> G4: *They hopefully recognise that [jug of water] and so we do that [keeping a water jug] as well. Always, girls [home support workers] always make sure that there is drink available.*

It was also highlighted that some older people do not like to drink water. Therefore, care workers are conscious that other preferred types of drinks need to be available at home.

> G3: *Having other things available on those days, because water is not, particularly in Adelaide, water is not the preferred drink.*

4.2.7.2 Node: *Monitoring the quantity of fluids*

Participants explained that it is essential to monitor the amount of fluids consumed in order to ensure that older people are adequately hydrated. Care workers use different strategies to check whether older people have had enough fluids. This included the care worker asking their clients how much they drank within the day, having a jug filled with water and monitoring by how much the water is reduced in between care worker

visits. In extreme weather situations, it becomes even more important to monitor the fluid intake. Then, care workers ring their clients frequently to check whether they have had something to drink. Furthermore, the care workers also drop-in at their clients' home to check the fluid consumption and to encourage them to drink often.

> G2: *For some clients, we are encouraged to monitor the fluid intake. We leave a jug of water on the bench, then we record how much in between us going there, how much they drink.*

> G3: *Hydration is always a big campaign on our behalf. Especially in the hot weather and across [institute name] we are on the alert daily to ensure that the clients in the home are drinking and all those sorts of things that may help to keep them safe and cool in their own homes. So hydration. We are ringing them up almost daily, aren't we, in the heat waves, saying 'have you got a glass of water there? how much have you drunk today?'. The home support worker is instructed to check, drop-ins.*

4.2.7.3 Node: *Monitoring the types of fluids*

Care workers monitor the types of fluids that the older people consume due to various reasons. These requirements included monitoring alcohol consumption of older people with dementia.

> G2: *I have to monitor client's alcohol consumption.*

4.2.7.4 Node: *Monitoring physical signs of dehydration*

Participants explained that they monitor the physical signs of dehydration of their clients. As care workers are unable to stay with their clients at all times, monitoring these physical parameters was considered important to identify clients' hydration issues as early as possible. In particular, care coordinators appreciated the home support workers commitment to checking these physical signs of their clients even when they visit clients for other services such as medication and meal preparation.

> G4: *That's why we rely on our HCAs [home care assistants] to notice the warning signs of dehydration, yeah, you know their skin tone and things like that.*

4.2.8 Concept: *Food quality*

Food quality describes care workers' role in monitoring the age of food and making sure the quality of food consumed by older people is maintained. The two nodes related to *Food quality* include: i) *Labelling of meals*; and ii) *Monitoring the storage of food*, and are described below.

4.2.8.1 Node: *Labelling of meals*

Participants stated that labelling of meals with dates is needed to keep a track of food that is going to expire. The care workers usually not only label the meals they prepared for clients but also label the leftover food that is stored in fridges. It was considered important to label food in both the fridge and the freezer.

> G3: *There is a lot of labelling of meals and dates to keep track of things.*

> G4: *Make sure we label whatever is in the freezer, how long has it been there.*

Furthermore, pre-packed food is also a common choice for older people and they are easy to label and place in the fridge.

> G4: *We do a lot of quality with perhaps employing the pre-packed food like [brand name], what are the other names we have, [brand names of pre-packaged food]. All those things. They are a popular choice because they can be put in the fridge and labelled and isolated and actually served.*

4.2.8.2 Node: *Monitoring the storage of food*

Participants reported that they frequently monitor the food stored in clients' fridges, freezers, and pantries to ensure that the food is clean and not expired. Sometimes older people keep food uncovered in fridges, as a result, the care workers monitor the storage of food and throw away the expired food. In particular, care coordinators appreciated the commitment of their home support workers to check clients' fridges even when visiting the clients to provide other services.

> G4: *The girls go and check it [fridge] regularly to see if there is anything outdated in the fridge and they just throw it in the bin.*

Furthermore, the care workers make sure that food is not lying around the house and that it is stored in appropriate places.

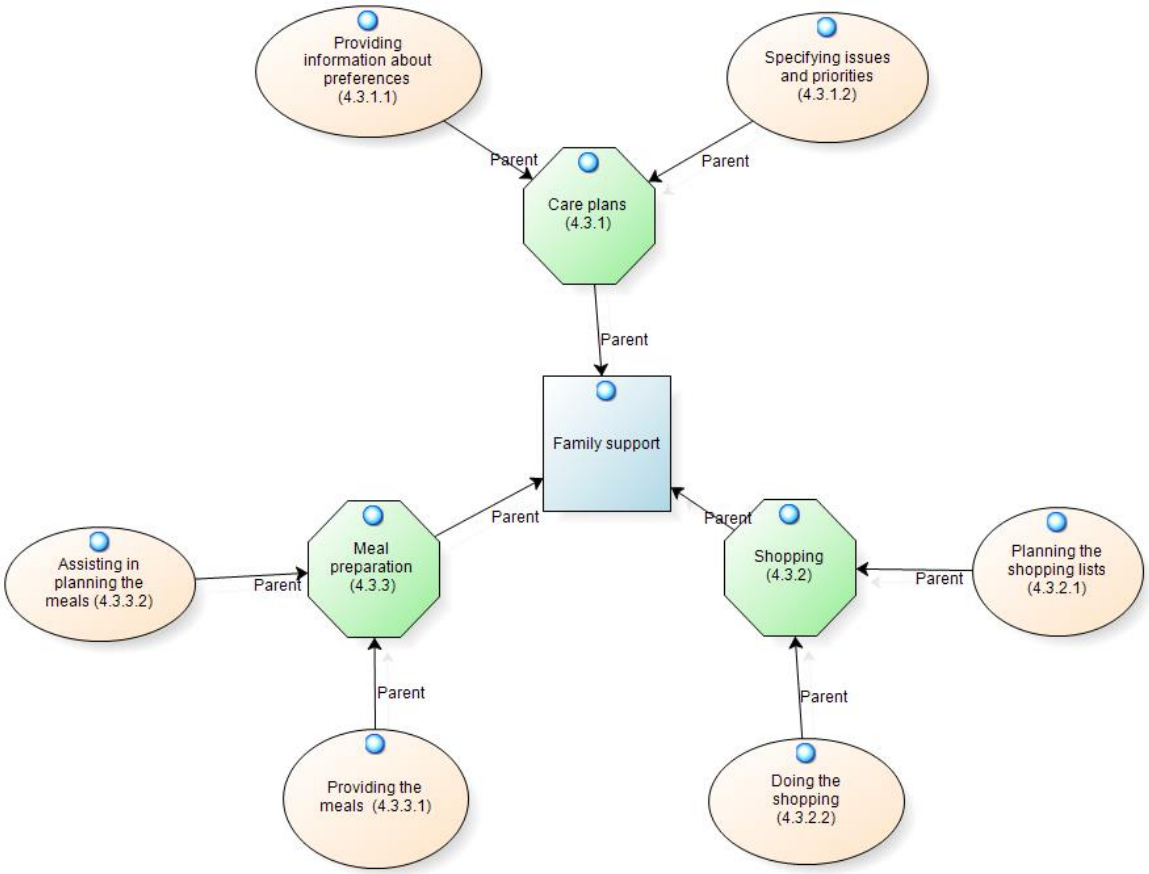


Fig. 4.2 Audit trail for the category: *Family Support*

G3: *The support worker's job in the morning, we go three days a week aside from the package, is to make sure that food is not lying around the house and it is clean in the fridge.*

4.3 Category: *Family Support*

Family Support describes the type of support provided by the family to improve the nutritional health of older people with dementia living in their own home. The audit trail for *Family Support* is presented in Figure 4.2. This category consists of three concepts: i) *Care plans* (see Section 4.3.1); ii) *Shopping* (see Section 4.3.2); and iii) *Meal preparation* (see Section 4.3.3), formulated from six nodes.

4.3.1 Concept: *Care plans*

Care plans concept describes the support provided by the families to care workers when creating the care plans. The two nodes related to *Care plans* include: i) *Provid-*

ing information about preferences; and ii) *Specifying issues and priorities*, and are described below.

4.3.1.1 Node: *Providing information about preferences*

Participants explained that often it is convenient for them to acquire knowledge about clients' food-related preferences from their families. This because older people with dementia often find it difficult to self-report their food-related preferences.

> G1: *Some families do have [food preference] lists in the folders or on the side of the fridge that they say, you know, that they do not buy, what their mother likes.*

> G4: *Lots of the time, when we set up packages, it is in consultation with their families. So the family would say sometimes likes and dislikes and allergies.*

4.3.1.2 Node: *Specifying issues and priorities*

Participants explained that it is important for them to identify the mealtime and nutrition-related issues of their clients when creating initial care plans. Identified needs are then prioritised to fit into the allocated budget. The participants emphasised that they try to incorporate the families of older people with dementia as much as possible in this decision-making process.

> G3: *When you come to a dementia client ... eating, food and hydration are all very important, but where does it fit into the scale of the family. So we then have to enlist family to help us. We have to complement them really.*

4.3.2 Concept: *Shopping*

Shopping describes the types of shopping related support provided by the family to older people with dementia living in their homes. The two nodes related to *Shopping* include: i) *Planning the shopping lists*; and ii) *Doing the shopping*, and are described below.

4.3.2.1 Node: *Planning the shopping lists*

Participants reported that sometimes the family gets involved in preparing shopping lists. Participants agreed that this can save a lot of time for them.

> G2: *I used to have a client when I worked in the [place of work], whose son used to do that [planning a grocery list] for his mother and it was just wonderful. When you are on the clock, that is brilliant. You just go, you know, you are not standing there and trying to determine exactly what type of tea bags, whatever.*

4.3.2.2 Node: *Doing the shopping*

Participants stated that family at times do the shopping on behalf of older people with dementia living in their homes. The participants further explained that this could be either on-line shopping or a family member physically doing the shopping for their loved ones.

> G1: *But the daughter does that [grocery shopping].*

> G3: *The family was doing on-line shopping.*

4.3.3 Concept: *Meal preparation*

The *Meal preparation* concept describes the types of support provided by the family to older people with dementia when preparing the meals. The two nodes related to *Meal preparation* include: i) *Providing the meals*; and ii) *Assisting in planning the meals*, and are described below.

4.3.3.1 Node: *Providing the meals*

Participants explained that, at times, the family provided meals for their loved ones. These were cooked or frozen meals and usually stored in fridges for later use. The older people with dementia were required to heat up the meals during their mealtimes. The participants also explained that, at times, meal preparation support is provided to older people with dementia by the care workers and family simultaneously.

> G4: *Sometimes families have already got a meal prepared for them.*

> G4: *We've got one client, in particular, we do meal preparation for him plus his family buy meals that he can heat up.*

4.3.3.2 Node: *Assisting in planning the meals*

The participants stated that families are often involved in setting up weekly menu plans. These menu plans mostly include frozen meals as well as meals prepared by the care workers.

G2: *They write out a menu for the week.*

G4: *They might have come in once a week and done the shopping and set the menu. I think other than that during the week they are always at work.*

4.4 Summary

In this chapter, an overview of the findings based on the research methodology and research methods described in Chapter 3 was presented. The chapter included a description about the characteristics of the care workers who participated in the focus group meetings. Furthermore, detailed descriptions related to two categories *Care worker support* and *Family Support* were provided.

Maintaining the nutritional health of an individual is a complex task and various aspects have to be taken into careful consideration. As a result, formal care support is often arranged when the older people with dementia live in their own homes with limited or no family support. Often, multiple care workers are allocated to an older person with dementia living in their own home. The care workers monitor their client's nutritional health and assist them to carry out nutrition and mealtime activities. Although overviews of the tasks carried out by care worker were described in Section 3.2.1, the care workers' descriptions in the focus groups were useful to obtain a deeper and more holistic view of the nature of formal care support generally received by older people with dementia living in their own home with respect to their nutritional health. The care workers provide diverse support to older people with dementia to promote nutritional health. The types and nature of formal care provided for each client are determined based on the care plans. The care plans are identified after a comprehensive assessment of the clients' needs, in conjunction with the family and allocated budgets. Based on the findings of this study, the current types of support provided by the care workers were broadly categorised into eight concepts, which included assistance with shopping, meal preparation, food consumption, fluid consumption and maintaining food quality.

Although the researcher did not explicitly request the participants describe the nature of nutritional health support older people with dementia living in their own homes may receive from their families, the findings of the study reveal several such ways. The nature of family support varies among the individuals. While some older people have families to support, some older people do not have any family. In the case where there is a family, the assistance provided by them include shopping and meal preparation. Furthermore, the care workers often liaise with the families when setting up care plans. Care workers strongly believe that it is paramount to work with the

family members of dementia clients, where possible, to ensure adequate nutritional health in this population.

The next chapter presents the findings related to the *Older people's nutritional health issues as perceived by care workers* category.

Chapter 5

Findings II - Older people's nutritional health challenges as perceived by care workers

This chapter reports the findings related to *Older people's nutritional health challenges as perceived by care workers* category. This category describes challenges related to nutrition and mealtime activities faced by older people with dementia living in their own homes based on care workers' perspectives. An audit trail for the *Older people's nutritional health challenges as perceived by care workers* is presented in Figure 5.1. This category consists of the concepts: i) *Shopping* (see Section 5.1); ii) *Meal preparation* (see Section 5.2); iii) *Food consumption* (see Section 5.3); iv) *Fluid consumption* (see Section 5.4); and v) *Food quality* (see Section 5.5), which are formulated from 30 nodes. A summary of these findings is presented in Section 5.6.

5.1 Concept: *Shopping*

Shopping describes diverse shopping related challenges of older people with dementia, as reported by the participants. Some of these challenges were faced by older people with dementia before doing their shopping and others were challenges faced by them when doing their shopping. Since the presence of local shops/corner shops were the norm for most of the older population reported in this study, care workers explained different ways in which older people with dementia struggle during shopping, partly because they are not used to supermarkets. The six nodes related to *Shopping* include: i) *Forgetting how to shop*; ii) *Forgetting when to shop*; iii) *Issues with creating shopping lists*; iv) *Overwhelmed by the variety available*; v) *Changes in packaging*; and vi) *Buying unsuitable food items*, and are described below.

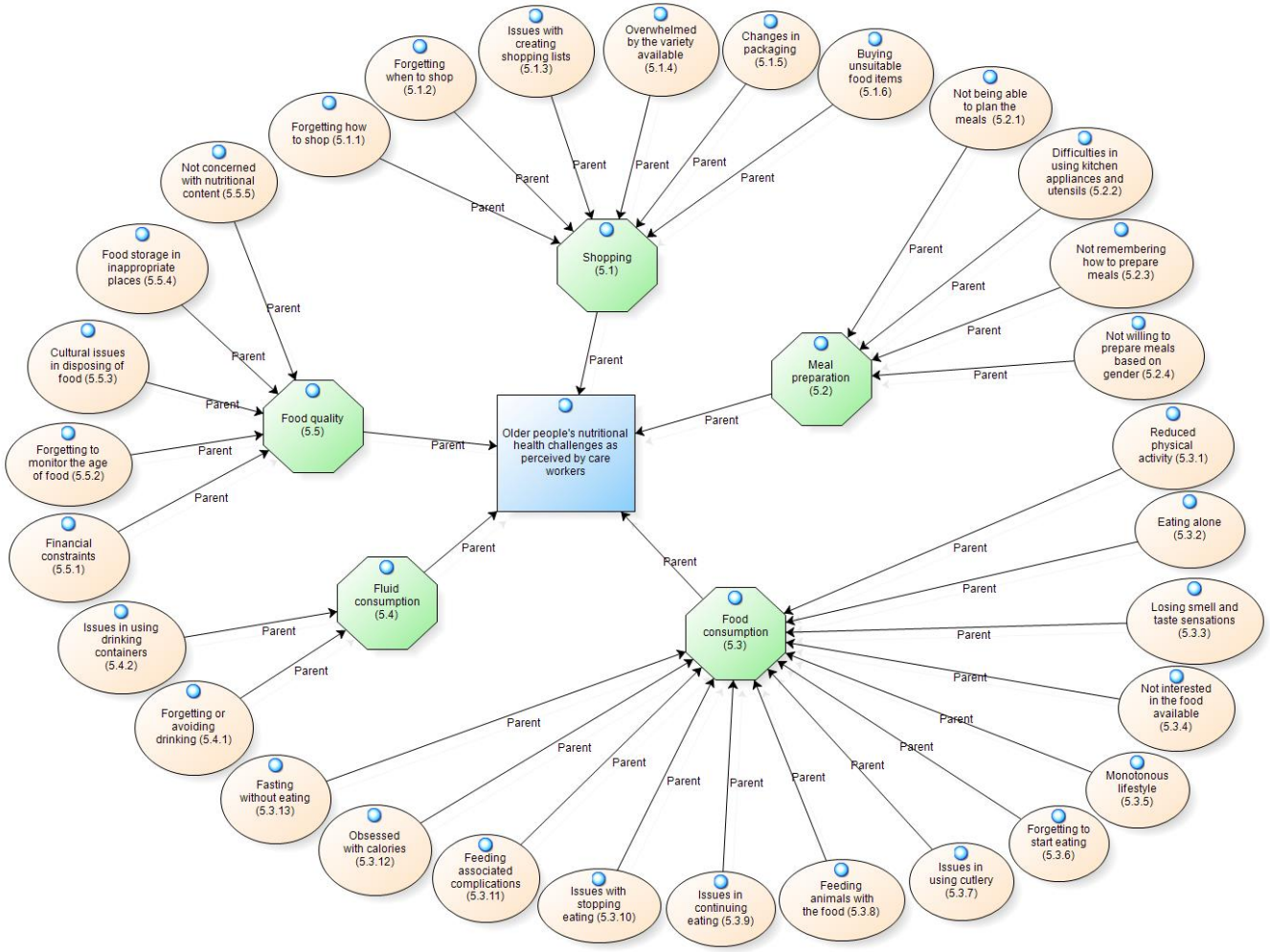


Fig. 5.1 Audit trail for the category: *Older people's nutritional health challenges as perceived by care workers*

5.1.1 Node: *Forgetting how to shop*

Participants reported that their clients, at times, may not comprehend the meaning of shopping. For example, they might not even understand what needs to be done before shopping and during shopping.

> G3: *They do not process this [shopping]. 'What do I need to do actually. What does it mean to go shopping?'. So there is a small task opening the fridge, counting tomatoes.*

> G4: *If they do not have any family support, they may have lost the ability to go shopping. So you know, that is a big thing as well when it comes to nutrition if they are not purchasing their food and they are not eating anything.*

> G4: *Forgetting how to shop.*

5.1.2 Node: *Forgetting when to shop*

Participants reported that often older people with dementia forget that they have already done shopping for the week and as a result request care workers to take them shopping repeatedly.

> G4: *Sometimes we have clients who have a domestic service and shopping service. So they might have already had their shopping for the week. So when it comes to domestic service they are adamant that the [home support] worker takes them shopping [because they have forgotten that they have done the shopping for the week].*

5.1.3 Node: *Issues with creating shopping lists*

Participants reported that clients may lose the ability to prepare their shopping lists because they often do not know what they like and dislike, and where to look to identify what food is running out. As a result, shopping lists prepared by their older people with dementia are mostly filled with snacks.

> G1: *They do not know where to look, they do not know what it is that they want a lot of the time.*

> G2: *It [shopping lists created by the clients with dementia] was just cakes, or just soft drinks and rubbishy things.*

5.1.4 Node: *Overwhelmed by the variety available*

Participants described that many clients are not used to the concept of supermarkets. As a result, they can easily get confused with the variety of food and brands available nowadays. In particular, walking through supermarkets, they can be overwhelmed by the choices available on the supermarket shelves and find it difficult to identify where to look and what to buy exactly.

> G3: *In the past, we would have gone to the butcher and green grocer and may be the little corner shop and there would be a deli which would have a small selection of things.*

> G3: *There are too many choices on the shelf, you cannot go to the shelf and buy a loaf of bread any more.*

5.1.5 Node: *Changes in packaging*

The appearance of food items changes regularly and participants stated that clients struggle to cope up with these changes. In particular, older people with dementia get confused at the supermarkets with packaging or brand name changes and often find it difficult to identify what they need to buy.

> G3: *Packaging changes regularly, so that they do not have that visual concept of what's actually in that package ... They might call things with different names that they just do not understand.*

5.1.6 Node: *Buying unsuitable food items*

Participants reported that their clients tend to buy unwanted food items while shopping. Sometimes, they do not adhere to their shopping lists. Furthermore, they do not have a notion of the inventory at home. Consequently, they keep on buying things that are already at home.

> G3: *They might keep buying the same things that they might have in their pantry, you know, they might get tins of tuna and they have already got six tins tuna in there.*

> G4: *She [a client with dementia] got a shopping list, but sometimes she just does not look at her shopping lists, she just brings what she wants.*

On the other hand, participants stated that at times their clients do not want to buy things on the shopping lists, assuming those products are already at home.

> G3: *By the time they are in the shops, she [a client with dementia] thinks that everything that they decided to buy is already in the house and she throws them out.*

5.2 Concept: *Meal preparation*

Meal preparation describes the difficulties faced by older people with dementia when planning and preparing their meals. The four nodes related to the *Meal preparation* include: i) *Not being able to plan the meals*; ii) *Difficulties in using kitchen appliances and utensils*; iii) *Not remembering how to prepare meals*; and iv) *Not willing to prepare meals based on gender*, and are described below.

5.2.1 Node: *Not being able to plan the meals*

Participants reported that their clients often struggle when planning their meals. Older people with dementia often do not understand their likes and dislikes, hence find it difficult to decide what meals to prepare.

> G2: *'Now do you know what you are having for dinner tonight'. She [client with dementia] had no idea.*

> G2: *'I don't know if I like that, do I like that, do I like it, do I normally have that, have I had that before'. This is the type of thing that will get thrown back at you.*

Participants also described that older people with dementia are overwhelmed by choices when planning their meals. Even choosing the type of Meals on Wheels food can become an issue for older people with dementia. As a result, the participants highlighted the importance of presenting a limited number of choices at a time to their clients when planning their meals.

> G3: *The impact of their dementia is that they are overwhelmed by every, every suggestion of any process. So to suggest mealtimes, a period for food, their protection mechanism is to say no, no, no. It is all too hard. So they start eliminating what overwhelms in their mind. They actually can't can't visualise it any more. They can't actually break down into steps, so it is easier to say no.*

> G1: *The choosing of the meal [Meals on Wheels] is very confusing for some of the dementia clients.*

> G1: *I do not give her too much choice, I say, you have got this or this in your fridge and I will pull it out and say, 'this or this in your fridge today, what would you like?'*

5.2.2 Node: *Difficulties in using kitchen appliances and utensils*

Participants stated that older people with dementia often have difficulties in operating kitchen appliances. Their kitchen appliances can be completely switched off due to the potential risks in operating them.

> G4: *Sometimes in their [older people with dementia] homes, cooking appliances have to be switched off.*

Participants reported that there are difficulties with respect to operating microwaves, even if detailed instructions are written down at home on how to operate them.

> G2: *The son [of the client with dementia] has written out specific instructions for 30 seconds and she put a wheat bag for three hours and it was just lucky that I walked in when it started to smell.*

Older people with dementia often have difficulties in operating the stoves. For example, they can forget to turn off stoves and remove the knobs.

> G4: *They may have left stoves on and burnt food before, so the family switches the stove off.*

Participants also explained a number of challenges with respect to operating kettles. Older people with dementia have difficulties in turning on kettles and also estimating the amount of water that needs to be put in.

> G2: *Putting on a kettle, I mean that is a simple process for us, but what if they have not put water in it.*

Participants emphasised that the capabilities of each older person are dependent on their level of dementia at any given moment. Even though older people are capable of using advanced kitchen appliances, at times, especially when the level of dementia progresses, they may not even be able to operate simple appliances such as kettles.

> G2: *It just depends on what level where they are at their dementia, I mean, obviously who can do that [use the microwave], when you get down-hill they have got no idea, would not know how to turn the kettle on.*

> G2: *You do not know what point in their level they are going to forget [how to operate appliances]. They may have levels but then, you know, you are talking about any one day, every time it is different.*

5.2.3 Node: *Not remembering how to prepare meals*

Participants stated that due to cognitive decline, most older people, even in the mild stages of dementia, lose the ability to prepare their own meals. Participants explained that their clients can often only perform simple tasks on their own, such as making tea, toast or a simple sandwich.

> G4: *Their [clients with dementia] cognition affects their ability to cook for themselves.*

> G2: *A toast would be about that. The most that I think any of mine can do.*

As a result, usually, care workers have to take over the meal preparation or make arrangements to have external meals such as Meals on Wheels delivered.

> G3: *That [care workers taking over meal preparation] is because either they forget or they can't.*

Participants highlighted that some of their clients can re-heat and perform simple meal preparation tasks with supervision.

> G4: *Supervised, some [older people with dementia] can still make cups of tea, some can't.*

> G1: *They can reheat.*

5.2.4 Node: *Not willing to prepare meals based on gender*

Participants reported that some males consider meal preparation to be an activity that only belongs to females, hence are reluctant to prepare their own meals.

> G2: *[Male older people with dementia think] that [preparing meals] is your [women's] job.*

> G2: *Yes I have had that [gender differences in meal preparation].*

5.3 Concept: *Food consumption*

Food consumption challenges are related to initiating, continuing and completing consuming food. The 13 nodes related to *Food consumption* include: i) *Reduced physical activity*; ii) *Eating alone*; iii) *Losing smell and taste sensations*; iv) *Not interested in the food available*; v) *Monotonous lifestyle*; vi) *Forgetting to start eating*; vii) *Issues in using cutlery*; viii) *Feeding animals with the food*; ix) *Issues in continuing eating*; x) *Issues with stopping eating*; xi) *Feeding associated complications*; xii) *Obsessed with calories*; and xiii) *Fasting without eating*, and are described below.

5.3.1 Node: *Reduced physical activity*

Participants find that reduced physical activity is a major contributing factor affecting initiation of food consumption. The older people with dementia are mostly seated all day hence do not have a desire to consume food.

> G4: *Physical deterioration as well. They just sit all day. Less physical activity, so they just lose their appetite.*

> G2: *They [clients with dementia] are not as active as we are. So their appetites are not going to be inclined with normal eating times.*

5.3.2 Node: *Eating alone*

Participants reported that often their clients' desire to eat can reduce because they have to eat alone. Having meals is regarded as a social activity, therefore, most of the time they are not interested in eating if they are alone.

> G3: *Their [older people with dementia] eating habits and eating motivation drops because they are alone. They are lonely and so to eat alone is not what we love.*

On the other hand, home support workers highlighted that some of their clients prefer to eat alone. Although care coordinators recommend home support workers sit down with their clients during mealtimes, some clients do not want to socialise during mealtimes due to their physical disabilities such as shaking. Talking while eating can also increase the risk of choking.

> G1: *They [older people with dementia] do not like it [somebody sitting with them during mealtimes] ... Specially someone who has got the shakes for example ... When they are watched they become under pressure ... [When eating alone there is] less risk of choking because they won't talk while eating.*

> G1: *Yet we do have clients, I know we do, don't we, we have got clients who don't want to eat in front of other people and so I have had one or two like that. So it is important that it is prepared and laid out and setting looks good and then you leave because they are shy in front of other people. Some have speech pathology issues or it is just a cultural thing.*

5.3.3 Node: *Losing smell and taste sensations*

Participants stated that loss of smell and taste sensations can result in a reduced desire to eat.

> G3: *Another identification when it comes to dementia is that their taste sensations [reduces] and it a stimulant that they do not like.*

> G1: *A lot of the time they [clients with dementia] lose some of their taste and smell for medication.*

5.3.4 Node: *Not interested in the food available*

Participants explained that clients are reluctant to initiate food consumption when the food available is not prepared according to their preferences. Participants emphasised that when dementia progresses, all that older people want is to eat the same types of food that they used to have previously.

> G3: *But that's [food they are familiar with] what they like, that's what they remember because when dementia progresses that's all what they want, that sort of food.*

Even though Meals on Wheels is a common choice by the care workers and family as a way to provide meals for older people with dementia, the participants stated that those meals may not be to the older person's liking. As a result they may not consume the food available or even throw away the food.

> G4: *They have thrown the whole [Meal on Wheels] meal out.*

> G1: *It [Meals on Wheels] is not to every one's liking.*

Furthermore, differences in the cultural backgrounds of care workers can affect the way food is prepared. This can have an impact on whether older people consume those foods or not.

> G3: *They may not even like what we are preparing, I mean, they may have their own food that they need to cook.*

5.3.5 Node: *Monotonous lifestyle*

Participants stated that older people with dementia living in the own homes are having a monotonous lifestyle and that sort of home environment does not stimulate their desire to eat.

> G2: *They are in that home environment. So everything is being perpetuated, it is the same every day ... Those things do not help to stimulate their appetite and their desire to eat.*

5.3.6 Node: *Forgetting to start eating*

Participants reported that forgetting to initiate food consumption is a common issue of their clients when the food is available at home. Participants described situations where clients forget to eat even when the food is available at home. For example, they forget to consume meals prepared by the care workers, Meals on Wheels food and frozen meals which are usually kept in their fridges or freezers. Furthermore, the participants explained that their clients often ignore the prompt notes set up to remind them to have their meals.

> G2: *Their minds are not even going to think about food.*

> G1: *I find memory, remembering to eat ... Sometimes we prepare a sandwich and have it in the fridge ... you can guarantee they forgotten to go and eat it.*

> G1: *Like you have said about forgetting to eat, I leave prompt notes stuck to the table, 'I have made a bowl of salad, it is in the fridge for lunch' ... It is not working.*

> G4: *Even some of the clients who get Meals on the Wheels, they just put that in the freezer and they might just nibble on some thing in the fridge.*

Participants explained forgetting to eat can be a result of the reduction in their appetite or being convinced that they have already eaten.

> G2: *I do think obviously they [clients with dementia] do forget to eat and they do not really think about it, you know. I do not know whether the urge goes or if it is just bit too much.*

> G3: *They [clients with dementia] are sometimes convinced that they have already eaten.*

> G4: *They might think that they have already had a meal. They forget that they haven't had breakfast or they forget that they haven't had their lunch. They think, 'oh you know, I have got up and got dressed and okay I must have had breakfast or I must have had lunch'.*

The older people with dementia can easily be distracted by external factors in the environment. Participants described that clients often forget to start consuming their meals when watching television continuously.

> G2: *Ones that sit all day watching TV, they just zoom on that TV ... They don't think to go out to the kitchen and you got a sandwich made for you or there is a frozen meal sitting there waiting.*

5.3.7 Node: *Issues in using cutlery*

Older people with dementia, at times, find it difficult to use cutlery. Participants stated that their clients sometimes have the desire to eat but have forgotten how to eat using cutlery. For example, they can struggle with understanding how to get a loaded spoon to the mouth and eat.

> G2: *You can tell that they want to eat but they have forgotten how [to eat] ... They are looking at the cutlery and hands are going towards it but they just have forgotten how to pick up the cutlery and what to actually do with it or even if they got it on the spoon, they will have it on the spoon and they don't really know where to go from there.*

Participants also stated that older people with dementia can struggle to use the modern cutlery as they are often only familiar with old cutlery.

> G1: *Half of them have the old bread and butter type knives and cutlery. They do not keep modern cutlery has a serrated edge on it and they struggle.*

5.3.8 Node: *Feeding animals with the food*

Participants reported that their clients frequently feed animals with their food while consuming meals. Older people living at their own homes may not have the opportunity to socialise with others during mealtimes, hence they are more interested in having social interactions with animals during mealtimes, rather than actually consuming their food.

> G3: *Thinking of a client who would save half of his Meals on Wheels food and then actually feed like a fox, and feral cat that would come every night. He would sit on the step and feed the fox. So he was more interested about keeping the food for the cat and the fox.*
>
> G4: *Clients who have got animals sometimes give the meal to the animals instead of to themselves.*
>
> G3: *That [feeding the animals] is socialising.*

5.3.9 Node: *Issues in continuing eating*

Participants reported that clients may not continue food consumption because of getting distracted or falling asleep while eating. They may also save half of the food for later use and subsequently forget about it. There is a possibility that food may not be fresh when they get back.

> G4: *They could be mid-meal and then something triggers in their head and they just get up and go and never go back.*
>
> G3: *So she will eat a smaller amount and then as soon as the carer has left she will fall asleep in her chair.*
>
> G3: *They may want to save half of that [Meals on Wheels] for later and then forget that they saved half of that for later.*

5.3.10 Node: *Issues with stopping eating*

Participants stated that older people with dementia sometimes lose track of how much they ate. As a result, they keep on eating continuously which can result in weight gain.

> G3: *I have a interesting client in [the place where the older person lives] who overeats, she keeps forgetting that she has already eaten and she keeps on eating.*

5.3.11 Node: *Feeding associated complications*

Participants described a number of feeding associated complications of older people with dementia that affect their food intake which included poor oral health and denture related issues. The older people with dementia may not wear their dentures due to various reasons, such as receding ulcers and gums. Furthermore, they may not know where the dentures are and struggle to find them. Participants explained that the food consumption of their clients can be negatively affected by not wearing their dentures.

> G3: *One thing to highlight, that set up our antenna, is that they are not wearing their dentures and oh why aren't they are wearing our dentures. Simply because they are wobbling in the mouth, they got ulcers and the gums are receding and so it might something that can be easily overlooked. But then that has an impact what they choose to eat and we go down the track.*
>
> G3: *But they may lose their dentures and they may not know where their dentures are.*

Participants also stated that older people with dementia can have chewing and swallowing difficulties that can have adverse effects on their eating.

> G4: *They might have swallowing difficulties as well.*

Participants explained that clients can also suffer from coughing or choking, especially when they start talking while consuming food.

> G1: *They like to talk while they eat and that runs the risk of choking or coughing.*

5.3.12 Node: *Obsessed with calories*

Participants stated that their clients, at times, are over-concerned about calories and are worried about overeating and gaining weight. As a result, they avoid consuming food in order to reduce their calorie intake and can decline in health as they may not be eating enough.

> G3: *Older people often think they need to maintain a certain weight ... 'We need to be thin, we need this, we don't eat this many calories', where it is exactly the opposite for an older person particular with dementia ... So they are calorie counting in a fashion, I mean they go, 'oh no I cannot any more of that because I might get fat'.*
>
> G3: *'I have always eaten like a bird. I have, always', you know, that sort of things.*

5.3.13 Node: *Fasting without eating*

Participants stated that older people can be fasting due to cultural and religious beliefs. This can affect their food consumption as they will not initiate eating during these times.

> G3: *So there is fasting times and different cultures.*

5.4 Concept: *Fluid consumption*

Fluid consumption describes the challenges faced by older people with dementia living in their own homes related to fluid consumption. The two nodes related to *Fluid consumption* include: i) *Forgetting or avoiding drinking*; and ii) *Forgetting to use drinking containers*, and are described below.

5.4.1 Node: *Forgetting or avoiding drinking*

Participants explained that inadequate hydration is a significant problem related to their clients. Older people with dementia often forget to drink enough liquids. Apart from forgetting to drink, participants stated that their clients could purposely avoid drinking in order to avoid going to the toilet. Care workers reported that they have experienced their clients becoming more confused than usual when they are not properly hydrated.

> G1: *Liquid is another issue with dementia customers. Drinking is a big issue. They need to drink. It helps with their memory. If they do not hydrate regularly you can go in at the end of the day, she rambles and is more confused than usual.*

> G3: *They do not like to drink because they have to go to the toilet especially if they are going out.*

5.4.2 Node: *Issues in using drinking containers*

Participants explained that their clients sometimes do not know how to handle a drinking container. As a result they struggle to drink even if they want to drink.

> G2: *Suddenly she [an older person with dementia] does not know how to pick that cup up or to hold it or what she is supposed to do with it.*

5.5 Concept: *Food quality*

Food quality describes the challenges faced by older people with dementia to maintain food quality. The five nodes related to *Food quality* include: i) *Financial constraints*; ii) *Forgetting to monitor the age of food*; iii) *Cultural issues in disposing of food*; iv) *Food storage in inappropriate places*; and v) *Not concerned with nutritional content*, and are described below.

5.5.1 Node: *Financial constraints*

Participants were concerned that most nutritious food are expensive. Most older people with dementia live on old-age pensions, therefore, struggle to afford nutritious food. Therefore, they tend to buy non-nutritious food that are cheap or on sale.

> G3: *It is also financial because nutritional food costs a lot of money. They do not have that with their pension and when they are paying for packages there is not a lot of money leftover and I think that is a big thing.*

> G3: *She [client with dementia] would buy the worst possible food on special ever.*

5.5.2 Node: *Forgetting to monitor the age of food*

Participants reported that their clients often forget to monitor the age of food items at home. It is common to see the food in fridges having mould and getting expired. It was also highlighted that older people mostly look at the food items placed in the front of fridges and no care is normally taken about the food items at the back of fridges.

> G3: *When you open the food, it smells and I do not know what on earth that is*.

> G1: *That is the yoghurt but then it sits in the back of the fridge, while she puts something in the front of it ... Next week I will go there and there will be, you know, some mould.*

5.5.3 Node: *Cultural issues in disposing of food*

Participants reported that often their clients are not concerned about the freshness of food. Most older people have experienced wartime and as a result, their generation has faced starvation and financial constraints. Therefore, they are thankful even to have a rotten piece of meat to eat; hence they are not willing to throw any food away.

> G2: *I guess I had one client who was brought up in the war and I would try and throw out meat that I knew that had been in the fridge for too long ... [The client would say] 'have you got any idea during the war, if you had a piece of rotten meal you would be grateful to eat it.'*

Some clients may leave the food in a pan for days without eating and do not see anything wrong with this.

> G3: *They do not actually see anything wrong with that meat that they cooked yesterday that is sitting on the stove top.*

5.5.4 Node: *Food storage in inappropriate places*

Older people with dementia often forget to store food in appropriate places. As a result, the food consumed by them may not be fresh and clean. Participants explained situations where food is lying down on cupboards and book shelves. Furthermore, they may also leave leftover food around the house after wrapping it in tissues or tea towels.

> G2: *Sometimes you find it [food] in inappropriate places as well, like you know, I used to find a client's meal quite often on the bookshelves, for some reason, in her bedroom.*

> G3: *The cleanliness, because the food is hidden. Like there is chicken drumsticks in the drawer and there is a urinal sitting in a bucket next to his bed that has got lolly wrappers in it.*

The participants explained several possible reasons for such behaviour with respect to their clients. Depending on the stage of dementia, they might not know where to store the food and might forget where to find the food later after placing it somewhere.

> G1: *Because at the stage of dementia that they are at, they are putting things in places that they do not know where they are putting at and that includes food.*

Furthermore, participants explained that clients' upbringing can also have an impact on not storing food properly in refrigerators. Participants explained that older people with dementia come from a generation who did not use refrigerators to store food. As a result, storing food in a refrigerator for later use may not be an idea that comes to them naturally.

> G3: *In some ways that may be the way that they were raised you know ... 'I never put meals in the fridge'. Sometimes it has to do with their upbringing.*

5.5.5 Node: *Not concerned with nutritional content*

Participants reported that often their clients may not be used to thinking about the nutritional content of their meals or lose their nutritional awareness completely. As a result, even though older people with dementia may consume food and fluids, they may not be obtaining adequate nutrition.

> G1: *They lose the awareness of actually understanding that nutrition is important ... So the loss of the awareness is the number one I guess.*

> G2: *We are probably working a lot of people that grew up on bread and dripping for dessert. So they perhaps don't yeah they do not particularly see the necessity for all the new ways of thinking about nutrition.*

Participants reported that despite the prompt notes set up by the care workers, it is common for their clients to select snacks, sweets or alcohol, over the nutritious meals available to them.

> G1: *Like you have said about forgetting to eat, I leave prompt notes stuck it to the table, I have made a bowl of salad, it is in the fridge for lunch. No, It is not working.*

Participants also stated their clients tend to obtain a lot of calories from alcohol which can affect their nutritional health negatively.

> G2: *A lot of them [clients] may have got their calories from alcohol.*

Participants highlighted that families provide non-nutritional snacks to older people with dementia because families are more interested in making sure their loved ones are eating something rather than being concerned about the nutritional content of the food consumed.

> G1: *The family also can be a problem with that. They provide snacks.*

> G2: *I have clients who just go to the fridge and eat snacks and so they are not hungry when the meal is produced for them ... The family has provided easy things for them to gain access to. Let's face it. Most of them are rubbish.*

Participants also stated that consuming non-nutritious meals consisting of sugar or alcohol can be detrimental, especially if their clients are suffering from any health problems such as diabetes or liver problems.

> G3: *They [older people with dementia having type-2 diabetes] eat a biscuit and yeah, drink a coke and eat a biscuit and that is the diet and how do you challenge that.*

> G1: *Your doctor would say you have got a liver problem, cut back the alcohol.*

5.6 Summary

The findings point to a number of nutritional health challenges faced by older people with dementia living in their own home. These were broadly categorised under five concepts: i) *Shopping*; ii) *Meal preparation*; iii) *Food consumption*; iv) *Fluid consumption*; and iv) *Food quality*.

Older people with dementia often forget to eat and drink. In addition, even if reminded, they may not have the desire to initiate and complete eating or drinking. This can be a result of many factors such as losing smell sensations or reduced physical activity. Most of the times, their minds do not give priority to food, especially when distracted by other stimuli, such as televisions. As a result of getting distracted, they may even forget to finish off what they have started to eat or drink. There is also the possibility of the food not being fresh when they return to having the meals later. It is also interesting to see how some older people purposely refuse to eat as a result of been over conscious about their calorie intake.

The findings also highlight the social dimension of food consumption. Having been deprived of social interactions, older people often seek mealtimes as a good opportunity to socialise with others. Furthermore, it was interesting to see how older people try to make social interactions with animals during mealtimes, especially when nobody was around. Feeding the animals with their food was a common problem. Care workers believed that for some older people with dementia, giving away food is a way of socialising. On the other hand, the findings also reveal how some older people find it disturbing to be watched by other people when having their meals.

The older people with dementia often forget where they are supposed to store food and also, later on, forget to use the food that they have stored. As a result, food can be lying around the house or expiring in the fridge, resulting in issues with food quality. Furthermore, it was interesting to see how older people are reluctant to throw away expired food, even if they are reminded to do so, due to cultural problems.

