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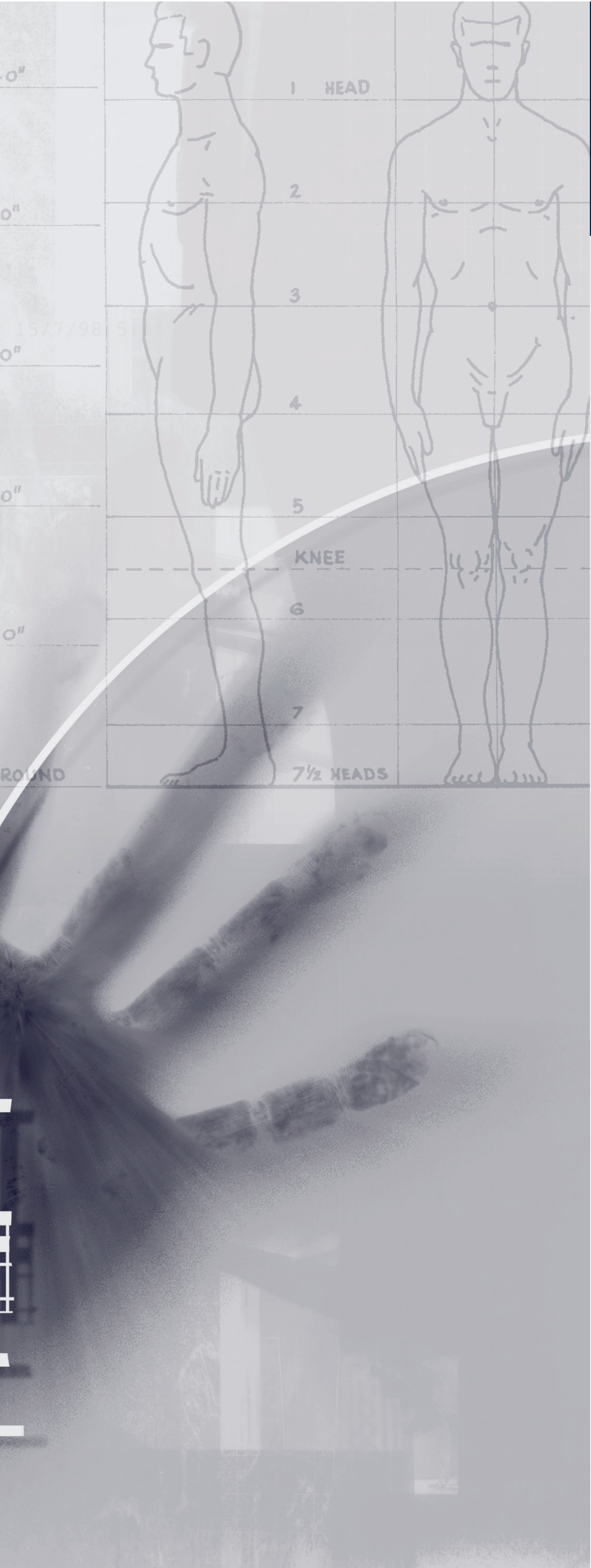
The Official Journal of the Human Factors & Ergonomics Society of Australia Inc



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HFESA Mission Statement Promoting systems, space and designs for People

Editorial

This March-June edition is a bumper two editions in one with four interesting and valuable papers. The program got off track at the end of last year and in spite of a continuing series of difficulties things are beginning to stabilize. All being well, and having papers to hand, the normal pattern should be resumed by September. The end and beginning of each year always have been the most difficult to accommodate. December-January are busy times for many people ... some of whom have been involved with a November Annual Conference and need to get back to their regular work. Others are winding up the year's activities and looking forward to holiday time. This year, a very early Easter put another spanner in the works! Until we have a steady backlog of papers it is hard to determine content in advance and time flies while gathering material and arranging for referee and editing processes. Many factors impinge on creating a reliable routine while a publication is getting firmly established. As stated many times previously, there is a need for an active all-states editorial committee to share the responsibility of promoting contributions and monitoring their progress. As demonstrated by the contributions from other countries over the years, *Ergonomics Australia* has the potential to become a significant voice promoting ergonomics in the southern hemisphere.

There are papers from authors in Australia, India and France in this edition. Recent media attention has focussed on the need to encourage more active lifestyles ... to both improve the national health profile and to limit the use of private vehicles and their consumption of finite oil reserves. While industry concentrates on developing alternative power sources to service the needs of a rapidly increasing world population, individuals are being encouraged to walk more and to ride a bicycle to work and/or for recreation. One of the biggest problems in this scenario is the lack of suitably safe traffic infrastructure in most metropolitan areas. The article about pedal cyclist traffic casualties in South Australia by Hutchinson, Kloeden, and Long is thus an important contribution to the general debate about future community infrastructure needs. It is another call to arms for ergonomists to be involved professionally in the wider aspects of planning debates.

The issues surrounding design and operational factors in Intensive Care Units at large and medium sized hospitals in India reflect problems that may be observed in developed as well as developing countries. In many instances there is a common thread of design as a stand-alone package that is simply delivered to the users without their prior input. Some ICU health professionals, in discussions with the editor, have also highlighted the systems failures in preparing staff rosters that ignore the need for experienced support staff rather than matching a new graduate with a single senior nurse on evening shifts and then requiring the senior to attend the emergency department to take responsibility for a critical case admission. This is a major concern for staff whose voice seems to be set aside in favour of budget restraints in discussions of risk management procedures in an acute hospital setting. Again, this is another facet of human factors that deserves to be addressed by ergonomists.

The second paper by another Indian ergonomist demonstrates the extremely hazardous task of manual brick manufacture. It highlights the lack of consideration of human factors which causes so many of the injuries experienced by the workers in this activity. While access to mechanization in developed countries may have reduced some of the hazards identified in this paper, some of the human factors information that is provided could well be noted for awareness in other forms of physical work activities. The nature of risk assessment and control involves fundamental tenets which need to be addressed, regardless of specific variations expected in any complex scenario. The complexity of risk management is the one constant factor across all workplaces.

The final article in this issue of EA has kindly been provided by Erik Hollnagel, who prepared it for use at the recent HFESA Workshop he presented in Brisbane, Queensland. It provides both a theoretical and a practical approach to risk management which neatly supports the earlier papers in this edition. By all accounts his workshop was greatly appreciated by those in attendance and Robin Burgess-Limerick suggested that other ergonomists would value access to Erik's paper. Both author and editor were very pleased to activate this suggestion.

Anyone following the trend of papers submitted to EA since it became a refereed journal in 2002 would realise that, increasingly, the authors are becoming more concerned with a philosophy of ergonomics rather than the mere analysis of specific physical conditions relating to human interaction with products and environments. This shift to a systems approach is leading HF/E practitioners into new areas of transdisciplinary involvement which can only benefit all parties. This concept is reflected in the theme of the 44th HFESA Conference to be held in Adelaide, South Australia 17-19 November 2008: Sustainable Performance - The Human Factor, Ergonomics and the Work Environment. This is a very topical title as sustainability is the current buzzword in just about every type of human work and academic endeavour.

It is a new way of requiring and describing 'intelligent buildings', 'effective programming' and 'green outcomes' for life-cycle rather than first-cost considerations in any design project. Members of the HFESA need to be pro-active in this scene.

Shann Gibbs PhD
Editor

From the Internet

You gotta love the Canadian sense of humour.

West Jet is an Airline with head office situated in Calgary, Alberta and airline attendants make an effort to make the in-flight "safety lecture" and announcements a bit more entertaining.

Here are some real examples that have been heard or reported:

On a West Jet flight (There is no assigned seating, you just sit where you want) passengers were apparently having a hard time choosing, when a flight attendant announced, People, people we're not picking out furniture here, find a seat and get in it!"

On another West Jet Flight with a very "senior" flight attendant crew, the pilot said, "Ladies and gentlemen, we've reached cruising altitude and will be turning down the cabin lights. This is for your comfort and to enhance the appearance of your flight attendants."

On landing, the stewardess said, "Please be sure to take all of your belongings. If you're going to leave anything, please make sure it's something we'd like to have."

"There may be 50 ways to leave your lover, but there are only 4 ways out of this airplane."

"Thank you for flying West Jet Express. We hope you enjoyed giving us the business as much as we enjoyed taking you for a ride."

As the plane landed and was coming to a stop at the Vancouver Airport, a lone voice came over the loudspeaker: "Whoa, big fella. WHOA!"

After a particularly rough landing during thunderstorms in Ontario, a flight attendant on a West Jet flight announced, "Please take care when opening the overhead compartments because, after a landing like that, sure as hell everything has shifted."

From a West Jet Airlines employee: "Welcome aboard West Jet Flight 245 to Calgary. To operate your seat belt, insert the metal tab into the buckle, and pull tight. It works just like every other seat belt; and, if you don't know how to operate one, you probably shouldn't be out in public unsupervised."

"In the event of a sudden loss of cabin pressure, masks will descend from the ceiling. Stop screaming, grab the mask, and pull it over your face. If you have a small child traveling with you, secure your mask before assisting with theirs. If you are traveling with more than one small child, pick your favourite."

"Weather at our destination is 50 degrees with some broken clouds, but we'll try to have them fixed before we arrive. Thank you, and remember, nobody loves you, or your money, more than West Jet Airlines."

"Your seat cushions can be used for flotation; and in the event of an emergency water landing, please paddle to shore and take them with our compliments."

"As you exit the plane, make sure to gather all of your belongings. Anything left behind will be distributed evenly among the flight attendants. Please do not leave children or spouses."

And from the pilot during his welcome message: "West Jet Airlines is pleased to announce that we have some of the best flight attendants in the industry. Unfortunately, none of them are on this flight!"

Heard on West Jet Airlines just after a very hard landing in Edmonton.

The flight attendant came on the intercom and said, "That was quite a bump, and I know what y'all are thinking. I'm here to tell you it wasn't the airline's fault, it wasn't the pilot's fault, it wasn't the flight attendant's fault, it was the asphalt."

Overheard on a West Jet Airlines flight into Regina, on a particularly windy and bumpy day.

During the final approach, the Captain was really having to fight it. After an extremely hard landing, the Flight Attendant said, "Ladies and Gentlemen, welcome to Regina. Please remain in your seats with your seat belts fastened while the Captain taxis what's left of our airplane to the gate!"

Another flight attendant's comment on a less than perfect landing: "We ask you to please remain seated as Captain Kangaroo bounces us to the terminal."

An airline pilot wrote that on this particular flight he had hammered his ship into the runway really hard. The airline had a policy which required the first officer to stand at the door while the Passengers exited, smile, and give them a "Thanks for flying our airline." He said that, in light of his bad landing, he had a hard time looking the passengers in the eye, thinking that someone would have a smart comment. Finally everyone had gotten off except for a little old lady walking with a cane. She said, "Sir, do you mind if I ask you a question?"

"Why, no, Ma'am," said the pilot. "What is it?"

The little old lady said, "Did we land, or were we shot down?"

After a real crusher of a landing in Halifax, the attendant came on with, Ladies and Gentlemen, please remain in your seats until Captain Crash and the Crew have brought the aircraft to a screeching halt against the gate. And, once the tire smoke has cleared and the warning bells are silenced, we will open the door and you can pick your way through the wreckage to the terminal."

Part of a flight attendant's arrival announcement:

"We'd like to thank you folks for flying with us today. And, the next time you get the insane urge to go blasting through the skies in a pressurized metal tube, we hope you'll think of West Jet airways.

Heard on a West Jet Airline flight. "Ladies and gentlemen, if you wish to smoke, the smoking section on this airplane is on the wing. If you can light 'em, you can smoke 'em."

A plane was taking off from the Winnipeg Airport. After it reached a comfortable cruising altitude, the captain made an announcement over the intercom, "Ladies and gentlemen, this is your captain speaking. Welcome to Flight Number 293, non-stop from Winnipeg to Montreal. The weather ahead is good and, therefore, we should have a smooth and uneventful flight. Now sit back and relax... OH, MY GOD!"

Silence followed, and after a few minutes, the captain came back on the intercom and said, "Ladies and Gentlemen, I am so sorry if I scared you earlier. While I was talking to you, the flight attendant accidentally spilled a cup of hot coffee in my lap. You should see the front of my pants! A passenger in Coach yelled, "That's nothing. You should see the back of mine!"

Shann Gibbs

Articles

1. Overview of pedal cyclist traffic casualties in South Australia

T. P. Hutchinson, C. N. Kloeden, and A. D. Long

Centre for Automotive Safety Research, the University of Adelaide, South Australia 5005

Characteristics of pedal cycle crashes (as reported to the police) in South Australia, and how they have changed over the period 1981-2004, are examined. The paper describes both the present situation (2001-2004) and how it has changed since 1981; both child and adult casualties; both the numbers of casualties and the proportions seriously injured; and both factors that are commonly tabulated and some that are relatively unusual. In 1981, pedal cyclist casualties were mostly children and teenagers, but in 2004, pedal cyclist casualties were mostly spread across the age range from 16 to 49. Child pedal cyclist casualties reached a maximum in 1982-1987, and have fallen sharply since. Adult pedal cyclist casualties reached a maximum in 1987-1990, and then fell. Concerning the proportion of casualties seriously injured (i.e., killed or admitted to hospital), in 2001-2004 this proportion among adults (16+) was 12% when the speed limit was 60 km/h or less, and 33% when the speed limit was 70 km/h or higher. Among the four most frequent types of crashes (right angle, side swipe, right turn, and rear end), the proportions of adult casualties seriously injured were 11%, 11%, 16%, and 18%. The proportion was 14% for male drivers of the motor vehicle and 9% for female drivers; it was 17%, 15%, 15%, 14%, 10%, and 11% for motor vehicle driver age groups 16-19, 20-29, 30-39, 40-49, 50-59, and 60-99.

Introduction

Many governments at present give a degree of encouragement to cycling, for reasons of health and environmental sustainability. In South Australia, the relevant document is *Safety in Numbers. A Cycling Strategy for South Australia 2006-2010* (DTEI, 2006). The opening sentence makes safety central: "Market research shows that many people choose not to cycle because they perceive cycling to be unsafe --- so the challenge lies in improving not only safety for the existing cyclists but the perception of safety for those not currently cycling". Indeed, a casual observer easily sees that much of the transport system does not fit the needs of the cyclist very well, the roads being too fast, the footpaths too slow, and many junctions a nightmare. The sides of many heavy goods vehicles are not enclosed, and the danger of cyclists (and pedestrians and motorcyclists) going under the rear wheels is ever-present. As to occupational safety, the bicycle is chiefly of interest as a means of getting to and from work, but it is also for some people a workplace: Dennerlein and Meeker (2002) studied accidents to bicycle couriers (using a self-administered survey form, rather than data routinely collected by police or hospitals).

Adelaide is mostly flat and the weather is largely dry, and cycling is feasible even without some great commitment of principle. Public transport (mostly buses) is reasonably good. The private car, nevertheless, is the dominant mode of travel. According to household travel surveys, the numbers of person trips per day in Adelaide (population 1.1 million) were 3.4 million in 1986 and also 3.4 million in 1999, the numbers as car driver being 1.8 and 2.0 million, and the numbers by bicycle being 0.089 and 0.040 million (Transport SA, 2002).

The present paper examines certain characteristics of pedal cycle crashes in South Australia, and how they have changed over the period 1981-2004. It is based upon a rather fuller account in Hutchinson et al. (2006). The organization of this paper is as follows. Section 2 describes the data, and Section 3 identifies the trends over the period 1981-2004. Sections 4-10 presents data for pedal cyclist casualties for the period 2001-2004, the Sections respectively referring to time of crash, place (postcode), the site and events, the pedal cyclist, the motor vehicle and its driver, fatalities, and the proportion of casualties seriously injured. The period 2001-2004 was chosen so as to be long enough to include sufficient accidents to give a good picture, yet not to extend too far into the past.

Data

The source of data is the Traffic Accident Reporting System (TARS) database, which originates from police reports. Statistics on child and adult pedal cyclist casualties will be given separately. To do this, it is necessary to exclude casualties of unknown age from the tabulations. In 2001-2004, these accounted for some 11.8 per cent of the total, and for casualties who were killed or admitted to hospital, the proportion was 7.5 per cent. Postcode groups 5000-5099, 5100-5199, and 5200-5999 will be used in some Tables below. The first two of these groups together refer to metropolitan Adelaide: the first to an area with a boundary that is between 8 and 16 km from the centre of Adelaide, and the second to outer Metropolitan Adelaide. Postcodes 5200-5999 refer to the rest of South Australia. For brevity, the term serious casualties will be used for those killed or admitted to hospital, adult casualties will mean those aged 16 and over, and child casualties will mean those aged 5-15.

Datasets based on police reports of crashes are always incomplete: they tend to under-represent crashes in which injury is minor, and those in which property damage is minor. Pedal cycle crashes are probably underrepresented to a greater degree than others. For pedal cycle crashes not involving a motor vehicle, it would undoubtedly be necessary to find another data source, such as the hospital system or self report. Police reports do not have information about nature of injury. In principle, this is available in hospital records (especially for in-patients), but these have not been utilised in the present paper.

Trends

Substantial changes in pedal cycle crashes have occurred between 1981 and 2004. In 1981, pedal cyclist casualties were mostly children and teenagers. In 2004, pedal cyclist casualties were mostly spread across the age range from 16 to 49. Adult pedal cyclist casualties reached a maximum in 1987-1990, and then fell, and child pedal cyclist casualties reached a maximum in 1982-1987, and have fallen sharply since. See Figure 1.

Figure 1. Pedal cycle casualties in South Australia 1981-2004.

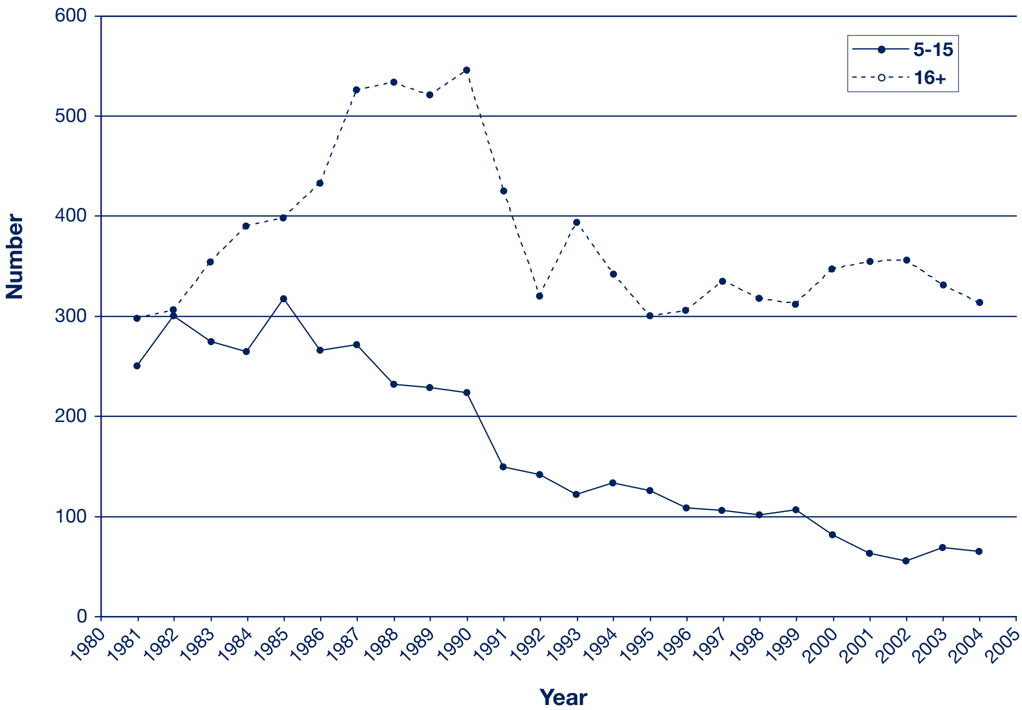
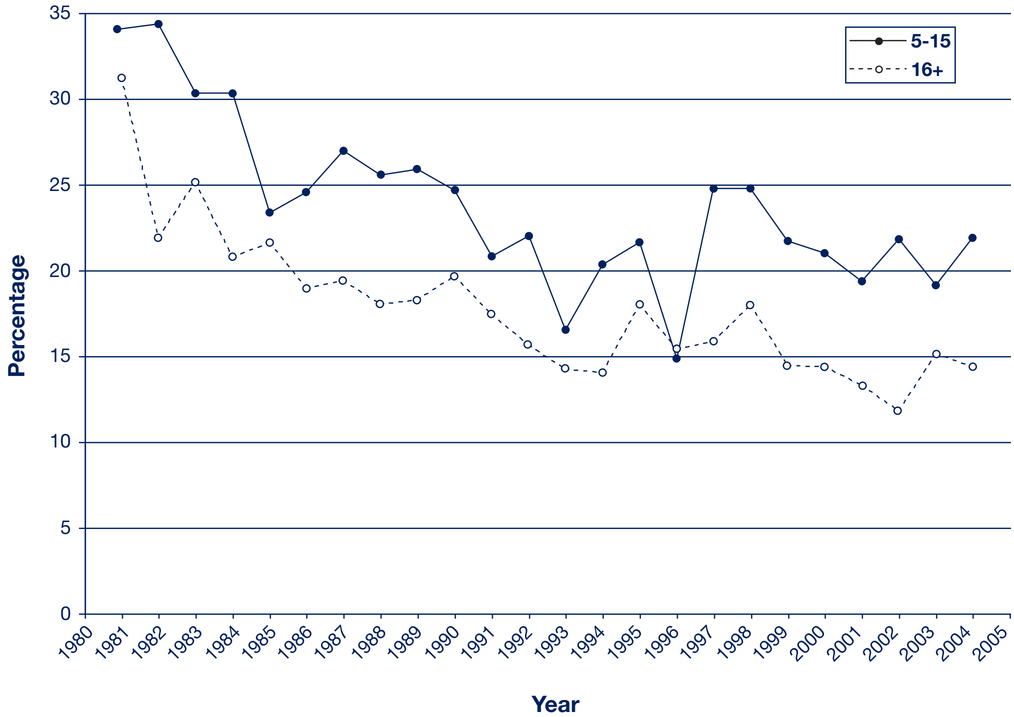


Table 1. Age distribution (percentages) of pedal cycle casualties, South Australia, for each of six four-year periods, 1981-2004. (Those of unknown age were excluded.)

Years	Age group (years)					
	5-7	8-12	13-15	16-19	20-59	60+
1981-1984	4.6	19.4	20.5	13.7	36.6	4.9
1985-1988	2.9	13.7	19.6	17.2	41.1	5.1
1989-1992	2.0	10.8	16.1	18.9	48.3	3.7
1993-1996	1.5	11.5	13.5	13.2	55.1	5.0
1997-2000	1.5	11.1	10.4	11.1	60.9	4.9
2001-2004	1.1	7.4	7.0	8.2	70.8	5.3

Figure 2. Pedal cycle casualties in South Australia, 1981-2004: percentage in which the rider was killed or admitted to hospital.



The wearing of helmets by pedal cyclists became compulsory on 1st July 1991. This probably deterred some people from cycling and in addition prevented some being injured (Marshall and White, 1994).

Percentages in the different age groups in different periods are given in Table 1. Those aged 0-15, as a proportion of total pedal cyclist casualties, have fallen from 45 per cent in 1981-1984 to 16 per cent in 2001-2004. Those aged 30-59 increased from 17 per cent to 48 per cent.

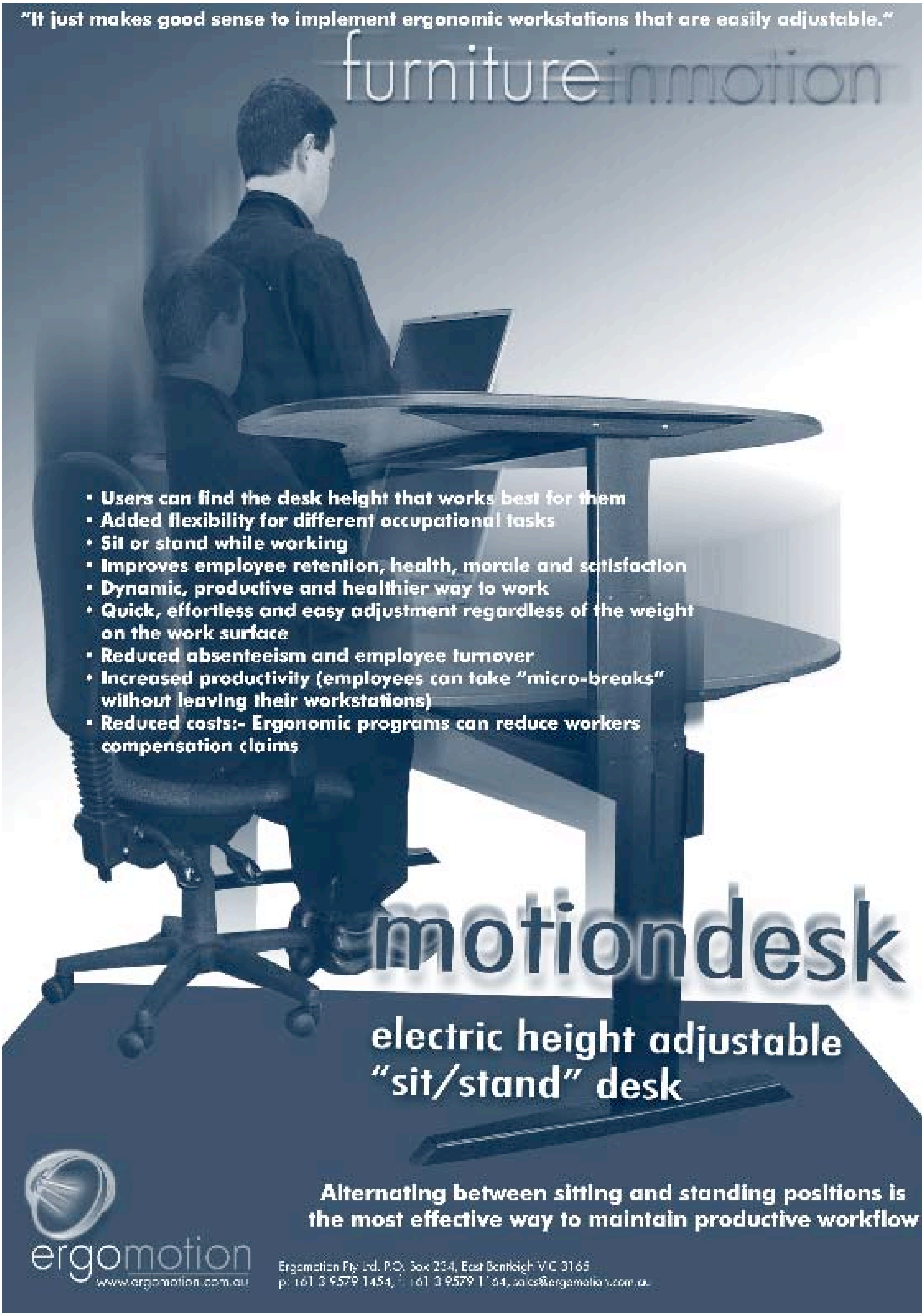
Figure 2 shows the percentage that were killed or admitted to hospital. In the case of adults, there has been a fall from 31 per cent in 1981 to 14 per cent in 2004. (Those killed, as a proportion of total pedal cyclist casualties aged 16 and over, also fell, from 1.4 per cent in 1981-1984 to 1.0 per cent in 2001-2004.) In the case of children, there has been a fall from 34 per cent in 1981 to 22 per cent in 2004. (Those killed, as a proportion of total pedal cyclist casualties aged 5-15, also fell, from 2.1 per cent in 1981-1984 to 1.2 per cent in 2001-2004.)

From 1 March 2003, the speed limit on most urban roads changed from 60 km/h to 50 km/h; it remained 60 km/h or higher on urban arterials. Did this reduce the number of pedal cyclist casualties? The data are suggestive of a reduction in the case of adult pedal cyclist casualties: there is no decline in the years up to 2002, but then the numbers in 2003 and 2004 are slightly lower. See Kloeden, Woolley, and McLean (2004) for the effect on road casualties (not specifically pedal cyclists) of the speed limit reduction. Child pedal cyclist casualties are too few for a detectable effect to be expected, and, indeed, the numbers in 2003-2004 were not lower than in 2001-2002.

Time of crash

Adult casualties are slightly fewer in midsummer and midwinter than at other times of the year. There tend to be fewer casualties per day on weekends than on weekdays. The times of day when casualties are most frequent are those when most people are travelling to or from work: the hours beginning 07, 08, 09, 16, 17, and 18.

For children, there are about the same number of casualties per day on weekends as on weekdays. The times of day when casualties are most frequent are those when most children are travelling to or from school: the hours beginning 08, 15, 16, 17. (As might be expected, the hourly pattern is different at weekends and in school holidays.)


"It just makes good sense to implement ergonomic workstations that are easily adjustable."
furniture in motion
• Users can find the desk height that works best for them
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Place (postcode)

For adults, postcode groups 5000-5099, 5100-5199, and 5200-5999 account for respectively 80 per cent, 13 per cent, and 7 per cent of casualties. Most casualties live in a different postcode from that of the crash.

For children, most casualties live in the same postcode as that of the crash --- to a lesser extent for those aged 13-15 than for younger children.

Site and events

For adults, the majority of casualties occur at junctions (Table 2). About 93 per cent of casualties occur on roads where the speed limit is 60 km/h or lower; in 2004 (i.e., after 50 km/h became the speed limit on most urban roads), fewer occurred on 50 km/h than on 60 km/h roads. The categories in Table 3 were chosen in an attempt to give a reasonable picture of the type of site (the speed limit, whether there was a junction or not, what type of road or type of junction, and the traffic control) yet keeping the list limited in length. Crashes termed "right angle" were the most common (Table 4).

For children, about the same numbers occurred at junctions and not at junctions (Table 2). About 94 per cent of casualties occur on roads where the speed limit is 60 km/h or lower, and in 2004, more occurred on 50 km/h than on 60 km/h roads. Crashes termed "right angle" were the most common (Table 5).

Table 2. Numbers of pedal cycle casualties in South Australia 2001-2004: comparison of adults and children in respect of road geometry.

Road geometry	Cyclist age group (years)	
	5-15	16+
Junction	121	808
Not at junction	116	521
Unknown	12	25
Total	249	1354

Table 3. Numbers of pedal cycle casualties aged 16 and over in South Australia 2001-2004, by postcode group of crash and the nature of the site.

Speed limit (km/h), whether at junction, and details	Postcode group 5000-5099	5100-5199	5200-5999	Total
0-60, no junction, divided road	256	21	3	280
0-60, no junction, not divided road	129	28	25	182
0-60, junction, traffic signals, T- or Y-junction	46			46
0-60, junction, traffic signals, crossroads	135	6	2	143
0-60, junction, priority, T- or Y-junction	310	45	16	371
0-60, junction, priority, crossroads	99	7	18	124
0-60, junction, roundabout	65	20	6	91
70+, no junction	14	23	18	55
70+, junction	10	15	6	31
Other and unknown	24	7		31
Total	1088	172	94	1354

Table 4. Numbers of pedal cycle casualties aged 16 and over in South Australia 2001-2004, by postcode group of crash and crash type.