The inability to comprehend complex processes can cause difficulties in shopping and meal preparation with respect to older people with dementia. The findings reveal that most older people with dementia have difficulties with cooking for themselves. It is interesting to note how an older person's ability to perform tasks can fluctuate significantly with time, even within a single day. For example, the findings reveal that an older person who is capable of heating up their meals using microwaves, at times, may not even be able to operate simple appliances such as kettles. It is common to provide external meals such as Meals on Wheels for the older people with dementia living in their own homes. Furthermore, care workers prepare meals for their clients. However, these techniques may not fully overcome food consumption

problems associated with older people with dementia. Older people throw away or hide food available at home if it is not prepared according to their preferences. Furthermore, they are often overwhelmed by choices which result in difficulties in both meal planning and shopping.

Older people with dementia face a range of shopping-related challenges. These included forgetting when to shop and difficulties in creating shopping lists because they do not know what they like and dislike, and where to look to identify what food is running out. Furthermore, older people often struggle at the supermarkets when doing their shopping, even when they have their shopping lists. For example, they have difficulties in selecting from a range of items in supermarkets, have issues related to changes in product packaging and buying unsuitable food items without following the shopping lists.

The findings related to *Care workers' challenges in supporting their clients' nutritional health* and *Care workers' information needs related to clients' nutritional health* categories are presented in the next chapter.

Chapter 6

Findings III - Care workers' challenges in supporting their clients' nutritional health and their information needs

This chapter presents the findings related to the two categories: i) *Care workers' challenges in supporting their clients' nutritional health*; and ii) *Care workers' information needs related to clients' nutritional health*. *Care workers' challenges in supporting their clients' nutritional health* (see Section 6.1) describes challenges faced by care workers when trying to assist their clients with dementia living in their own home to maintain good nutrition. *Care workers' information needs related to clients' nutritional health* category (see Section 6.2) describes the types of nutrition and mealtime related information that care workers believe would assist them to provide a better service to their clients. Although the challenges care workers face when trying to assist their clients in maintaining good nutrition may implicitly suggest their information needs, it is interesting to understand the sorts of information care workers themselves consider valuable to support their clients' nutritional health. A summary of the findings is presented in Section 6.3.

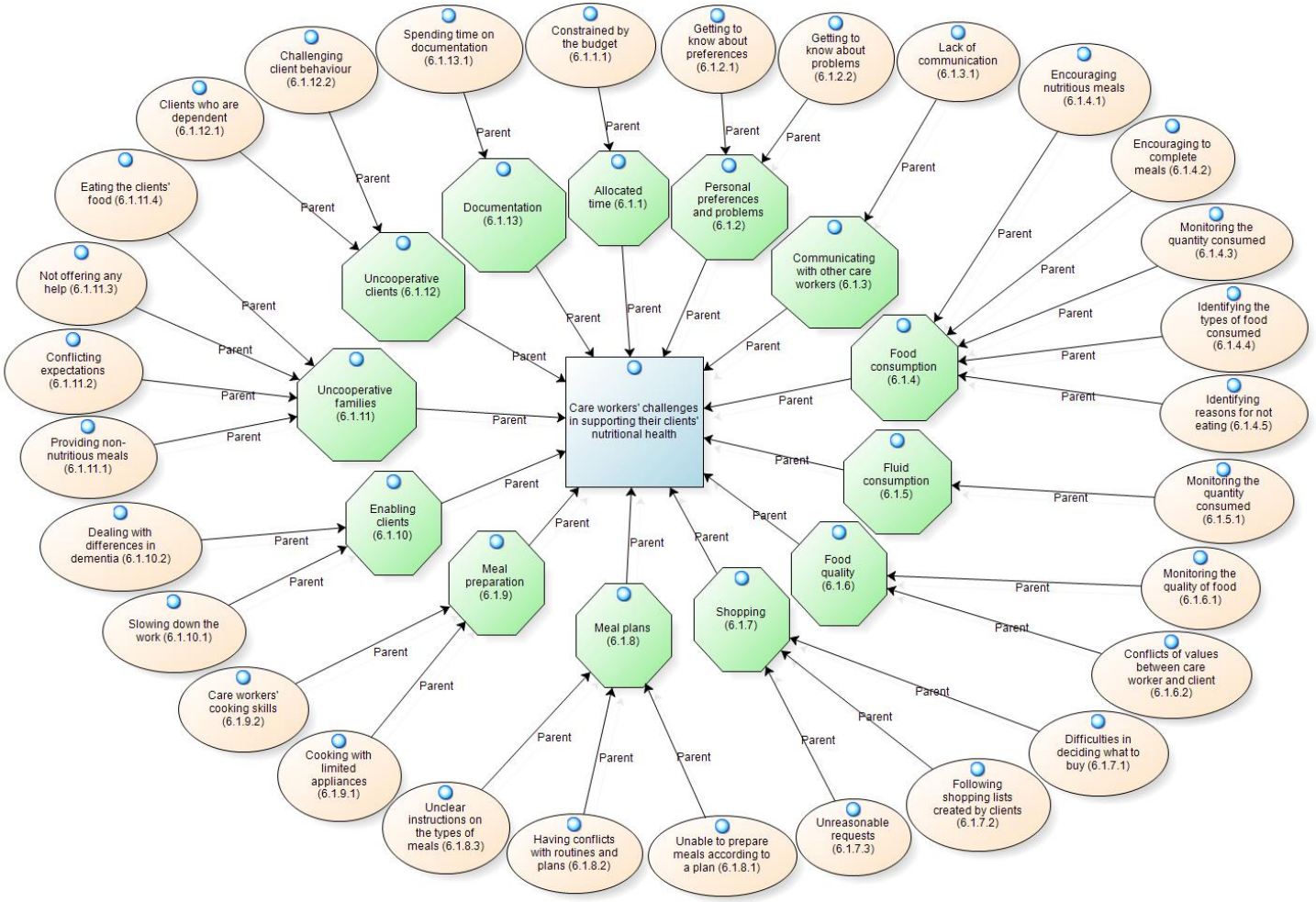


Fig. 6.1 Audit trail for the category: *Care workers' challenges in supporting their clients' nutritional health*

6.1 Category: *Care workers' challenges in supporting their clients' nutritional health*

The audit trail for *Care workers' challenges in supporting their clients' nutritional health* is presented in Figure 6.1. This category comprises 13 concepts: i) *Allocated time* (see Section 6.1.1); ii) *Personal preferences and problems* (see Section 6.1.2); iii) *Communicating with other care workers* (see Section 6.1.3); iv) *Food consumption* (see Section 6.1.4); v) *Fluid consumption* (see Section 6.1.5); vi) *Food quality* (see Section 6.1.6); vii) *Shopping* (see Section 6.1.7); viii) *Meal plans* (see Section 6.1.8); ix) *Meal preparation* (see Section 6.1.9); x) *Enabling the clients* (see Section 6.1.10); xi) *Uncooperative families* (see Section 6.1.11); xii) *Uncooperative clients* (see Section 6.1.12); and xiii) *Documentation* (see Section 6.1.9); formulated from 29 nodes.

6.1.1 Concept: *Allocated time*

Allocated time describes the challenges faced by care workers due to not having adequate time to assist their clients. The node related to *Allocated time* is described below.

6.1.1.1 Node: *Constrained by the budget*

Lack of funding is a significant problem, limiting the level of support that care workers can provide to their clients. Participants described that clients' needs are prioritised and care giving times are allocated based on the level of funding available. Due to funding constraints, at times, care workers do not have adequate time to prepare nutritious meals for their clients.

> G2: *I think the biggest thing in meal preparation and dealing with people with dementia is the time frames that we have. We would love to go and cook them a beautiful meal. I would. I love cooking and enjoy it. But we don't have time, you know, it is really frustrating for us.*

> G3: *With our limited budgets you can't go in there every morning and every night.*

Care workers only being able to physically stay with their clients at certain times of the day, they cannot monitor their clients continuously.

> G4: *Unfortunately, it's [monitoring older peoples' mealtime activities] a lot to do with funding. We can't be there 24/7. If there is no funding available, we can only do what fits in their budget.*

Participants described that they often have combined shifts where they have to provide assistance to clients with various activities of daily living such as cleaning, medication administration and showering. As a result, it becomes challenging for the care workers to provide adequate time to assist their clients in nutrition and mealtime activities.

> G2: *Sometimes it is combined shifts as well.*

Although care workers have learnt through experience that giving away rewards often encourages their clients to consume food and fluids, it is sometimes challenging for them to provide rewards to their clients with the limited amount of time available.

> G2: *Just the time factor for the staff ... She [client with dementia] is going to take 20 minutes to eat her meal but now I have promised to make her do this [giving a reward] and I have only got 10 minutes left in my shift.*

6.1.2 Concept: *Personal preferences and problems*

Personal preferences and problems describes the challenges faced by the care workers due to a lack of information about clients' personal preferences and problems. The two nodes related to *Personal preferences and problems* include: i) *Getting to know about preferences*; and ii) *Getting to know about problems*, and are described below.

6.1.2.1 Node: *Getting to know about preferences*

Participants emphasised that each client is different. Therefore, it is essential for the care workers to know about individual routines, likes and dislikes towards food with respect to each client. Even though some information is written down in initial care plans, other information has to be worked out by the respective care workers after working with their clients. The participants highlighted that obtaining comprehensive and accurate information can be difficult and time-consuming.

> G3: *I think the struggle also is that no case and no client is the same. Every time it is a new journey and adventure. So you need to learn about each individual.*

> G1: *A lot of the times it takes you several weeks, possibly months to really get to know that client.*

Participants explained that often clients are not able to describe their cultures, preferences or routines with respect to food and nutrition explicitly to their care workers. The care workers try to closely work with the family where possible to find out the details. However, when older people with dementia live alone, without any family support, obtaining such information becomes further challenging.

> G3: *They do not know how to articulate where they are coming from. It takes a lot of skill and listening and plucking it out and teasing it out.*

A care worker who works with the same client will eventually learn their behaviours, however, new care workers will still struggle in getting to know them.

> G1: *But someone [care worker] new will take longer because they do not know the routine.*

Participants further stated that even though there are notes left about the behaviours of their clients, with the time constraints it becomes challenging for the care workers to go through them and understand what needs to be done.

> G1: *I think if you know the client well, then you got time because you know what you are doing. But I think for a new [home] support worker to go into the home with dementia, half hour is not long enough for that person to really work out and go through and read those notes and know what to do.*

6.1.2.2 Node: *Getting to know about problems*

It is important for the care workers to know the problems faced by their clients with respect to nutrition and mealtime-related activities in order to identify ways for assisting them. The participants stated that care workers struggle identifying these challenges because the clients are unable to communicate their problems effectively or at times purposely avoid discussing them. On the other hand, the participants explained that their clients may not reveal some valuable information, assuming it will not be of interest to the care workers.

> G3: *We ask them [older people with dementia] to fill in a client self-assessment and it can prove unsuccessful at times because they just do not know how to articulate what mealtime means to them. 'Oh no, I do not have any problems' ... But that's what we want. We want them to articulate, 'I grow my own vegetables. I'm not touching the stuff at [supermarket name]'.*

> G3: *It is that pride too. When you are filling out a form, you are asking for help. You are asking for help, that means you cannot do it any more.*

> G3: *They do not see the relevance of what we see the relevance.*

6.1.3 Concept: *Communicating with other care workers*

Communicating with other care workers describes the challenges faced by care workers due to the lack of communication with the other care workers visiting the same client. This concept contains one node which is described below.

6.1.3.1 Node: *Lack of communication*

Participants stated that having good communication among all care workers who are involved in the care of an older person with dementia is crucial. This allows all the care workers to be up-to-date on matters, and details about nutrition and mealtime related care services provided to their clients. However, participants highlighted that a lack of communication among care workers is currently a significant limitation in providing better quality care for their clients.

Participants highlighted that their clients could receive the same types of meals because care workers do not what meals are prepared by each other. Furthermore, the participants described that meal preparation techniques used by care workers may not be consistent due to a lack of communication among them. When faced with dementia, older people always looks for consistency; hence they can be confused when the same food is prepared in different ways.

> G1: *One customer could have half a dozen of support workers regularly visiting that house. We do not see each other and talk to each other about that customer. Actually, communication books were gotten rid of a long time ago. They don't like them. However, in certain houses, we investigated for the very reason of communicating with the other [home] support workers and family. But unless we are brought for a meeting and sat down [...] we all will do in our own different things. I know, for example, when I prepare the meal for this said lady I do it this way. I've seen someone prepare a meal and put in the fridge for the previous day's meal. In the fridge, not eaten. Prepared completely different to how I do it. She didn't eat. We don't all communicate about it. If we communicated, we are able to be on the same page with each person. That would be fabulous. We will all do the same thing because they love routine. They love regularity.*

Participants stated that often new care workers are not properly informed about what they are supposed to in terms of food and nutrition.

> G1: *That is our challenge really. To try to communicate with the new staff to be aware of what they are supposed to do in terms of food monitoring.*

Even though manually maintained communication books are intended to be used by care workers to write down notes for other care workers, the participants explained that this process is not effective because the care workers do not necessarily read the communication books due to time constraints. Furthermore, the participants described that currently, at times, communication books are not properly maintained any more due to their drawbacks.

> G1: *It [going through a shopping list written in the communication book] still does not happen because people do not read things. Unfortunately, that is just a process of this job and that has nothing to do with the situation.*

6.1.4 Concept: *Food consumption*

Food consumption describes the challenges faced by care workers when trying to ensure their clients have adequate food consumption. The five nodes related to *Food consumption* include: i) *Encouraging nutritious meals*; ii) *Encouraging to complete meals*; iii) *Monitoring the quantity consumed*; iv) *Identifying the types of food*; and v) *Identifying reasons for not eating*, and are described below.

6.1.4.1: Node *Encouraging nutritious meals*

One of the duties care workers perform is to prepare nutritious meals and store them in clients' fridges for later use. The participants described that it is a challenge to encourage their clients to consume nutritious meals, especially when they are not left alone. Although, prompt notes are left to encourage clients to have nutritious meals, the participants highlighted that often the prompt notes are not effective and older people tend to eat the snacks available at home instead of nutritious meals.

> G2: *I left prompt notes stuck it to the table, 'I have made a bowl of salad, it is in the fridge for lunch' ... It is not working.*

> G2: *Prepare a meal put it in the fridge for lunch. Leave notes everywhere. But like I said that 9 times out of 10, they will eat whatever comes to hand first, a packet of crisps or whatever, instead of the meal that's in the fridge despite the amount of notes you leave. It is just out of our control.*

6.1.4.2 Node: *Encouraging to complete meals*

Participants stated that care workers struggle to make their clients sit down for meals. Even after clients sit down for their meals, it is challenging for the care workers to encourage them complete their meals. The participants stated that care workers need to continuously prompt their clients to ensure that they are not distracted from eating or indeed not sleeping in the middle of meals. Participants emphasised that continuous prompting is not always possible with the limited care giving time available.

> G2: *You can't force them if they don't want to [sit down for meals], you know.*

> G2: *We are just trying to get them to actually sit and it is a challenge.*

> G3: *But you are still only there for half an hour four times a day. So she will eat a smaller amount and then when the carer has left will fall asleep in the chair and the next carer comes in wakes her up, you know, she has not really hasn't had much of her breakfast, so okay you know, now its lunch time. Just that continual, you know, trying to keep her stimulated enough and waken up and wanting to have a meal.*

6.1.4.3 Node: *Monitoring the quantity consumed*

Participants stated that monitoring the actual amount of food consumed by their clients is quite challenging as the care workers cannot stay in their home continuously.

> G4: *It [monitoring whether older people with dementia really consume food] is not physically possible all the time.*

Participants stated that clients' self-reporting about food consumption is often unreliable. Furthermore, the participants stated that older people with dementia at times hide or throw away their food making care workers think that they have consumed all the food. Therefore, care workers can be misled about the amount of food consumed by their clients unless they physically witness older people consuming food. As a result, care workers, at times, have to set up tests at home to evaluate whether their clients actually consume food.

> G1: *I had a client years ago that who would hide her food. So you thought she was eating, but you go to clean but then you find she hadn't been eating.*

> G4: *There was one lady who had severe dementia ... She was supposed to make her own breakfast and she would like to have wheat bits every morning for breakfast and she said 'yes, I had breakfast this morning'. So we set up a little test for her and I had a brand new packet of little wheat bits there and spoon in the bowl. We set up all properly, when the worker came in later in the day. 'Oh yes, I had my breakfast'. She never [had breakfast]. All she had for breakfast every day was wheat bits. So wheat bits weren't touched, the bowl wasn't touched and the spoon wasn't touched. She really didn't have it.*

Older people with dementia frequently feed pets with food prepared for them, making it difficult for their care workers to measure the actual amount of food they have really consumed.

> G1: *But if somebody isn't watching what's going on, a lot may be going to the pet.*

Apart from the challenges in monitoring the amount of food consumed by older people with dementia, care workers find it difficult to recognise the time taken by their clients to consume those food items.

> G2: *But the thing is that when you put the bag of lollies near her bed, that is where she likes them. You don't know how many is eaten that day that hour. You know, it's just, here you go or just even it is even mandarins, you know. There she is on the toilet because she has actually eaten those five mandarins you bought for the week. She just sat down that was so nice, so let's have another one. So they are all gone in one sitting. So to monitor things like that is a bit of challenge I think. Well, there is nothing you can do.*

6.1.4.4 Node: *Identifying the types of food*

Participants stated that it is a challenge to continuously monitor the types of food that their clients consume. Care workers often worry whether their clients have nutritionally balanced meals. The only option they have is to rely on Meals on Wheels to provide nutritionally balanced meals for the clients.

> G4: *How can we check whether the meal variety got the proportion of vegetables, meat and vitamin and everything. So we probably rely a lot on Meal on Wheels ... I believe that Meals on Wheels, the meals that they deliver have vegetable and meat.*

6.1.4.5 Node: *Identifying reasons for not eating*

Participants reported that often they struggle to identify the reasons for their clients to not eat. Usually care workers identify the reasons for their clients to not eat by close observation of the clients' facial expressions which requires a lot of caregiving time.

> G2: *Sometimes just trying to work out why somebody would not want to eat one day when they usually eat. Like trying to observe their face, are they in pain or tired or constipated or what the reason would be. That takes a lot of observation and quite often not something you can tell straight away.*

6.1.5 Concept: *Fluid consumption*

Fluid consumption describes the challenges faced by care workers when trying to ensure adequate fluid intake in older people with dementia living in their own home. This concept contains one node, described below.

6.1.5.1: Node *Monitoring the quantity consumed*

Participants stated that monitoring the actual amount of fluids consumed by their clients is quite challenging as the care workers cannot be in the home continuously. Furthermore, monitoring fluid intake in extreme heat conditions is even more difficult.

> G4: *In saying that [care workers monitoring the signs of dehydration] they might have only one visit per week perhaps. So it is hard to monitor.*
>
> G2: *I do not how long that [5 litre cask of wine] lasts.*
>
> G4: *In case of extreme weather it is really hard.*

Participants explained that the reduction in water level is not a reliable indicator to measure the amounts of liquids consumed. The older people with dementia can throw away liquids without actually drinking hence care workers can be misled if only the fluid level is monitored. Therefore, the participants emphasised that it is essential for someone to be physically present in the home in order to guarantee that older people with dementia are actually consuming liquids.

> G2: *She might pour a glass of alcohol and tip it in the sink. You don't actually know unless you visually see something.*
>
> G2: *It [leaving a jug of water to monitor fluid intake] is half the story. That's right, you are assuming.*

6.1.6 Concept: *Food quality*

Food quality describes the issues faced by care workers when trying to monitor the freshness and expiration of food items available at the home. The two nodes related to *Food quality* include: i) *Monitoring the quality of food*; and ii) *Conflicts of values between care worker and client*, and are described below.

6.1.6.1 Node: *Monitoring the quality of food*

Participants stated that it is a challenge for care workers to monitor the quality of all food items at home. The monitoring of food items stored in fridges was highlighted as a major challenge for the care workers as a significant amount of time is required to go through all the items in the clients' fridges to ensure those are fresh.

> G4: *I think the biggest challenge is with the food in their fridges, like out of date things. That's probably the biggest challenge for us is monitoring that especially if they are not on the high-level packages and have got limited services.*

Participants explained that their clients at times, do not like care workers looking into their fridges. Therefore, going through contents of clients' fridges may need to be done carefully, without offending them. Hence care workers may have to carry out their inspections secretly, while their clients are engaged in some other work.

> G3: *There is a very sensitive negotiation process that goes on with clients to train home support workers and how to sensitively help that client to look at their fridge and determine what the used by date is and can we throw that out.*

6.1.6.2 Node: *Conflicts of values between carer worker and client*

Participants explained that throwing away expired food items is at times a major challenge, even when care workers are able to identify which food items have expired. This is because some clients won't allow the care workers to throw away any food items. Most older people have experienced wartime and as a result, their generation has faced starvation and financial constraints. Therefore, they are thankful even to have a rotten piece of meat to eat; hence they are not willing to throw any food away. In such situations, care workers have to use different strategies to throw away the expired food such as explaining to the clients that it is not good to eat rotten food or throwing away food secretly, without letting older people know.

> G3: *There is a lot of secrecy and I know that sounds terrible. But with the family on board and they say 'look while he is in the shower would you mind going to the fridge and getting rid of all of that'.*
>
> G2: *For this particular client I couldn't [throw away rotten food in the fridge] because she was sitting in that kitchen and there was no way I would be able to throw away anything.*

Even if the care workers throw away food, there are situations where older people get the thrown away food from the bins and put it back in their fridges. Therefore, it is a significant challenge for the care workers to ensure what was thrown into bins remains in bins as they cannot continuously track the items going in and out of clients' bins. Participants explained that at times they place clients' bins in the neighbours' yards or take the rubbish with them when going home to avoid their clients taking food items back into their fridges.

> G3: *We had a client that we had to put the bin in front of the neighbour's yard because ... he will go and get it back out of the bin.*
>
> G4: *He will go into the bin when they [home support workers] are gone and take it [what was thrown away by the home support workers] back out again.*
>
> G2: *That's [when older people with dementia do not allow care workers to throw away expired food] when you [care workers] add in [have to explain to the clients], 'you are older now and your belly is not going to take that as it did'.*

6.1.7 Concept: *Shopping*

Shopping describes the issues faced by care workers when providing shopping assistance to their clients. The three nodes related to *Shopping* include: i) *Difficulties in deciding what to buy*; ii) *Following shopping lists created by clients*; and iii) *Unreasonable requests*, and are listed below.

6.1.7.1 Node: *Difficulties in deciding what to buy*

Participants stated that their clients are not usually able to express what they want. Therefore, care workers, at times, may not be familiar with client preferences, especially regarding the brands that they like. As a result, they may struggle when preparing clients' shopping lists. Participants highlighted that this is a significant problem for care workers who are new to their clients.

> G1: *She [another care worker] was a fairly new [home] support worker .... Not knowing the customer she came back broccoli in the fridge, bacon and eggs in the fridge, pork chops. A lot of stuff that we ended up to get the family to take home because the support worker went with what the customer wanted. Yet, the customer in the four years I have been going has never eaten any of those.*

> G2: *Until you get to know your client that's a problem. If you are going into a temporary shift that's hard, that's difficult. Because you don't know the client. You don't know what is in her fridge, what is in her pantry, what brand she likes.*

On the other hand, participants stated that when they get familiar with the clients, often the clients expect them to know all details related to their food preferences. However, the participants explained that it is challenging to know all the food types and brands that their clients use, especially in situations where clients throw away food containers as soon as they use them and allow care workers to look into the fridges.

> G2: *We were in the shopping centre and going through all the aisles and she said to me 'you know which spaghetti sauce I have'. I said no because I didn't go there in a couple of weeks ... We stood in the aisle, I think for about half and hour trying out figure out which spaghetti sauce she wanted and she got really angry with me, because I didn't have a clue, you know.*

> G2: *I said, next time just leave me the empty bottle, she was a cleaning fanatic. So everything got thrown away to the bin. It was just terrible.*

> G2: *She didn't allow me to look at her fridge, she wanted to get out the house quickly to get into the shopping centre.*

6.1.7.2 Node: *Following shopping lists created by clients*

Care workers face a number of challenges when trying to follow shopping lists created by their clients. One such issue is the difficulties associated with reading the shopping lists created by the clients.

> G2: *Yes reading. Sometimes they make their own little lists and you got no idea what is this.*

> G2: *[They cannot prepare shopping lists] because they have lost the language skills.*

Participants highlighted that the shopping lists created by their clients may be not descriptive enough. This becomes a major problem when care workers do the shopping on their own, based on the shopping lists created by the clients. When older people with dementia have not specified the brand names of the products that they want, the care workers may buy inappropriate brands that the clients may refuse to use.

> G2: *They do not always come shopping with us. We are sent off to do the shopping for them. They might have 4 apples or something like that or there are 50 million different brands of apples, you know. Inevitably you bring home the wrong one.*

6.1.7.3 Node: *Unreasonable requests*

Participants stated that clients often request them to buy things that are not in the shopping lists or request them not to buy things already stated in the shopping lists, while shopping together. This is mainly because clients become unsure about their likes, dislikes, and food inventory at home while doing shopping. The participants further explained that they struggle because they do not have the authority to prevent older people from buying unnecessary things. As a result, care workers have to use different strategies to overcome the unreasonable requests from the clients while doing shopping. For example, care workers have to constantly remind clients that they picked up a food item that is already available at home or something that they normally do not cook with. However, such negotiations consume a lot of time.

> G3: *By the time she [the client with dementia] is in the shops, she thinks that everything that they decided to buy is already in the house and she throws them out.*

> G1: *During the shopping, I struggle with not being able to not buy what I don't want her [the client with dementia] to buy. You know, it's not in my power to say, 'no you cannot buy this because it is not good for you'. So she still has a sort of an authority in that situation and she wants to buy what she wants to buy. So sometimes she buys some completely useless things, that she never bought before or she never uses, but it is not in my power to say no to her.*

> G1: *I just tell her [the client with dementia] whenever she wants to pick up something that is not on the shopping list, I tell her we already got it at home and we don't need it. By the time we got home, she hasn't remembered and that's completely gone and it is every I aisle go down*

> *... We don't need that and I would say to her sometimes we don't get that because we can't cook and I would say that the stove isn't working or the stove is broken. So that's enough for her to keep moving forward. So you do, you have to, unfortunately, tell little white lies or tell them we don't have something or we already have it. So that we can keep moving and not purchasing things that's just wasting their money really.*

6.1.8 Concept: *Meal plans*

Meal plans describes the challenges faced by care workers when planning meals for their clients and when trying to execute those meal plans. The three nodes related to *Meal plans* include: i) *Unable to prepare meals according to a plan*; ii) *Having conflicts with routines and plans*; and iii) *Unclear instructions on the types of meals*, and are described below.

6.1.8.1 Node: *Unable to prepare meals according to a plan*

Even though participants agree that having a meal plan is beneficial, they highlighted the difficulties in executing those meal plans due to the unavailability of ingredients, especially in cases where shopping was done by the families.

> G2: *But then they would do the shopping and something wouldn't be there. So I couldn't do this [meal roaster] because of this.*

> G2: *Yeh! I have come across that [situations where care workers couldn't follow the meal plans due to missing ingredients].*

6.1.8.2 Node: *Having conflicts with routines and plans*

Participants stated that their clients could it find intrusive when someone else came into their home and instructed them about their routines with respect to shopping, eating etc. The participants thought that it is natural for their clients not to agree to follow pre-defined routines.

> G3: *This is relativity new. You were not getting these services 30, 40 years ago. When their [clients'] parents were old, they did for them. They didn't have strangers come in and tell them what to eat, when to shop and when they are coming back. Cause it has to fit in with this new world. Their whole life needs to change and with dementia, it must be huge.*

> G3: *They have to get up according to our roster, they eat according to our roster and they have to go shopping when we say.*

Older people with dementia's eating times may not align with eating times specified in the meal plans. As a result, participants stated that their clients may not agree to have meals when care workers come in because they are not hungry. Therefore, the participants explained that the challenge is to prepare the meals and ensure that clients eat when they are actually hungry.

> G2: *Their appetites are not going to be in line with normal eating times. So that is the challenge I guess, having meal prep and being able to ensure that they are eating when they are actually hungry.*

> G2: *So yeah, the timing, even though you can have plans in place sometimes that doesn't mean that you are going to be hungry at that time.*

6.1.8.3 Node: *Unclear instructions on the types of meals*

Participants stated that usually there are no clear instructions on the types of meals that need to be prepared for their clients. Even though meal plans are usually available for residential care facilities, the types of meals prepared for older people with dementia living in their own home, are generally decided on the day, by care workers who come in for meal preparation services.

> G2: *There are no clear instructions as to what to prepare for that person. Unless there has been a discussion around particularly favourite things, that is being put into the plan, generally no.*

> G2: *Not for my clients [meal plans]*

6.1.9 Concept: *Meal preparation*

Meal preparation describes the challenges faced by care workers when trying to prepare nutritious meals for their clients. The two nodes related to *Meal preparation* include: i) *Cooking with limited appliances*; and ii) *Care workers cooking skills*, and are described below.

6.1.9.1 Node: *Cooking with limited appliances*

Participants described that often cooking appliances available at their clients homes are switched off or disconnected from power to avoid safety hazards. As a result,

having been left with only a limit number of cooking appliances, the care workers find it difficult to cook nutritious meals for their clients.

> G1: *When the house has the stove disconnected for safety reasons, it makes it very hard for us to be able to cook from scratch if you have time unless you have the microwave. Let's face it, you cannot make a very nutritious meal you have to rely on things out of the freezer and stuff like that.*

> G2: *They would remove the knobs and stuff so that you cannot really use the stove.*

6.1.9.2 Node: *Care workers' cooking skills*

Participants explained that there is currently no assistance provided to upgrade their cooking skills. This is because that it is assumed all care workers have adequate cooking skills. However, participants highlighted that in reality not all care workers have the necessary cooking skills.

> G2: *It is considered that everybody has those skills. But as you say, not everyone does.*

Furthermore, cooking skills that care workers have may not match with clients' requirements. Participants stated that at times older people with dementia can refuse to consume meals prepared by the care workers because they are not prepared according to their preferred way. When selecting a care worker for an older person with dementia, efforts are taken to match the cultural backgrounds of the care worker with that of the older person with dementia. However, each client has their own ways of preparing meals, as a result, participants highlighted that still there can be conflicts between care workers' skills and the clients' needs.

> G2: *Carer does not always match the client.*

> G3: *That [the client refusing a particular home support worker] was only because she [the home support worker] did not know how to do bacon and eggs the way we do. But once she was taught how to do it they were the best of mates. So there is a lot of work going in behind the scenes as far as ensuring that people all have the same cooking skills because they are not meant to be chefs.*

6.1.10 Concept: *Enabling the clients*

Completely taking over activities carried out by older people with dementia is not something care workers encourage. Therefore, as explained in Chapter 4, the care workers make an effort to incorporate their clients into mealtime activities. However, enabling clients may pose challenges for the care workers. *Enabling the clients* describes such challenges faced by care workers. The two nodes related to *Enabling the clients* include: i) *Slowing down the work*; and ii) *Dealing with differences in dementia*, and are described below.

6.1.10.1 Node: *Slowing down the work*

Participants highlighted that it is important to enable their clients to carry out tasks on their own. However, at times, allowing older people with dementia to carry out certain mealtime activities on their own becomes challenging for the care workers as it demands more caregiving time.

> G4: *Time factor, slows you down. It is nice to see them doing things.*

> G2: *I think it is very hard to try and not to take over. You know like this is what I think you should be eating. Because as [name of a participant] said, they could take an hour and a half just to figure out a couple of meals what they want to have.*

6.1.10.2 Node: *Dealing with differences in dementia*

Participants explained that the level of dementia of a client can fluctuate even within a day. The care workers have to deal with the capacities of each individual with respect to their level of dementia at a given moment. As a result, participants stated that they struggle in enabling their clients because of being unaware of their levels of dementia at a given moment.

> G2: *You are dealing with them at all different levels. They've got different degrees of [dementia].*

> G2: *Every day its [the level of dementia] is different. Every time you visit a client you don't know what to expect. When you walk through that door.*

> G4: *They just have good days and bad days.*

> G2: *They may have levels but then, you know, you are talking about any one day, every time it is different.*

6.1.11 Concept: *Uncooperative families*

Uncooperative families describes the challenges faced by care workers when dealing with the families of their clients. The four nodes related to *Uncooperative families* include: i) *Providing non-nutritious meals*, ii) *Conflicting expectations*; iii) *Not offering any help*; and iv) *Eating the clients' food*, and are described below.

6.1.11.1 Node: *Providing non-nutritious meals*

Participants described that family members sometimes buy or prepare non-nutritional food and drinks for the older people with dementia living in their own home. For example, they at times bring junk food or alcohol for older people with dementia.

> G1: *The family would bring in bottles of brandy and bottles of wine when we are not around. When we find them, we get rid of them because they bring in the stuff that they are not supposed to have and families are thinking it is easier to give her [client with dementia] what she wants and make her quiet.*

> G4: *That is a challenge as well. We try to get his [an older person with dementia] meal proportioned between vegetables and meat. But he [the son of an older person with dementia] wants our home care assistant to feed his dad bottled drink all the time, he is not going to feel hungry.*

Participants explained that when families do the shopping, at times, they do not buy nutritious ingredients. In such situations, care workers struggle to prepare well-balanced meals for their clients.

> G4: *If the daughter [daughter of an older person with dementia] would complain, she was the one who was doing food shopping. So she should be the one who had the supplies there for the home care assistants to be able to make the meals.*

Participants also highlighted that children may not be providing non-nutritious meals intentionally and it can be a result of their lack of education about nutrition.

> G1: *He is not doing like that intentionally. It is unintentional.*

> G1: *Lack of education on their [family's] part really.*

6.1.11.2 Node: *Conflicting expectations*

Participants stated that, at times, the children are not willing to accept that their parents have got dementia. Children can try to deny that their parents have got dementia because they want them to be healthy. As a result, their nutrition and mealtime expectations can be different to from care workers.

> G2: *Family expectations are often a challenge for me because their mindset has still not caught up with the clients' ... I think in a lot of instances may be not all, they still desperately want their mom or dad to be functioning at that, what we perceive as a normal.*

Participants described that families sometimes have conflicting expectations with care workers and may request their parents to eat or drink items that are not recommended for them.

> G2: *The dietician suggests only 3 protein drinks but the son is concerned that dad didn't drink enough and he puts the client on 5 of that bottle.*

> G2: *I have one lady whose daughter basically has every thing ready for me to cook. But she just, the amount of food that I'm expected to serve up to her mom, I couldn't. Her mom couldn't eat over three little portions.*

6.1.11.3 Node: *Not offering any help*

Participants stated that some families are not willing to offer any help to care workers to look after their loved ones with dementia living alone. This is a significant challenge for the care workers as their role is actually to support the families to look after older people with dementia. The children can be either embarrassed by the dementia situation or may be thinking that they shouldn't help care workers are paid to look after their parents.

> G1: *I'm there to go there and give them a break basically ... That is supposed to be our role in going into people's homes. There are some families that go, 'oh god support worker is there, we do not have to ever deal with mom again or dad again', which is really sad and unfortunate. Especially for those, I do have a lady, quite advanced dementia. In that case, where the families are either embarrassed by her or whatever their reasoning would be, they have very little to do with her.*

Participants stated that, at times, the children even request care workers to prepare meals for them instead of the older person with dementia.

> G2: *Then he says 'oh can you get [care worker name] to cook a casserole so that there is enough for me for tea'.*

6.1.11.4 Node: *Eating the clients' food*

Participants described that families at times consume food belonging to their clients. This makes it harder for the care workers to monitor the food consumption of their clients and ensure the availability of food when clients are left alone.

> G2: *You know, 'it is not up to me whether you [grandson] eat the fruit and whatever. We need to observe what your grandma [client with dementia] is eating'. 'Oh, I [grandson] only had a grape'. 'That is not what I am [care worker] saying, I what to know the amount of fruit that I put there, is she eating or are you eating it'.*

6.1.12 Concept: *Uncooperative clients*

Uncooperative older people describes the challenges faced by the care workers when dealing with their uncooperative clients. The two nodes related to *Uncooperative older people* include: i) *Clients who are dependent*; and ii) *Challenging client behaviour*, and are described below.

6.1.12.1 Node: *Clients who are dependent*

Participants stated that they find it challenging to not prevent their clients from becoming too dependent on them. The participants described how clients at times request services from care workers, even when they can do things themselves. This can be a result of them being too lazy to do things on their own, or thinking that they should not do any work as they are paying for a service.

> G2: *I go to relief shift, meal prep at night, to make a sandwich for someone that I would have thought would done by themselves. So perhaps, bit too much taking over, you know, and it is like what I am doing here. There is no medication I have to give. He goes like the tomatoes are here, the cucumber is there. Can you make me this, this, this and walk around the house.*

> G2: *We are supposed to be enabling our clients ... rather than taking over. I have got one client who, and she knows and she looks at me with this cheeky little smile on her face and says I haven't got my breakfast yet.*

> *Well, I will put the kettle on and I will go and make your bed, while you make your cup of tea. So I set it all up and then she will go and do it. She will put her toast in, she knows that she can do it but some of them also have that I'm paying for a service and this is what I want you to do.*

6.1.12.1 Node: *Challenging client behaviour*

Participants highlighted that when clients have got a challenging behaviour it is difficult for the care workers to assist them in mealtime activities. For example, some of the older people with dementia are aggressive and demanding. However, these challenging behaviours were quite unique to each older person with dementia.

> G2: *Obviously you get the aggressive ones as well ... I mean obviously you cannot push them to eat but you know that they need something to eat and you really know especially when you have tablets to give them and they are quite, 'I'm not eating that. I do not want that', you know. They can be quite confronting ... You got to work through that with them cause they are not all nice.*

> G2: *Meal preparation, when they have interesting and challenging behaviour, you know, how do you go about encouraging nutrition.*

> G3: *I have one client with challenging behaviour she had dementia. She was accusing that all her food was tampered with. But that was a bit of a challenge for us because she would only eat the food that she actually visually sees us opening and preparing for her. Nothing could be left out, even her Meals on Wheels.*

6.1.13 Concept: *Documentation*

Documentation describes the challenges associated with documentation. The node related to this concept is described below.

6.1.13.1 Node: *Spending time on documentation*

Participants stated that they have to do a significant amount of record keeping on a daily basis which needs to be communicated to all the stakeholders, including the family.

> G4: *It [documentation and communication] takes a lot of time.*

Participants further explained that when family members have conflicting interests or values, communicating with them becomes more challenging, requiring more time.

> G4: *That is assuming that all family members are on the same page.*

6.2 Category: *Care workers' information needs related to clients' nutritional health*

The audit trail for *Care workers' information needs related to clients' nutritional health* is presented in Figure 6.2. This category consists of six concepts: i) *Food and fluid consumption* (see Section 6.2.1); ii) *Inventory* (see Section 6.2.2); iii) *Rewards* (see Section 6.2.3); iv) *Meal and shopping plans* (see Section 6.2.4); v) *Meal preparation* (see Section 6.2.5); and vi) *Routines* (see Section 6.2.6), formulated from 11 nodes.

6.2.1 Concept: *Food and fluid consumption*

Food and fluid consumption describes food and fluid consumption information of older people with dementia that care workers believe would be useful for them. The node related to this concept is described below.

6.2.1.1 Node: *Knowing the quantity and types*

Participants reported that they are keen to know the actual amount and types of food and fluids consumed by their clients.

> G1: *Monitoring the amount of liquid that they are drinking is also an important thing.*

> G3: *How much do they eat?*

> G4: *Knowing for sure, that is really sure, that they are eating, they are drinking and what they have had.*

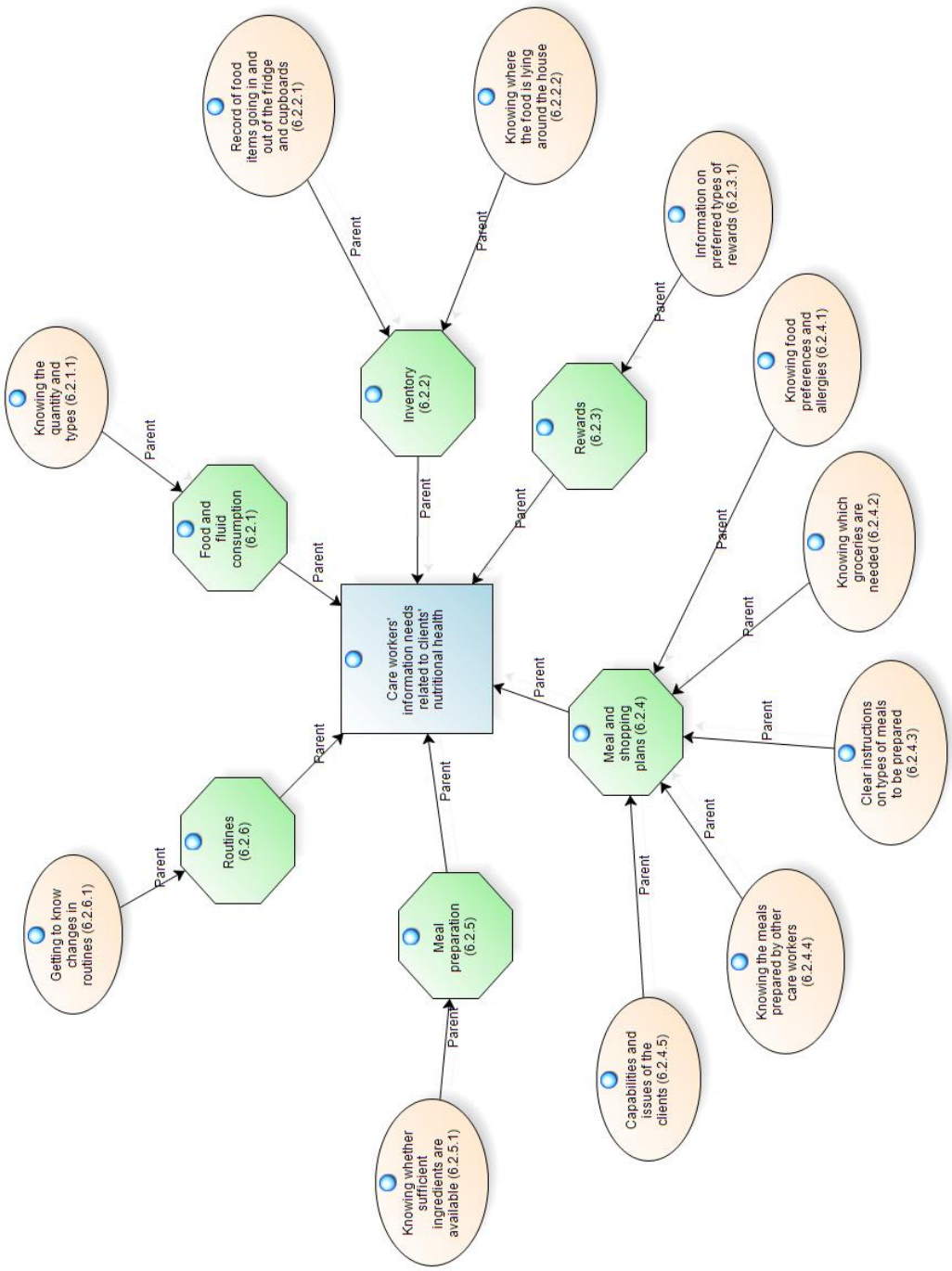


Fig. 6.2 Audit trail for the category: *Care workers' information needs related to clients' nutritional health*

The participants further explained that it is not that important for them to know the exact calorie intake information of their clients. However, knowing the portion sizes of food consumed by their clients was identified as useful.