Crash type	Postcode group 5000-5099	5100-5199	5200-5999	Total
Rear end	82	23	11	116
Hit fixed object	33	8	2	43
Side swipe	217	30	21	268
Right angle	394	74	33	501
Head on	16	8	1	25
Hit pedestrian	5			5
Roll over	46	9	8	63
Right turn	150	5	3	158
Hit parked vehicle	54	5	8	67
Hit animal	5	2	1	8
Hit object on road	7	1		8
Left road out of control	7	1	2	10
Other	72	6	4	82
Total	1088	172	94	1354

Table 5. Number of pedal cycle casualties aged 5-15 in South Australia 2001-2004, by crash type and age group of casualty.

Crash type	Age group (years) 5-7	8-12	13-15	Total
Rear end		5	7	12
Hit fixed object		1	3	4
Side swipe	5	12	12	29
Right angle	13	87	74	174
Head on		8	3	11
Roll over		1	1	2
Right turn		2	7	9
Hit parked vehicle		1	3	4
Hit object on road			1	1
Other		2	1	3
Total	18	119	112	249

The pedal cyclist

Among adults, male casualties outnumber females about 4 to 1.

Among children, male casualties outnumber females about 6 to 1.

For the age distribution, see Table 1. (The age groups for children were chosen so as to be the same as in *Road Crashes in South Australia 2002*.)

The motor vehicle and its driver

For this Section, the crashes have been restricted to those in which there was a single motor vehicle and a single pedal cycle. The numbers of casualties are consequently slightly fewer in Tables 6 to 8 than in other Tables.

For adult cyclist casualties, male and female drivers were in the approximate proportions 62 per cent and 38 per cent (Table 6). The distribution of their ages is shown in Table 7. Cars and car derivatives make up about 77 per cent of the total (Table 8). For serious casualties, the number of cases with other vehicle types involved was 34 per cent of the number with cars involved, as compared with 14 per cent for all severities of injury.

For child cyclist casualties, male and female drivers were in the approximate proportions 56 per cent and 44 per cent (Table 6). The distribution of their ages is shown in Table 7. Cars and car derivatives make up about 82 per cent of the total (Table 8). For serious casualties, the number of cases with other vehicle types involved was 19 per cent of the number with cars involved, as compared with 8 per cent for all severities of injury.

Table 6. Numbers of pedal cycle casualties in South Australia 2001-2004 in single motor vehicle vs single bicycle crashes: comparison of adults and children in respect of sex of motor vehicle driver.

Sex of motor vehicle driver	Cyclist age group (years)	
	5-15	16+
Male	124	631
Female	97	387
Unknown	15	72
Total	236	1090

For adult pedal cycle casualties injured seriously, male and female drivers respectively numbered 88 and 35.

For child pedal cycle casualties injured seriously, male and female drivers respectively numbered 34 and 9.

Table 7. Numbers of pedal cycle casualties in South Australia 2001-2004 in single motor vehicle vs single bicycle crashes: comparison of adults and children in respect of age of motor vehicle driver.

Age group of motor vehicle driver	Cyclist age group (years)	
	5-15	16+
16–19	13	64
20–29	40	168
30–39	45	168
40–49	36	203
50–59	32	137
60–69	16	37
70–99	5	44
Unknown	49	269
Total	236	1090

Table 8. Numbers of pedal cycle casualties in South Australia 2001-2004 in single motor vehicle vs single bicycle crashes: comparison of adults and children in respect of type of motor vehicle.

Sex of motor vehicle	Cyclist age group (years)	
	5-15	16+
Car (and derivatives)	193	839
Other	16	116
Unknown	27	135
Total	236	1090

Fatalities

For adults, fatalities were 1 per cent of the total casualties, those recorded as being admitted to hospital were 13 per cent, those treated at hospital were 53 per cent, and those treated but not at a hospital were 33 per cent.

For children, fatalities were 1 per cent of the total casualties, those recorded as being admitted to hospital were 19 per cent, those treated at hospital were 58 per cent, and those treated but not at a hospital were 21 per cent.

Proportion seriously injured

The proportions of adult casualties killed or admitted to hospital were 12 per cent, 13 per cent, and 18 per cent in age groups 16-19, 20-59, and 60+, and were 12 per cent, 14 per cent, and 33 per cent for crashes in postcode groups 5000-5099, 5100-5199, and 5200-5999. The proportion was 12 per cent when the speed limit was 60 km/h or less, and was 33 per cent when the speed limit was 70 km/h or higher. As seen in Table 4, the most frequent types of crashes were those recorded as right angle, side swipe, right turn, and rear end; the proportions killed or admitted to hospital were respectively 11 per cent, 11 per cent, 16 per cent, and 18 per cent. The proportions of adult casualties killed or admitted to hospital were respectively 14 per cent for male drivers of the motor vehicle and 9 per cent for female drivers (see footnote to Table 6). This proportion tended to decline with increasing age of the driver: 17 per cent, 15 per cent, 15 per cent, 14 per cent, 10 per cent, and 11 per cent for motor vehicle driver age groups 16-19, 20-29, 30-39, 40-49, 50-59, and 60-99. There was no effect of vehicle age: the proportions of adult casualties killed or admitted to hospital were 13 per cent when the motor vehicle dated from the 1980's, 13 per cent when it dated from the 1990's, and 13 per cent when it dated from the 2000's.

The proportions of child casualties killed or admitted to hospital were 44 per cent, 24 per cent, and 13 per cent in age groups 5-7, 8-12, and 13-15; and they were 18 per cent, 12 per cent, and 36 per cent for crashes in postcode groups 5000-5099, 5100-5199, and 5200-5999. The proportion killed or admitted to hospital was 20 per cent when the speed limit was 60 km/h or less, and was 35 per cent when the speed limit was 70 km/h or higher; it was 27 per cent for male drivers of the motor vehicle and 9 per cent for female drivers (see footnote to Table 6); this percentage was much the same for the different driver age groups, but there are only low numbers in each age group; and it was 19 per cent when the motor vehicle dated from the 1980's, 22 per cent when it dated from the 1990's, and 20 per cent when it dated from the 2000's.

Discussion

What accident countermeasure for cyclists is most worth highlighting? We think it is the same one as for other road users: reduce speed limits and enforce them. Speed has been known to be dangerous since long before the motor vehicle was invented. But in the last ten years or so, an increasingly strong belief has developed that a worthwhile reduction in risk accompanies even small reductions in speed. Case-control studies (Kloeden et al., 1997, 2001, 2002) were particularly influential. We would expect both reduction of the speed limit from 60 km/h on urban arterials to 50 km/h, and from 50 km/h to 30 or 40 km/h on local streets, to be among the most effective options for improving cyclist safety. Kloeden, Woolley, and McLean (2004) analysed the effect on road casualties, not specifically cyclists, of the reduction in default speed limit from 60 km/h to 50 km/h that was introduced in South Australia on 1st March 2003, and Kloeden, McLean, and Lindsay (2004) looked ahead to what might happen if the limit on urban arterials were reduced to 50 km/h.

Conclusion

Separation of vulnerable road users from motor traffic has been a well-known option for decades, and an obvious possibility in the case of cyclists would be to permit or encourage them to use the footpaths rather than the main roads. We have given some discussion of this in Section 5.1 of Hutchinson et al. (2006). For the design of cycle facilities, see Austroads (1999), and for a review of pedal cycle safety, see Meuleners et al. (2003). Governments, whether national, state, or local, have a degree of control over the amount of bicycling that is done. Rietveld and Daniel (2004) compared bicycle use in 103 Dutch municipalities using multiple regressions. Some variables not easily subject to control (e.g., population of the city, and how hilly it is) had effects. But policy variables also had effects --- both those that make cycling more attractive, and those that make motorised modes of travel less attractive. It seems likely that if cycle facilities in Adelaide were improved sufficiently to generate appreciable extra bicycle traffic, it would have to be by means that made cycling safer for existing cyclists. Thus there is reason to think that doubling the number of cycling trips (*Safety in Numbers* sets this goal for South Australia for 2015) would not result in a doubling of cyclist casualties. Speed management, as already noted, is a general measure that could benefit cyclists. But for the majority of feasible measures, the specifics of localities and the details of implementation are very important, and not much of universal applicability can be said briefly.

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2. Risk factors in manual brick manufacturing in India

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Abstract

The manual brick manufacturing process in Gujarat State, India is investigated. Most workers are female, with a few male supporting staff. Issues of work related musculoskeletal disorders and injury in different parts of the body are prominent. Manual material handling in the light of NIOSH equations indicate that the workers are working above the safe limit. Postural analysis using REBA, RULA and OVAKO methods indicate that different body parts at specific postures are vulnerable to injury and musculoskeletal disorders and warrant immediate ergonomics intervention.

Keywords: Manual handling, musculoskeletal disorder, posture, work load.

Introduction

Manual brick manufacturing in India is a very old profession employing millions of people. As an unorganized sector, no statistical data are available to date as to the number of people employed, accident rates, and other problems. Hence the only bases for such data are through direct dialogue with the people associated with this profession. However there are some data in this sector in the western world. Brick or clay product manufacturing in US ranked sixth out of the 10 highest job classifications in terms of percentage claim for cumulative trauma disorders (Brogmus and Mark, 1991). About 44% of over three days injuries reported by the brick industry (HSE, 1999) are strains, sprains and other manual handling injuries. An accident survey in the heavy clay sector (Brick Development Association, 2002) indicated 1, 959 accidents in 1999 leading to the loss of 3,829 man days (0.31%). The same group indicated that the number of accidents increased in 2000, leading to a loss of 4, 261 man days (0.27%). Brick making involves crude techniques causing considerable worker drudgery (Development Alternative, 2005). Brick workers, especially moulders, are exposed to the sun for long hours; additionally they are exposed to high concentrations of dust while manually breaking coal. There is also the risk of exposure to dust (from bottom ash spread on the kiln) and the open fire during manual coal feeding. The workers have to walk on a hot surface (top of the furnace) while monitoring and regulating the fire. They are also exposed to high concentrations of Respirable Suspended Particulate Matters (RSPM), while monitoring and regulating the fire, as the furnace chamber is covered with ash (ash acts as insulator). Carrying head loads on a regular basis causes health problems, especially in women.

The incidences of Work Related Musculoskeletal Disorders (WMSDs) were quite common in this sector. Investigations in a manual brick making factory, focusing on the moulding department, indicated that there was poor standing and lots of deviated wrist positions, accompanied by forceful exertions (Trevelyn and Haslam, 2001). In another study on manual brick manufacturing (Basra and Crawford, 1995) some potential problems were identified, such as a poorly designed work station and frequent bending and twisting of the trunk. Inadequate rest breaks also were observed. Brick handling among brick layers also showed incidences of WMSDs, which were responsible for lost time and additional physicians' visits (Cook et al, 1996). Awkward postures of the back and shoulders, and manual material handling of bricks and mortars in these awkward postures were identified as the causes of WMSDs. In a study of post kiln brick sorting activity a high level of back complaints and an increased frequency of upper limb disorders were observed (Ferreira and Tracy, 1991). These investigators inferred that these disorders were the result of a large amount of trunk bending and twisting in one plant and repetitive handling of several bricks at a time at another plant.

The industrial classification of bricks, pottery, glass and cement was identified as having greater risk of inflammation of tendons of the hand, forearm or associated tendon sheaths (Buckle and Stubbs, 1990). Chung and Kee (2000) evaluated the lifting tasks during fire brick manufacturing process, with a focus on forming, heating and packing process. The group inferred that the weight of the load significantly influenced the incidence of back injuries.

Thus it appears that to date there is dearth of data in the Indian scenario about to the different risk factors associated with manual brick manufacturing. It was also felt necessary to probe into this area of work as it provides an employment opportunity to thousands of people in rural areas. For any successful intervention, it is imperative to identify the hazards, and the level of risk implicit in performing the required tasks. This study was an attempt in that direction.

Method

Direct observation and activity analysis

A modified form of Drury's (1990) direct observation and activity analysis was applied. The subjects were observed in actual working conditions. The posture assumed, the path of travel of the hand, and repetitive activities were observed. A modified form of body part discomfort (Corlett and Bishop 1976) was applied to identify discomfort in different parts, as discomfort has been reported (Mukhopadhyay et al., 2007) to be a precursor to injury and musculoskeletal disorder in the long run. Subjects were asked to rate the zone of maximum discomfort. Each job was also analyzed by using a Hierarchical Task Analysis (HTA) in which the work was broken up into smaller components until it could not be broken down further.

Questionnaire and interview technique

Questionnaires were developed based on the method of Sinclair (1975). Four versions of questionnaires were made and validated before the final questionnaire was determined. The final questionnaire was validated by testing on subjects in the actual working conditions. The time taken to fill the questionnaire, the quantum of information being collected and the sequence of questions were carefully analyzed. Based on this analysis, further modification of the questionnaire design was made in order to extract the required information in the shortest possible time. The questionnaire comprised questions pertaining to different problems, related to this profession, including normal daily activity, pain experienced in different body parts, injury to different body parts, working hours, resting periods, total working duration, and problems faced in working under the sun.

Photography of different work stations

Still and video photography of different work stations was undertaken, with a specific focus on the postural issues. The design issues of the existing work station were also recorded. The photographs were later analyzed in the laboratory. The still photographs were used to identify the different categories of working postures vulnerable to injury, such as bending, twisting, and tilting the head forward. Video photography was used to analyze the number of repetitive movements, especially movements of the limbs, and forward and twisting activities. The video photography also helped in cross checking the detail of time and motion study done in the field.

Subjects

Forty eight subjects, all females, were selected for measurement of different parameters. The mean age was 28.1 years (SD = 1.8), mean stature 146.8 cm (SD = 3.2) and mean body mass was 47.3 Kg (SD = 4.2) respectively. As the majority of the workers were female, while only a few males acted as supporting staff, only females were selected for this study.

Measurement of environmental parameters

Radiant heat was measured by using a Vernon's Globe. Dry and Wet Bulb Temperature was measured by using a Whirling Psychrometer. Measurement of thermal parameters was taken every two hours for twelve hours duration and the mean was calculated.

Measurement of physiological parameters

Heart rate was measured (using a 30 seconds stop watch) by the ten beats method at the beginning of work, and at the end of thirty minutes of carrying a set of bricks onto the kiln. Blood pressure was also recorded for the same work, using a mercury sphygmomanometer. Ideally, heart rate should have been measured throughout the duration of the working period. This was not feasible for two reasons. Continuous recording of the heart rate requires a sport tester to be used. The female subjects had strong objections of strapping anything on their chest. Hence the pulse rate had to be recorded from the carotid pulse by the ten beats method. From the activity analysis and from a discussion with the workers, it transpired that recording the pulse rate from the carotid pulse would interfere with the subjects' normal activity. It might also be risky to record the pulse rate at some positions like load lifting on the head and unloading on the kiln top. Thus the idea of continuous pulse rate monitoring had to be abandoned. Instead, from the entire work-rest cycle, only half an hour was selected to see the pattern of the physiological parameters. Also it was observed that at a stretch the workers worked for half an hour. After this they took a rest of about 10/15 minutes before starting their activity once again.

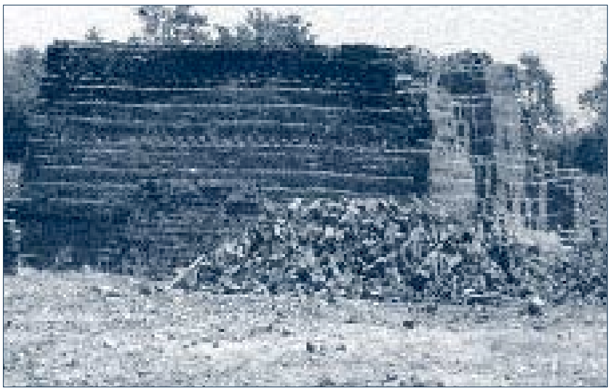
Oral temperature was recorded using a mercury thermometer. Subjects were instructed not to eat anything half an hour prior to measuring the temperature. The reason for measuring oral temperature by this method was that the subjects were familiar with this from their previous visits to the physician, and anything else would not be acceptable to them. Such methods have been used previously in the Indian scenario (Sen, 1982).

Results

Work process in general

Most of the brick kilns in this part of the country were of open type (Figure 1). The worker usually started working at 3 am and continued till 11 am. After lunch and rest they recommenced at 3 p.m. and continued till 7 p.m. The workers never worked continuously (as noted previously) but in bouts of 30 minutes, followed by resting for 10 or 15 minutes before resuming activity. As the workers were paid for the number of units of bricks produced, they had a normal tendency to work for longer hours and finish the work sooner, so that they could move to another kiln. Normally a group of 20-25 people worked at a kiln to produce 100,000 bricks.

Figure 1. Open type brick kiln unit



Body part discomfort mapping

At the end of the day's work, maximum pain and discomfort was experienced in the lower back (30%) followed by upper back (25%), shoulder (15%), elbow (10%), and wrist/hand (10%). Pain and discomfort in the knees was (5%) followed by neck (2.5%) and ankle (2.5%).

Activity analysis

There were two main steps. In the first step a brick was manufactured from mud (Figure 2) with the help of a mould. This was then stacked and dried in direct sunlight. In the second stage the dried brick was taken to the kiln (Figure 3, 4) and stacked on top of it for further curing and hardening. After a week the cured bricks were removed and ready to use. Manual brick making in this part of the country was sporadic and based on demand. Work was carried on only during the summer months, and during monsoon season all such kilns were closed.

Figure 2a, 2b. Brick manufacture from mud

Figure 3a, 3b, 3c, 3d. Carrying raw bricks for curing

Figure 4. Unloading bricks at kiln top

Figure 5. Aligning raw bricks on kiln top

On average, the workers stacked 9 bricks on their head and carried them to the kilns. The weight of each brick being 1.5 Kg they carried a total load of 13.5 Kg. The mean time taken for stacking 9 bricks on the head was 8.1 seconds. The mean time taken for unloading the same number of bricks on the kiln was 5.3 seconds. The mean time taken for the workers to stack the bricks on the head and run to the kiln top and unload a similar number of bricks was found to be 25.0 seconds. The time taken for completing one full work cycle, that is stacking the bricks on the head, running to the kiln top and unloading and then returning back to the initial position was 37.9 seconds.

Physiological parameters

There was a marked increase in the post exercise heart rate (80.8 beats per minute to 125.3 beats per minute) after 30 minutes of work (Table 1). Similarly the systolic blood pressure increased from 116.3 mm Hg to 139 mm Hg after 30 minutes. The diastolic blood pressure increased by only a marginal amount from 80.8 mm Hg to 92.3 mm Hg even after 30 minutes of exercise. Oral temperature increased from 36.80 C to 38.10 C after 30 minutes of work.

Table 1. Mean physiological parameters before and after working for 30 minutes

	Pre Exercise	After 30 min. of exercise
Heart rate (beats/min)	80.8(SD=2.8)	125.3(SD=6.7)
Systolic B.P. (mm Hg)	116.3(SD=3.5)	139(SD=5.0)
Diastolic B.P. (mm Hg)	80.8(SD=4.9)	92.3(SD=2.2)
Oral temperature (0 C)	36.8(SD=0.2)	38.1(SD=0.5)

Environmental parameters

The mean Dry Bulb (DB) temperature was 35.30 C, and the Wet Bulb (WB) temperature 23.20C. The Globe temperature was observed to be 43.80C (Table 2).

Dizziness (48%) and head ache (42%) were the most predominant heat related problems (Table 1), followed by vomiting (5%) and heat stroke (5%). Abrasions (36.3%) and cuts (33.2%) were the dominant injuries. This was followed by trips/falls (18.2%) and brick falling on the feet (6%).

Table 2. Mean environmental temperatures

Dry Bulb (0 C)	Wet Bulb (0 C)	Globe (0 C)
35.3 (SD=0.28)	23.2 (SD= 0.55)	43.8 (SD= 1.26)

Postural analysis for musculoskeletal risk factors

The entire process of manual brick manufacture was divided into certain components. Different methods were applied for each component to identify the risk factors associated with a particular task. Brick making, carrying bricks on the head to the kiln top and unloading the bricks on kiln top and aligning them, were the four main task components.

OVAKO working posture (Karhu et al. 1977)

Certain postures associated in brick making demanded immediate attention (Table 3). The legs with an OVAKO score of 6 while squatting and pressing the clay in the mould, with repeated twisting and bending of trunk, was a vulnerable posture. While squatting and then standing erect, with bricks on the head, the cervical and lumbosacral segments of the vertebral column were another vulnerable area requiring immediate intervention.

Rapid Entire Body Assessment (REBA) (Harnett and Mc Atamney, 2000) and Rapid Upper Limb Assessment (RULA) working posture analysis (Mc Atamney and Corlett, 1993)

REBA posture codes indicate that postures (Table 4) in the stacking area like stooping forward with bricks on the head and then standing erect (Figure 3), demands immediate attention (with a score of 12/12). Other postures are also at risk (with a score of 11/11) in manual brick making, load carriage and unloading and alignment (Figure 4) at kiln top. RULA posture codes indicate that all the working postures are equally vulnerable with a score of 7/7 that warrants intervention.

National Institute of Occupational Health and Safety (NIOSH) load lifting equation

NIOSH equation for load lifting was applied in the case of lifting bricks from the stacking area (Table 5) and putting them on the head. Based on different distances and constants, the average recommended weight lifted was found to be 27.87 lbs (12.9 kg). This was greater than the average weight carried by each subject (13.5 kg). The lifting index at both origin and destination of the lift was 1.05 and 1.08, which is more than the limit prescribed (it should be less than 1).

Table 3. OVAKO working posture analysis

Activity	OVAKO Posture codes			
	Back	Arms	Legs	Force
Manual brick making				
Cutting mud	4	4	4	2
Squatting and inserting clay in mould	4	1	6	1
Press clay and take out brick from mould	4	1	6	2
Load carriage from stacking area to kiln				
Squatting to stack bricks on head	6	3	4	3
Stack bricks on head one by one	2	3	4	3
Move up	1	3	3	3
Stand erect with bricks on head	1	3	2	3
Activity at kiln top				
Unloading brick with assistance	1	3	4	3
Align bricks on kiln	4	3	3	2

Table 4. REBA/RULA working posture analysis

Activity	REBA posture codes	RULA posture codes
Manual brick making		
Cutting mud	11/11	7/7
Squatting and inserting clay in mould	7/7	6/6
Press clay and take out brick from mould	7/7	7/7
Load carriage from stacking area to kiln		
Squatting to stack bricks on head	11/11	7/7
Stack bricks on head one by one	11/11	7/7
Move up	12/12	7/7
Stand erect with bricks on head	12/12	7/7
Activity at kiln top		
Unloading brick with assistance	11/11	7/7
Align bricks on kiln	11/11	7/7

Table 5. NIOSH load lifting equation, with weight in lbs, distance in inches and angle in degrees

Task Variables

Hand location	Vertical Asymmetric angles (degree)						Frequency		Duration	Object
Origin	Destination		Distance		Origin		Destination	lift/min	Hrs	coupling
Object weight	H	V	H	V	D	A	A	F	C	
	30	13	40	<=10	65	15	30	0.5	<=1	Poor

Multipliers and RWL

	RWL=LC	X	HM	X	VM	X	DM	X	AM	X	FM	X	CM
Origin	28.47	51		0.77		0.93		0.94		0.95		0.97	0.90
Destination	27.87	51		1.00		0.74		0.94		0.90		0.97	0.90

Lifting Index = Object weight/RWL

Origin	L1=	30	/	28.47	=1.05
Destination	L1=	30	/	27.87	=1.08

H= Horizontal, V=Vertical, D=Distance, LC= Load Constant, HM= Horizontal Multiplier, VM= Vertical Multiplier, DM= Distance Multiplier,

AM= Asymmetric Multiplier, FM= Force Multiplier, CM= Coupling Multiplier, RWL= Recommended Weight Limit,

LI= Lifting Index

Discussion

The relative duration of working in the sun was critical and this was substantiated by the elevated physiological parameters well above the normal resting value. The increase in heart rate after 30 minutes of work was possibly enough to categorize it as a heavy type of activity (Sen, 1982). The external heat of the environment was possibly an important factor adding to the stress level of the workers—also indicated by an elevated oral temperature. This was quite obvious as the radiant heat of the environment was well above the normal value. This might be a potential risk factor for the workers working under such conditions. This was further substantiated by the high rate of heat related incidences of heat stroke and other symptoms.

As regards the incidence of injuries in different parts of the body, the work process was primarily responsible. There were no personal protective devices, and even a complete absence of any protective work wear, so this was a significant issue in the injuries that were sustained. Since body- part discomfort is a valuable indicator of a mismatch between the job and the human operator Mukhopadhyay et al, 2007) it was found that the lower back was the part that was mainly affected, followed by upper back and other parts of the body. This was mainly caused by repeated bending and twisting of the trunk, leading to an enormous force generation at the lumbosacral segment of the vertebral column (Kumar, 2001). Pain in shoulder and forearm was possibly the result of repeated activity of the muscles of these parts as a result of repetitive movements of the upper limbs. The work cycle time for loading and unloading was found to be very short considering the fact that on an average the subjects were carrying a 13.5 kg weight on their head. Such activity under the intense heat of the sun is physiologically very demanding and might lead to fatigue and accidents if proper work rest and replenishment of fluid lost from the body is not addressed.

Postural analysis by different methods indicated that most of the postures were vulnerable to musculoskeletal disorders and injury and this demands immediate ergonomics design intervention. Even the NIOSH equation indicated that the weight being handled by the subjects was above the recommended value and demanded immediate attention. Garg et al (1992) reported that injuries to the vertebral column were linked to jobs which involved activities like lifting, pushing, pulling and carrying. All these were present in manual brick manufacturing. Investigations by other authors (Snook et al, 1978, Kelsey et al, 1984) indicated that repetition, twisting, or lateral bending, for even relatively light weights are significant factors in the genesis of low back musculoskeletal disorders and injuries.

Conclusion

Manual brick manufacturing in India is currently an extremely hazardous occupation. There are hazards in the working environment because of the high ambient temperature, as well as hazards associated with manual load lifting, which are well above the recommended limit. There are vulnerable postures, in which the workers are engaged for long periods, which further increase the risk of injury. Complete absence of any personal protective devices renders the workers vulnerable to all sorts of injury associated with material handling.

Relevance

There is still a paucity of data about different risk factors for musculoskeletal disorders in manual brick manufacturing in India. Jobs involving different awkward postures of the body along with high environmental heat load have a strong association with injury, disorders, a fall in productivity and the quality of work outcomes. This study presents different risk factors associated with these types of jobs. Therefore it is essential to use biomechanical models at the design stage to identify and suggest suitable ergonomics design interventions to minimize and control such high risk tasks.

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Articles

3. Scope of Ergonomics Design and Usability for an Intensive Care Unit (ICU): An Indian Perspective

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Abstract

In this paper, we have tried to identify the scope of ergonomics design and usability for an Intensive Care Unit (ICU) through the study of seven different hospitals in India. The feedback received from physicians about the usability of ventilator systems is also discussed. Our study highlights the need to evolve standards focusing on ergonomics design and usability of an ICU. It is also felt that the user interface design of medical equipment and hospital signage systems must support culture specific and localized adaptations for better comprehension.

Keywords

Intensive Care Unit (ICU), Medical Equipment, Ventilator System, Human Factors, Ergonomics Design, Usability

Introduction

In this paper, we are presenting the findings of our usability study of Intensive Care Units (ICUs) in Indian hospitals. Our study touches upon its various aspects such as location, layout, signage system, doors, windows, patient information boards, switchboards, power plugs, various medical facilities and equipment. Through this study, we have realized that there is vast scope for enhancement of ergonomics design and usability of an ICU and each aspect needs an individual focus. However, presenting an overview of these aspects will be helpful for appreciating the complexities and challenges faced by the physicians, ICU staff and patients. An example of this complexity was noted in relation to the usability of ventilator system, which is one of the most important pieces of medical equipment used in an ICU.

We came across many ICU standards that primarily focus on ensuring quality of service through process monitoring. Some of them make a passing mention of ergonomics design but do not provide any specific guidelines to enhance the usability of an ICU [13].

Critical role of an intensive care unit (ICU)

In the first instance we need to appreciate the purpose and objectives of an ICU. Mostly the ICUs are meant to offer emergency services to patients. ICUs are specialty-nursing units designed, equipped and staffed with skilled personnel for treating very critical patients or those requiring specialized care and equipment [7]. An ICU has a cognitively complex environment [14] like the cockpit of an aircraft or the operating room of a nuclear power plant where one is required to:

- monitor various systems and equipment;
- integrate and understand complex information;
- attend critically ill patients;
- judge the dynamically evolving situation; and
- take quick and accurate decisions.

Time critical

Densely populated cities in India, narrow lanes, traffic congestion and parking problems create hurdles for critically ill or accidentally injured patients en route to a hospital. In the process, such patients lose precious time at this life critical moment. Once the critical patient is brought to the hospital, without any further loss of time, it should be possible to give immediate attention and proper treatment. In this critical moment, the usability of an ICU becomes important for efficient and accurate treatment.

Life critical

Poor usability increases the risks associated with medical equipment [9]. It also results in undue expenditure in terms of unproductive time needed to be spent on learning how to operate the equipment and unsafe handling possibly resulting in accidents [10]. Furthermore, device-induced errors can also injure or kill a patient [8].

Emotionally stressful

ICUs have a very emotional and critical environment as they deal with life and death situations. The patients and their relatives can become emotional. Their reactions may be very sharp. Also, behaviour of physicians and ICU staff can be directly affected by the operating environment and physical characteristics of medical equipment [3].

Need for user friendly ICUs

Patients and their families need user-friendly environments that have a more natural look and feel [2]. They also expect improved décor, more privacy, reduced environmental stressors, natural surroundings and greater control over tasks and information.

On the whole, we can understand how important ICUs are and how critical ergonomics design and usability are for its users. Our study is very relevant, particularly in the Indian context, and it is also applicable to any other developing country scenario.

Method

Selection of hospitals

Our study is based on seven different ICUs belonging to different hospitals from cities and small towns from two different states in India. This has given us a proper representation of conditions in well-equipped and modestly equipped hospitals. For recording purposes the names of the hospitals are given below:

- Bharati Hospital, Sahyadri Hospital, Ratna Memorial Hospital and Siddhi Hospital from Pune city in Maharashtra State, India;
- Giriraj Hospital and Jogalekar Hospital from smaller towns namely Baramati and Shirwal in Maharashtra State, India; and
- People's Group Hospital from Bhopal City in Madhya Pradesh State, India.