> G4: *I don't think the calories [are important]. It is more, just knowing that they have had something to eat because you know the amount that they can intake gets smaller and smaller as well. I think it is also knowing that they actually had something that is [the] biggest concern.*

> G4: *They [Diabetes South Australia] also based on portion sizes. So that's what - not calories but portion sizes.*

6.2.2 Concept: *Inventory*

Inventory describes the types of information related to clients' food inventory that care workers are interested in. The two nodes related to *Inventory* include: i) *Record of food items going in and out of the fridge and cupboards*; and ii) *Knowing where the food is lying around the house*, and are described below.

6.2.2.1 Node: *Record of food items going in and out of the fridge and cupboards*

The participants explained that in order to monitor whether older people are consuming non-nutritious meals, it is valuable to have information about the types of food stored and taken out from their fridges and cupboards.

> G1: *What's in the cupboards if we are going through them in a regular basis and the fridge. You can see what is disappearing or what isn't.*

6.2.2.2 Node: *Knowing where the food is lying around the house*

The older people with dementia often place food items in inappropriate places around the house. As a result, food items may be hidden from the care workers. Therefore, participants stated that getting to know where the food is hidden is very valuable for them. They further explained that it is time consuming or hard to gather this sort of information, especially when care workers are not at clients' homes.

> G3: *So we are never going to find out [where food is lying around when care workers do not visit the clients]. Again we rely on other people, home support workers and ourselves to do a big sort of a look around, where is the food and where is the rubbish, that sort of thing. That's the sort of stuff we can't seem to gather.*

6.2.3 Concept: *Rewards*

Care workers believe that providing rewards can encourage older people with dementia to carry out certain tasks. The *Rewards* concept describes information related to rewards that the care workers wish to have.

6.2.3.1 Node: *Information on preferred types of rewards*

Participants explained that providing rewards can encourage their clients to sit down for meals and consume food and fluids. The types of rewards preferred by each older person can be different. According to the care workers' experiences, examples of such encouraging factors include audio and visual entertainment. Therefore, participants stated that it is important for them to know the most suited rewards for each individual client.

> G1: *We need that information [about the types of rewards that can get each older person with dementia to do a certain task]. We need all that.*

6.2.4 Concept: *Meal and shopping plans*

Meal and shopping plans describes the information that will assist care workers in planning the mealtime activities of their clients. The five nodes related to *Meal and shopping plans* include: i) *Knowing food preferences and allergies*; ii) *Knowing which groceries are needed*; iii) *Clear instructions on types of meals to be prepared*; iv) *Knowing the meals prepared by other care workers*; and v) *Capabilities and issues of the clients*, and are described below.

6.2.4.1 Node: *Knowing food preferences and allergies*

Having detailed information about client preferences and allergies is important for care workers to make meal plans and shopping lists. The clients' food-related preferences that care workers are interested in obtaining include the allergy types, food and fluid types and brands, mealtimes, places in the house meals are taken, meal preparation techniques and preferences related to eating while socialising with others.

> G1: *It is just working out the things [the food that they like to have].*

> G1: *It is just getting to know what they eat, what they like and again that could be just allergy things or what they like or dislike [to help clients in their shopping].*

> G3: *What times do they like to eat? What sort of food do they like to eat? How do they like their like it prepared? Do they prefer to eat alone or with somebody? Do they sit at their table or lounge room?*

Participants further explained that it usually takes time for them to discover individual client preferences related to nutrition and mealtimes, as most clients are not capable of self-reporting their preferences and how they used to live.

> G3: *There was one client who was Italian and who used to grow her own vegetables all the time. She wouldn't eat store brought vegetables and it took a while figure that out and then to put that in as a care plan to have the [home] support staff to assist her in her vegetable garden and that really helped. Finding out the history, what they like and how did they used to live and how can we support that.*

Participants explained that having information about food usage will make it easier for the care workers to understand about the likes and dislikes of their clients.

> G1: *It bit easier too if they still have got some remnants in the fridge of what they have. So you can pick up [the preference] from that.*

The possibility of obtaining information about client preferences by monitoring what goes into the rubbish bin was discussed.

> G3: *A good clue is looking in the rubbish bin too.*

Participants reported that nutrition and mealtime related preferences of older people with dementia may change over time. Therefore, the importance of care workers to obtain updated information about clients' preferences was highlighted.

> G1: *We all know from experience, those who deal with it all the time, yes things change on a daily basis with them. Right from their food needs to their behaviour needs. But if we have a book list of a variety of things that they like, like if they like yoghurt, they might only like strawberry, they might only like vanilla but next week they will want try strawberry, we will add it to the list. Put information, we have tried it we are not sure about it. We all will communicate via this food diary would be great.*

6.2.4.2 Node: *Knowing which groceries are needed*

Participants stated that it would be useful to obtain information about the types of groceries needed to be bought when shopping for their clients. They further explained the possibility of maintaining grocery lists for their clients which contain basic food items, and updating those lists based on the food usage at home. The importance of having brand information with respect to each food item was also highlighted.

> G2: *List of groceries that they would use. So if they needed butter, this is the brand of butter. You know the butter is getting bit like [expired], so you tick on that butter on that list and he likes this milk, he likes this type of butter and you take that list to the shop. Not a lot of people do that.*

6.2.4.3 Node: *Clear instructions on types of meals to be prepared*

Participants stated that having clear instructions on the types of meals to be prepared for their clients would be useful. However, the importance and challenges for obtaining personalised menu plans with respect to each client was highlighted.

> G1: *If we had a set menu that we run by in each [house]. The problem with that is tailoring that to everybody's needs because everybody is different. But, yes, if were to have clear instructions, we all do the same thing, that would be fantastic.*

6.2.4.4 Node: *Knowing the meals prepared by other care workers*

Participants highlighted the importance for all care workers visiting the same client to communicate with each other regarding client's meals to ensure variety in the food types prepared.

> G2: *It is knowing what other people have done [with meals in order to ensure variety].*

> G1: *The more information [regarding meals] we can put down for each other as [home] support workers the better for that customer, the client.*

Maintaining consistency in the way meals are prepared is an important consideration with respect to older people with dementia. Therefore, participants stated that sharing meal preparation techniques is useful for the care workers to be aware about how other care workers prepare the meals for a client.

> G1: *If we communicated and we are able to be on the same page with each person, that would be fabulous. We will all do the same thing and because they love routine. They love regularity.*

6.2.4.5 Node: *Capabilities and issues of the clients*

Participants explained the need to know about their clients' capabilities and issues in relation to nutrition and meals. Obtaining this information is challenging for the care workers due to their clients' inability to self-report.

> G1: *Finding out what they [clients] can do.*

6.2.5 Concept: *Meal preparation*

Meal preparation describes the information related to meal preparation that care workers believe would assist them when providing care services for clients. The node related to *Meal preparation* is described below.

6.2.5.1 Node: *Knowing whether sufficient ingredients are available*

When clients prepare meals themselves, participants believed it is important for them to identify whether enough ingredients are available at home. Obtaining this information was identified as crucial, especially when shopping is done by someone else.

> G4: *If they are actually physically making the meal and not heating something up, it is based around who does the shopping. Got to make sure that they have enough ingredients there that they can cook the meals.*

6.2.6 Concept: *Routines*

Routines describes the information the care workers would like to know about clients' daily routines. The node related to *Routines* is described below.

6.2.6.1 Node: *Getting to know changes in routines*

Participants stated that it is important for them to receive information about unacceptable behaviour with respect to their clients' daily routines, especially when care workers are not with them.

> G3: *How are we going to find out, when we are not there, that things are not going so well?*

6.3 Summary

Care workers face diverse challenges when providing nutritional health support to their clients. These challenges were broadly categorised into 13 concepts in *Care workers' challenges in supporting their clients' nutritional health* category.

By carefully analysing the challenges reported by care workers, it can be identified that care workers are not only allocated a limited time to provide services to their clients but also struggle to effectively use the allocated time due to various reasons. For example, when care workers have to spend time to understand a client's personal preferences and problems, and deal with families with conflicting expectations, their ability to socialise with clients and concentrate on their nutritional health is reduced. Furthermore, going through all items in fridges to provide assistance in shopping and for ensuring food quality is identified as a time-consuming task for the care workers. In addition, care workers find it extremely challenging to ensure that expired food thrown into the bins is not taken out by the clients when care workers leave the homes.

Care workers often struggle to monitor the types and actual amounts of food and fluids consumed by their clients reliably because is not possible for them to be at their clients' homes continuously. For example, given the possibility of older people with dementia hiding their food, throwing their food away, feeding animals with their food, even simply monitoring the initiation of food consumption or food leftovers may provide misleading information about food consumption for the care workers. Furthermore, simply monitoring the reduction of water level may not provide a reliable estimate of fluid consumption. Additionally, going through client's personal spaces to check what they have eaten, how much they have eaten and where they have stored food, at times is challenging for the care workers, as clients can be offended by these actions.

Care workers often find it hard to execute the care plans because clients resist following those plans. As an example, care workers highlighted that their clients often refuse to have their meals, as they are not hungry, when care workers arrive at clients' homes during the planned mealtimes. Furthermore, care workers struggle because of not having proper communication with other care workers, as well as family members of the client.

Although care workers prefer to enable clients rather than take over, they face a number of challenges in doing so. As the level of dementia fluctuates over time, care workers can be unaware of the capabilities of a client in a given day. Care workers are required to figure out how well the clients are doing before deciding how to enable them. Furthermore, enabling clients requires care workers to spend more time on a task, as clients can be slow in doing certain things.

It is important to highlight that care workers currently receive no assistance to upgrade their cooking skills. As Australia has a multi-cultural community where cooking techniques can have significant changes in different cultures, care workers constantly struggle to prepare meals according to their clients' needs. Furthermore, it is challenging for care workers to ensure a variety in clients' meals due to the lack of communication with other care workers.

Care workers' information needs related to clients' nutritional health presented the care workers' descriptions of the information that they think is valuable to assist with clients' nutrition and mealtimes. This category comprised of 11 nodes. Although *Care workers' challenges in supporting their clients' nutritional health* implicitly suggests some of these areas, it is interesting to see the types of information care workers themselves consider valuable. Based on the findings, the care workers are mostly interested to know whether their clients have had their meals and fluids properly. One of the most important pieces of information that care workers consider useful is knowing the exact amount of food and fluids consumed by their clients. Care workers highlighted that measuring the water level reduction or food leftovers is insufficient to know exactly whether their clients have had the food and fluids as they may hide, throw away or feed the animals their food and fluids. Furthermore, the care workers were interested in getting to know about individual client preferences related to food and mealtimes as figuring out such information can consume a lot of time. Care workers also consider having information about the food inventory, especially about fridges and bins, to be very useful to monitor clients' food usage. Additionally, care workers were interested to know the types of rewards that may motivate their clients to consume food and fluids.

The findings related to the *Care workers' wishes for technologies designed to support their clients*, *Care workers' wishes for technologies designed to support them* and *Care workers' technological concerns* categories are presented in the next chapter.

Chapter 7

Findings IV - Care workers' wishes and concerns about technologies

This chapter presents the findings related to the three categories: i) *Care workers' wishes for technologies designed to support their clients*; ii) *Care workers' wishes for technologies designed to support them*; and iii) *Care workers' technological concerns*. *Care workers' wishes for technologies designed to support their clients* (see Section 7.1) describes participants' wishes on types of technological assistance that could be offered to their clients to promote good nutrition. *Care workers' wishes for technologies designed to support them* (see Section 7.2) describes participants' wishes on the types of technological assistance that they think could be useful for them to provide improved care services to their clients with respect to their nutritional health. As the focus of the study was to understand the needs for technology development, the participants of focus group meetings were not explicitly requested to explain their technology development concerns. However, the study findings reveal a number of concerns care workers had about employing technologies to promote the nutritional health of their clients. *Care workers' technological concerns* (see Section 7.3) describes care workers' concerns related to translating technologies into practice. As explained in Section 3.2.2, it is not expected for care workers to provide detailed descriptions of the role of technologies; however, their wishes and concerns about technologies could provide useful hints, and serve as entry points for researchers to identify potential technology applications and considerations for technology development. A summary of these findings is presented in Section 7.4.

7.1 Category: *Care workers' wishes for technologies designed to support their clients*

The audit trail for *Care workers' wishes for technologies designed to support their clients* is presented in Figure 7.1. This category comprises six concepts: i) *Shopping support* (see Section 7.1.1); ii) *Meal preparation support* (see Section 7.1.2); iii) *Food and fluid consumption support* (see Section 7.1.3); iv) *Cleaning support* (see Section 7.1.4); v) *Toileting support* (see Section 7.1.5); and vi) *A single platform focusing on nutrition* (see Section 7.1.6), formulated from 17 nodes.

7.1.1 Concept: *Shopping support*

Shopping support describes participants' wishes for providing technological support to their clients during the shopping process. The two nodes related to *Shopping support* include: i) *Displaying the food inventory automatically*; and ii) *Having client specific online shopping*, and are described below.

7.1.1.1 Node: *Displaying the food inventory automatically*

Participants explained that an automatic visual display of the food items inside the fridge may indirectly remind their clients that they should not buy similar items over and over again when shopping.

> G2: *It [visually seeing the food inside the fridge] just reminds them, 'oh my fridge has got lots of food and I shouldn't buy some more'.*

7.1.1.2 Node: *Having client specific online shopping*

Participants stated that it would be useful to have technologies supporting on-line shopping. However, participants emphasised that these technologies should be client specific. The participants also highlighted that their clients can get offended if they are offered food brands not familiar to them.

> G3: *I think a lot of the new technology will be on-line shopping and that sort of thing would be fantastic if it was ... client based.*

However, a care worker also explained that on-line shopping might not be suitable for some clients who consider shopping as a method of socialising with others.

> G3: *They like that actual going and out doing shopping. It is the adventure rather than the actual task.*

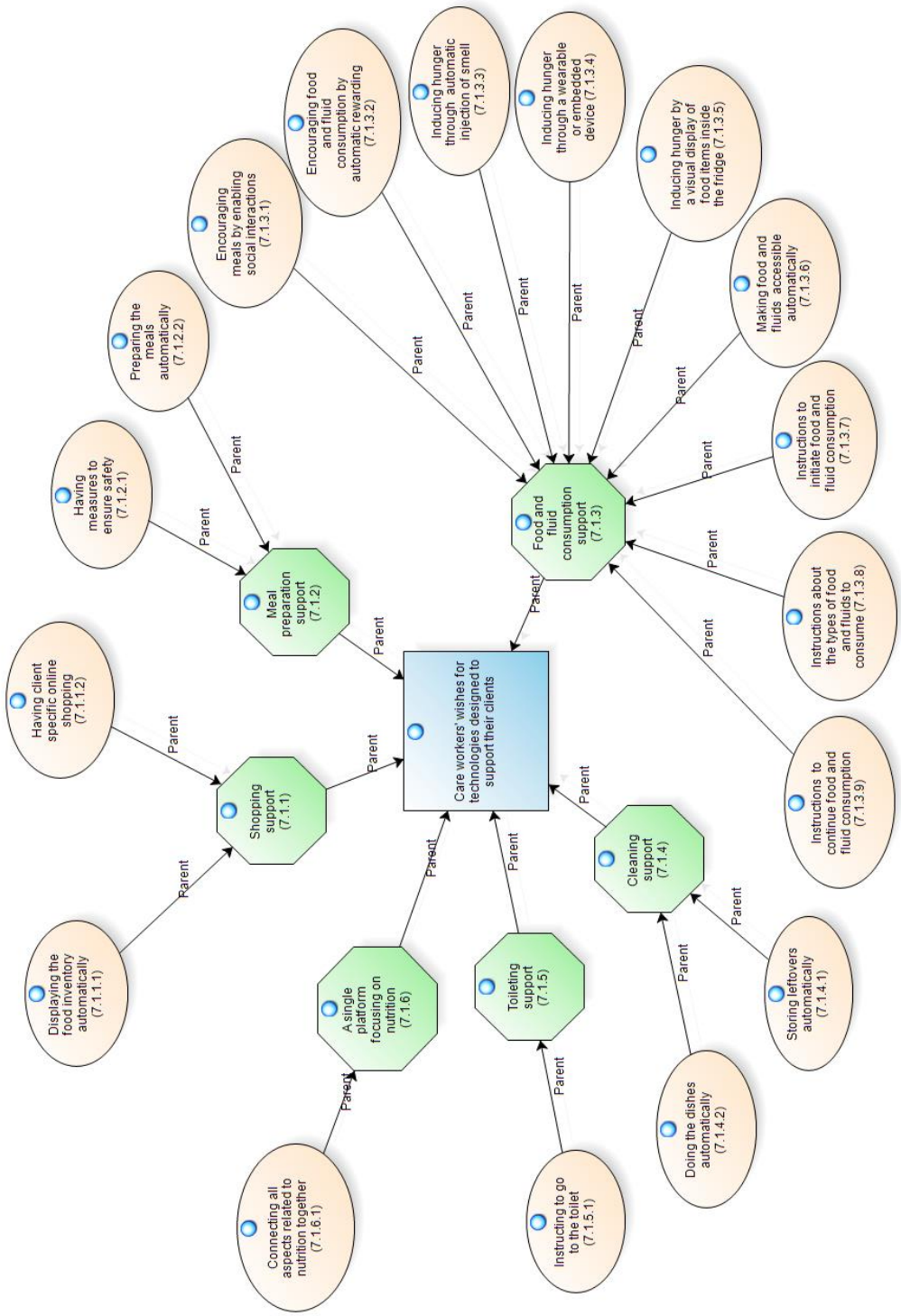


Fig. 7.1 Audit trail for the category: *Care workers' wishes for technologies designed to support their clients*

7.1.2 Concept: *Meal preparation support*

Meal preparation support describes the opportunities for technological interventions in assisting older people with dementia when preparing their meals. The two nodes related to *Meal preparation support* include: i) *Having measures to ensure safety*; and ii) *Preparing the meals automatically*, and are described below.

7.1.2.1 Node: *Having measures to ensure safety*

Participants described their wishes in having technologies to ensure the safe operation of kitchen appliances when older people with dementia prepare their meals.

> G2: *Knowing that they are safe when we walk out of the door [by have technological assistance to ensure safety in kitchen].*

7.1.2.2 Node: *Preparing the meals automatically*

Participants stated that it would be useful if technology could be employed to prepare meals for older people with dementia. They further explained the possibility of using robots for meal preparation especially when care workers are not around.

> G4: *[A robot] to prepare the meals [when the care workers are not there].*

> G4: *The robot that when we say steak and veg and goes and does it, cooks it and prepares it.*

7.1.3 Concept: *Food and fluid consumption support*

Food and fluid consumption support describes care workers' wishes in having technologies to assist food and fluid consumption of their clients. The nine nodes related to the *Food and fluid consumption support* concept include: i) *Encouraging meals by enabling social interactions*; ii) *Encouraging food and fluid consumption by automatic rewarding*; iii) *Inducing hunger through automatic injection of smell*; iv) *Inducing hunger through a wearable or embedded device*; v) *Inducing hunger by a visual display of food items inside the fridge*; vi) *Making food and fluids accessible automatically*; vii) *Instructions to initiate food and fluid consumption*; viii) *Instructions about the types of food and fluids to consume*; ix) *Instructions to continue food and fluid consumptions*, and are described below.

7.1.3.1 Node: *Encouraging meals by enabling social interactions*

Care workers highlighted that eating alone could be a reason for most clients not to be interested in consuming their meals. Therefore, participants stated that it would be useful to automatically interconnect clients with their families when the families are having their meals. Participants believed that seeing their loved ones having their meals may help to create a desire in older people with dementia to consume food. The participants further explained that enabling remote social interactions through televisions will be useful, as older people spend most of their time watching television.

> G4: *Can you switch on the TV at the same time your family is having meals somewhere else.*

Participants explained the usefulness of having an device during mealtimes, especially when care workers are not at the homes of their clients, to interact with them and to encourage them to eat more.

> G4: *[Something] that could sit with them and help them to eat their meals.*

7.1.3.2 Node: *Encouraging food and fluid consumption by automatic rewarding*

Participants explained that rewards most of the time have an amazing effect in making their clients sit down for meals and complete consuming those meals. Therefore, participants stated that it may be useful to have automatic rewarding mechanisms to encourage their clients to consume food and fluids.

Participants described several ways in which older people with dementia can be automatically rewarded during food consumption. These included turning on clients' favourite music or the television when they are having meals. However, participants emphasised that rewards need to be selected based on the individual preferences of clients.

> G2: *If you ... can [automatically] put the music on because she loves listening to opera and she will actually comply when you do that and it actually has an amazing effect obviously.*

> G2: *May be [automatically turning on] their music [to draw make them sit during mealtimes].*

> G2: *Let's [automatically] put the TV on [when the older person with dementia starts to consume their meal].*

Participants described their wishes for using technology to automatically reward older people with dementia to encourage fluid consumption. One such example would be to automatically play their favourite music when drinking container is lifted or when their drinking container touches their lips.

> G2: *If they lifted the glass and their music [automatically] comes on for example. They may make the connection.*

> G2: *When they touch it [the drinking container] with their lips may be [playing the favourite music automatically], you know.*

7.1.3.3 Node: *Inducing hunger through automatic injection of smell*

Participants stated that automatically injecting the smells of food that their clients like to eat would help them to create a desire to eat.

> G4: *Smell could be [automatically] defused at certain times [to create a desire to eat].*

Participants also stated that to create a greater impact, it may be useful to show pictures of relevant food items while automatically injecting smell. This way both smell and visual senses can be simulated together increasing the possibilities for creating an urge to eat.

> G2: *Get the senses going. So smell and sight.*

7.1.3.4 Node: *Inducing hunger through a wearable or embedded devices*

Participants stated that it would be useful to consider a wearable device that could create the urge to eat in their clients.

> G2: *How about belt or button, or something that you inject that makes you feel hungry.*

7.1.3.5. Node: *Inducing hunger by a visual display of food items inside the fridge*

Participants suggested that automatically displaying food items inside the fridges of older people with dementia may indirectly encourage them to consume those food items.

> G2: *What if they love bananas, what if a nice picture of bananas came up in front on the fridge door.*

7.1.3.6 Node: *Making food and fluids accessible automatically*

Participants described that at times, having food and drinks available at the dining table encourages their clients to consume them. Therefore, participants believe that intelligent and automatic ways of serving and refilling food and drinks at the table may be useful.

> G3: *If we ring and say ... 'you need to go and eat [client name].' Yeah, alright'. It is gone. But somehow if we can get the food on the table and drinks there constantly, small amounts, a sandwich, cheese and bickies, you know, a bowl of veggies or something. If somehow we can get something to appear, without staff going in 6 or 7 times a day and have small bits of food and drinks on the table all day, I'll be more than happy.*

Participants further explained that care plans at times encourage care workers to make food available around the house such as in the kitchen, bathroom and on side tables. Therefore, participants believed that a focus from a technology perspective should be on making food and drinks automatically available around the house.

> G3: *I had a care plan before, where we would leave food, snacks and drinks everywhere on the bedside tables in every room, bathroom, kitchen, where ever.*

7.1.3.7 Node: *Instructions to initiate food and fluid consumption*

Participants believe that it may be useful to have a reminding device that periodically reminds older people with dementia to have their meals, along with information about the types of meals and the locations of the meals. Participants suggested that the reminding service could be implemented through a wearable device or a device that is fixed to a specific location.

> G1: *A reminding device for meals when we are not there. Whether it is a pendant or a watch on their wrist or a device that sat where they sit all the time on their table that comes on at certain times of the day and speaks to the customer and tells them that it is lunch time and tells them where to find their meal and what is there to eat.*

> G2: *I think something to prompt them [clients] to go and have a drink of water.*

Participants also acknowledged their clients may not, at times, adhere to the prompts. However, participants stated that it may be still important to have continuous reminders to encourage their clients to consume food and fluids.

> G1: *But when we are not there, the prompting alert of making them eat and drink. Even if they had this talking screen thing that can see them and reminds them to have their lunch, every half an hour would say, have you had a glass of water or have you had a cup of tea. Whether they have or haven't, it's enough for them to continuously hear all day, going off every half an hour and forty-five minutes. That soon will become a habit that there is that drink there put up in the morning. They will eventually pick up and drink it at some stage.*

Participants explained their wishes in prompting their clients to drink fluids based on automatic diagnosis of urine and stools.

> G2: *Something to kick in [based on stools and urine diagnosis] and say go and have a glass of water.*

> G2: *Urine is not dilute enough. You need to drink some more water Mrs. [client name].*

Participants also described their wishes in automatically prompting their clients to drink more liquids based on the temperature.

> G2: *Something that can sense the temperature of the air and remind or prompt the client regularly throughout the day to have a drink.*

Participants described that it will be advantageous to verbally prompt their clients about the food stored in their fridges. Furthermore, the possibility of showing images of food items in fridges along with verbal prompts was highlighted as it would make it easy for the older people to understand the prompts.

> G1: *Like an alert on the fridge or something, a monitor will come up and say, have you eaten and will show you a picture of what you can eat in the fridge or something later on in life.*

Participants have highlighted that older people with dementia often get distracted when watching television, hence forget to consume food and fluids. In order to address this issue, the participants stated that it may be useful to integrate prompts with televisions.

> G1: *Got to come out [visual prompt] on their station [the TV channel that the older person with dementia watching] and have you eaten your tea tonight.*

> G1: *Something connected to the TV because they sit and watch TV.*

Participants explained the usefulness of extending currently used wearable technologies such as the caller alerts to prompt older people because they are simple and easy to use.

> G3: *Call alerts, simple call alerts that really still exist where that could be extended in its technology, to say, every three times or certain synchronised times ... It will come with a speaker and say, 'hi [client name] time to have a glass of water'.*

> G3: *If you could extend a care alert, bracelet ... to remind by having a message on it.*

7.1.3.8 Node: *Instructions about the types of food and fluids to consume*

Participants stated that they wish to have technologies to automatically prompt their clients about the types of food and fluids they should and shouldn't consume based on the automatic stool and urine diagnosis outcomes.

> G2: *'Too much alcohol for you love', you know, all those little prompting things [based on automatic stool and urine diagnosis outcomes].*

> G2: *Even diagnosis on the stools, 'okay, you better cut off on the lollies'.*

7.1.3.9 Node: *Instructions to continue food and fluid consumption*

Participants stated that it may be useful to have automatic prompting to remind their clients to continue food and fluid consumption, especially when they get distracted.

> G2: *Some sort of prompt would I guess be effective in drawing them back sitting down and whatever it is to get them to eat.*

7.1.4 Concept: *Cleaning support*

Cleaning support describes participants' wishes in providing technological support to their clients to store left over food and clean dishes. The two nodes related to *Cleaning support* include: i) *Storing leftovers automatically*; and ii) *Doing the dishes automatically*, and are described below.

7.1.4.1 Node: *Storing leftovers automatically*

Participants wished for technological support to be offered to their clients to store left over food in the correct places.

> G3: *Storing of the food afterwards, if they got left over food.*

7.1.4.2 Node: *Doing the dishes automatically*

Participants expressed their wishes in having the dishes cleaned automatically after meals to assist their clients.

> G4: *Handling the washing because they [clients] just can't.*

> G3: *Something to also clean their [clients'] dishes.*

7.1.5 Concept: *Toileting support*

Toileting support describes participants' wishes in offering technological support to their clients in using toilets. The node related to this concept is described below.

7.1.5.1 Node *Instructions to go to the toilet*

Participants described their wishes in having technological support to remind their clients to go to the toilet.

> G2: *It [a reminding device] will be going to prompt the clients with dementia to go to the toilet just before they go to bed.*

7.1.6 Concept: *A single platform focusing on nutrition*

A single platform focusing on nutrition describes participants' wishes to have a single technological platform that purely concentrates on all aspects related to nutritional health in older people with dementia and assist them when needed. The node related to this concept is described below.

7.1.6.1 Node: *Connecting all aspects related to nutrition together*

Participants highlighted the importance of interconnecting all the aspects related to their clients' nutrition through technology to provide them with assistance when needed.

> G3: *A service that concentrates purely on nutrition for clients with dementia.*

> G3: *That [system] would cater for folk living in their own homes with dementia. It purely concentrates on nutrition.*

Participants further explained the possibility of developing useful applications focusing on clients' nutrition, for example based on iPads, when all aspects related to nutrition are interconnected together.

> G1: *There is a lot of potential for it [an iPad application for older people with dementia that purely concentrates on nutrition].*

7.2 Category: *Care workers' wishes for technologies designed to support them*

The audit trail for the *Care workers' wishes for technologies designed to support them* is presented in Figure 7.2. This category comprises seven concepts: i) *Inventory monitoring support* (see Section 7.2.1); ii) *Meal preparation support* (see Section 7.2.2); iii) *Support to create the desire to eat* (see Section 7.2.3); iv) *Food and fluid consumption monitoring* (see Section 7.2.4); v) *Remote visual monitoring* (see Section 7.2.5); vi) *Cleaning support* (see Section 7.2.6); and vii) *Comprehensive nutrition evaluation* (see Section 7.2.7), formulated from seven nodes.

7.2.1 Concept: *Inventory monitoring support*

Inventory monitoring support describes care workers' wishes in having technologies to automatically monitor clients' food inventories at home. The node related to *Inventory monitoring support* is described below.

7.2.1.1 Node: *Monitoring the usage of food items in fridge automatically*

Participants described their wishes in getting to know when clients use food items in their fridges. However, the participants emphasised that monitoring only the open and close events of the fridge doors is not sufficient to make sure that older people are using the food items in the fridge. The participants suggested that automatically monitoring weight changes of individual items in fridges could be used to identify food usage reliably.

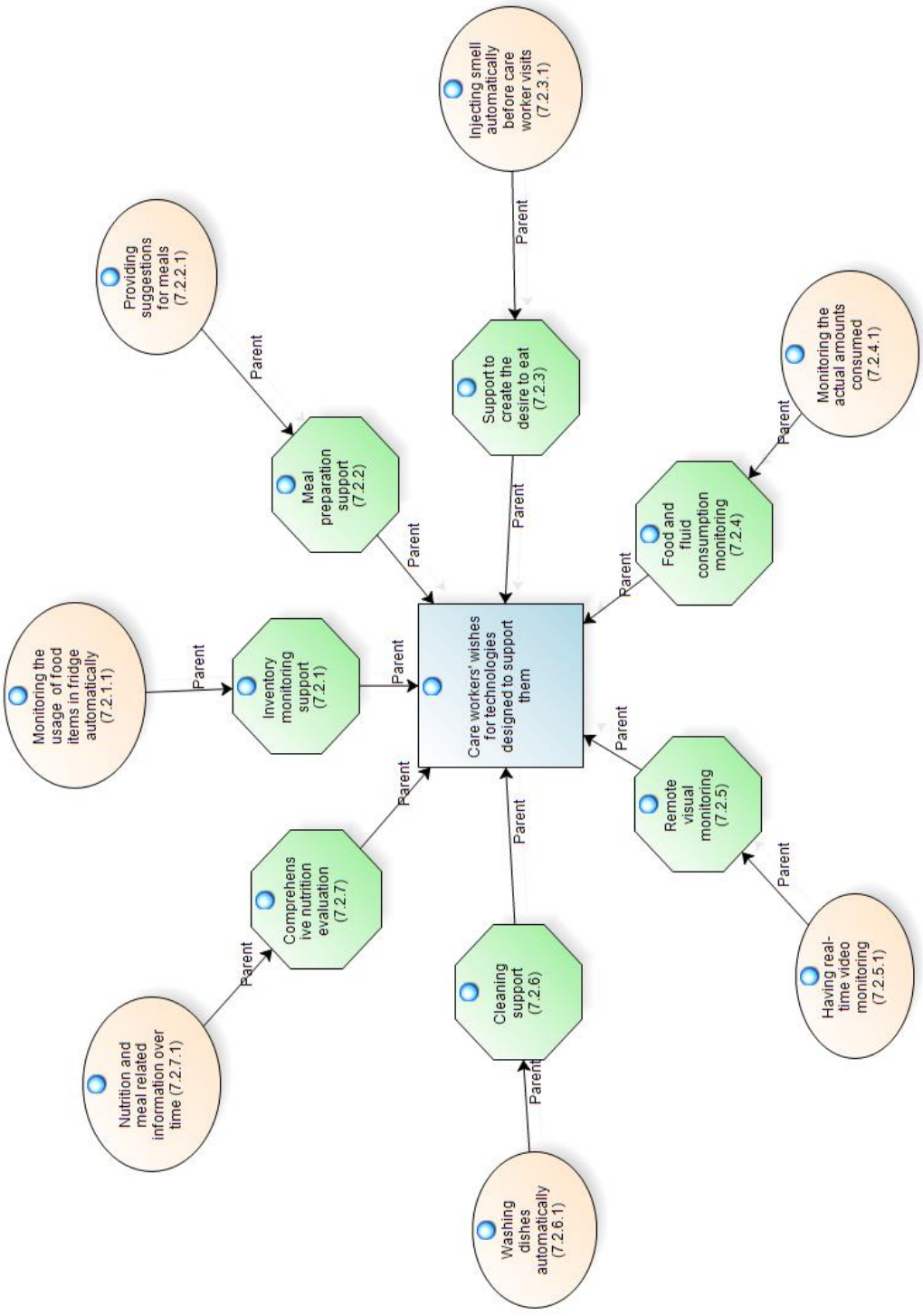


Fig. 7.2 Audit trail for the category: *Care workers' wishes for technologies designed to support them*

> G2: *Though alarms in the fridge, not the door but under food, the weight of something [weight changes in the food items in the fridge to recognise food usage].*

> G2: *An alarm or something on the fridge, you know, you can know someone is up because that is their general routine. But I thought how many times do you go to the fridge and you open it and it that does not mean that I'm eating it, eating something from it. It is just open, once again, okay, the alarms have gone off. yes, I'm awake and I'm up, but that does not necessarily mean that I'm taking something from the fridge.*

7.2.2 Concept: *Meal preparation support*

Meal preparation support describes participants' wishes for employing technologies to assist them when preparing meals for their clients. The node related to *Meal preparation support* is described below.

7.2.2.1 Node: *Providing suggestions for meals*

Participants described ways in which they think technologies can be used to assist them when preparing meals for their clients. The idea of a technology enabled cookbook for care workers was discussed. Cookbooks could be useful by care workers to learn the recipes and different meal preparation techniques based on their clients' wishes. Participants also stated that technology may be used to provide them with suggestions regarding the types of meals that could be prepared considering their clients' preferences. Such suggestions may be useful in ensuring the variety in the types of meals prepared by care workers for their clients.

> G2: *To give them ideas what to do [having recipes of the things that care workers can cook for the older people with dementia].*

> G2: *They have had sandwiches four days on the row. Maybe there is something else that could 'say today is the day for scrambled eggs'.*

> G2: *Something more structured [to provide suggestions to care workers about different types of meals that can be prepared considering what clients have consumed in the past].*

7.2.3 Concept: *Support to create the desire to eat*

Support to create the desire to eat describes care workers' wishes in employing technologies to create a desire in their clients to eat when care workers arrive at home during the planned mealtimes. Increasing the older people's desire to eat can reduce the efforts taken by care workers to persuade them to consume food. The node related to *Support to create the desire to eat* is described below.

7.2.3.1 Node: *Injecting smell automatically before care worker visits*

Participants stated that automatically injecting food smells just before care worker visits can be used as a technique to create a desire to eat in their clients. Participants expect that this way their clients may get an appetite to consume meals prepared by them without much hesitation, as a result, the efforts to persuade clients to eat can be reduced.

> G2: *Smell injected half an hour before you get there and therefore when you get there they should be hungry.*

> G2: *Just something that their favourite food smells are coming out [just before the care worker comes in].*

7.2.4 Concept: *Food and fluid consumption monitoring*

Food and fluid consumption monitoring describes participants' wishes in employing technologies to automatically monitor food and fluid consumption of their clients. The node related to *Food and fluid consumption monitoring* is described below.

7.2.4.1 Node: *Monitoring the actual amount of food and fluids consumed*

Participants described their wishes for having technologies to automatically monitor the amount of food and fluid consumed by their clients. As the disappearance of food or reduction in water level cannot guarantee the consumption of food and fluids, the importance of having innovative methods to monitor whether the food and fluid are really consumed by the clients was discussed. For example, participants described that automatically monitoring the food quantity on a dining plate may not guarantee the actual amount of food consumption.

> G2: *But they can take off [food] from that [dining plate] and put it in to the serviette.*

G2: *Put [food on the dining plate] in the bin or given to the cat.*

Participants further expressed their wishes for technologies to be capable of not only monitoring the amount of food consumption but also the rate of food consumption. Monitoring the duration of consumption can provide information about the freshness of the food consumed by older people with dementia.

G2: *I guess something that monitors how long, you know, if we can monitor, getting something to monitor how long they are taking to eat it. In other words, they are not sort of leaving the food that should be in the fridge an hour and coming back to it when it could have been spoiled.*

7.2.5 Concept: *Remote visual monitoring*

Remote visual monitoring describes care workers' wishes for monitoring the mealtime activities of their clients remotely using cameras. The node related to *Remote visual monitoring* is described below.

7.2.5.1 Node: *Having real-time video monitoring*

Participants expressed their wishes for using video cameras to remotely monitor nutrition and mealtimes activities of their clients in real time. The possibility of alerting the care workers based on the video data was also highlighted.

G4: *Cameras in the house, monitoring them 24/7.*

The participants further explained different types of cameras that can be employed to monitor older people with dementia in home settings. A participant explained that she has experienced a situation where children and grandchildren, at times, set up Skype systems with automatic answering to keep in touch with their loved ones. Hence, there is a possibility to extend such systems to specifically monitor nutrition and meal-related activities of older people with dementia. Furthermore, another participant stated that she has experience in using video monitoring to check whether older people, who live in their own homes, take insulin in a proper way. The described visual diabetes device was only employed during the medication period so that the care workers could see how their clients injected themselves with insulin. With the success experienced with this device, the participant believed that the same concept could be extended to monitoring the meal consumption of older people with dementia living in their own homes.

> G2: *That sort of thing [a device where care workers can call in at the medication time. When the older person answers the call, the care workers can remotely monitor how the older person is performing a task] can be adapted to people with eating.*

The participants also described the usefulness of wearable devices with inbuilt cameras for monitoring activities, especially activities related to nutrition and mealtimes of their clients. The participants further explained that wearable cameras may help to preserve the privacy of the older person with dementia.

> G2: *Like we have the caller alerts, we could have a thing where they have a little camera on there so that you can see exactly what that client is doing.*

> G2: *What about an earring [with a camera on it], which then you can see that top part.*

7.2.6 Concept: *Cleaning support*

Cleaning support describes care workers' wishes in having technological support to clean clients' dishes automatically. The node related to *Cleaning support* is described below.

7.2.6.1 Node: *Washing dishes automatically*

Participants described their wishes in employing technology to clean the dishes automatically after meals so that care workers can utilise their limited time socialising with the older people with dementia or providing other care services.

> G2: *If somebody did all the dishes and stuff so that we can spend more time with the client.*

7.2.7 Concept: *Comprehensive nutrition evaluation*

Comprehensive nutrition evaluation describes participants' wishes in having technological applications that focus on the comprehensive evaluation of all nutrition-related aspects of each client.

7.2.7.1 Node: *Nutrition and meal related information over time*

Participants described their wishes for having a comprehensive nutrition monitoring system where all nutrition related details and health parameters of each client can be stored and updated continuously. The usefulness of such a system to track progress over time with respect to the nutritional health of people with dementia was highlighted. A participant also mentioned that their organisation has been thinking about such applications implemented on iPads and stated that she strongly believes that such applications will be useful for the care workers.

> G2: *I think we have been thinking about an iPad or to put all the information on a client like do the weight chart on everyone, have all the health input in there. So three months down the track we have got everything in front of our computer to see where they are at.*

7.3 Category: *Care workers' technological concerns*

The audit trail for the *Care workers' technological concerns* category is presented in Figure 7.3. This category comprises two concepts: i) *Concerns related to care workers* (see Section 7.3.1); and ii) *Concerns related to older people with dementia as perceived by care workers* (see Section 7.3.2), formulated from 13 nodes.

7.3.1 Concept: *Concerns related to care workers*

Concerns related to care workers describes the types of concerns that care workers have when employing technologies to assist them to provide a better service for their clients. The three nodes related to *Concerns related to care workers* include: i) *Having a fear of losing their jobs*; ii) *Having to spend time to enter data into technological applications*; and iii) *Not having adequate technological education*, and are described below.

7.3.1.1 Node: *Having a fear of losing their jobs*

Participants were worried that the introduction of technology may threaten their employment. In particular, the participants were worried that technology may replace them in future.

> G2: *We won't have jobs [with the introduction of technology].*

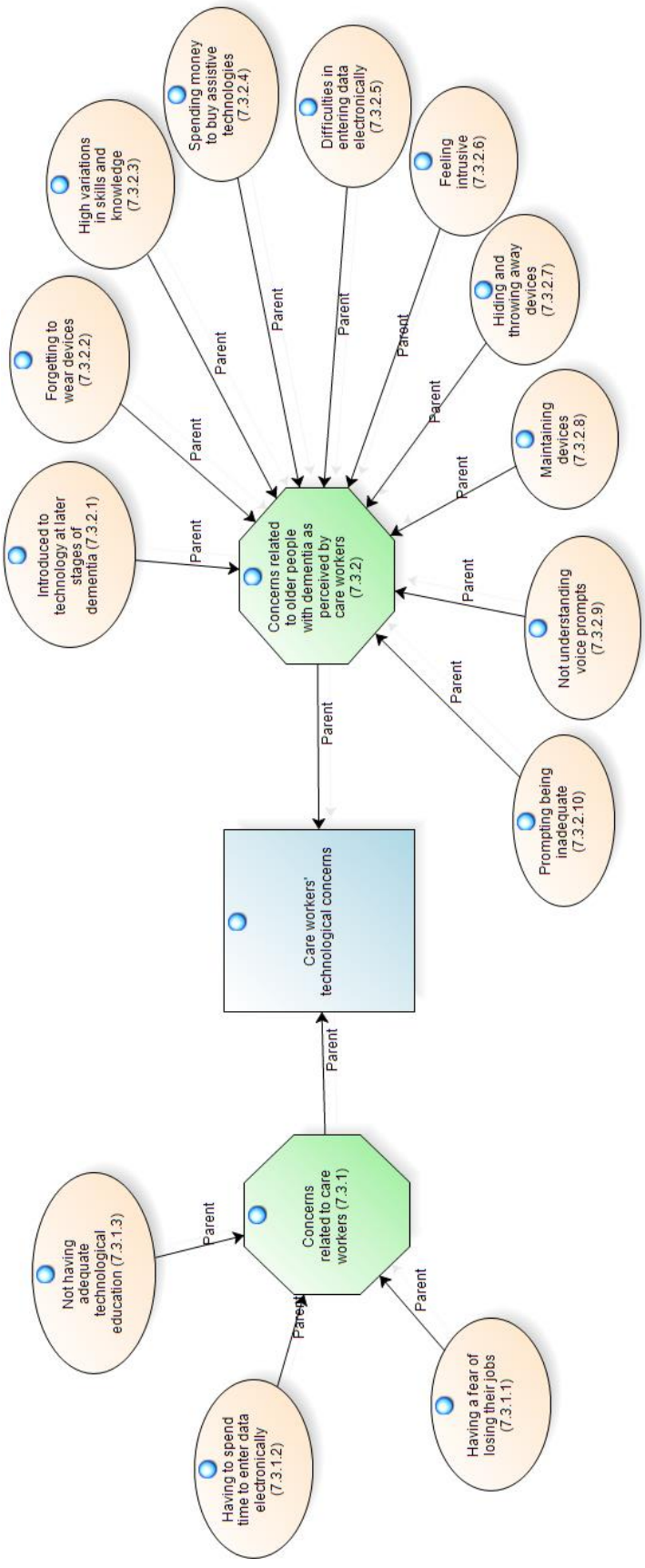


Fig. 7.3 Audit trail for the category: *Care workers' technological concerns*

7.3.1.2 Node: *Having to spend time to enter data electronically*

Care workers are already pressurised for time. Therefore, participants stated that it is not possible for them to spend time entering data into technological applications. This issue was highlighted when the need for having a comprehensive technological solution for care workers to monitor all aspects related to the nutrition of older people with dementia was discussed.

> G4: *It is time consuming [manually entering data].*

7.3.1.3 Node: *Not having adequate technological education*

Participants stated that they are often unaware of the ways in which technologies can assist them as well as their clients. A participant explained that a recent training session she attended helped her to understand some of the capabilities of technology. However, the need for having more training sessions to educate the care workers about the advances in technologies was highlighted.

> G4: *This is my challenge that I do not know what's [technologies] available out there, what sort of alert is going to work and I think there is a lot of research out there that I would like to get introduced to.*

> G4: *Technology already is out there. We don't know. Maybe we need someone to tell us.*

7.3.2 Concept: *Concerns related to older people with dementia as perceived by care workers*

Concerns related to older people with dementia as perceived by care workers describes care workers' concerns that their clients may have when employing assistive technologies to improve their nutritional health. The 10 nodes related to *Concerns for older people as perceived by care workers* include: i) *Introduced to technology at later stages of dementia*; ii) *Forgetting to wear devices*; iii) *High variations in skills and knowledge*; iv) *Spending on money to buy*; v) *Difficulties in entering data electronically*; vi) *Feeling intrusive*; vii) *Hiding and throwing away devices*; viii) *Maintaining devices*; ix) *Not understanding voice prompts*; and x) *Prompting being inadequate*, and are described below.

7.3.2.1 Node: *Introduced to technology at later stages of dementia*

Participants stated that their clients may not be willing to use assistive technologies and may feel threatened by those technologies. The participants explained that older people with advanced dementia always look for routines and consistency. Therefore, they believed that embedding technology into clients' daily routines as early as possible, possibly at the early stages of dementia, may provide a better opportunity for the clients to use those technologies, especially as dementia progresses.

> G1: *If they put that [technological] intervention in the early stages, it becomes part of their routine.*

> G4: *If we are using technology then you have to get them at the early diagnosis because if you had something that had anything to do with voice or noise, that's going to add to any delusional aspects of dementia that they have got.*

7.3.2.2 Node: *Forgetting to wear devices*

Participants highlighted that there can be disadvantages of using wearable devices for prompting older people with dementia as they could forget to wear those devices and also have difficulties in locating the devices.

> G1: *But that if they remember to use them or wear them or know where they are [wearable caller alerts].*

> G3: *Hurdles are there for [wearable] caller alerts. Some wear them reluctantly. Some choose to hang them on the walker.*

In contrast, the participants also believed that extending wearable caller alerts to provide automatic prompting may provide increased opportunities to obtain user acceptance as older people with dementia are already familiar with caller alerts.

> G3: *We are closer to their acceptance in that [wearable devices], if we are to extend that service in a different way perhaps or beyond reminders.*

7.3.2.3 Node: *High variations in skills and knowledge*

Participants explained that their clients have a high variation in technological skills and knowledge which can affect the way they perceive technologies. They further explained that some older people with dementia do not even know how to operate their microwaves, while others capable of playing games on their iPads.

G3: *So there is big variation in skills and knowledge.*

G3: *Because I have got a number of cases who play games on their i-Pads.*

G4: *Because they cannot even learn to use a microwave, so how can they use some things like these [technologies].*

However, participants stated that they believe that the technology gap amongst the older people with dementia is now getting less.

G3: *So it is getting less [the technology gap].*

7.3.2.4 Node: *Spending money to buy assistive technologies*

The participants stated that older people with dementia may not be willing to spend money on expensive technologies as most of them are living on their pensions. Therefore, the participants raised concerns as to who should pay for the assistive technologies.

G3: *It is all going to be free because they hate spending their money.*

7.3.2.5 Node: *Difficulties in entering data electronically*

Participants explained their experiences of the difficulties faced by their clients when providing manual input to technologies (such as pressing a button). Older people with dementia often forget or do not understand how to operate devices when manual input is required.

G2: *Some of them have buttons. They do not know what they are for.*

G4: *They don't remember how to press the buttons [in wearable caller alerts is an issue].*

7.3.2.6 Node: *Feeling intrusive*

Participants were concerned that older people with dementia may find assistive technologies intrusive and may feel that they are being tracked. Furthermore, the participants emphasised the privacy concerns with respect to cameras, especially when images of older peoples' whole body can be acquired by them. In fact, participants related the continuous monitoring of people behaviours in homes to the 'Big Brother' TV show.

G4: *Bit like Big brother [having cameras monitoring the home 24/7].*

G4: *They do not want to be tracked.*

The participants explained about a robotic head trialled in one of their cottages. The robotic head was designed to prompt older people with dementia to do certain tasks. However, the participants stated that this device was strange looking hence their clients were confronted by the technology.

G3: *It was an intrusion. Even the home support workers that worked there [thought] this looks a bit [strange]. It wasn't nice looking and it actually didn't work. We ended up turning it off because people with dementia were getting a little bit agitated.*

The participants further explained that some of their clients feel disturbed even when care workers open the laptop in front of them.

G3: *Even the client with no dementia, 70-year-old, when we take the computer out they feel very intrusive.*

7.3.2.7 Node: *Hiding and throwing away devices*

Although participants discussed the possibility of using iPad applications to assist their clients, concerns were raised about the possibility of clients hiding or throwing away such devices. For example, the participants explained that there is a possibility that clients would throw the devices into bins or toilets. Therefore, the need to have technological devices fixed to the home environment where older people with dementia cannot damage or hide them was highlighted.

G1: *The problem with those sort of things is that they got to be either one device in their home permanently fixed to something in their house where they cannot hide it or put it away or put it in the toilet or throw it in the bin.*

G1: *That's the other thing; they hide it.*

7.3.2.8 Node: *Maintaining devices*

The participants raised their concerns over the need to have somebody to maintain technological devices. The participants further stated that technologies can be placed in homes only if the family can take care of the maintenance of those technologies.

G1: *Someone has to look after it [technologies].*

7.3.2.9 Node: *Not understanding voice prompts*

Participants stated that certain clients have difficulties in comprehending what is being said. This is more prominent in older people who have severe dementia. Therefore, the participants were concerned that clients may not understand voice prompts generated by technological devices. As a result, the potential for combining visual prompts with voice prompts was highlighted.

> G1: *I think that [voice prompts] is fantastic. I really do and that's for the ones with dementia at a low level or whatever level they are of dementia. But when dementia gets severe they are still able to live at home if they have got the support but they are not able to understand what we are saying or what somebody is saying to them ... They hear it completely differently.*

> G1: *I think again it depends on the level of dementia because people with dementia-hearing that [prompts reminding to eat], they are not going to hear that. They might hear a noise but they are not going to understand.*

7.3.2.10 Node: *Prompting being inadequate*

Participants highlighted the importance and usefulness of automatic prompting to remind older people to do certain tasks. However, participants emphasised that it cannot be guaranteed that older people will perform the tasks requested by the prompts. Therefore, the need to follow up prompts to ensure that the requested tasks are completed was highlighted.

> G2: *We cannot say that just because some thing, for example like a robot or clock, is going to alert them that they are going to take notice of that. Because that is not what happens with dementia.*

7.4 Summary

Care workers' wishes and concerns related to technologies to assist their clients in maintaining good nutrition and for them to provide improved care services are described in this chapter. Exploring care workers' wishes regarding technologies may be useful to determine entry points to designing technological applications to address the challenges related to older people with dementia and care workers identified through this thesis. As the main focus of the study was to identify technological needs, care workers were mainly requested to describe their wishes regarding technologies

geared towards promoting nutritional health in older people with dementia living in their homes during the focus groups. However, participants also described several concerns regarding translating assistive technologies into practice, which were also described in this chapter. Overall, the findings reported in this chapter provide useful insights for identifying potential technology development avenues and for formulating technology design considerations in this space.

Participants wished for technological assistance to be offered to their clients in various nutrition and mealtime activities such as meal preparation, shopping, food and fluid consumption. The need for a single technological platform that purely concentrates on providing assistance to older people with dementia to maintain their nutritional health was highlighted. The importance of utilising technology to stimulate different types of senses was described. For example, care workers believed that it may be useful for technologies to be used for creating a desire in their clients to consume meals. This included automatically injecting food smell and showing images of food items. Furthermore, as care workers have experienced that providing rewards is a useful way to encourage older people with dementia to consume food, the possibility of providing automatic rewards (such as automatically turning on the music) were discussed. The importance of such rewards being as personalised as possible was emphasised. Care workers believed that technology may also be useful in enabling social interactions during mealtimes. The possibility of using existing tools which are commonly used by older people with dementia for developing nutrition health-related applications was pointed out.

Participants expressed their wishes in having technological assistance when providing nutritional health support to their clients. Here, the usefulness of having a technological system that facilitates the comprehensive monitoring of all aspects related to the nutritional health of older people with dementia over a period of time was emphasised. The participants explained that older people with dementia often forget to eat and drink even if prompted and hence were especially interested in having technologies to automatically monitor the food and fluid consumption of their clients. They further explained that automatic monitoring of the dining plate and the fluid level reduction may not provide an accurate estimate of their clients' food and fluid consumption. Furthermore, the participants wished technologies to be designed to assist them to be more effective during care worker visits in order to save time. Saving time meant that they could spend more quality time socialising with their clients and work closely on their nutritional health issues. Some possible technological interventions that aimed at maximising the effective use of caregiving time were highlighted. This included automatic injection of food smell before care worker visits to reduce the efforts needed to be taken to persuade clients to eat and automatic cleaning of

dishes. Furthermore, the possibilities for having technologies to automatically monitor inventory usage was discussed. However, the participants emphasised that simply monitoring the open and close events of the fridges is not sufficient to identify whether older people are using the food items in fridges. Automatic suggestions for meal plans based on the clients' food preferences was highlighted as a way for care workers to ensure variety in meals prepared for their clients.

The technology concerns described by the participants were twofold: i) concerns related to technologies designed to assist care workers; and ii) concerns related to technologies designed to assist older people with dementia. Without a suitable level of technology education care workers currently struggle to understand the capabilities of assistive technologies. Furthermore, they fear losing their jobs with the introduction of technology. The need for minimising the efforts needed to enter data into technology systems was identified with respect to both care workers and older people with dementia. Care workers' concerns over older people hiding devices, not understanding voice prompts and the high variation in technological skills were also identified. In addition, it was also highlighted that older people with dementia may easily feel insecure if they feel that they are in a new environment. Therefore, the significance of making simple and maintenance free devices was expressed. Moreover, older people with dementia need to be introduced to technology solutions as early as possible so that technology can become a part of their daily routines.

The next chapter will provide a detailed discussion on the findings of the qualitative descriptive study.

Chapter 8

Discussion on the findings of the technological needs investigation

Designing and developing effective technologies that offer innovative solutions to promoting good nutrition and independent living among older people with dementia demands deeper and more reliable insights to their nutrition and mealtime situations. To this end, this thesis reported a study rooted in the qualitative descriptive research design with the aim of obtaining an holistic perspective of needs for technologies geared towards promoting the nutritional health of older people with dementia living in their own home, utilising care workers employed by four leading aged care organisations in South Australia (n = 27) as the information source. As explained in Chapter 3, it was expected that care workers' voices will allow the researcher to identify: i) challenges faced by older people with dementia living in their own home that may prevent them from maintaining good nutrition; ii) challenges faced by care workers when assisting their clients to maintain good nutrition; and iii) considerations for developing technologies that may be effective for assisting older people with dementia to maintain their nutritional health and for facilitating care workers to provide improved care support to their clients.

Focus groups were employed as the data collection method. It was expected that care workers' expertise and experiences in supporting many older people with dementia living in their home, on a daily basis, will provide deeper and more reliable insights useful to identify the technological needs of both older people with dementia and care workers together. As explained in Chapter 3, during the focus groups, the care workers were mainly requested to describe their perspectives on challenges faced by their clients related to nutrition and mealtime activities and the challenges faced by them when providing nutritional health support to their clients. A broad understanding of these challenges is essential, as they can demonstrate the needs and opportunities

for technology development which collectively assist older people with dementia to maintain their nutritional health and facilitate care workers to provide improved care support to their clients. Overall, it is expected that the data collected from care workers will allow the researcher to formulate considerations for designing and developing effective technologies in this domain. The formulated design considerations suggest important aspects that need to be taken into account by technology designers and developers when designing and developing technologies to address the identified challenges.

Qualitative content analysis of the data collected from the four groups reveals eight categories: i) *Care worker support*; ii) *Family Support*; iii) *Older people's nutritional health challenges as perceived by care workers*; iv) *Care workers' challenges in supporting their clients' nutritional health*; v) *Care workers' information needs related to clients' nutritional health*; vi) *Care workers' wishes for technologies designed to support their clients*; vii) *Care workers' wishes for technologies designed to support them*; and viii) *Care workers' technological concerns*.

Although technology should not be seen as the sole solution for promoting good nutrition in the target group, the study findings show that there are opportunities and benefits in designing supportive technologies not only for assisting older people to maintain good nutrition but also for their care workers to provide improved care to their clients. In particular, through the study, a wide array of nutrition and mealtime-related challenges affecting older people with dementia and their care workers are identified; addressing these needs would help to uplift the nutritional status of the target population.

Based on data collected from focus groups, eleven design considerations, which are described in this chapter, to guide the overall design of technologies geared towards assisting older people with dementia to maintain good nutrition and care workers to provide better support for their clients are formulated. In particular, this includes six design considerations for technologies assisting older people with dementia and five design considerations for technologies assisting care workers. The proposed design considerations for technologies assisting older people with dementia are: i) *Intelligent ways to personalise support*; ii) *Innovative methods to influence human behaviours*; iii) *Intelligent and inter-connected appliances and objects*; iv) *Aggregating isolated subtasks to provide end-to-end assistance*; v) *Primitive human motion monitoring to facilitate effective assistance*; and vi) *Introducing technology without creating additional burdens*. The proposed design considerations for technologies assisting care workers are: i) *Avoiding additional stress after introducing technology*; ii) *Better understanding of the clients*; iii) *Inter care worker communication and information sharing*; iv) *Two-way communication among care workers and families*; and v) *Deci-*

sion support backed by real-time and periodic monitoring. In addition to the proposed design considerations, the chapter reports several potential technology development avenues by considering the findings of this study and existing technology development research.

This chapter is organised mainly as a discussion of findings in relation to the objectives of the study. In Section 8.1, a discussion of the nutritional health challenges of older people with dementia living in their own home is presented in relation to the existing knowledge in the field around the concepts that were identified through this study. Section 8.2 provides a discussion of the challenges faced by care workers when providing nutrition and mealtime care support to their clients in relation to the existing knowledge in the field. Section 8.3.1 presents design considerations for technologies assisting older people with dementia to maintain good nutrition and Section 8.3.2 presents design considerations for technologies assisting care workers to provide a better nutrition and mealtime support to their clients. Additionally, in Section 8.4 several potential avenues for technology development are presented. Section 8.5 presents the strengths and weaknesses of the study and the chapter ends with a conclusion in Section 8.6.

8.1 Older people with dementia's nutritional health challenges

To obtain an holistic view of technologies that assist older people with dementia to maintain good nutrition, as an initial step, obtaining a broad understanding of the nutritional health challenges faced by them is essential. This study reveals a large body of new findings related to nutrition and mealtime challenges faced by older people with dementia living in their own home (see Chapter 5), while supporting or further elaborating upon insights gained explicitly or implicitly from available relevant technology and non-technology literature (see Figure 8.1).

As explained in Chapter 2, most previous non-technology based research studies have focused on specific aspects related to nutrition and mealtimes by relying mainly on information obtained from families living with and/or managing older people with dementia's mealtime-related activities [27, 46, 39, 50]. Support from care workers is often arranged for older people with dementia living in their home, especially in situations where there is limited or no family support. Therefore, it is interesting to compare the findings of this study against the information obtained from families to understand how the findings add to existing knowledge about nutrition and mealtime challenges of older people with dementia living in the community. Furthermore, it is

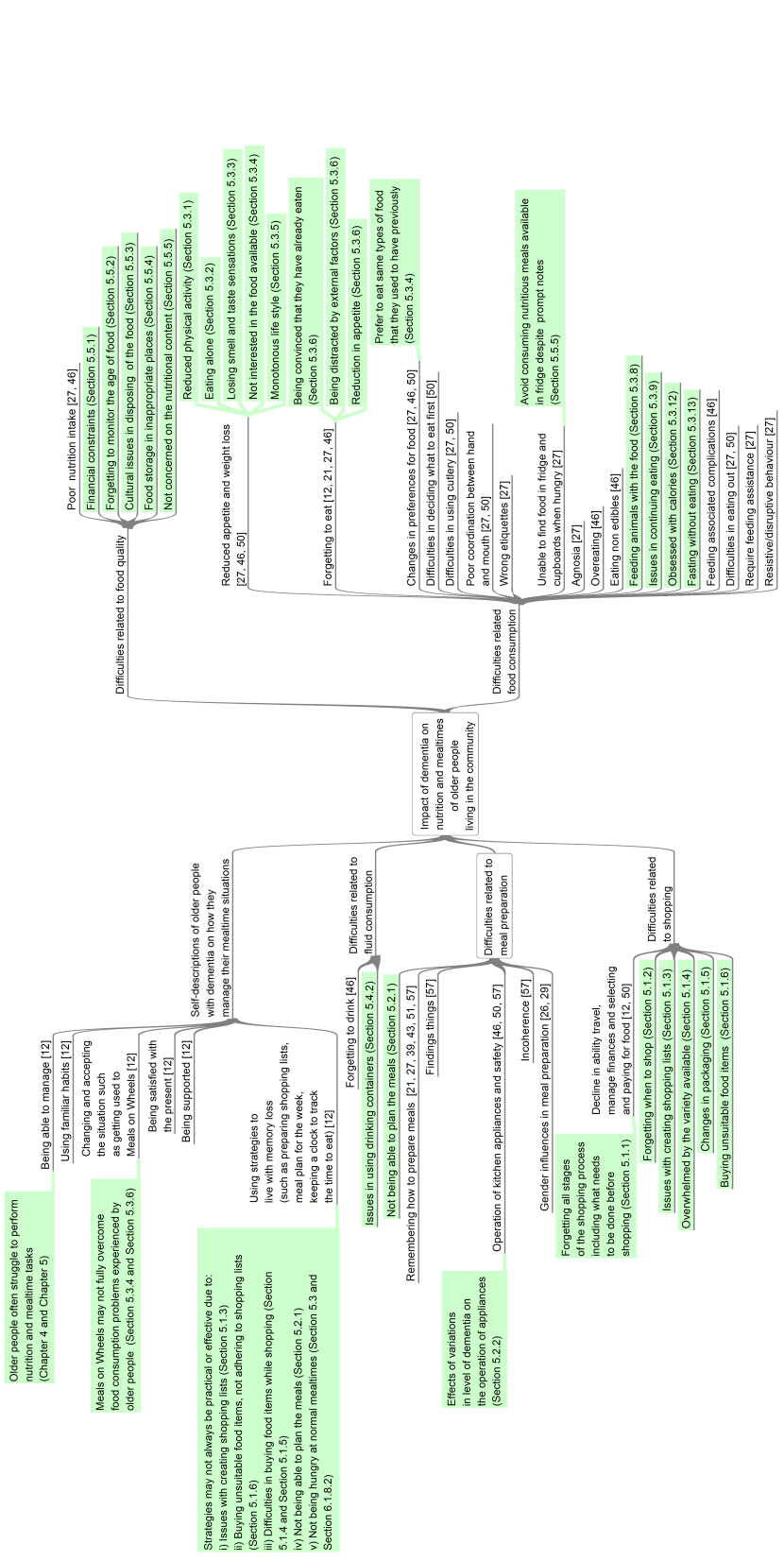


Fig. 8.1 Impact of dementia on the nutrition and mealtimes of older people living in the community. The shaded node indicate new knowledge or extensions to current knowledge.

interesting to discuss the findings of this study in the context of nutrition and mealtime challenges that are implicitly stated in research focused on care workers' perceptions [44, 21] and older people's self-descriptions [12] related to different aspects of nutrition and mealtimes of the target group. A discussion of the new insights gained from this study, around the concepts identified, in relation to existing knowledge in the field is given below.

8.1.1 Shopping

Shopping is one area where older people with dementia struggle [12, 50]. In fact, previous research has identified shopping as the first process to deteriorate among mealtime activities [50]. The findings of this study add to the existing knowledge and provide detailed insights into challenges related to the overall process of shopping.

Older people sometimes have difficulties in determining what needs to be done before and during shopping. They may also have difficulties in remembering when they need to shop. A study based on self-descriptions of older people with dementia reported that shopping lists are prepared by older people with dementia before going shopping [12]. However, according to the findings of this study, there are several challenges older people may face in creating and following such shopping lists. For instance, older people with dementia may lose the ability to prepare their shopping lists because of not having an understanding of their food preferences and food inventory. As a result, shopping lists prepared by older people with dementia may be mostly filled with snacks.

On the other hand, the findings of this study reveal that having a shopping list does guarantee that older people will buy what they want when shopping. There are several reasons for this. It is important to note that the study was conducted in South Australia where local shops or corner shops used to be the norm for some in the older population. Therefore, some challenges related to shopping are partly because of older people's lack of familiarity with contemporary supermarkets. Furthermore, the decline in cognition in older people aggravates these issues. Firstly, they may be overwhelmed by the variety of food items available on the supermarket shelves. Secondly, they may be confused with packaging changes, hence finding it difficult to decide what to buy. Finally, at times, older people with dementia may not follow their shopping lists. They may keep on buying the same items that are available at home or refuse to buy items on the shopping lists as a result of being uncertain about the food inventory at home while shopping.

8.1.2 Meal preparation

The findings of this study reveal that meal preparation is a key challenge faced by older people with dementia living in their own home. This is consistent with the findings in previous research [21, 39, 44, 57]. Similar to the findings of the study conducted by Wherton and Monk [57], the findings of this study emphasised the difficulties older people have to remember the different steps involved in the cooking process. In addition, the findings of this study reveal knowledge which was not previously documented in this field.

Although previous research has reported that weekly menu planning is a strategy employed by older people with dementia to identify what meals to prepare [12], the findings of this study identify several issues in executing this strategy. Firstly, older people struggle to decide what meals to prepare due to a lack of awareness about their food preferences. Secondly, because of their limited cognition, they can be easily overwhelmed by the meal choices when planning their meals. The findings reveal that, at times, even choosing the meal the from the limited choices available at Meals on Wheels can be challenging for older people with dementia. As a result, the findings reveal that it is best to provide a maximum of two options when providing meal choices to them in order to avoid confusion.

Interestingly, the findings of this study reveal the impact of the changes in older peoples' cognitive level with time on their ability to operate kitchen appliances, that subsequently affect their meal preparation. In particular, older people who are usually able to operate complex appliances such as stoves, may not be able to operate even simple appliances at times, such as kettles, depending on their cognitive level at a given moment.

8.1.3 Food consumption

The findings of this study highlighted a number of food consumption issues affecting older people with dementia living in their own home, while supporting or further elaborating upon insights gained explicitly or implicitly from the related literature.

A number of previous research studies have highlighted that older people with dementia living in their home often forget to initiate food consumption, which is consistent with the findings of this study [27, 46, 21, 12]. In addition, the findings of this study provide deeper insights into reasons why older people with dementia may forget to have their meals. For example, older people with dementia may be convinced that they have already eaten. They can also get distracted by the external environment. Continuously watching television is identified to be a major cause for older people to get distracted from their meals. Additionally, older people may forget to eat because

they do not have any desire to consume their meals. The findings of this study reveal that older people with dementia easily ignore prompt notes used to remind them to eat, as a result of not having a desire to eat.

The care workers in this study revealed a number of factors that cause a decline in their clients' desire to consume food. This included a reduction in physical activity, having to eat alone, losing smell and taste sensations, and leading a monotonous lifestyle. Furthermore, older people with dementia may not feel like eating because the food is not prepared to their liking. Although previous research studies report older people with dementia being pleased with Meals on Wheels food [12], care workers in this study were not convinced that Meals on Wheels can fully overcome food consumption problems experienced by older people with dementia. In particular, older people may forget to eat the Meals on Wheels food. Furthermore, older people with dementia could throw away or hide food if it is not prepared according to their preferences. These issues exist even when care workers take over meal preparation.

The findings of the study reveal issues related to continuing food consumption. Care workers were concerned food was not fresh when older people returned to eating after being distracted or falling asleep. Furthermore, the findings reveal how older people with dementia may avoid eating as a result of calorie counting and being anxious about gaining weight. Care workers were also concerned that older people often feed animals with the food they have, especially when nobody is around during mealtimes. Feeding animals was, at times, seen as a social activity. The findings suggested that often older people with dementia value socialisation around mealtimes, which is consistent with previous studies [21]. On the other hand, the findings of this study also reveal that certain older people may value privacy during mealtimes due to physical disabilities such as shaking. Furthermore, when eating alone, there is a lower risk of coughing and choking, due to reduced talking.

Previous research has reported that older people have difficulties in locating food in fridges [27]. In addition, the findings of this study emphasise the possibility of older people with dementia purposely avoiding consuming nutritious meals despite the food being kept in easily accessible locations in fridges. They choose to have non-nutritious meals, compared with nutritious meals which may cause issues in nutrition.

In addition to the nutritional health challenges identified in this study, previous research highlights that older people with dementia develop new food preferences, such as the need to eat soft, consistent texture foods without any lumps and may require feeding assistance [27, 46, 50]. Care workers in this study revealed that their clients are mostly capable of having meals on their own. Furthermore, the care workers highlighted the older people usually desire to eat the same types of food, prepared in a similar way to that with which they are familiar. One possible reason for these

differences may be because previous research mostly relied on families who are living with or managing older peoples' mealtime tasks. Formal care support is often provided when there is limited or no family support; hence it can be expected that the older people described in this study are less frail and more independent than some other older people who live with the support of their families.

8.1.4 Fluid consumption

Although previous studies have mainly focused on food consumption, findings of this study emphasised that fluid consumption is a major challenge faced by older people with dementia living in their own home. Care workers explained that inadequate hydration significantly affects clients' capabilities. Apart from forgetting or avoiding fluid intake, older people with dementia, at times, struggle to understand how to drink using drinking containers, even when they want to consume fluids.

8.1.5 Food quality

Although a lack of nutrition in food consumed by older people with dementia has previously been highlighted as a major concern [27, 46], there is no detailed account of food quality issues faced by older people with dementia living in their own home.

Older people with dementia often lose nutritional knowledge completely or may not consider the nutritional content of their meals as a priority. As a result, even if reminded through prompt notes, they may select snacks, sweets or alcohol, over nutritious meals available at home. Furthermore, they may buy non-nutritious foods that are cheap or on sale as they struggle to afford purchasing nutritious food with their old-age pensions. Food quality is also compromised due to issues in keeping track of the age of the food. Furthermore, older people may not store food or leftovers in appropriate places, affecting freshness and cleanliness of the food. Furthermore, they are at times reluctant to throw away food, even if the food has expired or gone rotten.

8.2 Care workers' challenges in supporting their clients' nutritional health

In order to design and develop technologies to assist care workers to provide better support and manage their clients' nutritional health, having a broad understanding of the challenges faced by them is essential. A large body of new findings that provide an holistic view of the range of challenges faced by care workers when assisting older people with dementia living in their own home to maintain nutritional health were

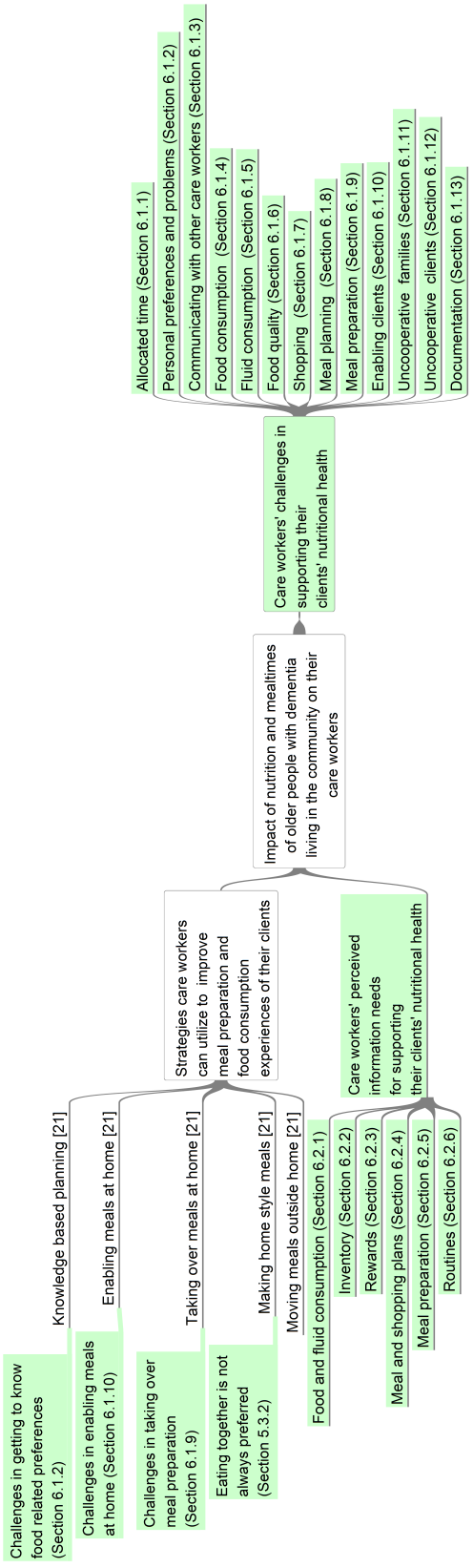


Fig. 8.2 Impact of the nutrition and mealtimes of older people with dementia living in the community on their care workers. The shaded nodes indicate new knowledge or extensions to current knowledge.

discovered through this study (see Section 6.1). As explained in Chapter 2, previous research has not looked at these challenges. The closest research reported to the current study focused on obtaining views of staff who are working in dementia care on strategies to improve meal preparation and food consumption of their clients with dementia living at home [21]. A discussion of the new insights gained from this study (see Figure 8.2), around the concepts identified, in relation to existing knowledge in the field, is given below.

8.2.1 Allocated time

Care workers face a number of diverse and complex challenges when trying to ensure the nutritional health of their clients. One of the biggest challenges care workers face is the inadequate amount of allocated time, due to funding constraints, to focus on clients' nutritional health. Having only a limited time, care workers struggle to effectively monitor and assist all aspects related to the nutritional health of their clients.

8.2.2 Personal preferences and problems

Similar to the findings of this study, the need for person-centred care with respect to older people with dementia has been emphasised in previous research [21, 170, 171]. Comprehensive assessment of the food-related preferences and needs is required for care workers to provide person-centred care with respect to nutrition and mealtimes. However, obtaining detailed information about older people's food-related preferences and needs is often challenging and time-consuming for the care workers. In the cases where there is no family support, obtaining this information becomes even more challenging. This is mainly because of the difficulties older people with dementia face in self-reporting and the inability of care workers to continuously monitor clients' behaviours to understand their preferences and problems. Therefore, based on the findings of this study, it is clear that providing personalised care with respect to nutrition and meals is not a straightforward task for the care workers.

8.2.3 Communicating with other care workers

Lack of communication between care workers who provide care services to a client is a major challenge faced by care workers. Although manually maintained communication books are employed by care workers to communicate with each other, the findings of this study reveal that such books are not effective. This is because care workers do not have time to document or go through detailed notes written by others. The lack of communication creates additional pressure, especially on new care workers, as it

becomes difficult for them to obtain information about their clients, potentially leading to challenges in providing support during shopping and meal preparation.

8.2.4 Food consumption

Several challenges faced by care workers with respect to clients' food consumption are revealed through the study findings. The most significant challenge faced by care workers is accurately monitoring the types and amounts of food consumed by the clients without physically being at their home. This is because care workers fail to obtain reliable information based on the self-reporting of older people. Care workers currently monitor leftovers at home to identify the types and amount of food consumed by their clients (see Chapter 4). However, the information obtained from this method can be unreliable in the light of the possibility that older people with dementia may throw away, feed animals with or hide their food.

The findings of the study reveal challenges care workers face when encouraging their clients to eat nutritious meals over unhealthy food available at home, especially when left alone. Furthermore, when care workers arrive at mealtimes significant efforts have to be made by them to ensure their clients sit down for meals after preparing or heating up the meals. Even after clients sit down for their meals, it is challenging for the care workers to ensure they complete the meals without getting distracted or falling asleep.

In previous research studies, care workers have indicated the importance of the social dimension of food consumption [21]. In particular, care workers have described allowing the older person with dementia to interact with others as a strategy to improve their mealtime experiences. While most of the care workers in this study agreed with this idea, some home support workers had a different opinion. They argued that although care coordinators recommend they sit down with clients for meals to provide them a social environment during mealtimes, it may not be effective for all of their clients. Some clients do not like to have anyone around when they have their meals as a result of their physical disabilities, such as shaking. Furthermore, same home support workers pointed out that talking while eating can also increase the risk of choking.

8.2.5 Fluid consumption

Difficulties care workers face when trying to monitor the actual amount of fluids consumed by their clients are unearthed through the findings of this study. As older people with dementia's self-reporting of the fluid consumption is not reliable, care

workers have to continuously visit their clients for short periods to ensure that they are adequately hydrated, especially in extreme heat conditions. Although some care workers measure the reduction in water level in the jug to identify whether older people actually have liquids, the findings of this study reveal that this may not be a reliable estimate.

8.2.6 Food quality

Ensuring the nutritional status of food, especially when sourced externally, has been identified as important [21]. However, there is no detailed account of the challenges care workers face when ensuring the quality of food consumed by their clients in previous literature. The findings of this study reveal that monitoring the freshness of the food is a major challenge for the care workers. Significant amounts of time are spent by care workers going through each and every food item at home to evaluate its freshness. Furthermore, some older people with dementia may feel offended when care workers go through their personal spaces. On the other hand, even in situations where care workers identify food items that are not fresh, throwing away those food items may not be a straightforward task as clients may not agree with such an action. In such situations, older people with dementia may even re-collect food already thrown away after care workers leave.

8.2.7 Shopping

Care workers may either assist their clients to do their shopping or may take over shopping completely. A number of challenges faced by care workers when providing shopping-related assistance to their clients are revealed through the study findings. For example, deciding what to buy is a significant problem faced by care workers when shopping for their clients. Apart from being unfamiliar with the types of food clients prefer, most of the time care workers have difficulties in identifying the food brands that the clients use, especially in situations where clients throw away food containers before care workers' visits or do not allow care workers to look into their fridges. Furthermore, when providing assistance for the older people to do their shopping, care workers find it challenging and time-consuming to persuade clients not to buy food items that are unsuitable for them or are already available at home.

8.2.8 Meal plans

Findings of the study reveal that care workers usually do not have clear instructions on the types of meals that need to be prepared for their clients, which affects their

meal planning abilities. Although meal planning can be used as a strategy to save time and ensure variety in clients' meals, care workers described a number of issues they have in adhering to such meal plans. For example, due to the lack of communication, the care workers do not have a common understanding about the meals prepared for clients during the week. The types of meals prepared for older people with dementia living in their own homes are usually decided on the day by care workers who come in for meal preparation services. On the other hand, although meal plans are in place there may not be adequate ingredients to prepare those meals especially when the shopping is done by someone else. Moreover, older people with dementia may also not have any desire to eat during the pre-specified times and, as a result, care workers have to spend a lot of time persuading their clients to eat.

8.2.9 Meal preparation

Similar to previous research [21], the findings reveal the need for care workers to take over meal preparation in situations where their clients lose the ability to prepare their own meals (see Chapter 4). However, various challenges care workers face when preparing meals for their clients are identified through the findings of this study. One such issue was the limited availability of cooking appliances. As most cooking appliances are turned off in clients' homes due to safety issues, care workers find it challenging to prepare nutritious meals for their clients. Furthermore, not all care workers have an adequate knowledge about meal preparation and no support is currently provided to the care workers to uplift their cooking skills. On the other hand, older people with dementia may have their own ways of preparing meals, which can conflict with the cooking techniques that the care workers' usually employ. No support is currently provided for the care workers on learn client specific cooking techniques.

8.2.10 Enabling the clients

Enabling clients to carry out tasks on their own is something that the care workers in this study regarded as highly valuable (see Chapter 4). Similar ideas have been reported in the previous literature as a strategy to improve the mealtime experiences of older people with dementia living in their own home [21]. However, the findings of this study reveal many challenges care workers face in executing this strategy. Particularly, allowing older people with dementia to feel they are contributing and responsible in some way demands care workers to spend more time with the clients to ensure that they complete the given task. Furthermore, with the frequent fluctuations in the level of dementia, older people's capabilities can differ frequently. Thus, care workers struggle

to enable their clients because they do not have a proper understanding of their levels of dementia and capabilities at a given moment.

8.2.11 Uncooperative families

Issues related to lack of nutrition education in the family have been highlighted previously [46]. The findings reveal that families can try to deny that their loved ones have got dementia because they want them to be healthy. As a result, they may have unrealistic nutrition and mealtime-related expectations, hence care workers can struggle with cooperating with such families. Sometimes families provide non-nutritious food and drinks to their clients. Furthermore, when families do the shopping, they may not buy nutritious ingredients. In such situations, it is difficult for care workers to prepare well-balanced meals for their clients. In addition, the findings reveal that families, at times, consume food available for the older people with dementia. This makes it challenging for the care workers to monitor the food consumption of their clients and ensure the availability of food when their clients are left alone.

8.2.12 Uncooperative clients

Care workers struggle to assist clients who are too dependent on them. Furthermore, some clients can be quite aggressive and demanding. Care workers often require more time to satisfy those clients.

8.2.13 Documentation

The findings of the study reveal the efforts care workers have to put into complete the necessary documentation with respect to each client. Given that a significant part of the documentation involves manual processes, it is time consuming for the care workers to work on the documentation as they are required.