Data gathering

- Structured interviews of many physicians and ICU staff were carried out. It was a very hectic and tricky challenge to get access to medical practitioners.
- A questionnaire was designed as per the guidelines given by Chauncey Wilson [4] to gather feedback.
- Field studies, observations of facilities and usage of equipment were photographed and documented.

Types of Users

Various users of an ICU have been are categorized as:

Primary users

Physicians, specialist physicians, resident doctors and sisters who actually use the equipment.

Secondary users

Intern doctors, ward boys, patients and biomedical technicians who also assist the primary users in maintenance of medical equipment.

According to Jennifer Martin et al [9], even when patients don't operate the medical equipment, they are subjected to the diagnosis and treatments produced using the equipments. Therefore even the patients are also considered as important users of medical equipments.

Tertiary users

Administrators, relatives of patients, visitors who come in proximity to medical equipment.

The planning team for an ICU design should include representatives of all the users—especially patients and their families as they are experiencing some of the most traumatic moments of their lives [2].

Discussion

Location of an intensive care unit (ICU) in the hospital premise

Table 1. Floor wise location of ICUs in different hospitals

Floor	No. of ICUs
Ground	2
First	2
Second	1
Third	2

As shown in Table 1, we have observed that the ICUs are located on different floors in different hospitals. This compels the patients to use elevators and as a result increases the dependency on power supply, maintenance and smooth functioning of the elevator. ICUs are not immediately approachable when you enter the hospital. In many places an exclusive entrance and parking facility is not provided.

Ideally, the ICUs have to be on the ground floor and not far from the casualty department and a general ward [7]. As recommended by Miranda et al [5] the supporting services such as an operating theatre, the department of radiology, the laboratories, and the blood bank should be nearby. On the contrary, we found that the ICUs are surrounded by random facilities and services. There does not seem to be any standard practice or design. Because of the unavailability of a standard location and easy pathway to reach the ICU, the patients and their relatives have to search for it, which results in delays and disturbance to other patients.

Figure 1. Signage for an ICU

Signage System

A good signage system is an imperative for directing the patients and visitors through the hospital. A proper signage system is also essential inside the ICU. It can help the users to navigate independently through various departments, without requiring any assistance or disturbing the patients. But many hospitals in India do not use signage systems. Where some signs and symbols are used they look different in different hospitals. One such signage board is shown in Figure 1. Standard guidelines for hospital signage are essential wherein the depiction of sign, colors, shapes, sizes and placement of signs should be consistent. Culture specific localization of hospital signage needs to be considered for effective communication with patients and visitors belonging to a geographic region.

Layout and Composition of Facilities in the ICU

The typical ICU includes various facilities such as a procedure room, visitors' room, counseling room, changing rooms for nurses and physicians, a security room, dead body room, conference room, reception, communication centre, pantry, store, places for clean and dirty linen, patient toilet, staff toilet, and gadget parking area [12]. In the ICUs visited by us, we found that the above-mentioned functions and facilities were all arranged differently. In many cases, some of the facilities were not provided at all.

During our interviews with the experienced physicians, they agreed unequivocally that the above-mentioned functions and facilities are interrelated and interdependent and hence should be considered at the time of architectural planning. Many facilities are created in any available space, in the built environment of the hospital. Design of the architectural layout along with all the facilities related to it, have a strong impact on overall usability and effectiveness of an ICU.

Figure 2. Patient Information Boards

Design of Patient Information Boards

Effective communication with patients, relatives and visitors is vital in healthcare settings where miscommunication may lead to misdiagnosis and improper or delayed medical treatment [1].

As shown in Figure 2, patient information boards are used to provide information about resident patients. This information helps the family members and newly visiting medical staff to find where their patient is located.

Figure 2 shows that the bed numbers have been hand-written on cards that are partly or fully covered by the cardholder. A typical information board has many such card-holders arranged in a grid format. Patient information on the board can be updated in random order. As a result, the family members of the patients have to take a walkthrough of an entire ICU to locate their patient. It would be ideal to have the cardholders arranged as per the layout of the ICU. It would help the family members get a proper orientation and eventually locate their patient without disturbing other critically ill patients.

A

B

Figure 3. ICU Doors with written instructions on whether to push or pull them open

Door Design and Window Positions

Figure 3. shows the doors of one ICU. Figure 3A shows the outside view of doors and Figure 3B shows the inside view of the same doors. Figure 3A shows an instruction in a blue color strip that says 'Push the Door'. Figure 3B shows another instruction that says 'Pull the door'.

The following usability problems with the doors are noted below.

- The instructions are written in Marathi, the regional language used in the Maharashtra State of India. This means that they may not be readable by the physicians, staff members and visitors who cannot understand Marathi language. These people will be left with no option but to explore pushing, pulling and may be even sliding the door and thus waste valuable time.
- The design of door itself should provide cues for one to know whether it should be pushed or pulled [11]. Design can transcend languages and be used to communicate effectively with the users.
- Such doors make it difficult, especially when the patient is taken in or out on a stretcher, as the radius of door opening is large. Thinking logically, sliding doors would be easier than doors which require to be pushed or pulled.

Figure 4. Windows causing bright reflections in the monitors

It is essential for every ICU to have windows as the source of natural light. It is extremely important for the patients as about 50% of them who have stayed for more than eight days in ICU, develop ICU psychosis [7]. It is a condition whereby a patient loses track of time.

At the same time, the relative positions of windows and monitors of medical equipment should be such that monitors won't lose readability because of reflections. Information displayed on the monitor must be easily readable for the physicians. Figure 4 shows bright reflections in the monitor which is on a shelf opposite wide glass windows.

Design of Power Switches, Plugs and Cables

We often found that some power plugs were marked with indications of where they belonged, or with which equipment they needed to be used. This was because the cables and plugs do not carry any pre-defined colour-code or symbols for their usage. This resulted in a potential mix-up of power cables. As a result the users had to stick labels—or scribble some information using marker pens—on the power plugs and cables. Power plugs and cables should be designed with unique color-coding, shapes and sizes for better identification [11]. The same approach is also applicable to switchboards ... as otherwise one has to operate them by trial and error.

Usability of Medical Equipment

An ICU has many medical types of equipment such as a ventilator system, defibrillator, multi-parameter monitoring system, central monitoring station, electrocardiogram (ECG) and analyzer. These are the most critical and commonly required medical equipment, which provide extensive information to help with medication.

In this wide variety of medical equipment, we focused mainly on the usability of ventilator systems, as many physicians specifically advised us to do so. They accorded the highest priority to the usability of this equipment. A ventilator system gives respiratory support to critically ill patients [10]. The usability issues commonly observed during this survey are summarized below.

Switches Don't Last, Labels and Symbols Fade Away

The ventilators are costly and are intended to be used for a long period in order to recover the initial expenditure. But the users' experience did not support this assumption. The switches, knobs and control panels did not last very long as a result of their frequent use. The labels and symbols printed on the buttons also tended to fade away [6].

Figure 5. Right-handed design of ventilator system

Right-handed design

Many ventilator systems are designed only for right-handed users. This is reflected in the layout of the control panels. The left-handed users are disadvantaged and not very efficient or effective with right-handed design of control panels. As shown in Figure 5, the circular button and the touch-buttons are positioned on right side of the display screen [15]. The circular button may be difficult for left-handers to rotate.

Legibility and contrast

Very often the physicians have to glance at the monitor of a ventilator system from a distance. The monitor shines and reflects the light. As a result the readability of information displayed on the monitor is compromised. In the case of physicians having poor eyesight, it makes it harder to read the information. Therefore, the legibility of information and its contrast in the display monitor need to be enhanced.

Clutter of features

Ventilator systems are provided with many functionalities and features, which remain unused. This complicates the routine usage and results in cognitive overload for the users.

Culture specific symbols

Users felt that interface labels, symbols and abbreviations were designed for western users. They need to be localized and tuned to suite different cultures.

Lack of templates and intelligence

Templates for frequently used settings, intelligent and predictive system behavior would enable quick usage during the moments of emergencies and in the absence of specialist physicians [6].

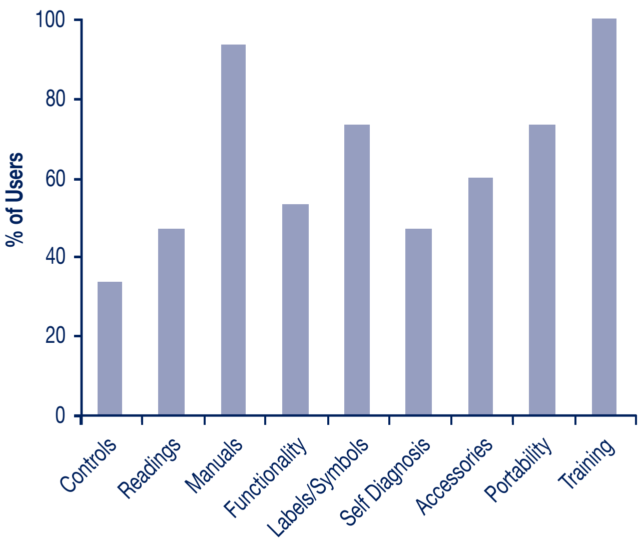
Mobility and portability

Users felt that ventilator systems [15] need to be more compact, along with a robust design that supports mobility and portability. Dismantling of a ventilator stand can be very time-consuming.

User manuals in foreign languages

During the interview, many sisters, intern doctors and ward-boys reported that the user manuals were difficult to locate when needed or manuals were not accessible because they were in the custody of some authority. User manuals were not readable for them when the information was presented in a foreign language such as English, French, or Dutch [9]. User manuals need to be provided in Indian languages like Hindi or other regional languages. The ventilators could also benefit from provision of online-help [10].

As shown in Graph 1, an increasing demand for training as well as the provision of better user manuals revealed the users' helplessness in understanding the controls and interface design. It indicated an alarming need to focus on overall usability of medical equipment in an intensive care unit.



Graph 1. User feedback

Conclusion

- Figure 6 illustrates the various aspects affecting the usability of an ICU, as separate layers of location and layout, signage system, internal facilities, medical equipment, control panels and software. Each aspect must be evaluated and designed to satisfy different human factors and user requirements. Our study has revealed many ergonomics and usability problems pertaining to these issues.

- The aspects of the ICU covered in this paper belong to diverse specialized disciplines namely architecture, visual communication, interior and furniture design, industrial / product design and user interface design. Ergonomics design and usability have to be accomplished through proper orchestration and integration of multi-disciplinary inputs.

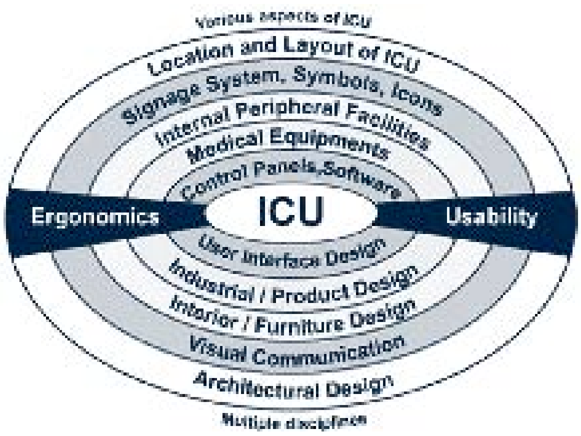


Figure 6. Scope of ergonomics design and usability for an Intensive Care Unit (ICU)

- It is imperative to evolve an encompassing design strategy to achieve ease, efficiency, goal fulfillment and overall effectiveness for the users of an ICU including physicians, patients, sisters, and ward-boys.

- Standards focusing on ergonomics and usability guidelines for an ICU need to be generated. Those standards should cater to the requirements of richly resourced ICUs in the developed countries as well as the modestly equipped ICUs in the developing countries. Healthcare should not be compromised in any part of the world.

- In addition to the considerations for various human factors, the user interface design of medical equipment and signage systems must support culture specific and localized adaptations for better comprehension.

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4. The Changing Nature Of Risks

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Introduction

Human life has always been fraught with risks. But until the first decades of the 19th century, risks were accepted as more or less natural in the sense that they were directly associated with human activity rather than with failures of systems or equipment. Accidents happened as a part of work (which often took place at home), during major building works, when travelling on land or at sea – and of course during wars. This perception changed dramatically after September 15, 1830, when William Huskisson became the first victim of a train accident. The occasion was the opening of the Liverpool and Manchester Railway and the train that hit the unfortunate Mr. Huskisson was George Stephenson's Rocket. More accidents soon followed, involving exploding boilers, derailings, head-on collisions, collapsing bridges, and so on. (As an aside, the first recorded automobile death took place in Ireland on August 31, 1869, when a woman, Mary Ward, was thrown from and fell under the wheels of an experimental steam car built by her cousins. In 2002, road traffic accidents worldwide were estimated to kill 1.2 million people, with at least 20 million people being injured or disabled.)

The crucial change that took place in the 19th century was that accidents became associated with the technological systems that people designed, built, and used as part of work, in the name of progress and civilisation. Suddenly, accidents happened not only because the people involved, today referred to as people at the sharp end, did something wrong or because of an act of nature, but also because a human-made system failed. Furthermore, the failures were no longer simple, such as a scaffolding falling down or a wheel axle breaking. The failures were complex, in the sense that they usually defied the immediate understanding of the people at the sharp end. In short, their knowledge and competence was about how to do their work, and not about how the technology worked or functioned. Before this change happened, people could take reasonable precautions against accidents at work because they understood the tools and artefacts they used sufficiently well. After this change had happened, that was no longer the case.

The Need to Understand Risks

Risks are real in the sense that things can and do go wrong. We – society, organisations, and individuals – therefore have to deal with them. But it is important that we do this in the right way, i.e., that we understand the risks appropriately. There are many definitions of risk, but most of them involve the notion of an adverse outcome or a potential negative impact that arises from some present process or future event. The occurrence of the event is possible rather than certain, either because it is unknown or because it occurs with some probability. This also means that the loss is probable rather than certain. A risk is deemed to be large if either the loss is severe, if the probability is high, or both together. Similarly, a risk is deemed to be small if the loss is small, if the probability is low, or both together.

Since negative outcomes are unwanted and undesirable, everyone – individuals, organisations, and society – are interested in finding ways to avoid that these outcomes happen. For example, we all know that it is risky to drive a car in traffic or to cross a busy street, but we do not know when a traffic accident involving us will happen. We therefore proceed with as much caution as we find necessary to remain safe. The same goes for individuals at work and for the larger socio-technical systems. But where the individual normally can rely on common sense and experience, socio-technical systems must employ more direct and explicit methods In order for a system to avoid accidents, which under normal circumstances is tantamount to being safe, it is critical to be able to identify and manage risks, and therefore to understand what the risks are in the first place. Classical risk assessment, for instance, normally starts from the unwanted consequences, such as the top event in a fault tree. In order to do this, the unwanted consequence must be recognisable either because it has happened before, which means that it is part of the individual or joint experience, or because it can be imagined – which usually means that it is a linear extrapolation of something that has happened before.

The Difficulty in Understanding Risks

Safety can be defined as the absence of adverse outcomes (accidents, incidents, personal injuries, work loss days, etc.), or more formally as a state in which the risk of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level. This safe state is achieved through a continuing process of hazard identification and risk management. Regardless of the precise definition, a critical prerequisite for safety is the ability to identify in advance the events that may lead to adverse outcomes, as well as the outcomes themselves. This is, indeed, what risk assessment is all about, and over the years a large number of methods and techniques have been developed to make this process more efficient and reliable. Methods and techniques are, however, of limited value unless they are based on an adequate understanding of the domain and the types of work involved. No risk assessment methods can be applied in a mechanically or unthinking fashion.

On the contrary, effective risk assessment depends critically on the ability of investigators and analysts to imagine what can possibly go wrong. This ability, or requisite imagination (Adamski & Westrum, 2003), comprises three steps. The first step is to understand what the problem is or indeed to appreciate that there is a problem at all. The second step is to understand the "mechanisms" or the ways in which the adverse outcomes can arise, to envisage the consequences, and to differentiate between large and small risks. The third and final step is to think of or find the means which can be used either to reduce or eliminate the risk, or to protect against the consequences. If one or more of these steps fail, the risk may not be noticed until something happens, at which time it is usually too late to do anything about it. Two characteristic examples will hopefully make clear what the three steps mean.

An uncomplicated risk: Smoking and cancer

As an example of a risk that is relative easy to comprehend, even for non-specialists, consider the relation between smoking and lung cancer. Ever since the publication of the British doctors study in the 1950s, it has been common knowledge – except, perhaps, in the tobacco industry – that tobacco smoking increases the risk of lung cancer. (But notice that before this study, few people considered smoking a risk. The study established an irrefutable statistical and causal relation between smoking and lung cancer.) The way in which this happens, the "mechanism", is well described and well understood; it is easy to envisage the consequences and therefore to differentiate between large and small risks, for instance between active and passive smoking. Finally, the solution to the problem is also known and in itself quite uncomplicated, although it sometimes seem to be difficult to apply individually. (This therefore nicely illustrates that knowing that a risks exists is a necessary but not a sufficient condition for reducing or eliminating it.) The relation between smoking and cancer is nevertheless a risk that is easy to understand.

A complicated risk: Global warming

We can use another kind of "smoking" as an example of a risk that it is difficult to understand. Global warming, also known as the greenhouse effect, is the phenomenon that changes in the levels of carbon dioxide in the atmosphere can lead to changes in the surface temperature of our planet. Although it is the general consensus of scientists and experts, such as the Intergovernmental Panel on Climate Change, that global warming is a reality, it nevertheless remains a fiercely debated issue. There are still many people, well-known writers, scientists, and politicians among them, that flatly deny the existence of global warming. In terms of the three steps mentioned above, already the first seems to be hard; it seems to be difficult to acknowledge that there is a problem at all. (This may, of course, be due to other reasons, such as economic interests and political expediency; the problem may thus be understood, but despite that not acknowledged.) So while for some people the problem is real, for others it is only an environmentalist fantasy.

The second step is to understand the "mechanisms" and the ability to envisage the consequences. As far as the mechanisms are concerned, they have been known since the Swedish scientist Svante Arrhenius in 1895 presented a paper to the Stockholm Physical Society entitled "On the influence of carbonic acid in the air upon the temperature of the ground." (The paper was published the following year. Yet it is a surprise to many people today that the greenhouse effect was described so long ago.) As far as the effects are concerned, estimates of their magnitude vary considerably; some even see global warming as a positive development (Arrhenius was in fact of that opinion himself). The third step is also difficult, since it is not easy to think of ways in which the risk or the outcomes can be reduced. (In this case, abandoning the collective "smoking" that leads to global warming may be even more difficult than in the case of individual smokers.) All in all, global warming is an example of a risk that is difficult to comprehend.

Large and small risks

Practically all industries explicitly deal with and acknowledge the serious risks, mostly because they understand the benefits of doing so, but sometimes simply because they have to. This has over many years established a practical understanding in the perception and handling of risks across industries and domains. One example of that is the ALARP (As Low As Reasonably Practicable) principle, where the determination of what is "reasonably practicable" reflects a combination of economic, practical, and ethical concerns.

The same does not go for risks with less spectacular outcomes. In these cases it is often difficult to understand what the problem is, or sometimes even to see that there is a problem at all – at least not until something has happened. It is the irony of risk assessment that the success of eliminating the large problems, where the "mechanisms" are easy to understand, inevitably and unfortunately leaves the problems that are harder to understand. Adverse outcomes are not always due to cause-effect chains or a linear propagation of the effects of a malfunction, but may also arise from unusual combinations of conditions that involve poorly understood characteristics of the socio-technical systems.

If socio-technical systems were relatively stable and only changed slowly, the experience from accidents and incidents that happened would over time be sufficient to ensure an acceptable level of safety. Unfortunately, industrialised societies continue to develop and the socio-technical systems become ever more complex. This means that the risks also change and that accumulated experience never will be sufficient. Since risk assessment and accident analysis methods necessarily are a product of accumulated experience, there will unfortunately and invariably be a lag between the changes in the real world and the corresponding changes or renewals or updates of models and methods. In other words, even if the risks of a system have been fully understood at one point in time (and even that may be debatable), this will not be sufficient to guarantee a safe state in the future.

The growing complexity of socio-technical systems

One useful characterisation – if not quite an explanation – of this development was given by the American sociologist Charles Perrow in a book called Normal Accidents (Perrow, 1984). The fundamental thesis of the book was that the industrialised societies, and in particular the technological environments that provided the foundation for those societies, by the end of the 1970s had become so complex that accidents were bound to occur. Accidents were thus an inevitable part of using and working with complex systems, hence should be considered as normal rather than rare occurrences. Since Perrow published his analyses neither the socio-technical systems, nor the problems that follow, have become any simpler.

Perrow built his case by going through a massive set of evidence from various types of accidents and disasters. The areas included were nuclear power plants, petrochemical plants, aircraft and airways, marine accidents, earthbound systems (such as dams, quakes, mines, and lakes), and finally exotic systems (such as space, weapons and DNA). The list was quite formidable, even in the absence of major accidents that occurred later, such as Challenger, Chernobyl, and Zebrügge.

Perrow proposed two dimensions to characterise different types of accidents: *interactiveness* and *coupling*. With regard to the interactiveness, a complex system – in contrast to a linear system – was characterised by the following:

- Indirect or inferential information sources.
- Limited isolation of failed components.
- Limited substitution of supplies and materials.
- Limited understanding of some processes (associated with transformation processes).
- Many control parameters with potential interaction.
- Many common-mode connections of components not in production sequence.
- Personnel specialization limits awareness of interdependencies.
- Proximate production steps.
- Tight spacing of equipment.
- Unfamiliar or unintended feedback loops.

According to Perrow, complex systems were difficult to understand and comprehend and were furthermore unstable in the sense that the limits for safe operation (the normal performance envelope) were quite narrow. Perrow contended that we have complex systems basically because we do not know how to produce the same output by means of linear ones. And once built, we keep them because we have made ourselves dependent on them.

Systems can also be described with respect to their coupling, which can vary between being loose or tight. The meaning of coupling is that subsystems and/or components are connected or depend upon each other in a functional sense. Thus, tightly coupled systems are characterised by the following:

- Buffers and redundancies are part of the design, hence deliberate.
- Delays in processing not possible.
- Sequences are invariant.
- Substitutions of supplies, equipment, personnel is limited and anticipated in the design.
- There is little slack possible in supplies, equipment, and personnel.
- There is only one method to reach the goal.
- Tightly coupled systems are difficult to control because an event in one part of the system quickly will spread to other parts.

Perrow used these two dimensions of interactions and coupling to illustrate differences among various types of systems, cf. Figure 1.

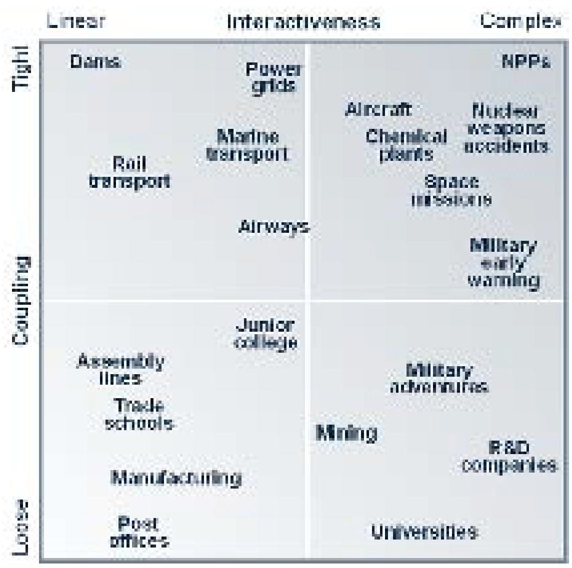

Figure 1: The coupling-interactivness diagram (after Perrow, 1984)

The worst possible combination in terms of risk and accident potential is, of course, a complex and tightly coupled system. Perrow's prime example of that was the nuclear power plant, with Three Mile Island accident as a case in point. Other systems that belonged to the same category were, e.g., aircraft and chemical plants. It was characteristic, and probably not a coincidence, that all the systems Perrow described in the book were tightly coupled and only differed with respect to their complexity, i.e., they were mostly in the upper right quadrant.

Perrow's thesis, as expressed by Figure 1, is relevant for risk assessment methods since the understanding of risk, either in accident investigation or in risk assessment, must be able to account for the nature of interactions and the degree of coupling in the system. If we, for the sake of argument, refer to the four quadrants of Figure 1, then it is clear that systems in the lower left quadrant in important respects differ from systems in the upper right quadrant. A method that may be adequate to understand risks and adverse outcomes in a system in the lower left quadrant, such as a person being injured while working at an assembly line, is unlikely to be sufficient to explain risks and adverse outcomes in a system in the upper right quadrant, such as an event at a nuclear power plant serious enough to be rated on the International Nuclear Event Scale (INES). (Even though the converse is not necessarily true, it may be inefficient to use the more complex and powerful methods to investigate accidents or assess risks in simple systems.) The diagram therefore provides an external frame of reference for risk assessment methods in addition to the more traditional requirements such as consistency, reliability, usability, etc.

In the description proposed by Perrow (1984), the notion of coupling is relatively straightforward. But the notion of complexity must be used with some care, since it can refer either to the epistemological or the ontological complexity (Pringle, 1951), i.e., either the complexity of the description or the supposedly "true" complexity of the system. For practical reasons it is preferable to use a different concept, namely how easy it is to manage or control the system, where the extremes are tractable and intractable systems. A system, or a process, is tractable if the principles of functioning are known, if descriptions are simple and with few details, and most importantly if the system does not change while it is being described. Conversely, a system or a process is intractable if the principles of functioning are only partly known or even unknown, if descriptions are elaborate with many details, and if the system may change before the description is completed. A good example of a tractable system is the normal functioning of a post office, or the operation of a home furnace. Similarly, a good example of an intractable system is the outage at a NPP or the activities in a hospital emergency department. In the latter cases the activities are not standardised and change so rapidly that it is never possible to produce a detailed and complete description (Wears et al., 2006).

Using this modification of the terminology, we can propose a new version of Perrow's diagram, as shown in Figure 2. (Note that this also means that some of the examples used by Perrow have to change position; in addition, some examples (e.g., nuclear weapons accidents) have been deleted, while others (financial markets) have been introduced. These changes are, however, illustrative rather than exhaustive.)

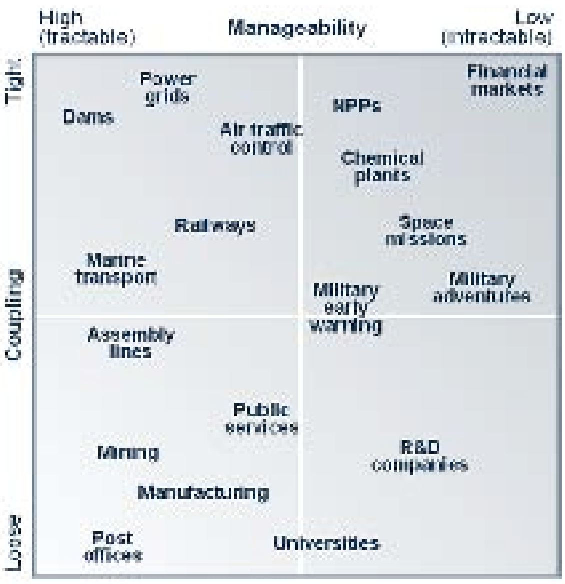

Figure 2: New version of Perrow's Diagram

Following this principle, risk assessment methods should be characterised in terms of the systems – or conditions – they can account for. For instance, a simple linear model – such as the domino model (Heinrich, 1931) – can be used to account for certain types of risks and not for others. The domino model is suitable for systems – hence for accidents – that are loosely coupled and tractable. This is not very surprising, since most systems were of that type at the time the domino model was developed. Nuclear power plants considered as systems are, however, tightly coupled and more or less intractable and require models and risk assessment methods that are capable of accounting for these features. It is therefore reasonable to characterise investigation methods in terms of which applications they can account for.

While this will not by itself determine whether one method is "better" than another, it will make it possible to choose a method that is suitable for a specific purpose and/or system and thereby also to exclude methods that are unable to meet the requirements of a given assignment.

The Power of Risk Assessment Methods

When problems are difficult to understand, it also becomes difficult to envisage the consequences and to pinpoint the significant risks. The events that one would want to avoid may first of all only occur very infrequently, cf., Westrum's (2006) notion of irregular threats. The events may even belong to the category of rare events – meaning that they are almost never repeated. Since their aetiology defies traditional explanations or accident models, it is usually difficult both to determine what consequences may obtain and to assess their likelihood. Finally, even when the risks can be assessed, the absence of easily understandable causes makes it hard to propose concrete and cost-efficient countermeasures. Without a clear focus, it is very difficult to know how to respond.

The problem is not made easier by the ongoing change from linear to non-linear accident and safety models. This change is a consequence of the growing recognition that accidents can be due to couplings or interactions among functions or events that are not in themselves failures or malfunctions, hence are not found by traditional risk analyses. One way of expressing that is to note that accidents more often are due to usual actions under unusual circumstances than to unusual actions under usual circumstances. In other words, the explanations cannot be found nicely tucked away in a single part of a socio-technical system, such as the operator or the interface, but are rather due to the ways in which normal performance variability can combine in unexpected ways. For risk assessment this creates a need for models and methods that can explain how adverse events can arise from normal performance variability as well as from failures and malfunctions.

The description of three steps in risk assessment, acknowledging that a problem exists, understanding the "mechanisms" and differentiating various consequences, and finding effective means, is applicable to both linear and non-linear accident types. But if it is hard to understand the "mechanisms" for classical risks, it is even more challenging for the risks that are described as emerging from more complex, socio-technical systems. Yet it is essential that we become able to do that, not only on the level of analysis but also on the levels of management and policy making. A failure to do so will limit safety management to be reactive and risk analyses to be nothing more than extensions of error counting. Yet failure is not an option, neither in what we do, nor in how we do it.

Changing notions of risk and safety

Most of the methods for risk assessment and accident investigation that are used today in safety critical industries have their origin in the 1960s. This was the period where new analysis methods were required to match the growing complexity, and therefore also the growing risk, of technological systems. Examples are Fault Trees, which were developed in 1961 to evaluate the launch control system for the Minuteman ICBM (cf. Leveson, 1995), Hazard and Operability Analysis (HAZOP) which was developed by Imperial Chemical Industries in England in the early 1960s (CISHC, 1977), and Failure Mode and Effects Analysis (FMEA) which was originally developed by the US military in 1949 but later superseded by the Failure Mode, Effects and Criticality Analysis (FMECA) (MIL-STD-1629A, 1980).