8.3 Technology design considerations

Through this study, a wide array of challenges faced by older people with dementia and their care workers were identified; addressing these challenges will help to uplift the nutritional health of older people with dementia living in their own home. To this end, a technological platform consisting of diverse and interoperable technologies which can collectivity address the identified challenges can be envisioned. Based on the broad understanding of the nutrition and mealtime situations of older people with

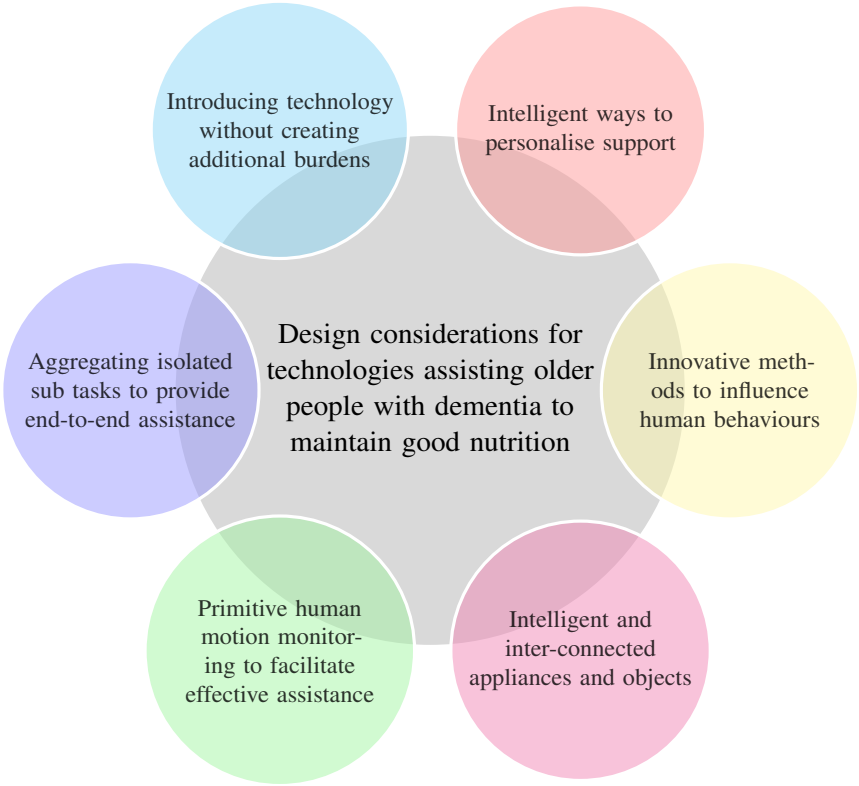


Fig. 8.3 Design considerations for technologies assisting older people with dementia to maintain good nutrition

dementia obtained through this study, design considerations for effective technology development in this space are formulated, considering older people with dementia and their care workers as technology users.

8.3.1 Design considerations for technologies assisting older people with dementia

The study findings on nutritional health challenges faced by older people with dementia as perceived by care workers (see Chapter 5), care workers' wishes and concerns regarding technologies to support their clients (see Chapter 7) provide useful insights for designing technologies geared towards assisting older persons with dementia to maintain good nutrition. Based on this information, six design considerations for technologies assisting older people with dementia living in their own home to maintain good nutrition are formulated (see Figure 8.3). These design considerations are described below.

Intelligent ways to personalise support

Although personalisation of assistive technologies is not novel [172, 173], the findings of this study confirm the need for personalisation. However, it is important to note that the nature of dementia adds an additional layer of complexity to the personalisation of technologies promoting nutritional health. This is a result of: i) fluctuations in an older person's level of dementia over time; and ii) difficulties in obtaining food and mealtime-related preferences of older people with dementia.

Fluctuations in a person's level of dementia over time potentially challenges technological capabilities to support them to retain as much of a sense of control as possible. Over simplification of a task can compromise one's independence and under simplification can make a task too complex for them. The findings of this study reveal the impact of the frequent changes in the level of dementia in the way older people carry out their nutrition and mealtime activities. For example, the findings reveal that an older person who is capable of heating up their meals using a microwave, at times, may not even be able to operate simple appliances such as kettles. This demands advanced technologies to be adapted to the level of dementia of older people in order to provide the appropriate level of support. Therefore, it is important to consider the automatic adaptation of technological functionalities by continuously tracking and inferencing each person's level of dementia at a given moment or a period.

The food and mealtime-related user preferences play an important role in the personalisation of nutritional health-related technological support provided to older people with dementia. These preferences may include food types, food brands, cuisines, meal preparation techniques, mealtimes and places in houses to have meals. Considering these user preferences in the technology development is important to seamlessly integrate developed technologies to older peoples' existing daily routines and environments, hence providing them with a sense familiarity. However, with the difficulties of older people with dementia to report their likes and dislikes, this becomes a challenging task especially in cases where there is limited or no family support. Therefore, it is important to employ innovative methods to acquire such information from older people's environments and their behaviours to automatically identify their nutrition and mealtime-related preferences. Care workers in this study reveal that monitoring food leftovers, contents in bins, and item usage in fridges and cupboards could provide useful clues for inferring one's likes and dislikes of food types and brands. Furthermore, according to care workers, older people's preferences are subject to change over time. Therefore, an important consideration is that technologies should be able to adapt to the changing nature of food preferences over time.

Innovative methods to influence human behaviours

It was evident through the findings that simple, direct methods of prompting older people with dementia to carry out nutrition and mealtime tasks may not be effective in all situations. For example, the findings of the study reveal that care workers utilise various prompting mechanisms such as prompt notes, telephone calls, and reminders during care worker visits, to encourage their clients to do certain tasks such as initiate eating, have nutritious food and dispose of expired food. However, despite all these efforts, older people with dementia may not carry out the requested activities because they do not have a desire to do so. In this context, it is important to look beyond direct methods of prompting and seek technological innovations to influence older people's behaviours by shaping their attitudes and creating an urge to perform activities.

The research findings suggest several ways to create a desire among old people with dementia to eat, such as stimulating human senses, providing rewards, and increasing physical activity. For example, according to care workers' experiences showing pictures of food, having the food smells around the house, and allowing older people to listen to their favourite music can encourage them to initiate and complete eating. Furthermore, based on the findings, creating awareness about the food inventory at home can be used as a strategy to indirectly influence older people with dementia to avoid buying the same things when doing their shopping.

Intelligent and inter-connected appliances and objects

Based on the study findings, monitoring appliance usage, contents in bins, item usage in fridges and cupboards is useful to assist older people with dementia to maintain their nutritional health. Therefore, embedding multiple sensors, and the provision of processing power and inter-object communication into objects and appliances at home is worthwhile.

The provision of processing capabilities creates the possibility of transforming everyday objects and appliances to carry out certain tasks autonomously. Examples of such tasks with respect to intelligent appliances can include but not limited to identification of inappropriate appliance usage, identification of anomalous appliance usage, and identification and maintenance of the device's status. For instance, a microwave oven may autonomously determine it has been turned on without an item inside, a stove may autonomously detect it has been used for an unusual duration, and a refrigerator may autonomously maintain an inventory of food items stored in it.

It can be seen that instead of standalone entities, enabling communication between entities provides more opportunities to develop innovative, effective and useful technological applications targeted towards the nutritional health challenges of older people

with dementia identified through this study. For example, given that safety in operating microwaves was a major concern that care workers described, allowing fridges to communicate with microwaves would create the opportunity for the microwave to automatically determine whether the correct settings were applied by the older person, based on the food items taken out from the fridge.

Primitive human motion monitoring to facilitate effective assistance

For technologies to intelligently assist older people with dementia to maintain their nutritional health, it is important to automatically recognise their behaviours related to nutrition and mealtime activities in their home environments. Inaccurate inferences from older people's behaviours may impact adversely on the effectiveness of technologies designed to provide support for them. For example, based on the findings of this study, simply monitoring the initiation of eating or food leftovers may provide misleading information about food consumption, given the possibility of older people with dementia hiding their food, throwing their food away, feeding animals with their food and not completing the eating activity. Furthermore, simply monitoring the reduction of the water level may not provide a reliable estimate of fluid consumption. Another consideration is that most common smart home technologies identify activities using object usage and interpret the movement of an object, such as a fridge door, as the resident performing the intended activity. However, as also pointed out by the care workers in this study, such assumptions can be inaccurate. Therefore, careful monitoring of primitive human motions is important for technologies to make reliable estimates of the activities performed by the older person with dementia and provide effective assistance.

Aggregating isolated sub tasks to provide end-to-end assistance

Based on cognitive theory, people with dementia struggle with processes having multiple tasks [174, 175]. The findings of this study reveal that older people with dementia find it difficult to comprehend complex processes related to nutrition and mealtimes including shopping, meal preparation, and food consumption. Each mealtime process can be considered as a series of sub-tasks which can be further decomposed into multiple steps. For example, the shopping process can be viewed as meal planning, inventory level monitoring, shopping list creation, doing the shopping and storing the goods. Most current research providing technological solutions focuses on the sub-tasks in the mealtime process in an isolated manner. Therefore, there are opportunities to develop much more effective and useful technological applications by focusing on

the end-to-end assistance of mealtime processors rather than providing assistance to selected sub-tasks.

Introducing technology without creating additional burdens

Older people with dementia may struggle to use technological devices even if they have had experience with them in the past. It can be expected that future older people with dementia will be more familiar with technologies than current older people, given their longer exposure to technologies. However, irrespective of the longer exposure to technologies, cognitive decline can affect technology usage capabilities and create complexities. Therefore, the study findings suggest that it is essential to look into ways of introducing technologies into older people with dementia's daily lives without creating additional complexities.

It is important to design technologies that are: i) unobtrusive; ii) maintenance-free (i.e. without any battery changing or recharging); iii) leverage familiar interfaces; iv) extend currently used tools; v) minimise the required user input, vi) minimise the number of choices presented to the user; and vii) have devices fixed to the environment in a way that older people cannot remove them, in order to increase the possibilities for integrating technologies into older people's lives seamlessly. Additionally, the findings of this study suggest introducing technologies to older people's lives as early as possible may create the possibility for them to integrate technologies into their habits. Given that older people live in different households and have different preferences, it may be worthwhile to develop multiple diverse technologies to address a given need, so that the best technology can be selected based on the individual's characteristics.

8.3.2 Design considerations for technologies assisting care workers

Study findings on challenges faced by care workers when assisting their clients (see see Section 6.1), care workers' information needs (see Section 6.2) and care workers' wishes and concerns regarding technologies (see Section 7), provide useful insights into designing technologies geared towards facilitating care workers to provide better nutritional health support to their clients. Based on this information, five design considerations for technologies facilitating care workers in providing improved nutritional health support to their clients are formulated (see Figure 8.4). These design considerations are described below.

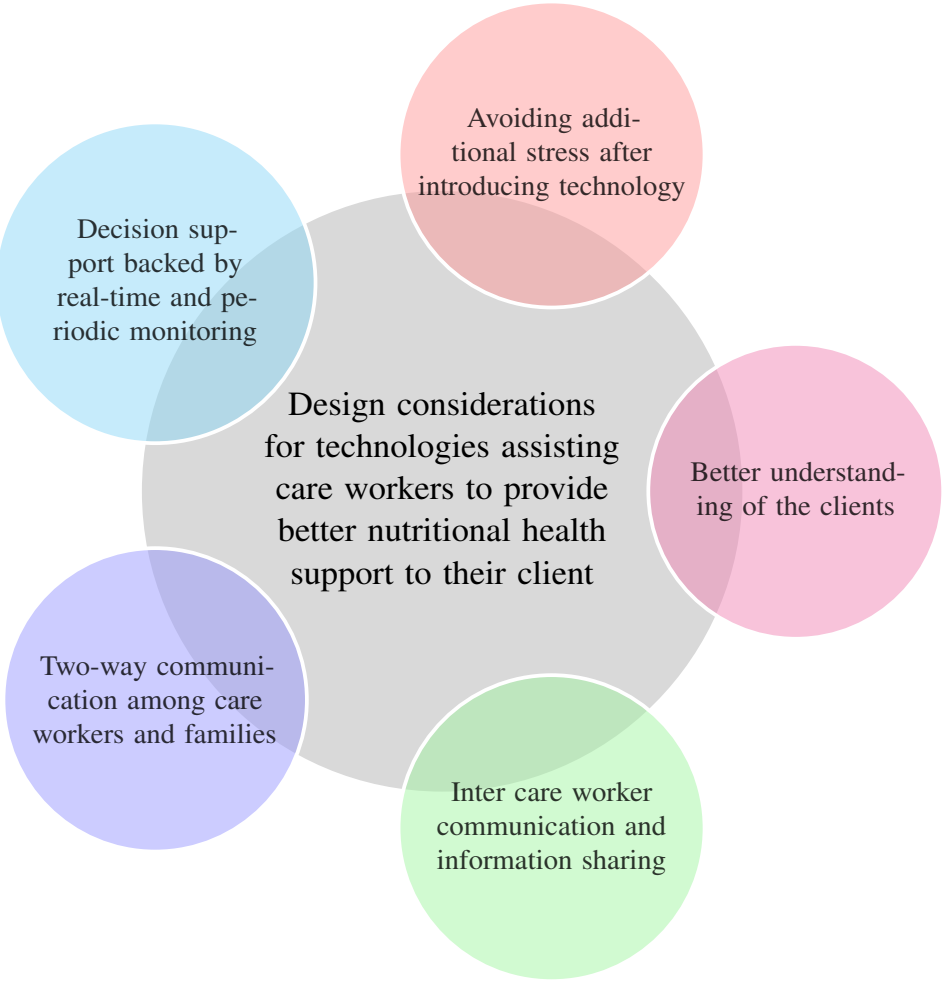


Fig. 8.4 Design considerations for technologies assisting care workers to provide better nutritional health support to their clients

Avoiding additional stress after introducing technology

The workforce involved in the dementia care is limited, and they often experience more workload and stress than other care workers [30, 68]. Even recruiting care workers for this study was a challenging task due to their limited availability. Furthermore, care workers often complained that they do not have enough time to assist their clients. Therefore, technology should be designed in a way that is simple, manageable and easy to access, without further increasing care workers' burdens. In this context, it is essential for technologies to: i) avoid information overload for the care workers; and ii) minimise the amount of manual work required from care workers.

A care worker often provides care support to multiple older people with dementia. These clients may have diverse cognitive and physical capabilities. As a result, the level of support required by each client can be different. This suggests that the types of nutrition and mealtime information made available for the care workers with respect to

each client, needs to be carefully selected, rather than overloading care workers with all possible nutrition and mealtime information. For example, while is it important for care workers to remotely monitor items going in and out of the bins and fridges for some clients, such a level of detailed information may not be required for other clients. Overloading care workers with information may potentially hinder their ability to focus on key areas with respect to the nutrition and mealtimes of each individual client.

With the introduction of technologies, requesting care workers to perform additional manual work in terms of data entry and system configuration, may increase their workload and potentially create additional stress. Therefore, it is important to design easy to use interfaces and reduce the amount of manual work required from the care workers to deploy and maintain technologies.

Better understanding of the clients

As each client is different, it is important that care workers properly understand individual client preferences and needs when providing care services. This allows the care worker to be mindful of the differences between their clients and provide them with personalised care. Based on the findings of this study, care workers often struggle to support their clients because of not being fully aware of clients' food preferences and needs. Furthermore, care workers find it difficult to identify client capabilities as a result of the fluctuations in the levels of dementia. Hence, it is important to consider how to provide care workers with easy access to clients': i) food and mealtime-related preferences; and ii) level of dementia at a given time.

According to care workers, recognising food and mealtime-related preferences of their clients can be challenging and time-consuming. A technological solution to this is to automatically learn those preferences by monitoring older people's behaviours and environments. An important consideration to be taken into account is the changing nature of the individual user preferences over time. As explained in Section 8.3.1, monitoring food leftovers, contents of bins, and item usage in fridges and cupboards could provide useful clues for inferencing someone's likes and dislikes towards food types and brands. However, recognising and recording this information is not sufficient. It is important to allow care workers to easily access such information with respect to each client. The findings of this study reveal that care workers are often unsure about their clients level of dementia on a given day which can have a negative impact on the care support provided. Creating awareness about the clients' level of dementia among care workers creates the opportunity for them to take proactive decisions about the nature of the support that should be provided for each client. Eliminating the

requirement to spend time understanding client needs and preferences allows care workers to better manage their caregiving time.

Inter care worker communication and information sharing

Based on the study findings, it is evident that not having efficient communication among care workers limits their ability to learn from the stories and experiences of others. Furthermore, strengthening communication among care workers increases the transparency in care practices and hence may create the opportunity to provide consistent support to a client despite the number of care workers involved in the care. Therefore, it is useful to employ technologies to bridge the communication gap among care workers to increase the efficiency and effectiveness of the support provided by them. Providing the opportunity for care workers to share information about client specific issues and care practices appears to be essential. Information shared among care workers may relate to different topics such as meal preparation and food consumption. Therefore, it is important to provide adequate flexibility for care workers to easily share and access information on different topics with respect to their clients.

Two-way communication among care workers and families

The findings reveal that issues in communication among care workers and families often affect the care support provided by care workers. Due to poor communication, families, at times, have conflicting expectations from those of care workers. An important consideration is to strengthen the two-way communication among care workers and families to facilitate a common understanding among them; thereby increasing the effectiveness of the support provided by the care workers. In particular, it is important to consider ways for care workers to provide families with a clear and up-to-date view on the older people's nutrition status and challenges. This may allow families to have realistic expectations and to be conscious about the nutritional status of their loved ones. Furthermore, informing families constantly about the older person's nutritional health targets and issues may prompt them to intervene autonomously where necessary, rather than waiting for care workers to inform them about client issues. In addition, facilitating the families to communicate with all care workers supporting their loved one's nutrition and mealtimes activities will allow care workers to obtain more information about their clients and collaborate with families more often when providing care facilities.

Decision support backed by real-time and periodic monitoring

To employ technology to support care workers overcome their challenges and accomplish their information needs, it is essential to automatically collect data on the home environments and related behaviours of older people with dementia. An important consideration is that the analysis of the collected data needs to be conducted in real-time (i.e. as and when the data are collected) as well as in a periodic manner. Real-time analysis of the collected data creates the opportunity for care workers to be notified about their client's nutrition and mealtime-related information immediately. Additionally, it is important to carry out periodic evaluations (i.e. yearly, monthly, weekly) based on the needs of each client to ensure that their nutrition targets are met.

8.4 Potential avenues for technology development

In order to provide additional information to guide technology development, several potential technology development avenues are derived based on the study findings and existing technology development research. However, it is important to note that the goal of this section is not to discuss possible technologies for each nutritional health-related challenge identified in Chapter 5 and Chapter 6 but to provide a brief overview of possible technologies in a preliminary basis as a stepping stone for future research. Although some technology development research referenced in this section was developed without a focus on older people with dementia, yet, it provides useful directions for designing technologies targeting the nutrition and mealtime-related challenges identified in this thesis.

8.4.1 Potential avenues for technology development to assist older people with dementia

This section provides several avenues for technology development that may be useful to address the nutritional health challenges faced by older people with dementia, considering existing technology development research.

Automatic identification of individual food and mealtime related preferences to provide personalised technological support

As proposed as a design consideration in Section 8.3.1, it is important to employ innovative methods to provide personalised technological support to older people with dementia. Identification of individual food-related preferences is important to facilitate the personalisation of technology development. Given the difficulties in obtaining food

and mealtime-related preferences of older people with dementia, it is useful to employ methods to automatically recognise those individual preferences by monitoring older people's environments and behaviours.

As described in Chapter 2, it is common to see research studies on smart homes where residencies are augmented with sensors to observe the environment with the goal of providing services to the resident [176]. Common smart home technologies collect data from different sensors, such as motion sensors, accelerometers, and video cameras, which are attached to the environment or to the residents' bodies [177–179, 176]. The information obtained from these sensors is mainly used to recognise the activities of daily living performed by the resident such as taking medication, sleeping, cooking and eating or ambulatory movements such as walking or detecting health hazards such as falls [81, 180]. However, the information obtained from these types of sensors is often inadequate to learn the details of food related preferences of older people with dementia.

There is an emerging field of research on smart appliances and objects, where miniature sensors and tiny processors are embedded in everyday appliances such as fridges and bins [99, 100]. Although these technologies are developed without a focus on dementia specific needs, there is scope in the future to extend them to closely monitor food usage, by recording information about food items going in and out of bins, fridges and cupboards, to automatically recognise the preferred food types and brand information of older people with dementia.

Automatic identification of the level of dementia to provide personalised technological support

As proposed as a design consideration in Section 8.3.1, to provide effective technological assistance to older people with dementia, technologies should have the capability to automatically adapt their functionalities by tracking and identifying the level of dementia of an older person at a given moment. This is particularly important given the impact of the frequent changes in the level of dementia in the way older people carry out their nutrition and mealtime activities. At present, clinicians usually use tests such as the Mini-Mental State Examination (MMSE) to manually assess cognitive health [181]. There is an emerging field of research that considers automatically identifying the level of cognitive decline of a person by employing pervasive technologies to closely analyse how activities of daily living are performed [177, 182–184]. In addition, automatic conversation analysis has been proposed as a method to recognise the level of dementia [185]. Therefore, it can be expected that similar concepts to be

extended in the future to facilitate dynamic adaptation of technologies to the varying cognitive levels of older people at a given time.

Technological assistance for shopping

Shopping can be viewed as a series of interlinked sub-tasks which include meal planning, inventory level monitoring, shopping list creation, doing the shopping and storing goods after shopping. As proposed as a design consideration in Section 8.3, it is important to support older people in carrying out the shopping related sub-tasks while having an overall view of the end-to-end assistance required.

Typically, the first task related to shopping is meal planning. As explained in Chapter 2, previous researchers proposed a system capable of generating weekly menu plans using a set of pre-defined recipes based on the users' disease conditions, health conditions and preferences, which were manually recorded in the system [122]. The users can interact with the system through a touch screen. In the future, it will be useful to extend such technologies to generate menu plans based on automatically identified patterns of user behaviours and user preferences. The challenge is to ensure variety in the generated menu plans and adapt the menu plans to changes in the food preferences of older people with dementia over time. Another interesting future direction is to tailor the meals plans considering the food inventory at home and their expiry dates, and the nutritional content of the food.

Technological assistance can be provided to older people with dementia to create their shopping lists. Although several non-dementia focused technologies for creating shopping lists have been proposed, they require significant amounts of manual input from the users [186–188]. For example, mobile and web-based applications that are capable of automatically generating the shopping lists based on the user selected recipes exist [188, 187]. Therefore, it can be expected in future to develop technologies which are capable of automatically generating shopping lists, considering the meal plans and food items available at home, along with their expiration dates, focusing on older people with dementia.

As highlighted in the findings of this study, having a shopping list does not guarantee that older people with dementia can carry out shopping by themselves without any issues and they may need assistance to buy goods. Several non-dementia focused technological support has been developed for people to easily navigate around supermarkets [103, 104]. For example, visually impaired people have been provided with shopping assistance based on mobile technologies consisting of an RFID navigation system and a product recognition component using embossed QR codes [103]. This research used headphones connected to the smart phone to provide verbal prompts.

While there is a potential for extending these applications to assist older people with dementia when doing shopping in supermarkets, careful attention should be given to dementia specific problems such as issues in recognising products despite package and name changes and selecting items from among the variety of items available on the supermarket shelves. In this context, it may be useful to explore avenues to prompt older people where a particular product on the shopping list is on a shelf when they enter the shop. Existing indoor localisation techniques [189, 190] could possibly be used to track older people walking around the shop, so that technologies could be designed to provide information about how to locate the correct shelves and select the items that they want.

It is also important to devise innovative methods to assist older people with dementia not to buy food items that are already available at their home when they are shopping, without following their shopping lists. Current, commercially available smart fridges allow people to remotely look at images of the food content inside the fridge while shopping [191]. These technologies can be extended in the future to develop applications to eliminate older people's doubts about their food inventory while shopping and notify them when they try to buy food items already available at home or not included in the shopping lists.

The findings of this study reveal that older people with dementia at times struggle to store food in appropriate places. Therefore, it is worthwhile to explore technologies to support older people with dementia to store their food items after shopping.

Technological assistance for meal preparation

Meal preparation can be viewed as a series of interlinked sub-tasks which include meal-type selection and meal preparation. As proposed as a design consideration in Section 8.3, it is important to support older people to carry out meal preparation related sub-tasks while having an overall view of the end-to-end assistance.

The meal preparation process typically starts with the selection of the type of meal to be prepared. Although previous researchers have proposed intelligent kitchen environments, which can guide older people with dementia with cooking after they select a preferred recipe from a given set of recipes [111], it is worthwhile to look into innovative methods to minimise the user input when designing technologies to assist older people with dementia in meal preparation. For example, it is useful to design smart kitchen environments which can propose what meal to prepare based on meal plans or ingredients available at home.

To provide meal preparation assistance to older people with dementia, it is important to monitor their behaviour in the kitchen. As explained in Chapter 2, research

studies that focus on automatic activity monitoring in kitchen environments with the aim of assisting older people with dementia, exists. However, the capabilities of activity monitoring technologies have a direct impact on the level of meal preparation assistance that can be offered. Currently used smart kitchen monitoring approaches are predominantly based on sensors attached to the environment, such as the motion sensors attached to appliances, to detect changes in the environment deriving from human activities [192–194]. Therefore, the nature of the information that can be obtained about user behaviour from these technologies limits the types of assistance that can provided. In the future, it will be useful to explore the use of data streams obtained from intelligent appliances in kitchen to infer the meal preparation activities of older people with dementia and provide assistance where necessary [99, 100]. Furthermore, it is worthwhile to incorporate information on activity primitives such as chopping, cutting and stirring to obtain further information about the meal preparation activities of older people with dementia to identify where they need assistance. In addition, when providing meal preparation assistance, it is important that technologies are capable of adapting to personal cooking styles and to levels of dementia.

Most of the existing safety measures in kitchen are implemented by considering each kitchen appliance as a separate entity [195]. One of the design considerations proposed in Section 8.3, was to employ intelligent, interconnected kitchen appliances and objects to develop technological applications to support older people with dementia. It can be expected that technological applications that focus on assisting meal preparation and safety in kitchens will benefit from having such intelligent, interconnected and context-aware kitchen objects and appliances. Therefore, one avenue to creating such an infrastructure is to consider leveraging the emerging Internet of Things (IoT) to link heterogeneous resources and services together by accessing sensors and actuators over the Internet [196].

Technological assistance for food and fluid consumption

Food and fluid consumption can be viewed as a series of interlinked sub-tasks which include initiation, continuation, completion, leftover management, and cleaning. As proposed as a design consideration in Section 8.3, it is important to support older people in carrying out the food and fluid consumption related sub-tasks, while having an overall view of the end-to-end assistance required.

Firstly, older people with dementia may require assistance to initiate food and fluid consumption. As explained in Chapter 2, simple reminder systems having pre-defined messages specifically designed for older people with dementia to remind them about medication times and mealtimes are commercially available [197, 198]. In the future, it

may be useful to extend such prompting systems to remind older people with dementia to have their meals, along with information about the type of meals and the location of where to find those meals. On the other hand, according to the study findings, only prompting older people with dementia to consume food or fluids may not be effective at all times. This is because they may not have a desire to eat or drink. In such instances, it is important to seek technological opportunities to create an urge among older people to consume food and fluids. Several avenues for technology development in this direction are described in detail in the next section.

Secondly, apart from supporting older people to initiate food and fluid consumption, they may have to be supported to continue and complete having their meals. Technological assistance to continue and complete eating and drinking when distracted is not a common research topic with respect to older people with dementia. As explained in Chapter 2, most previous research focuses only on the monitoring aspect of eating and drinking. On the other hand, previous researchers proposed an intelligent fork capable of monitoring eating related gestures, such as biting and poking, to encourage small children to continue eating when distracted [199]. A game suitable for children was designed by utilising a hungry panda as a virtual pet to motivate them to eat and concentrate during mealtimes [199]. It can be expected that similar technologies can be developed in the future specifically targeting older people with dementia.

Older people with dementia also need support to store leftovers in appropriate places systematically. Recently robots capable of cleaning the dishes have been proposed [200, 201]. Hence, it can be envisioned that these technologies to be extended to assist older people to clean dishes after storing the food leftovers.

Technological assistance to develop a desire to consume food and fluids

As explained in Section 8.3, simple direct methods of prompting may not always be effective for an older population with dementia. Therefore, it is important to utilise technology for influencing older people's behaviours to shape their attitudes and create an urge to perform activities. Based on the findings of the study, several avenues for technology development to create an urge to eat and drink are described below.

Providing rewards The care workers in this study revealed that they provide rewards as a method to encourage their clients to consume healthy food and fluids. Previously, technology enabled rewards have been utilised to encourage fluid intake [202] and food intake [199]. Although these technologies were not designed for older people with dementia, they provide useful ideas as to how rewards can be used to motivate people to perform certain tasks. All of these studies used metaphors, such

as trees, which were implemented in mobile applications to symbolise caring for the body. It is useful to extend these ideas to provide more personalised rewards, such as automatically playing favourite music and turning on the television, suitable for older people with dementia, to encourage them to maintain good nutrition.

Creating a social environment The care workers in this study revealed that creating a social environment during mealtimes is one method to encourage their clients to consume food and fluids. Previous research studies have looked at different ways of enabling social environments for older people using webcams and television [203], and social robots [164]. However, these were not particularly focused towards the mealtime activities of older people people with dementia. Furthermore, Grevet et al. [204] proposed a touch-pad based application to provide social awareness around mealtimes by employing simple tokens of communication (i.e. status changes) among technology-savvy young people. In the future, it will be useful to extend such technologies and devise novel socialising methods, specifically targeting the mealtimes of older people with dementia.

Stimulating human senses The findings of this study reveal that stimulating as many human senses as possible is helpful to create an urge to consume meals among older people with dementia.

Given that older people with dementia can easily develop an urge to eat when care workers cook their meals due to food smells being released when cooking, it would be interesting to investigate whether automatically releasing different food smells before mealtimes to create an urge to consume meals among older people with dementia would be effective. An important consideration is to personalise the released smells according to the preferences of older people. Another concern highlighted by the care workers in this study is that older people with dementia may not be able to associate smells with the relevant food. In such instances, it would be useful to investigate multi-modal stimuli, such as using smells with related pictures.

Often, older people with dementia do not have a notion of what food is inside their fridges. Smart fridges capable of taking photos of contents inside the fridges are commercially available [191]. In the future, it would be worthwhile to explore innovative methods to automatically recognise the food items available inside fridges and to show pictures of selected food items to older people with dementia to create an urge in them to their consume meals. An important design consideration is to select food items based on both nutritional value and personal preferences.

8.4.2 Potential avenues for technology development to assist care workers

The study findings reveal several types of nutrition and mealtime-related information that care workers believe would assist them to provide a better support their clients (see Section 6.2). Therefore, in this section, several potential avenues for technology development to obtain such information are presented.

Automatic ways to obtain clients' food consumption related information

The study findings reveal that care workers are interested in knowing about the amount and type of food consumed by their clients. When the food is not pre-packaged, automatically recognising the type of food becomes a challenging problem [205]. On the other hand, when a packaged food is consumed, the food type and related information can be obtained automatically by using an identifier in the package [205]. It would be interesting to conduct further research to integrate food purchases and meal preparation information with food consumption to recognise the type of foods consumed by older people with dementia.

The main technical challenge in monitoring food consumption is estimating the amount of food consumed [205]. A significant amount of non-dementia focused research has been carried out to analyse images of food items and dining areas to automatically identify the amount of food eaten [206, 207, 117]. However, most of this work demands manual input from the users, such as taking a digital image of the food before and after the meals using the mobile phones, to recognise the amount of food consumed. Findings reveal older people with dementia not only hide, throw away and feed animals with their food. Therefore, only monitoring the images food leftovers, would not enable care workers to obtain a reliable estimate of the amount of food consumed.

As explained in Section 8.3, monitoring primitive human motions is useful to obtain a reliable estimate of older people's food consumption. Previous researchers have mostly focused on body-worn sensors for this purpose [116]. In the future, it should be possible to have technology development in this direction, especially focusing on the unobtrusiveness of the developed technologies to suit older people with dementia. Additionally, technologies can be used to recognise food intake patterns, so that, later, any deviations in such patterns can be detected automatically.

Automatic ways to obtain clients' fluid consumption related information

The findings of this study reveal that care workers are interested to know the actual amount of fluid intake of their clients. There is non-dementia focused research that monitors the water-level, weight changes in the dining table and movement of the drinking container to identify fluid intake [208, 202, 208–211]. However, information obtained from these approaches may not be reliable. For example, the findings of this study reveal that solely the reduction in the level of water alone cannot be used as a reliable indicator to ensure that older people with dementia actually consume fluids. Furthermore, it is not appropriate to assume that the movement of a fluid container indicates that the person is drinking, as in reality people can interact with drinking containers without actually drinking. As explained in Section 8.3, monitoring primitive human motions is useful to obtain a reliable estimate of older people's fluid consumption. Previous researchers have mostly focused on body-worn sensors for this purpose [116]. In the future, it can be anticipated that more unobtrusive technologies will be developed in this direction.

Automatic ways to obtain clients' food inventory related information

The study findings reveal that care workers are interested in recording the types of food going in and out of fridges and cupboards and knowing where the food is lying around the house. Previous researchers have proposed object tracking infrastructures using different technologies such as RFID [212, 213] and ultrasound [214]. Although most of this work focuses on object and people tracking for activity monitoring, similar technologies can be extended in the future to develop applications focusing on food storage and waste disposal tracking in the homes of older people with dementia.

In order to record the types of food going in and out of fridges and cupboards, it is important to monitor the usage of kitchen appliances and spaces. As explained in Chapter 2, the smart home prototypes designed for older people with dementia are predominantly based on simple sensors, such as binary sensors or pressure sensors, attached to environments. However, information from these sensors does not provide adequate detail to monitor the food inventory in the home in a comprehensive manner. On the other hand, recently smart appliances, such as smart bins [215] and smart fridges [100], with additional capabilities have been proposed. Although most of these technologies are not designed to target older people with dementia and are still at the concept or prototyping stage, it can be expected that future smart appliances will be capable of automatically recording food items going in and out. Apart from that, current smart appliances operate in an isolated manner, hence limiting their monitoring capabilities. For example, when fridges and bins are isolated, it is difficult

to determine whether food in the bins is taken out and put back in the fridges; as issue which was identified as a major concern of care workers (see Section 6). Therefore, as highlighted in Section 8.3, it is important that intelligent everyday things at home are interconnected with each other in a seamless manner to design innovative applications, allowing care workers to remotely monitor their clients' food inventory related information.

Automatic ways to obtain clients' meal and shopping plan related information

The findings reveal that providing detailed information to care workers about client preferences can improve their ability to make meal and shopping plans (see Section 6.2). Several possible ways of employing technologies to automatically identify older people's nutrition and mealtime related preferences have been discussed previously (see Section 8.4.1). Communicating this information to all care workers who visit the client may possibly alleviate most of the meal preparation and shopping related issues that care workers currently face. Furthermore, it is useful to provide menu suggestions for the care workers with respect to each client. An important consideration is that the menu plans should be customised to each older person with dementia. Such menu plans can be created on a daily or weekly basis, considering meals prepared by other care workers, the food inventory at home, clients' health conditions, clients' food preferences and the nutrition content of the meals. One possibility is to develop a mobile application which can identify the location of the care worker and alert them regarding the possible menus for the respective client. It is important to note that although menu plans are presented to the care workers, they may not have the necessary cooking skills to prepare those meals. Therefore, the level of detail provided in the menu plans should be adapted, according to the care workers' cooking skills.

Having a shopping list is useful for care workers to determine which groceries should be bought during the shopping visits. Several possibilities for employing technology to automatically create shopping lists considering the food inventory available at home and their expiration dates have been described previously (see Section 8.4.1). An important consideration when creating the shopping lists for the care workers is that not only food types and quantities but also brand names that clients prefer should be specified.

8.5 Strengths and limitations

The strengths and weaknesses of this study can be broadly discussed based on the type of research methodology, research design and the research methods employed.

8.5.1 Strengths

Choice of the research design The qualitative descriptive research design employed in this study allowed the emergence of a number of challenges faced by older people with dementia living in their own home, that may prevent them from maintaining a good nutrition and challenges, which are faced by their care workers when providing nutritional health support to their clients. This allows for the design and development of a range of technologies that can collectively promote nutritional health in the target population. It is essential to identify such an array of technologies that can cater for the needs of a diverse population, due to the fluctuating and changing levels of dementia over time.

Engagement with the care workers working in the community Although recruiting care workers was a challenging task due to their limited availability as a result of their workloads, during focus groups it was observed that they were appreciative and welcomed the inclusion. They also treated the opportunity to participate in focus group meetings as a platform to describe their experiences and views. In fact, there were instances where some participants: i) wanted to continue the discussions beyond the time allocated from their respective care organisations; ii) expressed their willingness to participate in future research; iii) expressed appreciation of the opportunity to meet care workers who were in a similar role and to share their experiences with each other; and iv) appreciated the initiative taken by researchers to give attention to their experiences and views before technology development. Perhaps their motivation to participate in the research may be due to the feeling of having a voice and the power to create an impact on current and future research.

Using external material to spark discussion during focus groups A presentation of in-home assistive technologies was given as a tool to brainstorm and to stimulate ideas in the participants. The care workers were very keen to listen to the presentation. Images and the video of assistive technologies made them aware about the pervasiveness of technologies, even for some of which they were already familiar. Furthermore, most care workers did not have much experience with assistive technologies, and consequently, the presentation allowed them to broaden their understanding of existing technologies that can be used to aid older people in home environments. Some care workers who had already selective experience in using assistive technologies found the presentation further developed their understanding of available technologies. Based on these understandings, the care workers were able to describe what they wished for

from technologies used to promote the nutritional health of older people with dementia living in their own home.

Managing hierarchical relationships among participants Hierarchical relationships among the two types of participants can potentially inhibit free discussion. By holding separate groups, it was identified participants were relaxed with each other, shared the discussion with all providing input and were able to relate to and build on each other's experiences, thereby providing richer data. Data collected from both types of care workers revealed similar findings. However, at times, discussions involved sensitive matters related to participants' organisational positions. As an example, home support workers reported that they do not agree with the recommendations of the care coordinators regarding having meals together with all their clients. Having separate focus groups created 'safer' environments for the care workers to freely express their perceptions, in the absence of their supervisors or subordinates.

Efforts to minimise researcher bias In qualitative research, the influence of the researcher on data collection and data analysis could result in research bias. Researcher bias in data collection has been reduced by developing the focus group in consultation with all members of the supervisory panel and also an external geriatrics expert. Additionally, the moderator and the note taker iteratively improved the probes used during the focus groups by listening to the audio recordings after each group meeting. The possible research bias in data analysis is reduced by the researcher working together with the supervisor throughout the data analysis process. The supervisor's independent view resulted in improved the coding consistency and increased reliability in the data analysis. In fact, the data analysis was conducted by the same researcher (moderator) and the supervisor (note taker) involved in the data collection, which further increased the reliability of the study findings.

8.5.2 Limitations

Focus is on flexibility rather than standardisation Unlike quantitative research which requires the standardisation of data collection to allow statistical comparison, qualitative research requires flexibility to obtain details about human behaviours. Therefore, the qualitative research methods employed in the study are meant to provide subjective insights, with some consideration as to how findings may be applied to a larger population.

Inability to guarantee technology acceptance and product maturity Although this study reveals a large body of new findings which are important for designing and developing effective technologies for promoting nutritional health in older people with dementia, it cannot guarantee that technologies developed only based on the obtained information can be successfully deployed in the real world. In certain cases, it may be important to explore identified challenges more deeply before the technology is developed. Furthermore, suitable technologies are needed to be selected to address the identified needs. Later effectiveness of developed prototypes should be tested in real-world environments, with the results incorporated into further design and development in an iterative process to achieve the desired objectives.

Differences among cultures, countries, and regions As a strategy to maximise the variation in the study sample, both care coordinators and home support workers from four leading aged care organisations in South Australia were recruited for the study. However, the demographic of the participants in the study sample may not be representative of other geographical regions in the world population. There may be differences in nutrition and mealtime situations of older people with dementia and the support provided by the care workers from different cultures, countries, and regions.

8.6 Summary

Recent technological breakthroughs have created opportunities for designing technological applications to assist older people with dementia to maintain their nutritional health, as well as for their care workers to provide better support to their clients. Technology designers should be clearly informed about the nutrition and mealtime situations of older people with dementia in order to design inter-operable technologies that are likely to be usable and effective. However, to the best of the researcher's knowledge, there is no study that focuses on obtaining an holistic perspective of technologies geared towards promoting nutritional health in this cohort, especially considering both older people with dementia and their care workers as technology users.

The qualitative descriptive study reported in this thesis was undertaken with the aim of minimising the existing knowledge gap and informing technology design and development for promoting nutritional health in older people with dementia living in their own home. The data collected from four focus group discussions involving care workers in four leading aged care organisations revealed useful information, specifically for designers working on technologies to promote the nutritional health of older people with dementia. In particular, the study revealed a wide array of challenges

affecting older people with dementia and their care workers; addressing these would help to enhance the nutritional health of the target population.

This chapter presented a discussion on findings of the qualitative descriptive study, mainly based on the research objectives. Firstly, the nutritional health challenges of older people with dementia identified through the study were positioned within the existing literature to describe how the findings add to the existing knowledge in this domain. Secondly, novel findings related to challenges faced by care workers were discussed with respect to what was already known in this field. Thirdly, technology design considerations were proposed to guide the overall design of technologies to assist older people with dementia as well as their care workers. Fourthly, several potential avenues for technology development, considering the current technology development research, were discussed in order to provide further insights.

It is important to note that although an array of technologies can be developed based on the identified challenges and proposed design considerations, identifying and prioritising the needs of each individual is important before technology deployment. However, who should decide on the selection of assistive technologies for a particular individual is still a debatable topic. Nevertheless, the importance of obtaining the consent of the older person with dementia prior to technology deployment has been highlighted [216, 217].

The next section of the thesis reports two technology development demonstrations, considering several design considerations proposed in this chapter.

Section III

Technology development demonstrations

Section III of this thesis presents demonstrations of two possible technology development studies aimed towards promoting the nutritional health of older people with dementia. The technology designs proposed in these two studies have been derived from based on of several technology design considerations proposed in Chapter 8.

The technology demonstration presented in Chapter 9 is centred around the issue of the poor fluid consumption of older people with dementia, as highlighted by the care workers. To provide assistance to older people to hydrate adequately, monitoring their fluid intake behaviours is important. The importance of primitive human motion monitoring for reliable recognition of human behaviours was described as a design consideration in Section 8.3.1. However, as also proposed in two design considerations in Section 8.3.1 and Section 8.3.2, the applied monitoring technologies should not create any burden to the older people with dementia or additional workload for their care workers. Therefore, Chapter 9 proposes and investigates the efficacy of using passive UHF RFID technology for automatic monitoring of human motions related to drinking, for the first time, to the best of the researcher's knowledge. Automatic recognition of drinking related human gestures provides the opportunity to make reliable estimates about the fluid intake behaviours of older people with dementia. The proposed simple drinking container design allows the drinking related human gestures to be recognised based on streaming RFID information, without the need for any obtrusive body-worn devices or privacy invasive cameras. The batteryless RFID tags do not require any battery replacement or recharging and can be easily embedded inside the drinking containers, allowing older people to carry out their activities without any alterations.