Another period of rapid growth occurred in the beginning of the 1980s, mainly in response to the TMI accident in 1979. This led to the recognition that human factors and human errors played a significant role in system safety, hence that it was necessary for risk assessment and accident investigation methods to go beyond the technological system. The concern for the human factor was later extended to cover organisations and organisational factors as well, with the prominence of 'safety culture' as a good example. The direct motivation was also in this case a serious adverse event, namely the Chernobyl accident in 1986. Since the mid-1990s there has been an additional growth, although more often incremental than innovative. This growth has taken place to meet the perceived need among researchers and practitioners of a re-orientation in thinking about safety, in order to develop methods and approaches that are both more efficient in use and better grounded in their concepts and constructs.

Some of the major changes and developments since the mid-1990s have been:

- An increasing emphasis of the organisational factor, spurred by Jim Reason's book on organisational accidents (Reason, 1997);
- the increasing importance of software (e.g., the concept of Safeware; Leveson, 1995);
- the emphasis on high reliability organisations, (e.g., Weick, Sutcliffe & Obstfeld, 1999);
- the changing perspective on causality, moving from sequential models to systemic models (Hollnagel, 2004);
- the associated change in view on "human error", from the "old" look to the "new" look (Dekker, 2006);
- the change from training in specific skills to training in general communication and collaboration (Helmreich, Merritt & Wilhelm, 1999); and
- the change from reactive to proactive safety, as marked by resilience engineering, (Hollnagel, Woods & Leveson, 2006).

In the same period, that is, since the mid-1990s, the growing complexity of socio-technical systems has also necessitated the development of more powerful accident investigation and risk assessment methods and a revision of the underlying analytical principles. This complexity, which was aptly diagnosed by Perrow (1984), has unfortunately often been marked by serious accidents, and shows no sign of abating. Some of the better known examples are the JCO accident at Tokai-Mura, Japan (1999), the space shuttle Columbia disaster (2003), and the Überlingen mid-air collision (2002) – plus literally thousands of small and large accidents in practically every industrial domain. This development has not been isolated to a specific domain but can be found in many different industries and service functions.

One consequence of this has been the realisation that accident investigation and risk assessment are two sides of the same coin, in the sense that they consider the same events or phenomena either after they have happened (retrospectively) or before they happen (prospectively). In the prospective case there is, of course, the possibility that an event may never occur; indeed, the main rationale for risk assessment is to ensure that this is the case. The dependency between accident investigation and risk assessment has been emphasised both by the so-called second generation HRA methods (in particular ATHEANA, Cooper et al., 1996; CREAM, Hollnagel 1998; and MERMOS, Le Bot, Cara & Bieder, 1999), and is also a central premise for Resilience Engineering (Hollnagel, Woods & Leveson, 2006).

Development of New Accident Analysis and Risk Assessment Methods

One reason for the development of new methods and approaches has been the inability of established methods to account for novel types of accidents and incidents. Another reason has been a lack of efficiency, in the sense that recommendations and precautions based on the usual explanations have not lead to the desired effects and improvements. A third reason has been new theoretical insights, although this rarely has happened independently of the former.

In the two cases the inability and/or lack of efficiency of existing methods is a consequence of the continued, rapid development of socio-technological systems, in turn driven by a combination of technological innovation, commercial considerations, and user demands. This contrasts with risk assessment and safety management methods that develop at a much more moderate pace – if at all – which means that they rarely are able to represent or address the actual complexity of industrial systems. To the extent that methods develop, it is usually as a delayed reflection of "new" types of accidents. The outcome can be that new methods focus on a specific, salient factor of an event (e.g., violations after Chernobyl), or that they become more comprehensive by trying to draw together the collective experience and changes in view (e.g., second generation HRA).

In order to determine whether a given method is adequate for a given system and scenario, it is necessary to be able to characterise both. A system – or a scenario – can conveniently be described using the dimensions of coupling and managability, cf., Figure 2 above. For the sake of this discussion, we will assume that the dimensions can be considered as binary. This leads to the following four classes of systems.

- Systems that are loosely coupled and tractable (lower left quadrant).
- Systems that are tightly coupled and tractable (upper left quadrant).
- Systems that are loosely coupled and intractable (lower right quadrant).
- Systems that are tightly coupled and intractable (upper right quadrant).

The various accident investigation and risk assessment methods can in a similar manner be characterised in terms of the assumptions they make about the nature of risks. For instance, whether risks are seen as being due to single failures and malfunctions, to human factors, to combinations of failures and weakened defences, or to systemic failures. Combining these characterisations gives rise to the following considerations.

Methods suitable for systems that are loosely coupled and tractable

In terms of frequency or numbers, most systems are even today loosely coupled and tractable. Many of the commonly used investigation methods are best suited for systems with those characteristics – or even explicitly assume that this is the case. In practical terms this implies that it must be possible to provide a more or less complete description of the system and to account for events (e.g., failures or malfunctions) in a one-by-one or element-by-element fashion. While these assumptions make for methods that are easy or simple in terms of use, it also means that such methods are inadequate for systems in high-risk domains, such as nuclear power production, chemical production, or air traffic management.

Out of the many types of methods that are adequate for loosely coupled and tractable systems, a number of characteristic subtypes can be distinguished.

Methods that focus on the identification of failed barriers

The Accident Evolution and Barrier Function (AEB; Svensson, 2001) is a method that focuses on barriers and/or defences and explains accidents as the result of failed or deficient barriers. It is primarily an accident investigation method that describes the evolution towards an accident or incident as a series of interactions between humans and technical systems. The interactions are represented as failures, malfunctions or errors that could lead to or did result in an accident. The method forces analysts to integrate human and technical systems simultaneously when performing an accident analysis.

The method starts by modelling the accident evolution in a flow diagram. The AEB method only models errors and therefore does not work with or represent the full event sequence. The flow chart initially consists of empty boxes in two parallel columns, one for the human systems and one for the technical systems. The second phase consists of the barrier function analysis. In this phase, the barrier functions are identified as the failures, malfunctions or errors that constitute the accident evolution, i.e., as error boxes. In general, the sequence of error boxes in the diagram follows the time order of events. Between each pair of successive error boxes there is a possibility to arrest the evolution towards an incident/accident. According to the AEB model, the same barrier function can be performed by different barrier function systems. Correspondingly, a barrier function system may perform different barrier functions.

The result of an AEB analysis is a list of broken barrier functions, the reasons for why there were no barrier functions or why the existing ones failed, and to suggestions for improvements.

Methods that focus on human error

HERA (Human Error in ATM) is a an examples of a method that focus on human error as the primary contributor to risks and adverse events (Isaac, Shorrock & Kirwan, 2002). The purpose of HERA is to identify and quantify the impact of the human factor in incident/accident investigation, safety management and prediction of potential new forms of errors arising from new technology. Human error is seen as a potential weak link in the Air Traffic Management (ATM) system. Measures must therefore be taken to prevent errors and their impact, and to maximise other human qualities such as error detection and recovery. HERA is predicated on the notion that human error is the primary contributor to accidents and incidents.

The HERA method comprises the following steps:

1. Defining the error type.
2. Defining the error or rule breaking or violation behaviour through a flowchart.
3. Identifying the Error Detail through a flowchart.
4. Identifying the Error Mechanism and associated Information Processing failures through flowcharts.
5. Identifying the tasks from tables.
6. Identifying the Equipment and Information from tables.
7. Identifying all the Contextual Conditions through a flowchart and tables.

The outcome of a HERA analysis is the identification of human errors and violations, with quantitative data on the relative frequency of error types and working conditions.

Methods that focus on root causes in isolation

The purpose of root cause analysis (e.g., Wilson et al., 1993) is to identify the deficiencies in a safety management system that, if corrected, would prevent the same and similar accidents from occurring. Root cause analysis is a systematic process that uses the facts of the accident to determine the most important reasons or causes.

1. Determine sequence of events.
2. Define causal factors.
3. Analyse each causal factor's root causes.
4. Analyse each root cause's generic causes.
5. Develop and evaluate corrective actions.
6. Report and implement corrective actions.

The result of a root cause analysis if the identification of specific (root) causes that then can be made the object of specific remedial or corrective action.

Methods that focus on root causes in combination

Although it in some cases may be sufficient to look for and find specific causes, most industrial systems are designed so that single failures will not constitute a risk or lead to an accidents. Risks are therefore more often due to a combination of individual failures, and methods are therefore needed that can accommodate that.

One example of such methods is HINT (Takano, Sawayanagi & Kabetani, 1994), which is based on the Japanese version of the the Human Performance Enhancement System (HRES; INPO, 1989). The overall principle of HINT is to make a root cause analysis of small events to identify trends, and to use this as a basis for proactive prevention of accidents. The same principles can be found in SAFER (Yoshizawa, 1999), although the latter method has a wider scope, and therefore may be applicable to accidents in tightly coupled systems as well.

The HINT method comprises the following four steps.

1. Understand the event.
2. Collect and classify causal factor data.
3. Causal analysis, using root cause analysis.
4. Proposal of countermeasures.

The method differs from the traditional root cause analysis by focusing on minor human error events, i.e., on incidents rather than accidents. By supporting a trend analysis of these events, it becomes possible to consider safety proactively and to focus on the prevention of serious accidents.

Methods suitable for systems that are tightly coupled and tractable

The increasing frequency of non-trivial accidents during the 1980s and 1990s made it clear that explanations in terms of sequences or chains of causes and effects were insufficient. This also meant that risk assessment could not be limited to looking for single failures or malfunctions – whether of technical components or humans. In order to be able to deal with the increasingly complex systems, it was necessary to account for how combinations of multiple sequences of events, or of events and latent conditions, could arise. This led to the proposal of complex linear models, sometimes also called epidemiological models (Hollnagel, 2004). The two major types of methods suitable for tightly coupled and tractable systems are associated with the Swiss cheese model and the Man-Technology-Organisation (MTO) model. A third and principally different approach is the Cognitive Reliability and Error Analysis Method (CREAM), which also can be seen as a precursor of methods applicable to tightly coupled, intractable systems.

The Swiss cheese model (SCM)

One of the best known accident investigation methods of the 1990s is associated with the so-called Swiss Cheese model (Reason, 1990). This model represents an organization's defences against failure as a series of barriers, represented as slices of Swiss cheese. (To be precise, this must be the Emmenthaler cheese, which is a medium-hard cheese with characteristic large holes.) The holes in the cheese slices represent weaknesses in individual parts of the system that are assumed to vary continually in size and position in the slices. The holes can therefore also be seen as representing the risks in a system. According to this analogy, an accident can happen when holes in each of the slices momentarily align, permitting "a trajectory of accident opportunity", so that a hazard passes through all of the holes in all of the defenses, leading to a failure.

The basic method for using the SCM is to trace backwards from the accident. The analysis looks for two main phenomena: *active failures*, which are the unsafe acts committed by people (slips, lapses, fumbles, mistakes, and procedural violations); and *latent conditions*, which arise from decisions made by designers, builders, procedure writers, and top level management. Latent conditions can translate into error provoking conditions within the local workplace and they can create long-lasting holes or weaknesses in the defences. Unlike active failures, whose specific forms are often hard to foresee, latent conditions can be identified and remedied before an adverse event occurs. Understanding this can support proactive rather than reactive risk management. There are several specific methodologies associated to the Swiss cheese model, the best known being the TRIPOD method (Hudson, Primrose & Edwards, 1994).

MTO (Människa-Teknologi-Organisation or Man-Technology-Organisation)

Another method is the so-called MTO-analysis, which explicitly considers how human, organisational, and technical factors can interact to constitute a risk, and therefore also serve to explain accidents that have happened (Bento, 1992; Rollenhagen, 1995). An MTO investigation comprises three methods:

1. Structured analysis by use of an event- and cause-diagram.

2. Change analysis by describing how events have deviated from earlier events or common practice.

3. Barrier analysis by identifying technological and administrative barriers which have failed or are missing.

The first step in an MTO-analysis is to develop the event sequence longitudinally and illustrate the event sequence in a block diagram. Then, to identify possible technical and human causes of each event and draw these vertically to the events in the diagram, i.e., as factors or conditions influencing the event. The next step is to make a change analysis, i.e. to assess how events in the accident progress have deviated from normal situation, or common practice. Further, to analyse which technical, human or organisational barriers have failed or were missing during the accident progress. The basic questions in the analysis are how the continuation of the accident sequence could have been prevented, and what the organisation could have done in the past in order to prevent the accident.

The last step in the MTO-analysis is to identify and present recommendations. These should be as realistic and specific as possible, and might be technical, human or organisational. The MTO analysis thus produces a detailed description and a clarification of factors that either led to or contributed to the accident.

Cognitive Reliability and Error Assessment Method (CREAM)

CREAM was developed to be used both predictively and retrospectively (Hollnagel, 1998). Unlike the Swiss cheese and the MTO approaches, CREAM has a clearly defined theoretical basis in the Contextual Control Model (COCOM). This emphasises that risks are a function of the degree of control in a socio-technical system, and associates the degree of control with four different modes called strategic, tactical, opportunistic, scrambled, respectively. It is assumed that a lower degree of control corresponds to less reliable performance. The level of control is mainly determined by the Common Performance Conditions (CPC), i.e., by external factors rather than by internal failure probabilities. The retrospective use of CREAM (accident investigation) is based on a clear distinction between what can be observed (called phenotypes) and what must be inferred (called genotypes). The genotypes used in CREAM are divided into three categories: individual, technological and organisational, corresponding to the MTO triplet.

The procedure for CREAM for accident investigation comprises the following steps:

1. Produce a description of what actually happened
2. Characterise Common Performance conditions
3. Produce a time-line description of significant events
4. Select all actions of interest
5. For each action, identify failure mode (this is done iteratively)
6. For each failure mode, find relevant antecedent-consequent links (this is done recursively)
7. Provide overall description and draw conclusions.

The analysis can be documented by a graph, or a network, of antecedent actions (functions) and conditions that together constitute an effective explanation of the accident. The graph shows how various actions and conditions affected each other in the given situation. The use of CREAM for risk assessment basically follows the same approach, leading to a value for the failure probability (Fujita & Hollnagel, 2004).

Methods suitable for systems that are loosely coupled and intractable

There are no methods applicable to socio-technical systems in this category. The reason for that has to do with the historical development of accident investigation and risk assessment methods. At the beginning, effectively in the 1930s, industrial systems were loosely coupled and tractable. As technologies and societies developed, systems became more tightly coupled through vertical and horizontal integration and at the same time less tractable because new technologies allowed faster operations and more extensive automation. The latter meant in particular that they became more or less self-regulating under normal conditions, which reduced tractability. Since accidents 'followed' these developments, methods were developed to be able to address the new problems. Conversely, few if any accident of note took place in loosely coupled, intractable systems, hence no methods were developed to account for that. The basic reason is that such systems are social rather than technological, e.g., universities, research companies, and the like. They are therefore not designed in the same sense, nor do they have the potential for accidents with direct consequences for human life and/or material.

Methods suitable for systems that are tightly coupled and intractable

The continuously growing complexity of socio-technical systems, and the consequent reduction of tractability, has led to a fundamental change in the approach to risk and safety. The most prominent example of that is the development resilience engineering (Hollnagel, Woods & Leveson, 2006), which changes the focus from failures and actions gone wrong to the usefulness of normal performance variability. With respect to accident investigations this means that the aim is to understand how adverse events can be the result of unexpected combinations of variations in normal performance, thereby avoiding the need to look for a human error or a root cause. This view is often referred to as a systemic view. There are presently two main proposals for a method, STAMP and FRAM.