Allowing appliances and objects to be intelligent and inter-connected is one of the design considerations proposed in Section 8.3.1. Additionally, as explained in Section 8.3.1 and Section 8.3.2, technologies should be developed without creating any additional burdens to older people with dementia or increasing the workload of care workers. Following these considerations, Chapter 10 presents a possible architecture, the HoTAAL, for allowing appliances and objects at home to be intelligent and inter-connected. Embedding sensors in appliances and objects at home provides the opportunity for unobtrusive in-home monitoring of activities performed by older people with dementia. HOTAAL architecture, by combining the ubiquity of Internet connectivity in homes with pervasive and intelligent sensors, allows appliances and objects at home to exhibit seamless interactions with each other and humans (e.g. older people with dementia and their care workers), creating the possibility of designing diverse innovative applications geared towards promoting the nutritional health in older people with dementia living in their own home.

Chapter 9

Real-time fluid intake gesture recognition based on passive UHF RFID technology

The qualitative descriptive study findings revealed poor fluid intake as a significant problem for older with dementia. Furthermore, based on the care workers' perspectives, older people with dementia can become more confused than usual when poorly dehydrated, which can threaten their ability to stay in their own homes independently. To provide assistance to older people with dementia to maintain adequate fluid consumption, monitoring their fluid intake behaviours is important.

Chapter 4 revealed a number of different strategies care workers use to monitor clients' fluid intake, such performing check-ups through the phone. Furthermore, since self-reporting by older people with dementia can be unreliable, care workers frequently visit clients in their homes to check on their fluid intake, especially in hot weather. However, with the increasing number of clients and the limited time available, the care workers find it extremely challenging to perform such regular check-ups by visiting clients' homes (see Chapter 6). One strategy is to have a jug filled with liquid so care workers can monitor how much the liquid reduces between visits. Nevertheless, only measuring the reduction in the liquid-level may not provide a reliable indication of whether older people actually drink (see Chapter 6). As a result, care workers often have to rely on monitoring physical signs of dehydration to identify any hydration issues in their clients as early as possible.

Automatic fluid intake monitoring approaches have the potential to alleviate the aforementioned limitations of manual methods. As proposed in Section 8.3.1, to develop technological applications to provide assistance, it is important to monitor primitive human motions. Therefore, in this context, continuous monitoring of human

gestures related to drinking can be used to reliably identify individual instances of where drinking takes place. This information is useful to determine the timing and the rate of fluid consumption [218, 116]. Furthermore, such information may be used later to infer the volume of liquids consumed by linking the information with human activity profiles [218]. Nevertheless, as explained as design considerations in Section 8.3.1 and Section 8.3.2, any applied monitoring technology should not create an additional burden on the older people with dementia or on their care workers.

A number of studies have looked at monitoring human movements related to fluid intake. These can be broadly categorised based on the sensor deployment strategy as body-worn and environmental approaches. Although body-worn battery-powered sensors provide rich sensor data, older people with dementia may forget or refuse to wear the devices due to their large size and the requirement for maintenance (such as charging batteries) [116, 218, 219]. These approaches can also suffer from false recognition because drinking gestures can have a similar motion to eating [220]. In contrast, computer vision techniques do not require attaching sensors to a person and do not require maintenance such as changing or replacing batteries [221–223, 202]. However, the use of cameras has raised privacy concerns among community-dwelling older people despite the use of silhouettes to preserve privacy [224]. Monitoring drinking related human motions using data from environmental sensors attached to everyday objects, such as drinking container and dining tables, was proposed previously [202, 225–227, 209]. Although battery-powered environmental sensors produced rich sensor data, higher per unit cost [202, 225] and the need for maintenance [226] make them less applicable in the real world. Additionally, most of this research assumes that a person is drinking based on the movement of the drinking container. In addition to monitoring the periods of drinking, researchers have employed 'move' events of passive, UHF, RFID tagged objects to infer high-level activities of daily living which included drinking [209]. However, in reality, people may move drinking containers without actually drinking.

Passive UHF RFID tags are small, inexpensive and have an infinite lifetime making them ideal candidates for unobtrusive monitoring of human behaviour in real world settings [228, 229]. These tags can easily be embedded into everyday objects, creating the possibility for users to carry out their normal routines, without any alterations.

In this chapter, the efficacy of automatically recognising periods of drinking (i.e. drinking episodes) using passive UHF RFID tags by attaching them to drinking containers is investigated as a step towards a comprehensive fluid intake monitoring system. To this end, the chapter proposes a design of an RFID tagged drinking container (i.e. *smart cup*) suitable for recognising drinking episodes and machine learning based methods to recognise drinking episodes based on the streaming RFID information.

Data was collected from: i) ten young volunteers using broadly scripted activity routines (age: 30.7 ± 1.6 years); and ii) five older volunteers (age: 69.0 ± 4.6 years) in an unscripted setting. Broadly scripted activity routines permit greater variability in participant behaviours compared with well-scripted activity routines and ensure diversity and complexity of the data collected. Data collected without any scripts (i.e. unscripted), allows for an evaluation of the system in a more naturalistic setting. Given the difficulty in recruiting older participants compared to young participants for collecting data to train algorithms, it is beneficial to assess the systems' performance with data collected from older participants using algorithms trained on data collected from young participants. Anonymised and annotated datasets have been made publicly available to support other researchers as well as to serve as a baseline for future research[1]. In this chapter, a drinking episode is defined as the time period of moving the fluid container towards the mouth, having a sip and moving the fluid container away from the mouth. Recognising such human movements can be considered a gesture recognition problem [116, 218]. Although a limited amount of research on passive RFID-based gesture recognition has focused on specific well-defined gestures, recognising natural human gestures, particularly related to drinking, has not been looked at previously [230–233].

Despite the clear advantages of using passive UHF RFID technology for fluid intake gesture recognition, accurate and real-time recognition of drinking episodes embedded in RFID data streams is challenging. Firstly, a drinking episode involves non-repetitive movements that have very short durations, in contrast with steady or repetitive movements such as walking, running and sitting [116]. Secondly, previous studies [234, 235] have clearly illustrated the unreliable, inconsistent nature (noise) of Received Signal Strength Indicator (RSSI) information. Thirdly, RSSI values are directly affected by water based liquids and the material of the drinking container. Additionally, cold drinks cause water vapour to condense on the outer surface of the drinking container and can affect the performance of the RFID tag. Fourthly, participants may cover RFID tags from the fingers or palm or might move objects or parts of the body in between the reader antenna and the tagged objects, blocking radiations from the antenna to the RFID tags.

This chapter is organised as follows. Section 9.1 presents the design and realisation of the *smart cup*. The data collection procedure from young volunteers based on broadly scripted activity routines and older volunteers in an unscripted setting is described in Section 9.2. Section 9.3 describes the proposed machine learning based approach to recognise natural drinking episodes embedded in the RFID data stream in real time. The results of the evaluation are presented in Section 9.4. The chapter

[1] http://autoidlab.cs.adelaide.edu.au/research/inutricare

ends with a Discussion in Section 9.5. This chapter presents the work extended from publications in IEEE RFID conference and Pervasive and Mobile Computing journal [236, 237].

9.1 Design and realisation of the *smart cup*

9.1.1 RFID preliminaries

In this section, an insight into RFID technology, on which the *smart cup* design is grounded, is provided. There are three main types of RFID tags: i) passive RFID tags; ii) active RFID tags; and iii) semi-passive tags. Passive RFID tags harvest energy radiated by RFID reader antennas. Once successfully powered, they respond by backscattering the Radio Frequency (RF) signal back to the RFID reader via the RFID antenna. Backscattering requires less power as it reflects the incoming RFID signals as compared with transmitting data. Active RFID tags contain a battery and are capable of transmitting signals back to the RFID reader antenna. Therefore, active RFID tags can communicate over larger distances. Semi-passive tags have a battery that powers the circuitry but backscatter to send data back to the RFID reader. Semi-passive tags have a higher operational range than passive RFID tags and a higher operational life than active tags.

This study uses passive UHF RFID technology where the communication is governed by RFID protocols such as ISO-18000-6C [238]. Apart from the unique identification of the tag, modern RFID readers are able to measure detailed Radio Frequency (RF) communication-related properties such as RSSI and phase. RSSI is an indicator of the power received from the RFID reader antenna. Phase is a measure of the phase angle between the RF carrier transmitted by the reader and the return signal from the tag. The RFID reader performs frequency hopping from one channel to another; as a result, phase values are dependent on the frequency [239]. RF phase (Ψ) is generally affected by even small movements of an RFID tag and RSSI are primarily affected by much larger movements.

RSSI is predominantly affected by the distance between the reader and the tag, as well as the orientation of the tag antenna. Based on the Friss transmission equation, the RSSI of a backscattered signal that is captured by an RFID reader has the form of $P_t G_t^2 G_{path}^2 K$ [240]. Here, P_t is the output power of the reader, G_t is the gain of the reader antenna, K is the backscatter gain. The G_{path} is the one-way path gain of the deterministic multipath channel determined as $G_{path} = \left(\frac{\lambda}{4\pi R}\right)^2 |H|^2$. RSSI is predominately determined by R as $RSSI \propto 1/R^4$. The tag radial velocity can be

Table 9.1 Typical relative permittivity of materials reported in the literature

Air	Styrofoam	Water (20 °C)	Water (0 °C)	Tempered glass	Porcelain	Glass	Plastic
1	1.03	80.4	88	7.3	5-6.5	5-10	1.5-3.5

estimated by measuring the phase of the tag signal at two-time instances, as $V_r \propto \frac{\partial \Psi}{\partial t}$ [239]. Additionally, the distance between reader and the RFID tag is proportional to the partial derivative of the phase with respect to the derivative of frequency as $d \propto \frac{\partial \Psi}{\partial f}$ [239].

9.1.2 *Smart cup* design considerations

Water based fluids can greatly reduce the readability of the tag due to the radio frequency absorption as well as result in detuning of the RFID tag antenna in the presence of moisture. Furthermore, water vapour can get condensed over the outside surface of the drinking container due to the presence of a colder fluid inside. Additionally, people may cover RFID tags with their fingers or palm, affecting the performance of the tag and might even move objects, or parts of the human body in between the reader antenna and tagged objects blocking radio frequency paths to RFID tags. As a result of the issues discussed above, detection of RFID tags can be severely reduced, also variations in RSSI and phase information may not relate to the movements of the *smart cup*. For example, Bhattacharyya et al. [208] proposed a passive RFID tag attached to the side of a drinking container to identify when a refill was needed, based on the full and empty state of the fluid levels. According to their cup design, the RFID tag was only visible when the glass was empty. However, unlike in the study conducted by Bhattacharyya et al. [208], the aim of the study described in this chapter is to recognise variations in RSSI and phase data extracted from tag replies. Therefore, the RFID enabled cup design proposed by Bhattacharyya et al. [208] is not suitable because to recognise drinking episodes, at least a single RFID tag must be observable. Therefore, the proposed *smart cup* design should: i) increase the possibility of detecting at least a single RFID tag, even when the cup is filled with liquids; ii) facilitate reliable RSSI and phase patterns from the *smart cup*.

9.1.3 *Smart cup* prototype

In order to design the *smart cup* prototype, a preliminary investigation was conducted by attaching a commercially available RFID tag to the bottom of a regular tempered glass cup. A single tag reading consisted of the 5-tuples: i) RSSI; ii) phase; iii) frequency; iv) antenna ID; and v) time stamp. In order to increase the possibility of

obtaining readings from the tag even when the drinking container was completely filled with liquids, a styrofoam base was used to separate the RFID tag at the bottom of the cup. Styrofoam's dielectric constant is very close to that of air (see Table 9.1). As a result, the effects of liquids on the tag are reduced and the possibility of successfully reading the tag is increased. Smartrac Frog 3D tag[2] was specifically selected as the bottom tag due to its orientation insensitivity to the reader antenna and larger operational range ($>$ 6m). Furthermore, Smartrac Frog 3D tag was well suited to be placed at the bottom of the drinking container due to its size (53×53 mm) and symmetrical shape. A preliminary investigation of data collected from 8 young participants demonstrated the feasibility of this approach for recognising drinking episodes even when a cup is filled with liquids. A detailed description of this preliminary evaluation was published in IEEE RFID conference proceedings [236].

In order to further increase the drinking episode recognition performance, three additional RFID tags were attached to the side of the drinking container. The *smart cup* prototype with the four commercially available passive UHF RFID tags is shown in Figure 9.1a. As discussed earlier, liquids or a human hand may cause RFID tags undetectable. It is expected that the redundancy with multiple tags can increase the drinking episode recognition performance. It was observed that, due to the relatively large dimensions of the Smartrac Frog 3D tags, placing them on the side of the drinking container can lead to poor tag performance as a consequence of: i) tags being in the vicinity of a liquid at most times; and ii) increased obstructions of the tag from a human hand. Hence Alien Squiggle tags (ALN 96402[3]) with a good operational range ($>$ 4.6 m) and small size (94.8×8.1 mm) were selected as a more suitable candidate for attaching to the side wall of the drinking container.

A horizontal tag placement on the side of the *smart cup* was used to: i) increase the possibility of reliably reading the tags to obtain information rich RSSI and phase data when the water-level changes and the distance of tags on the wall to liquids in the drinking container increases; and ii) facilitate liquid level recognition in the future using the same *smart cup* design. Three Alien Squiggle tags were attached opposite to the handle of the *smart cup* so that they are less likely to be obstructed by a human hand or occluded by a human body while drinking takes place. As demonstrated by Bhattacharyya et al. [208], the detectability of the RFID tags is affected by the fluid level. Therefore, in the future, the work proposed by Bhattacharyya et al. [208] would be extended to determine the fluid level to a reasonable granularity in real-time using information from the multiple tags on the *smart cup*.

[2]https://www.smartrac-group.com/frog-3d.html

[3]http://www.alientechnology.com/wp-content/uploads/Alien-Technology-Higgs-3-ALN-9640-Squiggle.pdf

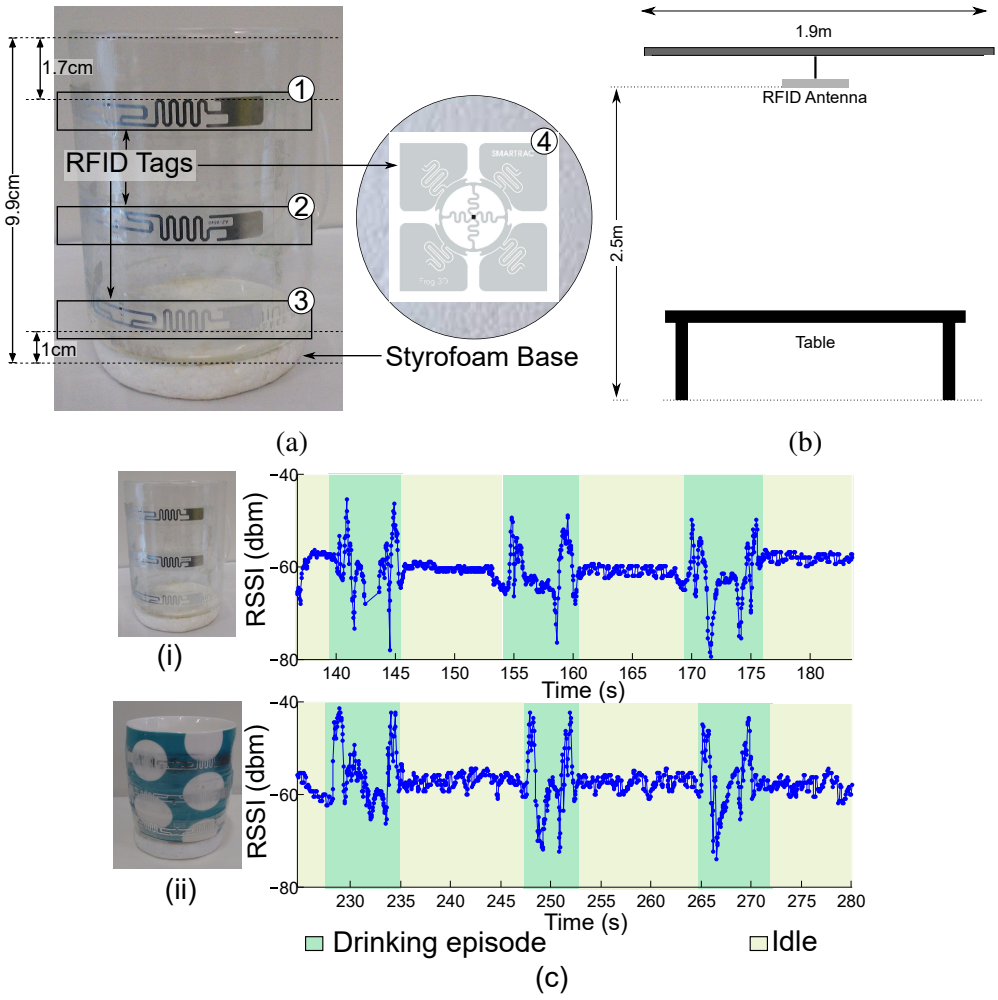


Fig. 9.1 a) The *smart cup* used in the experiment with the 4 RFID tags; b) re-created dining room setting used for data collection; and c) typical variations of RSSI for two regular cups with the proposed tag placement: i) data collected for a tempered glass cup; ii) data collected for a porcelain cup.

Although a regular tempered glass based *smart cup* prototype was used in the experiments described in this chapter to recognise drinking episodes, RSSI patterns of the tempered glass based *smart cups* were compared against the RSSI patterns from a porcelain based *smart cup* (see Figure 9.1b for the data collection set-up and Figure 9.1c for the RSSI patterns obtained from the two *smart cups*). Both *smart cups*, having similar dielectric constants (see Table 9.1), have depicted similar variations in the RSSI patterns when drinking took place. Therefore, it can be expected that the proposed approach to recognising drinking episodes will be generalisable across other drinking containers made out of material having similar dielectric constants.

(a) (b) (c) (d)

Fig. 9.2 a) A young participant drinking water while having her lunch; b) a young participant drinking orange juice while reading a newspaper; c) an older participant drinking a cold wine while reading a message on the phone and having his lunch; and d) an older participant refilling his favourite orange juice while enjoying his lunch.

9.2 Data collection

9.2.1 Participants and set up

Ten young volunteers (age: 30.7 ± 1.6 years) and five older volunteers (age: 69.0 ± 4.6 years) participated in this study. The older participant cohort also included an older adult diagnosed with Parkinson's disease. Parkinson's is a progressive neurological condition. Shakiness, muscular rigidity and imprecise movements are common symptoms of the Parkinson's disease.

Similar to previous studies [116, 241, 225, 226, 225], our experiments were conducted in a re-created dining room setting (see Figure 9.1 b). Even though multiple antennas may increase recognition performance [225, 230], minimising the number of antennas used is important to reduce the overall system cost. Therefore, experiments were conducted by employing a single antenna placed unobtrusively above the dining table, near the ceiling and focusing downwards. The antenna was carefully placed near the ceiling as opposed to underneath the table for two reasons: i) easy installation; and ii) better coverage. Previous studies also identified that placing antennas near the ceiling provided a good balance between the reader coverage area and the reduction of signal blocking events caused by human movements [209].

9.2.2 Experiment with young volunteers

Broadly scripted activity routines were employed to collect data from young participants. Such activity routines permit greater variability in participant behaviours compared with well scripted activity routines and ensure the diversity and complexity of the collected data by making sure the existence of realistic other gestures involving the *smart cup* and avoiding long periods of inactivity [218, 116].

During the experiments, participants were requested to select any type of drink according to their preference from a given set of choices: i) water (hot/cold); ii) cold

Table 9.2 Dataset statistics for data collected from young participants using broadly scripted activity routines

Drinking	Moving	Dragging	Telephone interruption	Taking	Bringing	Holding	Idle
Count							
196	48	27	16	13	20	9	296
Mean of the episode durations (s)							
4.9	1.4	1.1	2.6	6.8	7.7	1.6	14.3
Standard deviation of the episode durations (s)							
1.4	0.7	0.7	1.3	2.0	3.4	0.7	12.8

soft drinks; iii) apple/orange juice; iv) tea or coffee. Then they were requested to drink it as they would normally do (see Figure 9.2). The participants had the freedom to drink as much as they like and to freely mix the drinking activity with other high level activities (such as eating, reading, working on the computer) according to their preference. Even though there was no intention to recognise high level activities such as eating and reading, this set up ensured that drinking movements occurred naturally. Furthermore, the experiments being conducted during lunch time, early morning and tea time allowed participants to undertake drinking normally during their lunch, breakfast or tea time.

The broadly scripted activity routines ensured the existence of non-drinking gestures involving the *smart cup*. These non-drinking gestures were created based on the different ways users typically interacted with the cup apart from drinking and involved: i) moving the cup while changing the sitting position; ii) dragging the cup while changing the sitting position; iii) getting interrupted by a phone call, as a result not completing an already initiated drinking episode; iv) bringing the cup to the dining area; and v) taking the cup away from the dining area. Participants were not given specific instructions except to perform these gestures with the *smart cup* multiple times during the experiment and they were free to decide how and when to perform them. For the telephone interruption, the researcher rang a telephone as soon as the participant lifted the *smart cup* to drink. As informed before the experiment, the phone ringing cue prompted the participants to answer the incoming call without completing the drinking episode.

The dataset collected from the young participants contained 196 drinking episodes, 133 non-drinking user interaction episode , and 296 idle episodes (see Table 9.2). On average a trial lasted for 621.1 ± 194.8 s and a drinking episode lasted for 4.9 ± 1.4 s. The dataset contained 332,621 tag readings where 56,133 of them related to drinking episodes. The read rate of the RFID platform was approximately 55 tags per second.

Due to the effects of liquids, the read rate of individual tags varied and tag 4 reported the highest average read rate of 23 tags per second. This was followed by tag 1 with an average read rate of 21 tags per second.

9.2.3 Experiment with older volunteers

The data collected from older participants were unscripted. Prior to the experiments, the participants were asked to nominate a beverage of their choice. The requested beverage was made available during the experiment. Such requested beverages included cold soft drinks, fruit juice, coffee and wine. During the experiments, the participants filled the *smart cup* with any amount of their preferred liquid and drank it as they wished. According to their preference, the participants performed one or more other high level activities while drinking. Other activities carried out during the experiments included eating, solving puzzles, reading and using the mobile phone for texting and calls. They also had the freedom to refill the cup with the preferred liquid, if needed and were not given any other specific instructions (see Figure 9.2).

The dataset collected from the older participants contained 79 drinking episodes. On average a trial lasted for 518.1 $\pm$ 376.0 s and a drinking episode lasted for 6.3 $\pm$ 1.5 s. The dataset contained 241,110 tag readings where 30,001 of them related to drinking episodes. The read rate of the RFID platform was approximately 56 tags per second. Due to the effects of liquids, the read rate of individual tags varied and tag 4 reported the highest average read rate of 25 tags per second. This was followed by tag 1 with an average read rate of 20 tags per second. These read rates are similar to the read rates reported for data collected from young participants.

9.2.4 Dataset annotation

During the experiments the researcher manually labelled the ground truths as much as possible using an in-house developed software. After the experiments, a researcher manually corrected ground truth labels using video recordings. To get a deeper understanding about a drinking episode, it was annotated using three labels:

- up: the movement of the cup towards the mouth
- sip: the cup touches the lips
- down: the movement of cup away from the mouth

The periods where there were no user interactions with the *smart cup* were labelled as idle. Furthermore, the following non-drinking interactions with the *smart cup* were

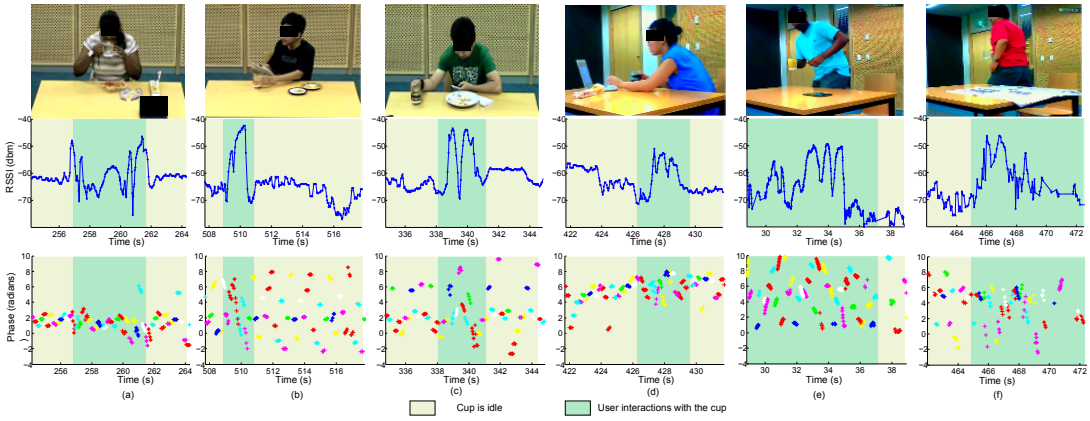


Fig. 9.3 Analysis of the data collected from young participants illustrating RSSI and phase (unwrapped) for tag 4: a) drinking; b) moving the cup while changing the sitting posture; c) placing the cup on the table without completing the drinking action already initiated due to the interruption from the phone call; d) dragging the cup to a convenient location; e) bringing the cup to the dining area; f) taking the cup away to get a refill.

annotated: i) moving; ii) dragging; iii) telephone interruption; iv) taking; v) bringing and vi) holding. Holding indicates the time periods where participants were holding the drinking container in between drinking episodes without placing it back on the table.

Figure 9.3 illustrates how participants typically interacted with the *smart cup*, along with the respective RSSI and phase data streams. It can be observed that non-drinking user interactions (Figure 9.3 b - 9.3 f) have resulted in RSSI and phase patterns that were partly or mostly similar to RSSI and phase patterns obtained during a drinking episode (Figure 9.3 a). Figure 9.4 illustrates the typical RSSI and phase variations for a drinking episode for data collected from a young participant and an older participant. When closely analysing Figure 9.4, it can be observed that RSSI and phase values are generally stable when the cup is idle on the table. During the period of a drinking episode, a 'sip' depicts generally stable RSSI and phase values as a result of the cup being in a stationary position compared with the cup being moved towards the mouth (up) or the cup being moved away from the mouth (down).

9.3 Methodology

9.3.1 Data segmentation and feature extraction

The collected data stream is a time series. As highlighted in the previous literature, the information obtained from a single tag reading can be noisy and thus challenging to use as a source of information for statistical learning algorithms [209, 242, 243].

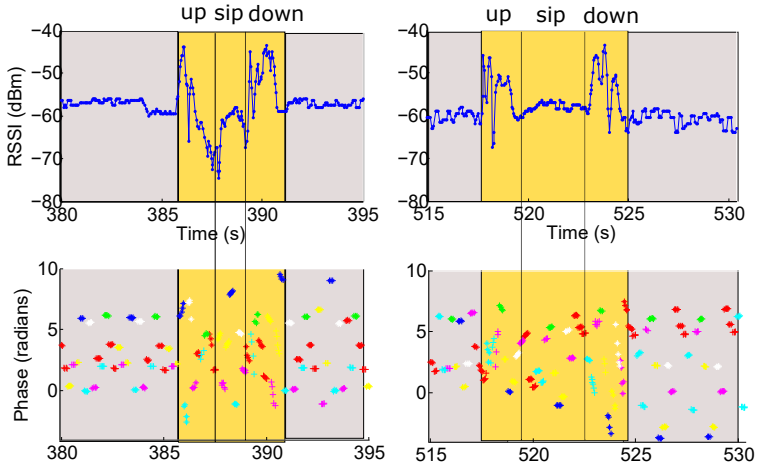


Fig. 9.4 Typical RSSI and unwrapped per channel phase patterns for a drinking episode w.r.t. tag 4: a) a drinking episode of a young participant; b) a drinking episode of an older participant

Therefore, the time series was segmented using a fixed time overlapping segmentation method with a segment size (δw) of 5 s, which is advanced each 0.1 s. The segment size was selected based on the mean duration of the drinking episodes in the young people dataset.

The baseset of features used in this study are listed in Table 9.3. Previous research has proposed RSSI and phase features for a motion classifier [209]. Additionally, standard statistical features with respect to RSSI and phase were employed to capture their underlying distribution of the data stream. Given the i^{th} tag reading, Constant Frequency Phase Rate (CFPR) is calculated as $(phase[i] - phase[i-1])/(time[i] - time[i-1]))$ and Variable Frequency Phase Rate (VFPR) is calculated as $(phase[i] - phase[i-1])/(frequency[i] - frequency[i-1])$. VFPR is proportional to the distance of the tag to the antenna, hence the standard deviation of VFPR can be used to determine tag movement. Before extracting phase features raw phase values need to be corrected for flipping and wrapping. The RFID reader wraps the phase signal in the range of 0 to 2π and flipping can occur randomly where π is added to the original phase measure. RFID reader hops the transmitted frequency in a pseudo-random manner in order to reduce interference. Given a stationary tag, the value of the phase depends on the frequency and therefore phase should be corrected considering a selected frequency.

For a given segment, three feature extraction approaches were investigated and henceforth these three methods are referred to as *s1*, *s2* and *s3* respectively. The first feature extraction approach, *s1*, directly calculates the features listed in Table 9.3 from data stream segments. The second approach *s2*, utilises the relative RSSI obtained with respect to the first observation of the given segment when obtaining features. Use of

Table 9.3 Summary of RSSI and phase features used for binary classification

#	Feature Description
Phase	
1	Median of the CFPR *
2	Sum of the absolute values of CFPR *
3	Standard Deviation of the CFPR *
4	Standard Deviation of the VFPR *
5	Mean of CFPR
6	Mode of CFPR
7	Range of CFPR
8	Skewness of CFPR
9	Kurtosis of CFPR
RSSI	
10	Standard Deviation of RSSI *
11	Mean of RSSI Standard Deviation within each frequency *
12	Mean of difference between neighbouring RSSI *
13	Mean of RSSI
14	Mode of RSSI
15	Median of RSSI
16	Range of RSSI
17	Skewness of RSSI
18	Kurtosis of RSSI

* RSSI and phase features proposed in [209] for a motion classifier. CFPR indicates Constant Frequency Phase Rate and VFPR indicates Variable Frequency Phase Rate.

relative RSSI values in features in *s2* forces classifiers to learn models for the variation in RSSI within a given segment. In contrast, *s1* allows classification models to learn RSSI variations with respect to a fixed position, which is the RFID antenna in our case. It is assumed that using relative RSSI makes the features and subsequent models more robust to environmental conditions affecting RSSI. In the third feature extraction approach *s3*, a segment is equally divided into three sub-segments. It is assumed that the three sub-segments in *s3* could capture the typical drinking behaviour of a person that includes a sequence of movements involving the cup: i) moving the cup towards the mouth; ii) having a sip; and iii) moving the cup away from the mouth. For *s3*, features were calculated based on relative RSSI values considering the sub-segments and the full window. Taking advantage of having three sub-segments, differences of the central tendency measures of each sub-segment were obtained as features. The other measures of the sub-segments, apart from the central tendency measures, were

used as they were. Feature extraction considered each tag individually and *s1*, *s2* and *s3* consisted of 72, 72 and 288 features respectively.

9.3.2 Drinking episode recognition

In this study, the problem of determining whether a tag reading corresponded to *drinking* or *non-drinking* was treated as a binary classification problem. A continuous series of drinking classifications were considered as a drinking episode. Drinking episodes were only recognised if they are longer than a $\mu/2$ time period, where μ is the mean drinking episode duration in training data. This mitigates the effects of noise in RFID data and consequently increases the drinking episode recognition precision. Six machine learning algorithms were investigated for the binary classification: i) Naïve Bayes (NB) [244]; ii) Linear Support Vector Machine (LSVM) [245]; iii) Non linear Support Vector Machines (NSVM) [245]; iv) Random Forest (RF) [246]; v) Logistic Regression (LR) [247]; and vi) Linear Conditional Random Fields (CRF) [248].

These six classification algorithms have different characteristics. NB is a simple generative model that assumes features are conditionally independent [244]. NB implementation provided in Matlab (R2015a) is used in this study. Support Vector Machine (SVM) is a state of the art discriminative machine learning algorithm which has a strong theoretical generalisability [245]. NSVM supports non-linear decision boundaries using kernels. The two libraries LIBLINEAR [249] and LIBSVM [250] were used to implement LSVM and NSVM classifiers respectively. NSVM employed the Radial Basis Function (RBF) kernel.

RF is an ensemble classifier based on the CART algorithm [246]. The output from RF is obtained considering the majority votes of all trees (nTrees) in a Decision Tree (DT) ensemble. As a result, based on the concept of the law of large numbers, RF achieves a higher generalisation performance than a single DT. RF implementation provided in Matlab (R2015a) is used in this study.

LR assumes that the sample of tag readings used to learn are drawn independent and identically distributed (i.i.d) from an unknown distribution. Unlike linear models similar to linear SVM, LR models the posterior probability of the predicted classes using linear functions in the input space [247]. Logistic regression implementation in the LIBLINEAR [249] library was used in this study.

CRF is a probabilistic graphical model that models a Markov chain. As a result, CRF is capable of modelling the relationships between consecutive elements in a sequence. Inferencing in traditional CRF algorithms considers the entire input sequence. Therefore, traditional CRF can only work in finite sequences, hence cannot be used for real-time sequence prediction. The CRF proposed by Shinmoto Torres et al.

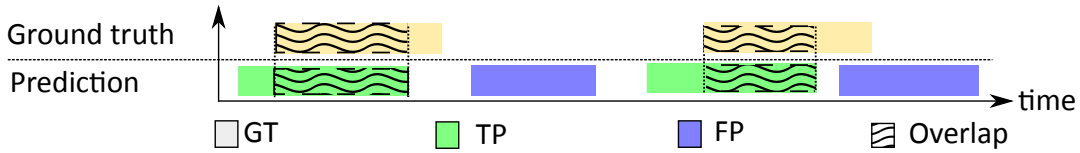


Fig. 9.5 Drinking episode recognition evaluation. GT indicates a Ground Truth drinking episode, TP indicates a candidate drinking episode classified and evaluated as a true positive. FP indicates a misclassified drinking episode. Overlap indicates the alignment of a correctly predicted drinking episode with the respective ground truth episode.

[251] where the sum-product algorithm is used during inferencing to obtain real-time predictions was used in this study. The work proposed by Shinmoto Torres et al. [251] is based on the concept of belief propagation. In the case of real-time applications, the focus is on the belief of the last variable given the input observation. Therefore, given a sequence of feature vectors $X = (x_t)_{t=1}^{T}$, where $x_t \in \mathbb{R}^d$ and T is the length of the sequence, the marginal probability of variable y_k is calculated as:

$$p(y_k|x_{1:k},\lambda) = \frac{1}{Z(x_{1:k},\lambda)} \psi(y_k;x_{1:k},\lambda) m_{y_{k-1},y_k}(y_k;x_{1:k},\lambda)$$

where messages $m_{i,j}$ are calculated as:

$$m_{i,k}(s_k) = \sum_{s_i} \psi(s_i)\psi(s_i,s_k) \prod_{t \in N_i \setminus \{k\}} m_{t,i}(s_i)$$

where s_i represents the variable node i, $N_i \setminus \{k\}$ represents the set of neighbours of the variable node i with the exception of node k, and $\psi(s_i)$ and $\psi(s_i,s_k)$ are the node and edge potentials respectively.

9.3.3 Statistical analysis

As the *smart cup* employs four RFID tags (see Figure 9.1), it is worthwhile investigating which tag combination yields the highest drinking episode recognition performance. Therefore, four tag combinations were considered based on the proportion of tag visibility in the dataset: i) tag 4 only (*1-tag combination*); ii) tag 1 and tag 4 only (*2-tag combination*); iii) tag 1, tag 2, tag 4 only (*3-tag combination*); and iv) all four tags (*4-tag combination*). Previous research on dietary intake recognition has evaluated approaches based on the precision and recall of the relevant intake movements [218, 241, 116]. Similarly, the drinking episode recognition performance was evaluated mainly using the precision and recall of the recognised drinking

episodes. Additionally, the alignment of a correctly recognised drinking episode with the respective ground truth episode was evaluated using overlap performance.

In this study, a True Positive (TP) drinking episode is defined as a drinking episode predicated during an actual drinking episode (see Figure 9.5). A False positive (FP) drinking episode is a predicted drinking episode that did not follow the TP criteria. Additionally, any re-identified drinking episodes were treated as FPs because such identification will adversely impact on applications where the rate of fluid consumption is calculated. The missed drinking episodes were considered as False Negatives (FN). Drinking episode recognition precision was calculated as $P = TP/(TP+FP)$. Precision measures the number of true positives with respect to all drinking episode recognitions and higher precision indicates lower false recognitions of drinking episodes. The drinking episode recognition recall was calculated as $R = TP/(TP+FN)$. Recall measures the true positives with respect to all actual drinking episodes and higher recall indicates lower numbers of missed drinking episode recognitions. The F-score, is a single measure of the harmonic mean of the precision and recall. Therefore, finally, based on precision and recall, the drinking episode recognition F-score was calculated as $(2 \times P \times R)/(P+R)$.

The leave one person out cross-validation scheme was used in the evaluation [247]. This cross-validation scheme allows the measurement of the performance of the system for data that it has never seen before. The data collected from the young participants were partitioned into three subsets as training, validation and testing. The testing set was from the data of a single young participant. The model parameter selection was carried out by training the models using the training sets and evaluating the performance using the F-score based on the validation sets. The performance was then evaluated using testing set based on the selected model parameters. This process was repeated for all the participants to obtain the mean performance measures.

The model for older people was trained using data collected from young people. This evaluation scheme also created the opportunity to ascertain the realistic performance of the system for older participants in a practical deployment where the learnt model needs to make predictions for unseen participants. At this stage, the data collected from young participants were partitioned into two subsets for training and validation. The model parameters were selected by training the model using training sets and evaluating their performance using the F-score based on the validation set. Finally, performance was evaluated by using data from older participants.

In order to evaluate overlap performance, two measures 'overlap recall' and 'overlap precision' were defined, inspired by the general recall and precision measures. Given a TP drinking episode, 'overlap recall' was calculated as OD/GD and 'overlap precision' was calculated as OD/PD, where OD, GD and PD represent the overlap

Table 9.4 Mean *drinking* and *non-drinking* binary classification performance (F-score %) for young participants

	CRF	LSVM	NSVM	LR	NB	Random Forest
4-tag combination						
s1	86.9± 3.2	85.8 ± 3.4	88.5 ± 3.1	85.2 ± 3.3	74.9 ± 3.9	89.1 ± 4.3
s2	86.4± 2.9	85.5 ± 3.4	87.8 ± 2.8	84.5 ± 3.5	74.1 ± 3.9	88.6 ± 3.4
s3	89.0± 3.9	87.9 ± 3.1	**90.4 ± 2.5**	87.9 ± 3.3	76.0 ± 4.9	89.6 ± 3.4
3-tag combination						
s1	86.4± 3.3	85.8 ± 2.9	88.6 ± 3.1	85.2 ± 3.1	76.4 ± 4.8	89.0 ± 3.9
s2	85.9± 2.9	85.4 ± 3.1	88.5 ± 2.8	84.5 ± 3.1	76.2 ± 4.3	88.1 ± 3.1
s3	88.7± 4.0	87.8 ± 3.1	**90.3 ± 2.6**	87.3 ± 3.3	77.9 ± 4.3	89.5 ± 3.3
2-tag combination						
s1	86.5± 3.2	85.2 ± 3.3	89.1 ± 3.2	84.5 ± 3.8	76.7 ± 4.8	89.1 ± 4.0
s2	86.1± 2.9	84.8 ± 3.5	88.3 ± 2.8	84.3 ± 3.4	76.6 ± 4.2	88.4 ± 3.5
s3	88.6± 4.0	88.7 ± 4.1	**90.6 ± 3.0**	87.6 ± 3.3	77.9 ± 4.5	89.6 ± 3.3
1-tag combination						
s1	80.0± 4.3	79.4 ± 3.4	82.9 ± 3.0	78.8 ± 2.7	76.7 ± 4.8	82.2 ± 3.6
s2	80.1± 4.5	79.6 ± 3.0	82.8 ± 3.2	78.5 ± 2.4	74.9 ± 3.9	82.1 ± 3.7
s3	81.9± 5.2	81.9 ± 3.8	**86.3 ± 3.6**	80.2 ± 3.7	72.9 ± 4.2	85.2 ± 3.4

duration, ground truth duration and prediction duration. The overlap F-score was calculated using the standard definition using 'overlap precision' and 'overlap recall'.

9.4 Results

As explained in Section 9.2, two datasets were collected during the experiments. The data from young people were collected using broadly scripted activity routines and the data from older people were collected in an unscripted setting. Broadly scripted activity routines were employed to increase the diversity and complexity by making sure of the existence of other realistic gestures involving the *smart cup*. On the other hand, unscripted data collection allows the drinking episode recognition performance to be evaluated in a more realistic setting. As explained in Section 9.3.3, for both data sets, leave one person out cross validation has been employed [247]. In particular, the performance of drinking episode recognition for the dataset collected from older people has been evaluated by training the machine learning models using data collected from young people. This evaluation scheme also created the opportunity to measure the realistic performance of the system for older participants in a practical deployment where the learnt model needs to make predictions for participants that were never seen before.

Table 9.5 Drinking episode recognition performance (%) using the *s3* feature extraction method for different tag combinations using different classifiers.

	CRF	LSVM	NSVM	LR	NB	Random Forest
4-tag combination						
Recall	87.9 ± 11.1	81.2 ± 11.2	88.9 ± 8.1	77.5 ± 12.5	82.3 ± 10.4	85.8 ± 11.4
Precision	95.2 ± 4.9	95.5 ± 5.6	96.6 ± 5.0	95.8 ± 5.2	72.4 ± 5.9	97.9 ± 4.8
F-score	91.0 ± 6.7	87.1 ± 5.9	**92.4 ± 5.4**	85.0 ± 8.1	76.7 ± 6.1	91.0 ± 7.2
3-tag combination						
Recall	87.7 ± 9.4	80.9 ± 12.2	88.3 ± 9.1	74.0 ± 12.5	94.2 ± 6.5	84.0 ± 12.0
Precision	96.5 ± 3.9	95.4 ± 4.0	97.3 ± 5.0	92.5 ± 7.4	73.4 ± 7.9	97.6 ± 5.5
F-score	91.7 ± 5.8	87.0 ± 7.4	**92.4 ± 6.4**	81.5 ± 8.6	82.3 ± 6.3	89.9 ± 8.2
2-tag combination						
Recall	86.9 ± 12.1	79.7 ± 12.2	90.0 ± 11.3	75.5 ± 12.1	95.1 ± 5.5	84.4 ± 13.0
Precision	96.6 ± 3.9	95.1 ± 4.7	97.6 ± 3.2	95.4 ± 6.0	69.6 ± 6.4	97.0 ± 5.6
F-score	91.0 ± 7.1	86.0 ± 6.7	**93.3 ± 7.4**	83.8 ± 8.7	80.3 ± 5.4	89.7 ± 8.5
1-tag combination						
Recall	66.8 ± 17.7	72.4 ± 17.7	73.8 ± 16.1	62.1 ± 14.4	93.2 ± 5.2	68.8 ± 16.7
Precision	94.5 ± 5.4	88.8 ± 7.4	97.3 ± 3.6	89.9 ± 7.3	62.8 ± 6.5	93.7 ± 6.5
F-score	76.8 ± 12.5	78.1 ± 9.3	**82.9 ± 11.5**	72.1 ± 9.8	74.7 ± 4.0	78.0 ± 12.0

* See Appendix G.1 for model parameters used.

9.4.1 Results for young participants

The performance of drinking episode recognition depends on the feature extraction approach employed. Therefore, before evaluating the performance of the system for recognising drinking episodes, the best feature extraction approach based on the binary classification results for data collected from the young participants was selected. Table 9.4 lists the mean drinking *drinking* and *non-drinking* binary classification results (F-score) for data collected from the young participants based on the three feature extraction approaches *s1*, *s2* and *s3* on different tag combinations. From Table 9.4, it is evident that *s3* has outperformed *s1* and *s2* for all instances expect for NB in *1-tag combination*. The main reason for this higher performance is *s3* is able to capture the drinking pattern based on the information from the sub-segments. On the other hand, in general, the *s1* approach has outperformed the *s2*. As explained in Section 9.3.1, *s1* uses the original RSSI value instead of the relative RSSI value as in *s2*. Since data collection has been conducted using similar configurations, particularly the RFID reader, RFID reader antenna and the height at which the antenna was placed above the ground. Therefore, when *s1* is utilised, classification models can use this information for improved prediction, as raw RSSI values are inversely proportional to the fourth power of the distance between the tag and the fixed RFID antenna. Both *s3* and *s1* rely

on the relative values of RSSI and hence, unlike *s1*, are expected to be more resilient to changes in the environment.

When comparing the binary classification performance across different tag combinations, it is interesting to note that increasing the number of tags beyond 2 has only resulted in marginal performance differences. The mean performance differences among *2-tag combination*, *3-tag combination* and *4-tag combination* for corresponding feature extraction methods are in fact less than 1%, except in the case of the Naïve Bayes (NB) classifier. Furthermore, the SVM classifiers, i.e. LSVM and NSVM, depicted their highest performances in *2-tag combination*. When RF is considered, both *2-tag combination* and *4-tag combination* have depicted similar mean F-score. By design, tag 4 is the least affected by liquids compared with other tags (see Figure 9.1a). Tag 1 attached to the top of the cup, stays above the liquid level longer, compared with tags 2 and 3, as the liquid level decreases. Therefore, information from tags 2 and 3 is unreliable, compared with tag 1.

When each classification algorithm is considered for its binary classification performance, it can be seen that NSVM has consistently depicted the highest performances across all classification algorithms. Random Forest has closely followed the performance of NSVM. Least performance, in terms of classifiers, is shown by NB.

Since, the *s3* approach depicted the highest binary classification performance, *s3* is used for subsequent analysis of the drinking episode recognition. Table 9.5 shows the drinking episode recognition performance using *s3* for each tag combination for different classifiers.

From Table 9.5, it is evident that highest drinking episode recognition performance in terms of F-score has been achieved by the *2-tag combination* using the NSVM classifier; there NSVM has depicted an F-Score of 93%. Similar to binary classification, the NSVM classifier has outperformed all the classifiers for all tag combinations in drinking recognition in terms of the F-score. Apart from NSVM, the next highest performance is depicted by CRF despite CRF being the third highest performer in *drinking* and *non-drinking* binary classification. In fact, Random Forest, the second best *drinking* and *non-drinking* classifier, depicted the third best drinking episode recognition performance. This indicates that drinking episode recognition is not only influenced by the *drinking* and *non-drinking* classification but also the position of the correct predictions of the data stream.

Furthermore, a higher precision has been depicted by all classifiers except NB in all tag combinations. The higher precision indicates the lower number of false positives. This higher precision is significant as the experiment is specifically designed to include natural other movements, similar to that of drinking; there were 196 drinking episodes and 133 other movements.

Table 9.6 Mean overlap performance (%) of the drinking episodes using the *s3* feature extraction method for different tag combinations and different classifiers.

	CRF	LSVM	NSVM	LR	NB	Random Forest
4-tag combination						
Recall	82.3 ± 2.1	82.2 ± 2.2	84.2 ± 2.4	82.3 ± 1.2	82.8 ± 1.3	82.5 ± 1.8
Precision	77.2 ± 2.1	77.3 ± 2.2	79.4 ± 2.4	77.5 ± 1.2	58.9 ± 1.3	78.6 ± 1.8
F-score	79.7 ± 2.3	79.7 ± 2.6	**81.7 ± 2.6**	79.8 ± 1.5	68.8 ± 0.9	80.5 ± 1.9
3-tag combination						
Recall	81.9 ± 2.2	82.2 ± 1.6	85.0 ± 2.0	83.4 ± 1.7	83.5 ± 1.7	81.8 ± 1.8
Precision	76.7 ± 2.2	77.2 ± 1.6	80.1 ± 2.0	78.3 ± 1.7	60.5 ± 1.7	77.9 ± 1.8
F-score	79.2 ± 2.4	79.7 ± 1.8	**82.5 ± 2.3**	80.8 ± 2.1	70.1 ± 1.3	79.8 ± 1.8
2-tag combination						
Recall	80.6 ± 2.8	85.4 ± 1.7	85.3 ± 1.9	82.7 ± 1.4	87.0 ± 2.1	82.2 ± 1.8
Precision	75.6 ± 2.8	80.2 ± 1.7	79.6 ± 1.9	78.1 ± 1.4	61.6 ± 2.1	77.7 ± 1.8
F-score	78.0 ± 3.2	**82.7 ± 2.0**	82.3 ± 2.3	80.3 ± 1.5	72.1 ± 1.4	79.9 ± 2.0
1-tag combination						
Recall	78.1 ± 1.2	77.2 ± 3.6	81.6 ± 2.3	73.1 ± 2.7	79.8 ± 1.7	82.6 ± 2.5
Precision	70.9 ± 1.2	72.8 ± 3.6	76.4 ± 2.3	68.3 ± 2.7	53.6 ± 1.7	78.7 ± 2.5
F-score	74.3 ± 1.6	75.0 ± 4.0	**78.9 ± 2.6**	70.6 ± 3.2	64.1 ± 1.1	80.6 ± 2.8

Table 9.6 lists the overlap performance for recognising drinking episodes using the *s3* feature extraction method, using different classifiers and tag combinations. As stated in the Section 9.3.3, the overlap performance measures the degree of temporal alignment between actual and recognised drinking episodes. It is important to note that overlap results are only calculated for true positive drinking episode detections. According to Table 9.6, the highest overlap performance with respect to overlap F-score and overlap precision has been achieved by Liblinear in the *2-tag combination*. In this instance, Liblinear achieved an 83% overlap F-score and 80% overlap precision. It can be observed that the values of overlap precision of *2-tag*, *3-tag* and *4-tag* combinations, with classifiers except NB, are greater than 75%. This indicates that, on average, 75% a predicted drinking episodes correspond to actual drinking episodes. This is significant as the mean drinking episode duration is approximately 5 s.

Generally, it can be observed that the overlap performance in terms of recall for tag combinations except for the *1-tag combination* is greater than 80%. Although NB generally depicted the lowest drinking episode recognition performance, it has achieved the highest overlap recall of 87% for *2-tag combination*. This indicates that during correct drinking episode detections, using NB, a larger portion of the actual drinking episodes can be captured. However, in this instance, the lower overlap precision

Table 9.7 Number of ground truth (GT) , true positive (TP) and false positive (FP) drinking episodes for each young participant obtained using the *s3* feature extraction method with a NSVM classifier for considered tag combinations

Participant	1	2	3	4	5	6	7	8	9	10	Total
GT	29	24	21	14	14	13	15	37	15	14	196
4-tag combination											
TP	25	22	16	14	13	11	15	29	14	12	171
FP	0	0	1	1	0	0	1	5	0	0	8
3-tag combination											
TP	26	22	16	14	13	11	15	28	14	11	170
FP	0	0	1	0	0	0	1	5	0	0	7
2-tag combination											
TP	27	20	14	14	14	12	15	29	15	12	172
FP	0	1	1	0	0	0	1	2	0	0	5
1-tag combination											
TP	23	19	10	9	12	10	13	17	14	11	138
FP	1	0	0	0	1	1	0	1	0	0	4

indicates that the drinking episode durations of the predicted drinking episodes are likely to be larger than the actual drinking episode durations.

To further analyse the performance of the drinking episode recognition, true positive and false positive drinking episodes were compared against the ground truth drinking episodes in the data stream (see Table 9.7). From Table 9.7, it can be seen that the *2-tag combination* has the highest number ($n = 172$) of TPs but *3-tag* and *4-tag* combinations had less than 2 and 1 TPs respectively. The lowest number ($n = 4$) of FPs was depicted by *1-tag combination*. However, the number of TPs ($n = 138$) for the *1-tag combination* is notably lower than the number of TPs ($n = 172$) for the *2-tag combination*, which has the second best performance in terms of the number of FPs ($n = 5$). The three tag combinations *2-tag*, *3-tag* and *4-tag* were able to recognise all drinking episodes for participant numbers 4 and 7. In addition, all the drinking episodes of participant 9 have been recognised by the *2-tag combination*. A lower performance in terms of TPs can be observed for participant 3. When closely analysed, it can be identified that 12 out of 21 drinking episodes for participant 3 were consecutive drinking episodes, where multiple drinking motions were performed before leaving the smart cup 'idle' on the table. Some of these drinking episodes have been missed resulting in a lower sensitivity. Each *3-tag* and *4-tag* combination depicted 5 FPs for participant 8 who has the highest number of drinking episodes, while the *2-tag* combination only depicted 2 FPs.

Table 9.8 *Drinking* and *non-drinking* binary classification performance (%) for older participants with NSVM models trained using young participant data

Tag combination	Recall	Precision	F-score
4-tag combination	83.7 ± 4.5	92.0 ± 3.9	87.2 ± 4.1
3-tag combination	83.3 ± 4.8	92.1 ± 3.8	86.9 ± 4.4
2-tag combination	84.4 ± 4.3	91.2 ± 3.9	**87.3 ± 4.1**
1-tag combination	78.8 ± 4.8	89.1 ± 5.2	82.8 ± 4.7

* See Appendix G.2 for model parameters used.

Table 9.9 Drinking episode recognition performance (%) for older participants using *s3* feature extraction and NSVM models trained using young participant data

Tag combination	Recall	Precision	F-score
4-tag combination	84.0 ± 12.1	94.0 ± 5.6	88.3 ± 7.6
3-tag combination	82.7 ± 11.1	96.3 ± 5.1	88.8 ± 7.9
2-tag combination	85.7 ± 8.8	94.1 ± 5.6	**89.5 ± 5.9**
1-tag combination	64.8 ± 7.9	96.1 ± 5.5	77.1 ± 5.5

9.4.2 Results for older participants

In Section 9.4.1, it was observed that the NSVM classifier with the *s3* feature extraction method depicted the highest performance for recognising drinking episodes. Therefore, the generalisability of the drinking episode recognition method for an older population was evaluated based on models trained using data from young participants.

As the first step, the binary classification performance for classifying the data stream segments as *drinking* or *non-drinking* was evaluated. These results are shown in Table 9.8. From this table, it can be observed that tag combinations except for *1-tag combination* depicted similar performances having F-scores greater than 86%. However, the performance depicted for the older participant dataset is marginally lower than the respective performance values from the young participant dataset. One possible reason for this lower performance compared with the young participant data is the longer drinking episode duration; in fact, on average, young people took approximately 5 s and older people took approximately 6 s. Furthermore, a high precision (over 90%) was observed.

The drinking episode recognition performance for data collected from older participants is listed in Table 9.9. The *2-tag combination* has depicted the highest performance in terms of mean F-score ($>$ 89%). Nevertheless, the tag combinations, *3-tag* and *4-tag* depicted comparable performances. It is important to note the higher precision

Table 9.10 Overlap performance of drinking episode recognition (%) for older participants using *s3* feature extraction and NSVM models trained using young participant data

Tag combination	Recall	Precision	F-score
4-tag combination	68.8 ± 4.8	63.5 ± 4.8	$\mathbf{66.0 \pm 4.1}$
3-tag combination	67.6 ± 5.6	62.3 ± 5.6	64.8 ± 4.9
2-tag combination	62.8 ± 6.7	58.0 ± 6.7	60.3 ± 6.0
1-tag combination	60.4 ± 5.6	57.1 ± 5.6	58.7 ± 5.1

Table 9.11 Number of ground truth (GT), true positive (TP) and false positive (FP) drinking episodes for each older participant

Participant		1	2	3	4	5	Total
	GT	15	16	9	15	24	79
4-tag combination	TP	15	15	7	11	18	66
	FP	0	2	0	1	2	5
3-tag combination	TP	15	14	7	11	18	65
	FP	0	0	0	1	2	3
2-tag combination	TP	15	14	7	12	20	68
	FP	0	2	0	1	2	5
1-tag combination	TP	10	12	6	8	15	51
	FP	0	1	0	0	2	3

($> 94\%$) for all tag combinations. As with the young participant dataset, the lower recall has degraded the *1-tag combination* performance.

The overlap performance for detected drinking episodes is listed in Table 9.10. For all tag combinations, considerably lower overlap F-scores compared with that for young participant dataset can be observed. It is important to note that, unlike in other instances, increasing the number of tags has increased the overlap performance.

To evaluate the drinking episode recognition of individual participants, drinking episode recognition in terms of TPs and FPs were analysed (see Table 9.11). It is important to note that the *2-tag combination* recognised the highest number of drinking episodes which is 68 out of 79. Both *3-tag combination* and *1-tag combinations* depicted the lowest total FP count ($n = 3$). It is important to note that for participant 1, all tag combinations except *3-tag combination* were able to detect all drinking episodes without any FPs. Participant 5 is diagnosed with Parkinson's disease and using the proposed methods, particularly with *2-tag combination*, 20 out of 24 drinking episodes have been recognised with only 2 FPs.

In summary, it is observed that the proposed methods depicted good drinking episode recognition performance for data collected with older participants using machine learning models trained using data collected from young participants. Furthermore, good performance was observed even for the participant with Parkinson's disease. Therefore, it is evident that the proposed drinking episode recognition approach is robust and generalises across different age groups.

9.5 Discussion

In this chapter, an investigation into the feasibility and efficacy of using passive UHF RFID technology for automatic monitoring of fluid intake gestures was reported for the first time. In particular, a fluid intake monitoring approach that includes a passive RFID enabled *smart cup* capable of monitoring drinking episodes based on the variations in the RSSI and phase patterns is proposed. Embedding or attaching passive RFID tags in a *smart cup* eliminates the need to wear any monitoring devices and allows people to carry out their daily routines without any hindrance. The passive nature of the sensor is particularly advantageous as there is no requirement to charge or replace batteries as in battery-powered devices. Furthermore, washable and printable passive RFID tags are currently available [252, 253]. These RFID tags can be embedded easily inside a cup when manufactured, as an alternative to being pasted on, as in our prototype. The promising results achieved for drinking episode recognition for data collected from young participants (F-score $\approx$ 93%, precision $\approx$ 98% and recall $\approx$ 90%) and older participants (F-score $\approx$ 90%, precision $\approx$ 94% and recall $\approx$ 86%) demonstrate the efficacy of using batteryless RFID technology for recognising natural fluid intake gestures in real time.

Although there are two types of human gestures [116]: i) artificial; and ii) natural, most of the previous passive RFID-based gesture recognition approaches focus only on artificial human movements [230–233]. Artificial gestures are specific, well-defined movements, mostly designed to provide strong discrimination for human-computer control applications. On the other hand, natural human motions such as fluid intake related human gestures are not well defined, occur unconsciously and challenging to spot than artificial gestures. There are several systems to recognise fluid intake gestures using battery-powered devices. However, it is difficult to make a fair comparison with these recent studies, mainly due to the differences in the experimental setting. Amft et al. [218] recognised drinking gestures with an 84% recall and a 94% precision. They conducted experiments using broadly scripted activity routines with six young volunteers. Junker et al. [116] recognised drinking gestures with an 83% recall and an

88% precision based on data collected from 4 young participants. However, none of the previous researchers have evaluated their approaches with older people.

Even though passive RFID tags are preferred over active RFID tags in smart home applications as they do not require any batteries, passive RFID tags require an RFID reader antenna to transmit energy and also for communication [209, 254, 229, 225]. In smart homes, having an RFID reader and antenna dedicated to a single application, such as fluid intake monitoring, can be costly. In a typical RFID infrastructure, multiple RFID antennas can be connected to a single RFID reader and unlike other sensor deployments [226, 241, 227, 202], after an initial investment in the RFID infrastructure, the same technology can also be utilised in other smart home applications such as ambulatory monitoring [243] and Activities of Daily Living (ADL) monitoring [229, 209]. Even though the use of fixed reference tags and multiple reader antennas deployed in the monitoring area may provide additional information for drinking episode recognition, they were purposely avoided in this study to increase the simplicity of the system when deployed in a real home and reduce the overall cost. In particular, the proposed system only relied on a single RFID antenna that was deployed in an unobtrusive location (i.e. near the ceiling). Furthermore, having the reader antenna near the ceiling is: i) simpler for installation; and ii) provides a good balance between reader coverage and reduction of signal blocking events caused by human movements [209]. Due to the better coverage, the possibilities of monitoring other potential RFID tags in the living space are also increased.

The experiments were conducted in an almost realistic setting using a ceiling mounted antenna, dining table and chair. In order to further facilitate the realistic environment and natural behaviour, participants were allowed to: i) drink as they would normally do without being given any specific instructions on how or when to drink; ii) select their preferred drink; and iii) select the amount of liquid to consume. The participants were allowed to perform various tasks they would typically do while having a drink such as reading, eating, using a laptop according to their wish. This set up allowed drinking to occur naturally. Furthermore, broadly scripted activity routines employed by young participants ensured the presence of other non-drinking user interactions with the drinking container such as telephone interruption, dragging, moving, taking in order to further increase the richness of the collected data. Furthermore, given the difficulty in recruiting older people, collecting training data from young participants is more advantageous when evaluating the system's performance for an unseen older population.

Even though the results are promising, the study is not without limitations. Due to the diversity of human behaviour, drinking episode durations can depict inter-subject and intra subject variabilities. Therefore, a dynamic segmentation approach,

as opposed to a fixed time segmentation, may further improve the drinking episode recognition performance. Even though our experiments were conducted in a realistic but controlled setting, it is also interesting to investigate the technical performance and user acceptance of our approach with older people having dementia over a longer period in a real-world deployment. Furthermore, in the future, to achieve a comprehensive fluid intake monitoring system it would be useful to extend the present work to recognise fluid levels in real time by considering previous research studies [208, 211].

In conclusion, the promising results achieved in this study demonstrate the efficacy of recognising short duration, short distance natural human gestures, particularly related to fluid intake, based on passive UHF RFID technology.

Chapter 10

Home of Things for Ambient Assisted Living (HoTAAL)

Older people with dementia living in their own homes and their care workers have diverse technological needs, and there is an opportunity to employ a number of heterogeneous technologies to support them. However, the same set of technologies may not suit all households. Furthermore, new technologies may need to be introduced into the existing home environments as dementia levels change over time. As proposed as a design consideration in Section 8.3.1, it is important to develop methods to inter-connect heterogeneous technologies together, rather than deploying them in an isolated manner, in order to allow them to work collaboratively with each other, as well as humans, in a naturalistic manner. Such an infrastructure creates the opportunity for developing innovative, effective and useful technological applications to provide assistance for the nutritional health issues identified in this thesis. However, as proposed as design considerations in Section 8.3.1 and Section 8.3.2, it is important that technologies to avoid creating additional burdens for older people with dementia or increasing the workload of their care workers.

Unobtrusive in-home monitoring technologies are predominantly based on sensors attached to the environment [74]. There are several research efforts on building intelligent ambient environments, employing environmental sensors, which include smart homes such as CASAS [255], House_n in MIT [178] and Adaptive House [256]. These technologies were only capable of sensing or actuation and designed in an isolated manner. In particular, the sensors were used to detect changes in the environment as a result of human activities [193]. Examples of such sensors include switches, passive infra-red (PIR) sensors and proximity sensors. Switches were commonly attached to doors, drawers, refrigerators, microwaves and were capable of recognising the open and closed status of the attached object or appliance. Motion sensors such as

PIR sensors were capable of measuring nearby heat-based movements. A limited number of studies have moved from simply attaching sensors to embedding sensors and processing capabilities into objects or appliances at home and connecting them to the internet [225, 257, 258]. For example, researchers have implemented a smart bin capable of capturing images and uploading them to Facebook with the aim of creating behavioural change in the food waste and recycling habits of young adults [258]. Recently, a radio frequency-based smart home monitoring system to infer people's activities by analysing received signal strength fluctuations of RFID tags has been proposed [259]. However, these types of appliances or objects use heterogeneous communication mechanisms and are mostly designed as stand-alone solutions. With the recent emergence of the Internet of things (IoT) and related technologies such as miniature sensors and tiny processors, everyday objects at home have been made interconnected via the Internet [196]. Previous researchers have proposed an architecture for a Social Internet of Things (SIoT) which is suitable for developing a social network of intelligent objects [260]. The proposed SIoT architecture includes a central server to manage the communication. The architecture is driven by demand, whereby components are required to request services from other components. This sort of architecture is less suitable in an ambient assisted living environment where a set of actions is predominantly triggered by the actions of the resident. Therefore, the previous work still lacks some aspects required for ambient assisted living environments.

Things not only capable of sensing, actuation, and Internet connectivity, but also social interactions with other things, as well as humans, in a seamless manner—that is, *social things*—create new possibilities to design innovative ambient assisted living applications. Such a social home facilitates the seamless integration of a heterogeneous set of pervasive technologies with older people whereby they are free to carry out their daily routines in an unobtrusive manner. This provides a wide array of opportunities for designing novel nutrition health promoting applications, as well as other ambient assisted living applications, compared with previous studies [261, 262].

This chapter describes HoTAAL, a possible architecture for combining the ubiquity of Internet connectivity in homes with pervasive and intelligent sensors to exploit user interactions with everyday home appliances and objects, in order to facilitate the development of a new generation of assistive technologies, with the aim of helping older people with dementia to live in their own homes independently for a longer time. The HoTAAL architecture creates the possibility of transforming everyday objects and appliances to intelligent entities by providing them with processing capabilities to carry out certain tasks autonomously, and for those intelligent entities to exhibit social interactions with each other as well as humans, in a naturalistic manner. As a proof of concept, three social kitchen appliances have been developed employing the HOTAAL

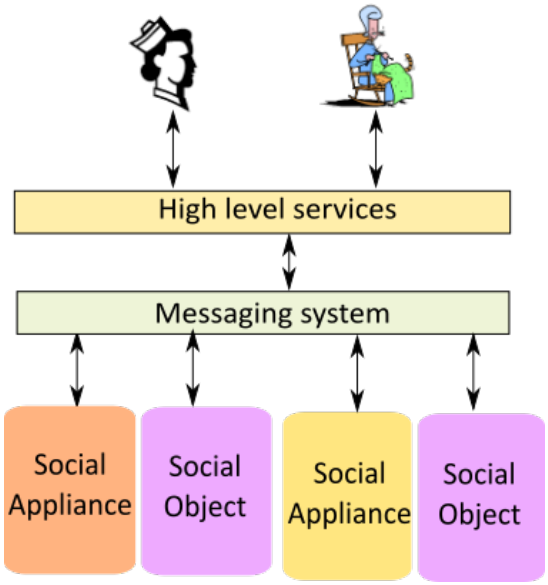


Fig. 10.1 The high-level architecture of HoTAAL

architecture in the Auto-ID Lab of the University of Adelaide. A demonstration of the possibility of employing the developed social kitchen appliances for providing meal preparation assistance has been conducted. In addition, a discussion of three possible technological applications based on HoTAAL architecture for three scenarios devised from the focus group findings has been conducted in order to describe the diverse nature of the applications that can be supported through the HoTAAL architecture.

This chapter is organised as follows. Section 10.1 presents the high-level architecture of HOTAAL. Section 10.2 presents a proof of concept implementation and a demonstration of three social kitchen appliances. Section 10.3 discusses possible technological applications, employing HoTAAL architecture, for three scenarios devised from the focus group findings. The chapter ends with a discussion in Section 10.5. This chapter presents the work extended from the publication in IEEE International Conference on Pervasive Computing and Communication Workshops [263].

10.1 HoTAAL architecture

The proposed high-level architecture for HoTAAL is illustrated in Figure 10.1. There are three main components: i) social things; ii) a messaging system; and iii) high-level applications. The following sections describe these components in detail.

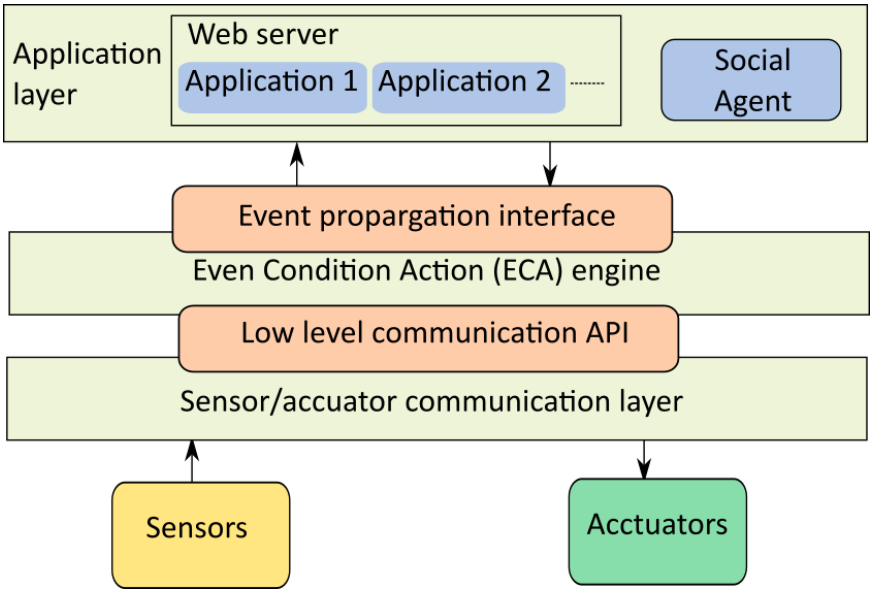


Fig. 10.2 The architecture of a social thing

10.1.1 Social thing

A social thing is an intelligent appliance or object at home that can coherently communicate with other social things at home (i.e. machine to machine communication) as well as humans (i.e. machine to human communication) with the aim of providing assistance to older people with dementia when needed. The proposed architecture of a social thing is illustrated in Figure 10.2.

The main components of a social thing include sensors, actuators, sensor/actuation communication layer, Event Condition Action (ECA) engine and the application layer. Multiple sensors such as a thermometer (temperature), hygrometer (humidity) and scale (weight) may be embedded in a social thing. Additionally, social things may include actuators. Actions of social things are driven by the events caused as a result of activities of residents, activities of others such as care workers or other social things. Therefore, an ECA engine is best suited for a social thing. Sensors and actuators communicate with an ECA engine through a low-level communication Application Programming Interface (API). This communication can take place over any communication mechanism such as Bluetooth and Inter-Integrated Circuit (I^2C). ECA engine manages and exposes the low-level capabilities of the social entities.

The application layer of a social thing may include functionalities that can be performed autonomously with a limited number of resources. For example, the social refrigerator may manage its food inventory and identify the expiration dates of food items through an application implemented in its application layer. A web server is included in the application layer to host multiple applications. The application

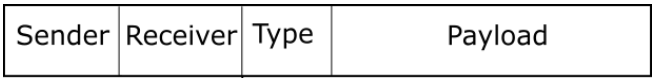


Fig. 10.3 Messaging protocol

layer can send and receive notifications to and from the ECA. The social agent in the application layer manages the communication of the social thing.

Whether the sensors, actuators, ECA engine and the application layer are physically located together in the social thing or not, may depend on the appliance or object characteristics. The following two scenarios can be foreseen. In a scenario where an appliance or an object does not have sufficient power and is small in size (for example a drinking container), the ECA engine and the application layer may be implemented in a remote location and accessed wirelessly. In another scenario where there is a continuous power supply to the appliance, such as a refrigerator, the sensors, actuators, ECA engine, and application layer may be co-located inside the refrigerator.

10.1.2 Messaging system

The messaging system is employed to facilitate seamless communication of social things with other social things as well as humans. As explained in Section 10.1.1, the actions of social things in HoTAAL are driven by the events. These events can be predominantly caused as a result of the activities of residents, activities of others such as care workers, and other social things. In an ambient assisted living environment, it is essential to have the flexibility for social things to be added and removed from HoTAAL easily. In this context, publisher-subscriber architecture is selected for the messaging system in HoTAAL. In a publisher-subscriber architecture, the sender and receiver do not need to know anything about each other for the information to be sent or received. The senders/publishers publish messages (events), without any knowledge of the subscribers. Similarly, subscribers register their interest and will only receive messages that are of interest to them, without any knowledge of any publishers. To realise this, an intermediary called a "message broker" receives published messages and then forwards them on to those subscribers who are registered to receive them.

A simple messaging protocol which facilitates the use of a publisher/subscriber mechanism is proposed for communication (see Figure 10.3). This contains four parts: i) sender; ii) receiver; iii) type; and iv) payload. As the name suggests, the sender is the message sender and the receiver is the message receiver. The payload is the message. The message types can be defined based on the needs of the technological applications. Some examples of possible types of information include actions, timer events, and locations. The social things and humans (such as older people and care workers)

Table 10.1 Capabilities of the social kitchen appliances

Appliance	**Capabilities**
Refrigerator	Detecting open and close events of the refrigerator doors Detecting door angular displacement Capturing bar codes of the content in the refrigerator Capturing RFID tag information of the objects in the refrigerator Capturing images of what's inside the refrigerator Detecting the temperature, humidity inside the refrigerator Detecting the weight of each plate
Microwave	Detecting open and close events of the microwave door Capturing an image of the food inside the microwave after cooking finished Detecting the user selected cooking time Detecting the temperature when the microwave is working
Bin	Detecting open and close events of the bin Capturing an image of what's inside the bin when the bin lid is opened Capturing the weight of the contents in the bin Recognizing when the bin is full Detecting when the inner bin is misplaced Wireless powering capability

can be subscribed for specific senders or message types which allow them to receive messages of interest, which are then published with the intention of being received by any party—a public message. If a message needs to be sent to a specific receiver, then the sender can send that message to the receivers private channel by populating the receiver section of the message. In a publisher/subscriber context, public messages can be thought of as a topic with multiple subscribers and publishers and the private messages can be thought of as a queue with one consumer.

Although service device and discovery have not been considered in this study, devising a protocol for social things to autonomously register and withdraw themselves will eliminate or minimise the requirement for manual configuration to deploy, maintenance and upgrade technologies. It can be expected that the existing messaging protocol could be extended for this purpose.

10.1.3 High-level applications

All applications which go beyond the realm of a single social thing can be implemented as high-level applications. For example, nutrition monitoring systems require information from multiple social things to determine whether adequate nutrition levels are maintained by the resident. Therefore, such applications can be implemented under high-level applications. The high-level applications can send/receive notifications to/from residents, external parties such as care workers and social things, through the messaging system.

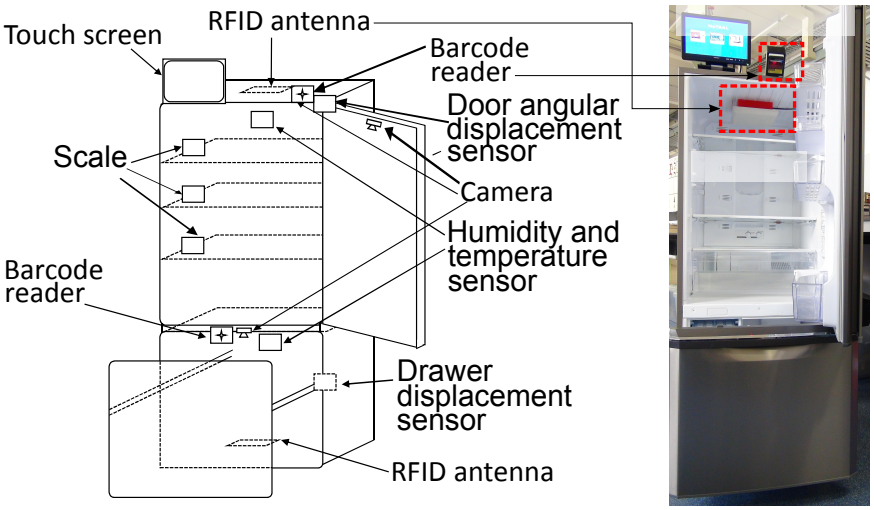


Fig. 10.4 Social refrigerator

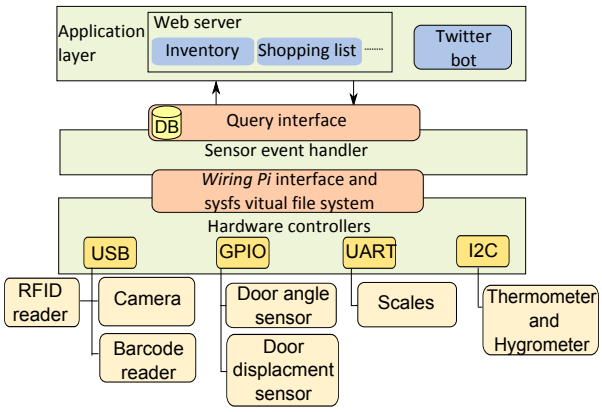


Fig. 10.5 Implementation of a social thing architecture presented in Figure 10.4 to realise the social refrigerator

10.2 Proof of concept implementation and demonstration

As a proof of concept of the HoTAAL architecture described in Section 10.1, three social appliances have been developed at the Auto-ID Lab of the University of Adelaide. These three appliances are: i) a social refrigerator; ii) a social microwave; and iii) a social bin. All these social appliances were developed utilising off-the-shelf kitchen appliances. A summary of their capabilities is listed in Table 10.1.

10.2.1 Social refrigerator

Figures 10.4 and 10.5 illustrate the social refrigerator realisation. The social refrigerator is equipped with a RFID reader (Thingmagic M6e) connected to three RFID

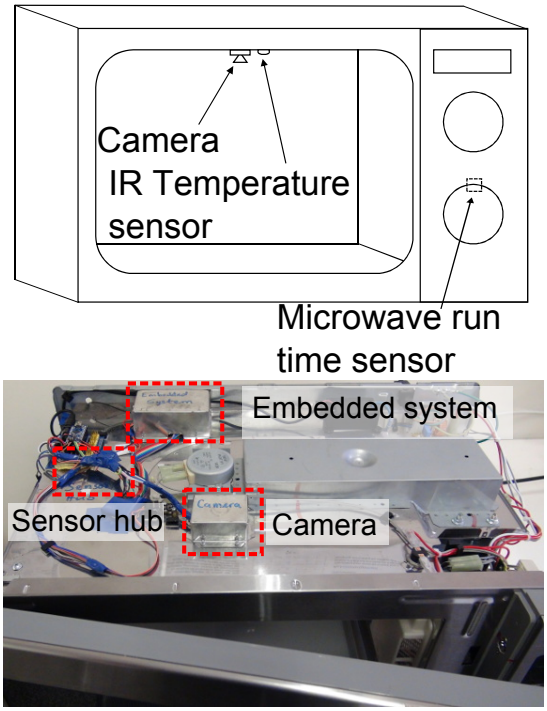


Fig. 10.6 Social microwave

antennas, two bar-code readers and scales. Using the information from these sensors, a food inventory can be maintained by identifying and quantifying food in the refrigerator cabinet. Furthermore, the refrigerator is capable of capturing an image of its content once the door is opened using the two cameras attached. The refrigerator contains switches to identify door movements, and thermometer and hygrometer to measure the environmental parameters within the refrigerator. All sensors are sampled using a Raspberry Pi single-board computer. The social refrigerator is currently capable of providing high-level services such as inventory management (based on bar codes and RFID tagged products), a cookbook and an automated shopping cart, based on monitoring food consumption and product expiry dates.

10.2.2 Social microwave

Figure 10.6 illustrates the social microwave realisation. The microwave is capable of identifying when its door is opened or closed, capturing an image while it is working, recording the temperature of the food being heated and identifying the cooking time. It has a camera and a non-contact IR thermometer both mounted on the ceiling of the cooking chamber (between the inner and the outer chassis). Additionally, a travel switch is attached to the timer dial to capture user selected time information.

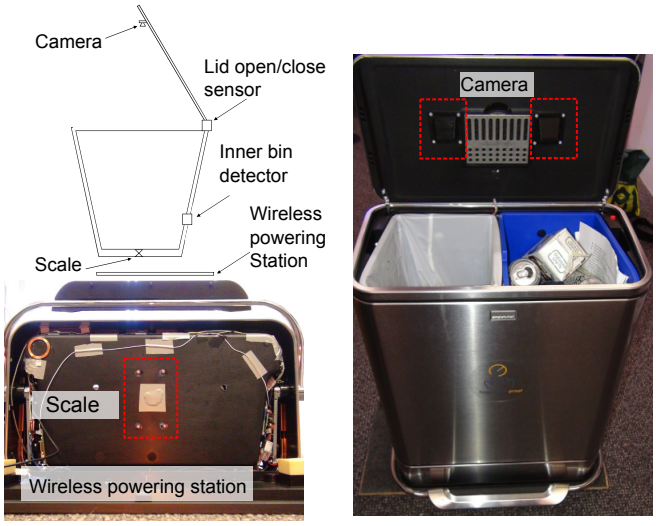


Fig. 10.7 Social bin

10.2.3 Social bin

Figure 10.7 illustrates the social bin realisation. The social bin employs a stainless steel bin equipped with two cameras (for the landfill and recycling bins) and switches. As a result, the bin is capable of identifying when it is opened or closed and capturing an image of the bin's content when the bin lid is opened. Additionally, weighing sensors attached to the bottom of the bin measure the amount of garbage. Therefore, the bin is capable of recognising when the bin is full. The bin is equipped with wireless powering capability in order to increase the ease of deployment in the real world.

10.2.4 Messaging system

For this proof of concept implementation stage, the Twitter social computing platform [261] was utilised as the messaging broker to implement the publisher-subscriber architecture. Each social thing maintained a private Twitter account. Using the privacy options available in Twitter, the Tweets were protected. Only those who are authorised– for example care workers and other social things at home will receive Tweets from a social appliance. Despite the simplicity in employing Twitter for communication, knowing its drawbacks is important when developing real-world applications. Twitter only allows 1,000 direct messages and 2400 tweets per day. Therefore, if these are found to be constraints, then Twitter can be replaced with a messaging scheme that can operate in a local area network, such as Telemetry Transport (MQTT) in future.

10.2.5 Demonstration scenario

In order to demonstrate the capabilities of the implemented social kitchen appliances, a demonstration was conducted at the IEEE International Conference on Pervasive Computing and Communication Workshops [263]. A video of the demonstration is available online at the Auto-ID Lab web site[1].

The demonstration was based on a meal preparation scenario centred around Elizabeth who is aged 82 years, diagnosed with dementia and living alone in her own home. In particular, the scenario was designed to demonstrate: i) the inventory management capability of the social refrigerator; ii) machine to machine communication between the social refrigerator and social microwave; iii) social interactions of all three appliances with an older person, mainly in the form of prompting; iv) open and close event detection capabilities of all three appliances; v) the capability of the microwave to capture the user selected cooking time information; vi) the capability of the microwave to capture an image after cooking finished; vii) the capability of the bin to capture an image of its content when the bin lid is open; and viii) full state detection capability of the social bin. It is also important to note that, for the demonstration purposes, the Twitter timeline has been used to provide information for the older person with dementia along with the voice prompts. The messages are displayed on a screen set-up in the kitchen. The interactions of social appliances and objects are illustrated in Figure 10.8. A twitter feed extract related to the demonstration is illustrated in Figure 10.9. The demonstration scenario is described below.

One day, Elizabeth's social refrigerator discovers that a frozen meal, is going to expire within a day. The social refrigerator notifies about this to Elizabeth to create awareness. The information is displayed on a screen and a voice prompt is used to draw attention to an important event. Elizabeth takes a frozen meal out of the refrigerator for her lunch. The social refrigerator recognises that the frozen meal is taken out and notifies the microwave to be ready to receive the frozen meal.

Elizabeth heats the meal using the social microwave. However, Elizabeth forgets the heating instructions and only heat the meal for 3 minutes. Elizabeth throws the food container away into the social bin and the social bin takes a photo of the bin content and uploads it to the HoTAAL twitter feed. Once cooking is finished, the microwave takes a photo of the food inside it and reports the status via the Twitter feed. Furthermore, the social microwave recognises that the meal is undercooked hence another 1 minute is needed to fully cook the meal based on information received from the social refrigerator. This information is provided as a suggestion to Elizabeth. After having the meal, Elizabeth throws the leftovers away into the social bin. With the

[1] http://autoidlab.cs.adelaide.edu.au/HoTAAL

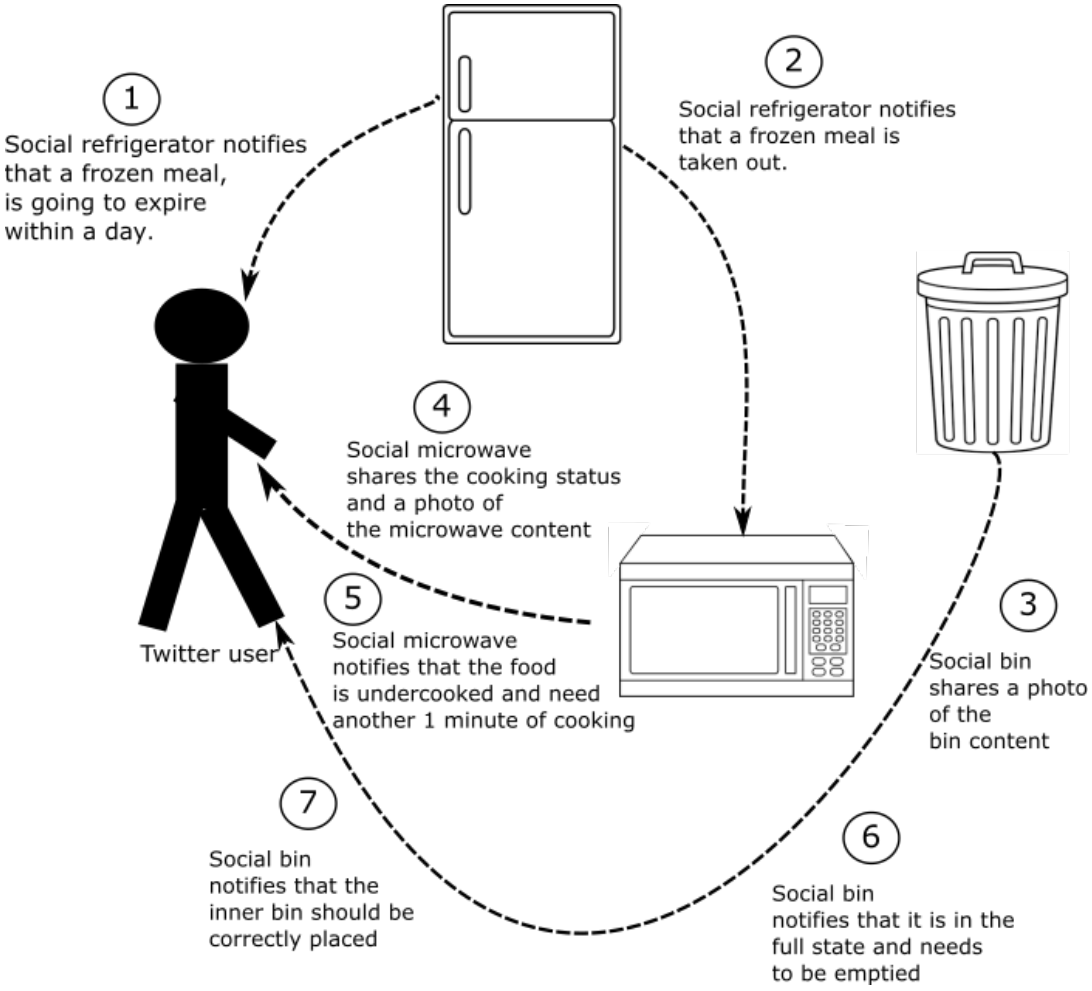


Fig. 10.8 Social interactions of the kitchen appliances and objects

newly added rubbish, Elizabeth's social bin recognises that it is in a full state, hence reminds Elizabeth that it needs to be emptied. After emptying the social bin, Elizabeth forgets to place the inner bin back correctly and the social bin instructs Elizabeth to do so.

10.3 Sample applications

Many technological applications are expected to show up to address the nutritional health issues identified through this thesis which can benefit from the proposed HoTAAL architecture. In this section, firstly, three such interesting applications derived from the focus group findings are described. These were selected to demonstrate the diverse nature of the applications that can be supported through the HoTAAL architecture. It is important that the developed technological applications need to be refined iteratively until they become suitable to be used in the real world. Therefore, secondly,

Fig. 10.9 Twitter feed extract for the demonstration. For the demonstration, only the sender, receiver and payload of the message have been populated.

several recommendations for evaluating such potential technology applications are being made.

10.3.1 Several potential technological applications

1. Care workers believed that providing rewards is an effective method for encouraging fluid intake. In particular, the following quotations from the focus groups presented in Section 7.1 demonstrate care workers' wishes for employing methods to automatically reward clients when they drink, in order to encourage them to drink more often:

   > *If they lifted the glass and their music [automatically] comes on for example. They may make the connection.*
   >
   > *When they touch it [the drinking container] with their lips may be [playing their favourite music, automatically], you know.*

   A possible way to realise this is to have a social drinking container and social music player. Chapter 9 presented a *smart cup* design and related methods to automatically recognise natural fluid intake gestures. Such a *smart cup* can be extended to realise fluid intake related applications in HoTAAL. As explained in Section 10.1.1, since the drinking containers are usually small in size, an ECA

engine and application layer could be implemented in a remote location and accessed wirelessly. The social music player can learn the favourite music or type of music of the older person. Thus, once the fluid container notifies that the older person is drinking, the music player can play the older persons' favourite music.

2. As described in Section 5.2, the capabilities of an older person are dependent on their level of dementia at any given moment. Even though older people are capable of using advanced kitchen appliances, at times, they may not even be able to operate simple appliances such as kettles. The following quotations presented in Section 5.2 further demonstrate this issue:

   > *It just depends on what level where they are in their dementia, I mean, obviously who can do that [use the microwave], when you get down-hill they have got no idea, would not know how to turn the kettle on.*
   >
   > *You do not know at what point in their level they are going to forget [how to operate appliances]. They may have levels but then, you know, you are talking about any one day, every time it is different.*

   The straightforward approach to ensure safety is to turn off the kitchen appliances which are unsafe. However, this may potentially challenge the older person's sense of control, dignity and independence. Therefore, based on the recommendations in Section 8.3.1, it is important for kitchen appliances to automatically adapt their functionalities according to older people's levels of dementia.

   As highlighted in Section 8.4.1, it is possible to design high level applications to automatically identify the level of cognitive decline of a person by closely analysing how activities of daily living are performed, based on the information obtained from diverse pervasive technologies deployed around the home [177, 182, 183]. Subsequently, the high-level applications can publish the level of dementia, allowing the social kitchen appliances to automatically adapt their capabilities to suit the individual.

3. As described in Section 6.1, the care workers explained that it is a challenge to continuously monitor whether their clients take out thrown away food items from the bin and put them back in refrigerators. As a result, care workers at times place clients' bins in the neighbours' yards or take the rubbish with them

when going home. The following quotations from the focus groups presented in Section 6.1 further demonstrate this issue:

> *He will go into the bin when they [home support workers] are gone and take it [what was thrown away by the home support workers] back out again.*

A possible way to address this issue employing HoTAAL is through the use of a social bin and a social refrigerator. The bin, equipped with sensors and cameras, is able to recognise when food items are placed inside or taken out. The bin prompts the older person as well as the care workers when a food item is taken out. The bin also notifies the refrigerator that a food item was taken out. Subsequently, if the older person places the food item in the refrigerator, based on the information obtained from the bin, the refrigerator prompts the older person with dementia to put the food items back into the bin. Furthermore, the refrigerator informs care workers that food items previously placed in the bin are currently placed inside the refrigerator.

It is also important to note that although monitoring items going in and out of the bins and refrigerators is important for some clients, such detailed information may not be required for other clients. As explained in Section 8.3.2, overloading care workers with information may increase their stress and potentially hinder their ability to focus on key areas with respect to nutrition and mealtimes of each client. Therefore, care workers should only be subscribed to messages of social bins and refrigerators of their clients when there is a need monitor those details.

10.3.2 Recommendations for evaluation

In this section several recommendations for evaluating technological applications based on the HoTAAL architecture are discussed.

Suitability of the HoTAAL architectural against different scenarios HoTAAL architecture facilitates the development of diverse technological applications for assisting older people with dementia. Hence, it is important to evaluate the suitability of HoTAAL against different scenarios derived from the findings of the qualitative descriptive study described in this thesis and other related literature. During this evaluation, it is important to consider how different technologies can be integrated or mapped into the HoTAAL architecture. This would raise any limitations, as well as ways in which HoTAAL can be used with a wide array of technologies.

Extensive user evaluation based on long-term in-home deployment Often technology prototypes are evaluated in laboratory environments. However, the households of each older person with dementia can be different. Therefore, it is essential to conduct an evaluation of HoTAAL with assistive technologies deployed in different households for a longer duration. This will allow users to experience the technologies in their natural environment for a longer time. Furthermore, it is important to take into account the perspectives of all active technology users, including older people with dementia, in the evaluation, where most designers only include them at the end of design and development process. It is expected that incorporating the active technology users and stakeholders from the outset of product development will increase its acceptance after real-world deployment.

10.4 Acknowledgement

A proof of concept implementation in HoTAAL using the social kitchen appliances was conducted by Yang Su, Timothy Stevens and Scott Huynh undergraduates at the University of Adelaide. The researcher's contribution has been in the architecture and demonstration aspects of HoTAAL.

10.5 Discussion

In this chapter, the possibility of seamlessly gluing heterogeneous technologies together, leveraging the emerging Internet of Things (IoT), in order to allow them to work collaboratively with each other as well humans to support older people with dementia living in their own homes was described. The proposed HoTAAL architecture allows everyday appliances and objects at home to exhibit seamless social interactions with each other and older people to provide assistance with daily living activities. It is expected that the HoTAAL will open up a new research paradigm where many useful applications for older people living at home and care workers can be developed to address the nutritional health issues identified by the focus groups in this thesis. As a proof of concept, three social kitchen appliances were implemented at the Auto-ID Lab based on the proposed HoTAAL architecture and a demonstration of the possibilities as to how those social appliances can assist older people with dementia in a meal preparation scenario was presented. Furthermore, several sample technological applications, based on HoTAAL, geared towards promoting the nutritional health of older people with dementia living in their own home were described. These sample application scenarios were devised from the findings of the qualitative study described

in this thesis and were selected to illustrate the diverse nature of applications that can be implemented utilising the HoTAAL architecture.

There are several major advantages of HoTAAL, compared with those in the previous literature. Firstly, HoTAAL utilises a publisher-subscriber mechanism for communication and does not use any central servers to host specific services, as in the SIoT proposed by Atzori et al. [260], as the social things and high-level applications manage their own data. Secondly, the proposed messaging protocol is simple, flexible and allows social things to communicate with each other as well as humans in a naturalistic manner. This is an advantage over previous research which was primarily developed as IoT-based stand-alone applications [225, 257, 258]. Based on the publisher-subscriber mechanism, social things and humans (such as older people and care workers) can only receive messages of interest by subscribing to the selected senders or message types. Thirdly, as the publisher/subscriber messaging mechanism facilitates easily introducing and removing social things with minimal changes to other devices or applications, it is expected that ambient assisted living environments can be easily updated according to the evolving needs of older people with dementia. Fourthly, the proposed architecture for a social thing allows it to be intelligent and perform a certain amount of tasks autonomously, which can be considered an advantage compared with previous research [259].

In summary, HoTAAL can be used to seamlessly inter-connect intelligent things at home to facilitate many ambient assisted living applications. Although through the proof of concept implementation, the limited capabilities of HoTAAL in a meal preparation scenario have been demonstrated, it could be well used in realising other social things and diverse technological applications useful for promoting the nutritional health in older people with dementia.

Chapter 11

Discussion on the findings of the technology development demonstrations

Section III of the thesis presented two technology development demonstration studies. The technologies were designed considering several design considerations proposed in Section II.

In Chapter 9, the feasibility and efficacy of a RFID enabled fluid container (i.e. *smart cup*) to recognise human motions related to fluid intake is investigated as a step towards a comprehensive fluid intake monitoring system for the first time, to the best of the researcher's knowledge. Continuous monitoring of fluid intake gestures is essential for reliable monitoring of fluid intake behaviours. From the results of the experiments conducted with young people using broadly scripted activity routines and older people in an unscripted setting, it is evident that fluid intake related human gestures can be successfully recognised based on the variations in the RSSI and phase patterns obtained from the data stream of the proposed *smart cup*, despite the other movements involving the *smart cup*. The batteryless RFID tags can be easily embedded into everyday objects, creating possibilities for monitoring fluid intake behaviours without the need for any body-worn sensors or cameras, while allowing users to carry out their normal routines without any alterations. The findings of this study can be extended for developing diverse technological applications related to fluid intake, considering older people with dementia or their care workers as the technology users. Furthermore, the findings of the study suggest the potential for employing RFID enabled objects to monitor other primitive movements related to other mealtime activities such as eating and cooking.

In Chapter 10, HoTAAL, is presented as a possible architecture for combining the ubiquity of Internet connectivity in homes with pervasive and intelligent sensors, to allow physical sensors to exhibit seamless interactions with each other as well as humans. The chapter reported a demonstration of the possibility of employing three social kitchen appliances for providing meal preparation assistance. Additionally, possible technological applications to address three scenarios devised from the focus group findings are described in order to illustrate the diverse nature of technologies that could be realised by employing the HoTAAL architecture. Here the possibility of employing the *smart cup* proposed in this thesis to realise a fluid intake related application in HoTAAL was also described. Although the proof of concept demonstration only showed limited services that can be realised in HoTAAL, in the future, it is envisioned that diverse technological applications will be developed employing HoTAAL to address the nutritional health related challenges identified through the qualitative descriptive study reported in this thesis.

Section IV

Revisiting the purpose

Chapter 12

Conclusion

Reduced nutritional health in older people can have many adverse outcomes which include increased frailty, reduced wound healing, recurrent hospitalisation, and increased mortality [16–19]. In particular, poor nutritional health can be more challenging for older people with dementia as it can further complicate their cognitive level and threaten their ability to live independently in their own home for longer [20]. Therefore, with the rapidly growing ageing population, there is an urgent need to explore ways to promote nutritional health in older people with dementia living at their own home. This thesis has presented an investigation, through cross-disciplinary research, as to how technologies can be used to promote nutritional health in older people with dementia living in their own home.

The need for acquiring a deeper understanding of nutrition and mealtime situations related to older people with dementia for effective technology development is argued throughout this thesis. It is important that technology needs are identified without pre-defining the technology delivery mechanisms. An in-depth qualitative descriptive study, involving 27 care workers, provides a deeper understanding about the nutrition and mealtime situations of older people with dementia living in their own home which is useful for developing effective nutritional health-promoting technologies. To the best of the researcher's knowledge, this is the first study in this direction. Rooted in the concepts of qualitative descriptive research design, eight categories emerged from the focus group data. Each category was formulated by one or more related concepts. Each concept consisted of one or more related nodes. Although providing technological assistance should not be considered as the sole solution in this context, it is evident that there are certainly opportunities and benefits for designing and developing nutritional health-promoting technologies, by considering both older people and their care workers as technology users.

The identified challenges faced by older people with dementia and their care workers demonstrate a demand for support, need for technological assistance and opportunities for developing technologies for promoting the nutritional health of older people with dementia living in their own home. Given the fluctuating and changing levels of dementia and physical capabilities of older people over time, an holistic view of nutritional health situations and associated challenges facilitates the development of a range of technological applications that can collectively cater for the needs of a diverse population. In particular, the findings of the qualitative descriptive study reported in this thesis allow future technologies in this space to be effective, usable, acceptable, easily translated into practice and introduced only where required rather than being forced into areas which do not require them. Moreover, although care workers' wishes have not been evaluated against their technical feasibility, they provide future directions for technology development worth exploring further. In addition, the findings of the study may provide useful hints for developing aged care policies, and training programs for staff involved in dementia care.

Apart from the knowledge in the form of categories, concepts and nodes, eleven design considerations to guide the overall design of technologies geared towards assisting older people with dementia to maintain good nutrition and care workers to provide better support to their clients are resulted from the qualitative descriptive study. These design considerations draw important aspects related to technology design for promoting nutritional health of older people with dementia to technology designers' attention. In particular, this included six design considerations for technologies assisting older people with dementia and five design considerations for technologies assisting care workers. The thesis also presented several potential avenues for technology development considering findings of the qualitative descriptive study and existing technology development studies to provide useful additional information for future technology development. It is important to highlight that although a range of technologies can be developed based on the nutritional health related challenges and the design considerations described in this thesis, identifying and prioritising the needs of each individual is important before technology deployment, as each individual can be different.

In addition to the in-depth qualitative descriptive study, this thesis reported two technology development demonstrations based on several proposed design considerations. This included an investigation into the feasibility and efficacy of automatically recognising periods of drinking (i.e. drinking episodes) using batteryless UHF RFID tags by attaching them to drinking containers for the first time to the best of the researcher's knowledge. This is important as the qualitative descriptive study findings revealed that simply monitoring the water levels alone may not be a reliable estimate of fluid consumption. To this end, based on the proposed design considerations, it is

necessary to monitor primitive human motions, particularly human motions related to drinking. Nevertheless, applied monitoring technologies should not create any additional burden to the older people with dementia or to their care workers, which have been proposed as design considerations. Although batteryless RFID technology has practical advantages over battery-powered sensors and cameras [116, 218, 219], the RFID data stream generally result in greater challenges for human motion recognition, compared with rich sensor data obtained from other sensors. On the other hand, most previous batteryless RFID based approaches have considered recognising well defined gestures [230–233]. However, the feasibility of recognising natural human gestures, particularly related to fluid intake, has not been investigated. Despite these challenges, the results obtained from experiments demonstrate that short duration, short distance, natural drinking episodes can be successfully recognised using the variations of RFID information from the proposed *smart cup*. Additionally, the successful identification of drinking episodes for the older people dataset using machine learning models trained using the data from young people dataset are indicative of the robustness and the generalisability of the proposed approach. This is advantageous as young people could be easily recruited compared to older people for collecting training data. The findings of the study suggest the potential for employing RFID enabled objects to monitor other short distance, short duration, natural primitive movements related to other mealtime activities such as eating and cooking. Furthermore, the findings provide the opportunity to develop diverse fluid intake related technological applications useful for older people with dementia and their care workers.

The thesis also reported a possible architecture and a demonstration for combining the ubiquity of Internet connectivity in homes with pervasive and intelligent sensors. Making intelligent appliances and objects at home inter-connect with each other as well as humans was proposed as one of the technology design considerations. However, it is important that technologies to not create an additional burden to older people with dementia or create additional workload for their care workers as proposed as design considerations. Previous unobtrusive smart home technologies, have predominantly been based on sensors attached to everyday objects to provide them with sensing capabilities and mostly designed in an isolated manner [255, 178, 256, 225, 100, 258]. This poses great limitations on the nature of technological applications that can be designed and developed. In HoTAAL architecture, a publisher/subscriber messaging mechanism is employed for communication among the social things as it provides a simple and flexible way for them to communicate with each other, as well as with humans, in a naturalistic manner. Only the social things and humans (such as older people and care workers) who subscribe to a specific sender or message type will receive relevant messages when they are published. The message format employed in

HoTAAL enables the publisher/subscriber messaging mechanism to be implemented using the Twitter social computing platform. Several capabilities of the HoTAAL architecture, including interactions among social things and interactions between the older person and social things, were demonstrated, employing a social fridge, social microwave, and a social bin to consider a meal preparation activity for older people with dementia. Although HoTAAL is still not fully realised, based on the demonstration and the discussion on potential technology applications, it can be envisioned that diverse technologies can be developed in the future employing HoTAAL to address the nutritional health related challenges identified through the qualitative descriptive study reported in this thesis.

12.1 Suggestions for future research directions

A number of future research avenues exists as a result of this thesis.

When proposing technologies to address a specific challenge related to older people with dementia or their care workers, as described in Section 8.5.2, it cannot be guaranteed that technologies developed using the obtained information alone can reach the desired level of maturity. Although the findings of the qualitative descriptive study provide a firm ground to develop such technologies, further investigation into each issue may be required prior to technology development and evaluation. It is also important to note that the technology development is an iterative process wherein each iteration is built upon the feedback from the previous iteration.

It is important to explore the question about who should make the decisions about whether or not to use technologies for assisting older people with dementia to maintain their nutritional health. Although previous researchers have highlighted that older people with cognitive decline, even having mild dementia, may have difficulty in making decisions about their everyday life [264, 265], a parallel line of researchers argues the importance of obtaining the informed consent from older people with dementia, despite their cognitive impairments, prior to deploying any assistive technology [266, 216, 217]. In addition, previous research highlights that it is useful to consider the wishes and interests of families, care workers and medical professionals in the decision making process on the use of technologies for assisting older people with dementia [216].

In order to deploy nutritional health-promoting technologies, it is important to consider a financial model for the purchase and maintenance of those technologies. In particular, an investigation as to who should pay for those technological systems should be undertaken. One possibility is for the respective aged care organisations to

pay for the cost involved in technologies assisting care workers. However, it is unclear as to who should pay for the technologies supporting older people with dementia. Previous research highlights that older people may not be willing to pay for assistive technologies [267, 268]. In such situations, it may be worthwhile to explore the possibilities to develop policies to reimburse the cost involved in buying those devices through a health care insurances of older people with dementia [217].

Care workers highlighted a high variation in technological skills among older people with dementia. This can be a result of the differences in their familiarity with technologies and their cognitive level. Therefore, it is useful to investigate the effects of the technology skills of older people with dementia on the successful use of different types of nutritional health promoting technologies.

Two types of care workers were recruited to increase the variation in sampling. No attempts were made to compare their perspectives during the data analysis, as the goal of the qualitative descriptive study is to obtain an holistic perspective of the needs for technologies geared towards promoting nutritional health in older people with dementia living in their own home. However, it will be a useful exercise to compare the perspectives of the different types of care workers in future.

Care workers' wishes in communicating and collaborating with the families of their clients, where possible, to improve the effectiveness of the care services provided were evident through the focus group findings. Therefore, it is useful to conduct further research on families' technology needs with respect to nutrition and mealtimes of older people with dementia living in their own home.

Although the proposed batteryless RFID enabled fluid intake recognition approach has been evaluated in a realistic settings as described in Chapter 9, using data collected from young and old participants, it is important to evaluate the technical performance and user acceptance of the proposed approach by deploying the system in the homes of older people with dementia for a longer period. Furthermore, the differences in drinking episode duration have been identified as one of the reasons for the lower performance in the older people dataset, compared with the young people dataset. This was because the segmentation relied on the average drinking episode duration of the training data and performance of the older people dataset was calculated based on models trained from data collected from young participants. Therefore, a dynamic segmentation approach needs to be explored to alleviate this issue and subsequently improve the performance. In the future, to achieve a comprehensive fluid intake monitoring system it will be useful to recognise fluid levels in real time by extending the proposed system by considering previous research studies [208, 211]. Furthermore, successful recognition of fluid intake related human gestures suggests the potential

for employing RFID enabled objects to monitor primitive movements related to other mealtime activities such as eating and cooking.

Although a part of the HoTTAL architecture was realised as a proof of concept to demonstrate some of its capabilities in a meal preparation scenario, as reported in Chapter 10, future work is required to increase the easy deployment of HoTAAL in the homes of older people with dementia. This includes devising a protocol for social things to autonomously register and themselves, including the services exposed from HoTAAL. This will allow technologies to be added and removed from HoTAAL seamlessly based on the fluctuating needs of older people with dementia, thus eliminating or minimising the requirement for manual configuration to enable easy maintenance and upgrades. Such a protocol could be realised by extending the existing messaging format. Furthermore, the proof of concept implementation employed the Twitter platform to implement the messaging system. However, this demands social things to have a continuous internet connectivity and an email address. Also, Twitter imposes constraints on the number tweets per day and rate of tweets that can be posted. If these circumstances are found to be constraints, then Twitter can be replaced with a messaging scheme that can operate in a local area network, such as MQ Telemetry Transport (MQTT).

12.2 Concluding remarks

In conclusion, although poor nutrition will continue to be a major issue threatening the health and independence of older people with dementia, the findings of this thesis suggest that the design and development of nutritional health-promoting technologies targeting older people with dementia are beneficial. Such technologies may have an impetus to improve the nutritional health of older people with dementia and subsequently delay their admission to residential care or hospitals. By obtaining an holistic perspective of the needs for technologies geared towards assisting older people with dementia to maintain good nutrition and for facilitating care workers to provide improved support to their clients, and proposing a set of technology design considerations, this thesis provides a solid foundation for future technology development in this space.

The technology development studies reported in this thesis demonstrate several examples, as stepping stones, for designing and developing technologies geared towards promoting the nutrition health of older people with dementia. In particular, the fluid intake gesture recognition study successfully demonstrated the feasibility and efficacy of recognising short distance, short duration natural human gestures particularly related to fluid intake using drinking containers attached with passive

RFID tags. This finding can be extended to monitor other mealtime-related activities such as eating and cooking unobtrusively. Furthermore, it can be expected that the HoTAAL architecture will facilitate the development of a collaborative environment where heterogeneous technologies can have seamless integration with each other as well as humans to develop a wide array of innovative technological applications to promote the nutritional well-being of older people with dementia. In the future, it will be essential to ideate technology solutions for nutritional health related challenges uncovered through this thesis, based on the proposed design considerations.

It is believed that the contributions made in this thesis are a significant step towards designing and developing technologies for the promotion of nutritional health in older people with dementia living in their own home.

Appendix A

Ethics approval

The following document presents the ethics approval obtained from the Human Research Ethics Committee, of The University of Adelaide to conduct the focus groups with the care workers recruited by the aged care organisations.

THE UNIVERSITY of ADELAIDE

RESEARCH BRANCH
OFFICE OF RESEARCH ETHICS, COMPLIANCE AND INTEGRITY

LEVEL 7, 115 GRENFELL STREET
THE UNIVERSITY OF ADELAIDE
SA 5005 AUSTRALIA

TELEPHONE +61 8 8313 5137
FACSIMILE +61 8 8313 3700
EMAIL hrec@adelaide.edu.au

CRICOS Provider Number 00123M

6 October 2015

Associate Professor A Wilson
School of Medicine

Dear Associate Professor Wilson

ETHICS APPROVAL No: **H-2014-246**

PROJECT TITLE: **Informing technology development to prevent malnutrition in older people with dementia living alone in the community**

Thank you for the application dated 01 October 2015 requesting amendment to the above project. The amendment to applicant, participant information sheets, letters of introduction and survey as detailed in the submitted ethics application has been reviewed by the Low Risk Human Research Ethics Review Group (Faculty of Health Sciences) and approved.

The ethics expiry date for this project is **30 November 2017**.

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled *Annual Report on Project Status* is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/ethics/human/guidelines/reporting. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the Information Sheet and the signed Consent Form to retain. It is also a condition of approval that you **immediately report** anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol; and
- the project is discontinued before the expected date of completion.

Please refer to the following ethics approval document for any additional conditions that may apply to this project.

Yours sincerely,

Sabine Schreiber
Secretary, Human Research Ethics Committee
Office of Research Ethics, Compliance and Integrity

Appendix B

Consent form

Following document presents the consent form used during the focus group meetings with the care workers.

Human Research Ethics Committee (HREC)

CONSENT FORM

1. I have read the attached Information Sheet and agree to take part in the following research project:

Title:	**Informing technology development to prevent malnutrition in older people with dementia living alone in the community**
Ethics Approval Number:	**H-2014-246**

2. I have had the project, so far as it affects me, fully explained to my satisfaction by the research worker. My consent is given freely.

3. I have been given the opportunity to have a member of my family or a friend present while the project was explained to me.

4. Although I understand the purpose of the research project it has also been explained that involvement may not be of any benefit to me.

5. I have been informed that, while information gained during the study may be published, I will not be identified and my personal results will not be divulged.

6. I understand that I am free to withdraw from the project at any time.

7. I agree to the discussion being audio recorded. Yes ☐ No ☐

8. I am aware that I should keep a copy of this Consent Form, when completed, and the attached Information Sheet.

Participant to complete:

Name: _____Signature: _____ Date: _____

Researcher/Witness to complete:

I have described the nature of the research to _____
(print name of participant)

and in my opinion she/he understood the explanation.

Signature: _____Position:_____ Date: _____

Appendix C

Contacts for information on project and independent complaints procedure

The following document presents the contacts for information on project and independent complaints procedure used during the focus group meetings with the care workers.

The University of Adelaide
Human Research Ethics Committee (HREC)

This document is for people who are participants in a research project.

CONTACTS FOR INFORMATION ON PROJECT AND INDEPENDENT COMPLAINTS PROCEDURE

The following study has been reviewed and approved by the University of Adelaide Human Research Ethics Committee:

Project Title:	**Informing technology development to prevent malnutrition in older people with dementia living alone in the community**
Approval Number:	**H-2014-246**

The Human Research Ethics Committee monitors all the research projects which it has approved. The committee considers it important that people participating in approved projects have an independent and confidential reporting mechanism which they can use if they have any worries or complaints about that research.

This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research (see http://www.nhmrc.gov.au/publications/synopses/e72syn.htm)

1. If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the project co-ordinator:

Name	**Associate Professor Anne Wilson**
Phone	**(04) 19030436**
Name:	**Professor Renuka Visvanathan**
Phone:	**(08) 82226000**
Name:	**Dr. Damith Ranasinghe**
Phone:	**(08) 83130066**

Name:	**Ms. Asangi Jayatialaka (asangi.jayatilaka@adelaide.edu.au)**
Phone:	**(08) 83134519**
Name	**Mr. Asanga Wickramasinghe**
Phone:	**(08) 83134519**

2. If you wish to discuss with an independent person matters related to:
   - making a complaint, or
   - raising concerns on the conduct of the project, or
   - the University policy on research involving human participants, or
   - your rights as a participant,

   contact the Human Research Ethics Committee's Secretariat on phone (08) 8313 6028 or by email to hrec@adelaide.edu.au

Appendix D

Participant information sheet

The following document presents the participant information sheet used during the focus group meetings with the care workers.

PARTICIPANT INFORMATION SHEET

PROJECT TITLE: Informing technology development to prevent malnutrition in older people with dementia living alone in the community

PRINCIPAL INVESTIGATOR: Associate Professor Anne Wilson
STUDENT RESEARCHERS: Asangi Jaytailaka (PhD Candidate),
Asanga Wickramasinghe (PhD Candidate)

Dear Participant,

You are invited to participate in the research project described below.

What is the project about?
Many people diagnosed with dementia living in the community are at high risk of developing malnutrition. A wide range of valuable technology solutions can be designed towards the prevention of malnutrition. The application of these solutions could create a great potential to reduce the occurrence of malnutrition, thereby enhancing the quality of life of people with dementia, and ensuring independent living for a longer period of time. In order to design such usable and acceptable solutions, this study focuses on understanding your expectations and views regarding such technological interventions. The knowledge gained through this research will help to identify the technological requirements for interventions leading towards the prevention of malnutrition of people with dementia.

Who is undertaking the project?
This project is being conducted by Ms Asangi Jayatilaka and Mr Asanga Wickramasinghe who are PhD students of the University of Adelaide. This research will be completed under the supervision of Associate Professor Anne Wilson, Professor Renuka Visvanathan (Director, Adelaide Geriatrics Training and Research with Aged Care Centre (G-TRAC) and Director, Aged & Extended Care Services, the Queen Elizabeth Hospital, Adelaide) and Dr Damith Ranisinghe (Lecturer, School of Computer Science, Director of Adelaide Auto-ID Lab).

Why am I being invited to participate?
You are invited to participate in this study as you are a formal care giver, providing care support to older adults diagnosed with dementia living in the community.

What will I be asked to do?
You will be asked to participate in a focus group meeting with other formal caregivers. During the meeting you will be requested to discuss your expectations and views regarding technology solutions geared towards preventing malnutrition and facilitating independent living of older people with dementia. The discussion will be audio recorded.

How much time will the project take?

It will take up to 90 minutes to complete the focus group meeting and this will be considered as paid time.

Are there any risks associated with participating in this project?
There are no foreseeable risks in the study.

What are the benefits of the research project?
There will be no immediate benefit for you by participating in this study. However, if the study is successful, the results of the study will contribute towards the design of technology solutions which could prevent the development of malnutrition, especially in older people with dementia living alone in the community.

Can I withdraw from the project?
Participation in this project is completely voluntary. If you agree to participate, you can withdraw from the study at any time. Your employment will not be impacted if you choose not to participate or withdraw from the research.

What will happen to my information?
Your study data will be handled confidentially. Your consent forms and the audio recording (CD) of the discussion and any notes made by the researcher will be securely stored in a locked cupboard in the School of Medicine, University of Adelaide for 15 years. Only the researchers stated in the application will have access to this information. The findings of the study will be published in conference and/or journal papers and used for education or awareness programs. It is guaranteed that the participants in this research will not be identified in any publication. The findings of the study will guide the design decisions of technology enabled solutions geared towards preventing malnutrition of older people with dementia who live in the community. Upon direct request, results of this study will be made available to you.

Who do I contact if I have questions about the project?
For any information regarding the project you should contact:
Associate Professor Anne Wilson (primary contact person) – (04) 19030436
Professor Renuka Visvanathan - (08) 82226000
Dr Damith Ranasinghe - (08) 83130066
Ms Asangi Jayatilaka - (08) 83134519
Mr Asanga Wickramasinghe - (08) 83134519

What if I have a complaint or any concerns?
The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2014-246). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. Contact the Human Research Ethics Committee's Secretariat on phone (08) 8313 6028 or by email to hrec@adelaide.edu.au. if you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant. Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

If I want to participate, what do I do?

If you are interested in participating in this study please express your willingness to your manager. Then the manager will confirm with you the date, time and exact location (meeting room) for the focus group meeting depending on the availability of all the participants. We encourage you to attend the focus group meeting in person. However, we understand there might be practical difficulties in doing so. In this case you can attend the focus group meeting through the telephone. In the case where you will attend the focus group meeting in person, the written consent will be obtained just prior to the focus group meeting in the presence of the researcher. In the case where you will attend the focus group meeting through telephone, you need to send the signed consent form to the researchers before the meeting date. You can either email (asangi.jayatilaka@adelaide.edu.au) or post the signed consent form (Ms Asangi Jayatilaka, Level 4, Ingkarni Wardli North Terrace Campus The University of Adelaide SA 5005 Australia).

Yours sincerely,

Associate Professor Anne Wilson : ……

Professor Renuka Visvanathan (Director, Adelaide Geriatrics Training and Research with Aged Care Centre (G-TRAC) and
Director, Aged & Extended Care Services) : ……

Dr Damith Ranasinghe (Lecturer, School of Computer Science,
Director of Adelaide Auto-ID Lab) : ……

Ms Asangi Jayatilaka (PhD Candidate) : ……

Ms Asanga Wickramasinghe (PhD Candidate) : ……

Appendix E

Participant basic information collection form

The following document presents the document used to collected basic information from the care workers who participated in the focus groups.

Researcher only

ID: ….. Date: …….. Organization: ……..

THE UNIVERSITY of ADELAIDE

Informing technology development to prevent malnutrition in older people with dementia living alone in the community: Participant basic information collection form

Please email this form to asangi.jayatilaka@adealide.edu.au after completing.

Full name	……..
Age	……..
Role	☐ Coordinator ☐ Home support worker ☐ Other; please specify .....…….....
Main tasks/responsibilities	……. ……..
Office location/regions responsible (postcodes)	……
How many days per week do you work?	……
Do you have any professional qualifications?	☐ No ☐ Yes; please specify .....…….....
Your Experience	……years in the aged care industry ……years in supporting older people with dementia living in their own homes
On average, how many clients do you handle per month?	…… clients per month (in general)

	……clients, who are diagnosed with dementia living in their own home
On average, how many times per month, do you directly interact with a client who is living at his/her own home?	**In person (**per month per client**)** in general:…… times who is diagnosed with dementia: …… times **Through Phone (**per month per client) in general:…… times who is diagnosed with dementia: …… times
If you directly interact with clients who are living in their own homes**,** how many hours do you spend with each client per month?	**In total** (per month) in general:…… hours with a client who is diagnosed with dementia: …… hours **In person** (per month) in general:…… hours with a client who is diagnosed with dementia: …… hours
Do you provide services by visiting your clients at home?	☐ Yes ☐ No ☐ Other; please explain .....……....
What sort of nutrition or meal time (meal planning, shopping, food preparation, meal/fluid consumption etc…) support do you provide to clients who are with dementia and are living in their own home?	…….. ……
What sort of information do you currently record about nutrition or meal times (meal planning, shopping, food preparation, meal/fluid consumption etc…) of clients who are with dementia and are living in their own home?	…… ……
How do you currently record and manage information about your clients?	☐ Electronically; can you explain ☐ Manually; can you explain ☐ Both; can you explain …….

Do you have experience in using any kind of technology when proving care services (e.g. tools that assist with Activities of Daily Living, remote monitoring, alerts, reminders, email, etc...)	☐ Yes; please let us know what tools or technologies you use …….. ☐ No

Thank you very much for your participation.

Appendix F

Focus group guide

The following document presents the guide used to conduct the focus groups.

Informing technology development to prevent malnutrition in older people with dementia living alone in the community

Focus Group Guide

1. **Welcome**

Good morning/good afternoon, I'm Asangi Jayatilaka. I'm a PhD student of the University of Adelaide. I warmly welcome all of you to this focus group meeting. I also want to thank each and every one of you for agreeing to participate in this study and for spending your precious time with us today. Let me also introduce my supervisor Associate Professor Anne Wilson, from the School of Medicine of University of Adelaide, who is here with me today.

2. **Explanation of the purpose and the process**

Let me explain to you the purpose of this study.

It has been identified that older people living in their own homes, especially ones diagnosed with dementia, are at a high risk of developing malnutrition. As you know, malnutrition can increase morbidity, increase treatment costs and reduce the capability of older people of living independently in their own home.

There is increasing interest in the use of technology to support independent living at home. From what we can tell, there has been little technology development looking specifically at how we can monitor/assist/promote nutritional intake in older people with dementia in order to help them stay in their own home for a longer period of time and also to assist caregivers to provide a better service to the clients in order to ensure good nutrition.

The main question that will be discussed today is printed and given to you..

3. **Ground Rules**

   Participation is voluntary and you can terminate at any time you wish but please let us know if you are doing so. So let us define some ground rules for the meeting.

   1. Firstly, everyone should participate.
   2. There are no right or wrong answers
   3. As we are audio recording, please speak one at a time. This can done on a first come, first served basis.
   4. Stay with the group and please don't have side conversations, as this will cause distractions and we may lose good information

4. **Consent forms** - Your consent form is on the table, so please sign it before starting the discussion. Additionally, please fill in the demographic information sheet, if you have not already done so before leaving today.

5. While you are signing the consent forms, I'm happy to answer any questions that you might have.

6. **Turn on recorders**

7. Before moving into the discussion we would like to get to know you. As we are also recording, can you very briefly let us know who you are and what your role is in this organization very briefly.

8. **Questions:**

   Thank you, we will now move onto the discussion.

   I want to make it clear that this focus group is centered around your clients' who are diagnosed with dementia and living in their own homes with or without the support of family. So whenever I say the word "target group", I am always referring to this group.

- Opening question –

1. *To start the discussion, please let us know how you (or other staff) currently support the target group to achieve good nutrition.*

2. *According to your experience, what are the difficulties for the target group in maintaining good nutrition?*

   Probes: Challenges related to eating, drinking, cooking, adequacy and quality of the meals, shopping, meal planning issues, cultural and religious issues

3. *Please tell us what sort of meal time activities of the target group do you as caregivers (or other staff) currently struggle to support?*

   Probes: Challenges in executing the plans, monitoring, shopping, meal plans and meal preparation

4. *What information related to nutrition and mealtime activities of the target group do you consider useful if available, on a day to day basis, to provide better support to them?*

   Probes: Information related to eating, drinking, cooking, shopping, alarming situations

6. Technologies can be used to promote independent living and also monitor older people at home. There is a wide variety of in-home monitoring and supporting technologies. For example have a look at this one <show video>. So this is just one example. There are also other types of technologies that are commonly used to monitor or support people living in their own home <show slides>. Also many other such technologies can be designed, based on your needs and wishes.

   We would like you to think out of the box and not limit yourselves to the technologies available in the market today.

   So, if you could wish for anything and technology can be used to achieve those wishes...

   1) What kind of assistance do you wish for from a technology?

   2) What kind of assistance do you think your clients would wish for?

   to help monitor/promote/maintain good nutrition, among older people diagnosed with dementia living in their own home?

Appendix G

Model parameters used for the fluid intake gesture recognition

Here we lists the model parameters optimised for each classification algorithm.

1. Conditional Random Fields (CRF)

   λ: Regularisation parameter

2. Linear Support Vector Machine (LSVM)

   C: Cost of misclassification [249]

3. Non linear Support Vector Machines (NSVM)

   C: Cost of misclassification [250]

   γ: γ in the radial basis function kernel, where the kernel is $k(x_i, x_j) = e^{-\gamma \|x_i - x_j\|^2}$ [250]

4. Logistic Regression (LR)

   C: Cost of misclassification [249]

5. Random Forest (RF)

   $nTrees$: Number of trees in the ensemble

G.1 Model parameters for young people dataset

Table G.1 Model parameters for young people dataset when using the *s3* feature extraction method for different tag combinations using different classifiers

CRF	LSVM	NSVM	LR	RF
4-tag combination				
$\lambda = 512$	$C = 0.125$	$C = 2.0, \gamma = 0.015625$	$C = 0.25$	$nTrees = 100$
3-tag combination				
$\lambda = 512$	$C = 0.125$	$C = 2.0, \gamma = 0.015625$	$C = 512$	$nTrees = 100$
2-tag combination				
$\lambda = 1024$	$C = 1.0$	$C = 2.0, \gamma = 0.0625$	$C = 0.5$	$nTrees = 100$
1-tag combination				
$\lambda = 512$	$C = 8.0$	$C = 8.0, \gamma = 0.0625$	$C = 512$	$nTrees = 100$

G.2 Model parameters for older people dataset

Table G.2 Model parameters for old people dataset when using *s3* feature extraction and NSVM models trained using young participant data

Tag combination	Model parameters
4-tag combination	$C = 2.0, \gamma = 0.015625$
3-tag combination	$C = 2.0, \gamma = 0.015625$
2-tag combination	$C = 2.0, \gamma = 0.0625$
1-tag combination	$C = 8.0, \gamma = 0.0625$

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