System-theoretic model of accidents (STAMP)

The hypothesis underlying STAMP is that system theory is a useful way to analyze accidents, particularly system accidents (Leveson, 2004). Accidents occur when external disturbances, component failures, or dysfunctional interactions among system components are not adequately handled by the control system. Safety is viewed as a control problem, and is managed via constraints by a control structure embedded in an adaptive socio-technical system. Understanding why an accident occurred requires determining why the control structure was ineffective. Preventing future accidents requires designing a control structure that will enforce the necessary constraints. Systems are viewed as interrelated components that are kept in a state of dynamic equilibrium by feedback loops of information and control. STAMP thus uses a feedback control system as a specific causal model. A STAMP analysis proceeds along the following lines:

1. In teleological systems, various subsystems maintain constraints which prevent accidents.

2. If an accident has occurred, these constraints have been violated.

3. STAMP investigates the systems involved, especially human-organisational subsystems, to identify missing or inappropriate features (those which fail to maintain the constraints).

4. It proceeds through analysing feedback & control operations.

The most basic component of STAMP is not an event, but a constraint. Risks and accidents are therefore viewed as resulting from interactions among components that violate the system safety constraints. The control processes that enforce these constraints must limit system behavior to the safe changes and adaptations implied by the constraints. Inadequate control may result from missing safety constraints, inadequately communicated constraints, or from constraints that are not enforced correctly at a lower level.

Functional Resonance Accident Model (FRAM)

If it is acknowledged that risks and accidents can arise from unexpected combinations of normal performance variability, then the assumption of causality must be partly abandoned. If risks and accidents cannot always be linked to failures and malfunctions of components, then methods should not be restricted to causal explanations. The alternative is to develop methods for accident investigation and risk assessment that describe system functions rather than components or structures, and that can account for the non-linear propagation of events. This can, for instance, be achieved by using functional resonance instead of causality, and by using normal performance variability instead of malfunctioning (e.g., Hollnagel, 2004; Sawaragi, Horiguchi & Hina, 2006).

The method associated with FRAM proceeds along the following steps:

1. Define the purpose of modelling and describe the situation being analysed. The purpose can be either risk assessment of accident investigation.

2. Identify essential system functions and characterise each function by six basic parameters (input, output, time, control, pre-conditions, resources).

3. Characterise the (context dependent) potential variability using a checklist. Consider both normal and worst case variability.

4. Define functional resonance based on possible dependencies (couplings) among functions.

5. Identify barriers for variability (damping factors) and specify required performance monitoring.

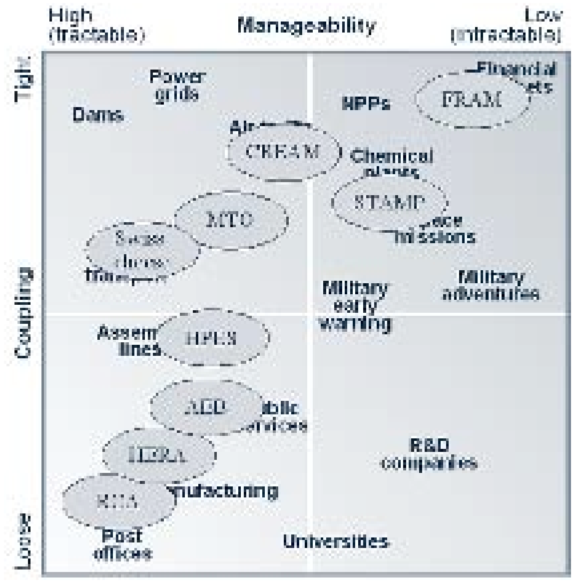

Figure 3: Characterisation of accident investigation methods

The analysis uncovers dependencies among functions or tasks that normally are missed. It also identifies the information needed for the investigation. The concrete result can be a graphical rendering of how the accident developed and/or a detailed written description (Nouvel, Travadel & Hollnagel, 2007). The basis for a risk assessment is the performance variability of normal actions.

Discussion and Conclusions

One way of summarising the characterisation of the methods described above is to map them onto the diagram shown in Figure 2. The result of that is can be seen in Figure 3. This shows that most methods are applicable to tractable systems, or rather that most methods assume that the systems are tractable. Conversely, one may conclude that these methods should not be used for intractable systems, since they will not be able to produce adequate explanations. Several of the commonly used methods, including root cause analysis, AEB, and HERA, also require that systems only are loosely coupled. These methods are therefore unable to account for the consequences of tight couplings, hence unable adequately to explain accidents in systems of that type.

It makes sense that any method would be just about adequate for the typical type of problems at the time it was developed. Indeed, there would be little reason to develop a method that was more complex or more powerful than required, not least because it would be difficult to imagine what that should comprise. As argued in the beginning, new methods are usually developed because the existing methods at some point in time encounter problems for which they are inefficient or inadequate. This, in turn, happens because the socio-technical systems where accidents happen continue to develop and to become more complex and more tightly coupled. The inevitable result is that even new methods after a while become underpowered because the nature of the problems change, although they may have been perfectly adequate for the problems they were developed for in the first place.

The position of the various methods on the diagram in Figure 3 presents a characterisation of the methods using the two dimensions of coupling and manageability, and thereby indirectly represents the developments of socio-technical systems since the 1980s – and indeed since the 1930s. Without going into the details of this development, the lower left quadrant can be seen as representing industrial systems before the middle of the 20th Century, i.e., before the large scale application of information technology. The development since then has been one of tighter coupling (moving up into the upper left quadrant) and a loss of tractability (moving right into the upper right quadrant). This has in turn required the development of new methods, as shown in the diagram.

The position of a method reflects the assumptions behind the method, specifically what has been called the accident model. The arguments for each method were presented above. To illustrate the significance of the position, consider for instance the two extremes RCA and FRAM.

- Root cause analysis (RCA) assumes that adverse outcomes can be described as the outcome of a sequence (or sequences) of events or a chain (or chains) of causes and effects. The investigation is therefore a backwards tracing from the accident, trying to find the effective cause(s). The method requires that the system is tractable, since it otherwise would be impossible to carry out this backwards tracing. The method also requires that the system is only loosely coupled, since it otherwise would be impossible to feel confident that the correction or elimination of the root cause would prevent a recurrence of the accident.

- The functional resonance accident model (FRAM) assumes that adverse outcomes are the result of unexpected combinations of normal variability of system functions. In other words, it is the tight couplings that lead to adverse outcomes and not sequences of cause(s) and effect(s). Since the investigation furthermore looks for functions rather than structures, it is less problematic if the description is intractable. Indeed, functions may come and go over time whereas system structures must be more permanent. Functions are associated with the social organisation of work and the demands of a specific situation. Structures are associated with the physical system and equipment, which does not change from situation to situation.

This characterisation does not mean that FRAM is a better method than RCA in an absolute sense. (A similar argument can be made for any other comparison of two methods.) But it does mean that FRAM is well-suited for some kinds of problems and that RCA is well-suited for others, more precisely that FRAM is better suited for risks in tightly coupled, intractable systems. (It of course also means that there are problems for which either method is ill-suited.)

The risks that dominate in present day systems have a different aetiology than the risks that dominated one or two decades ago. This has two important ramifications. The first is that it is more difficult to understand these risks. It is harder to understand that risks may exist, at least until an accident has happened. It is harder to understand the "mechanisms", because risks can arise from non-linear interactions among normal performance variability as well as from consequences of failures and malfunctions. And because of that it is also more difficult to think of ways to reduce or eliminate the risks. In tractable systems, risks are often associated with specific components or subsystems, or with specific actions or operations. Risk reduction can therefore be achieved by either eliminating the risk, by preventing certain actions, or by protecting against the outcomes. But only the last option is available for intractable systems. Eliminating or preventing performance variability may well reduce the risk, but it will also impede normal functioning.

The second ramification is that many of the established risk assessment and accident investigation methods are inadequate for tightly coupled, intractable systems. This dilemma was made clear when Perrow proposed that accidents could be seen as normal, because risk assessment and accident investigation methods naturally focus on that which is abnormal or dysfunctional. The lesson to be learnt from that is that we must continue to evaluate critically the methods that are at our disposal. The fact that a method has worked in the past is no guarantee that it will also work in the future. The development of new socio-technical systems means that new risks will emerge, and therefore that existing methods sooner or later will need to be complemented with more powerful approaches. What these will be, no one can say for certain.

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Noticeboard

1. Call for 2008 HFESA Awards

Nominations are being sought for 2008 Awards and further details may be found on the HFESA website www.ergonomics.org.au. Persons interested in nominating a candidate for any of the awards should contact the HFESA Secretariat.

The Human Factors and Ergonomics Society of Australia presents nine national Awards that reflect outstanding achievement by individuals or groups for service to the Society and the human factors and ergonomics profession as well as to the research and application of human factors and ergonomics in Australia. Five of the Awards are named after Founders of the Society who have been Presidents and Fellows of the Society.

The Executive of CHISIG, the Computer-Human Interaction Special Interest Group of the Society, nominate a recipient for the CHISIG Medal. CHISIG also has an Award for the best paper at their annual OZCHI conference that is named in honour of Gitte Lindgaard.

The HFESA Board and the Annual Conference Committee nominate the Society Medal and the Ron Cumming Memorial Lecturer, respectively. Members of the HFESA are invited to nominate eligible people for the remaining Awards. The David Ferguson Award requires the support and endorsement of the student's supervisor.

The Honours and Awards Committee of the HFESA processes and endorses the Awards. All are based on merit and may not be bestowed every year.

Fellowship

- For outstanding contribution to the Society and the human factors and ergonomics profession over a period of at least ten years.
- Awarded to a member of the Society in good standing.
- The Award is based on the assessment of the Honours and Awards Committee and ratified by the Society Board.
- The Award is in the form of a membership certificate showing Fellow and confers honorary status.

The Society Medal

- For outstanding service to and promotion of the Society over at least seven years.
- Awarded to a member of the Society in good standing.
- The Award is based the collaborative assessment of the Society President and the Honours and Awards Committee.
- The Award is in the form of a medal suitably inscribed with the recipient's name.

Cumming Memorial Medal and Lecture

- For highly esteemed human factors and ergonomics-related research or application in a relevant area of human factors and ergonomics.
- Awarded to an Australian resident, preferably a member of the Society.
- The Award is based on the assessment of the Honours and Awards Committee.
- The Award is in the form of a Medal suitably inscribed with the recipient's name together with the presentation of the Cumming Memorial Lecture at the Society's Annual Conference for the year of the Award.

Ken Provins Award

- For the best paper presented during the Society's Annual Conference for the year of the Award.
- Awarded to individual or joint authorship, but not for a keynote speaker.
- The Award is based on both the written paper and the oral presentation at the conference.
- The Award is in the form of a Certificate for each author.

Alan Welford Award

- For the best paper on a human factors and ergonomics topic published in a peer reviewed journal within the calendar year prior to the Award.
- Awarded to individual or joint authorship, one of whom is a member of the Society.

- The Award is based on the intrinsic merit of the paper itself and its readability for the target audience.
- The Award is in the form of a Certificate for each author.

John Lane Award

- For a major systematic contribution to advancing the science of human factors and ergonomics and its application in Australia. This contribution may have been made at any time.
- Awarded to an individual, group or organisation having a relevant human factors and ergonomics connection with Australia.
- Covers work carried out over several years during the last five to ten years.
- The Award is in the form of a Certificate.

David Ferguson Award

- For the best postgraduate project report or undergraduate honours thesis produced in the 18 months prior to the Award.
- Awarded to an individual student enrolled in a relevant Australian University program of study.
- The Award is based on a paper summarising the report or thesis together with a supporting statement from the student's supervisor.
- The Award is in the form of a Certificate plus one year's appropriate membership of the Society. The paper will be published in Ergonomics Australia.

The CHISIG Medal

- For outstanding service to and promotion of the CHISIG over at least seven years.
- Awarded to a member of the CHISIG in good standing, or a retired member of CHISIG.
- Nominations can be submitted by any CHISIG member.
- The Award is based the collaborative assessment of the CHISIG Executive.
- The Award is in the form of a medal suitably inscribed with the recipient's name.

Gitte Lindgaard Award

- For the best paper presented during OZCHI, CHISIG's annual Conference for the year of the Award.
- Awarded to individual or joint authorship, but not for a keynote speaker.
- The Award is based on both the written paper and the oral presentation at the conference
- The Award is in the form of a Certificate for each author.

2. Postgraduate Ergonomics at Queensland University

There have been some changes. 2007 was a transitional year in which the frequency of offering each course was reduced. From 2008 the GCErg, GDipErg and MErg programs will be available in part-time remote mode only. While we intend to integrate opportunities for face to face contact each year via a "winter school", attendance at these blocks will be optional. An information sheet can be obtained from www.ergonomics.uq.edu.au/pgradergo8.pdf or contact:

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3. HFES Digital Library

The Human Factors and Ergonomics Society has opened Phase I of the HFES Digital Library. The online collection of HFES periodicals is available for purchase/subscription to non-members. Members of the Human Factors and Ergonomics Society of Australia are entitled to a special discount from the regular non-member rates. To view the FAQ, go to http://www.hfes.org/web/PubPages/DigitalLibraryFAQ.html.

The Digital Library now contains *Human Factors, Ergonomics in Design*, and *HFES Annual Meeting Proceedings* since 1993. By the end of 2008, content going back to 1980 will be available. When the third phase is complete (end of 2009), all the back volumes will be available, in addition to *Reviews of Human Factors and Ergonomics*. For those who hold a current subscription to the new journal from HFES, *Journal of Cognitive Engineering and Decision Making*, that content will also be accessible.

Two packages are available: Digital Library-Archive contains older volumes for a one-time purchase of US$638, and Digital Library-Current contains the three most recent years of all five titles for an annual subscription rate of US$611. Save another US$100 when you purchase both Archive and Current.

Please contact HFES at store@hfes.org, 310/394-1811, fax 310/394-2410 if you would like to purchase the Digital Library at the special HFESA rates. Do not order online.

4. CYBERG 2008

Fifth International Cyberspace Conference on Ergonomics (CybErg'08)
Local Knowledge, Global Applications

15 September—15 October 2008.

CybErg'08 is the fifth conference in the series, and is intended to cover issues on all aspects of ergonomics, highlighting the latest developments and current technologies in those areas. The theme of this upcoming CybErg'08 is "Local knowledge, Global Applications" which aims to deliberate and discuss ergonomic issues such as those applied in developing economies in Asia, Africa and Latin America.

However, one of the deterrents to greater participation from countries with developing economies has been the high international travel costs. As CybErg'08 is an online conference, it is easy to see how an international conference based on the World Wide Web can drastically reduce travel-related costs. In addition, with greater participation from the under-represented communities, it is anticipated that issues normally not discussed at major conferences would be covered. In addition, participation and responses received from the industries and organizations associated with previous CybErg Conferences have been very encouraging.

Last but not least, given the conference is on-going for a month, there is ample opportunity to discuss issues which may not normally get air-time given the limited amount of period available to conduct a lengthy discussion. With "bulletin boards" available, participants will have an opportunity to discuss with the authors and other attendees with similar interests.

Please note that awards for best paper and most active discussion groups, will be also be presented at this conference.

For more information, please visit http://www.cyberg2008.org. Should you have any queries, please contact Ms. D'oria Islamiah (CybErg'08 Secretary) (mailto:secretariat@cyberg2008.org) or me (mailto:alvin@fit.unimas.my).

Dr Alvin W. Yeo
Chairman
Fifth International Cyberspace Conference On Ergonomics 2008 (CybErg '08)

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5. HEPS International Congress (Healthcare Ergonomics and Patient Safety)

Strasbourg on June 25-27, 2008.

The HEPS 2008 conference will focus on the strategic role of citizens, patients and clinicians in the design and improvement of healthcare systems.

HEPS2008 is an International Ergonomics Association (IEA) sponsored event, organized with the support of the Italian and French Health Ministry, and Tuscany region, and endorsed by the European Parliament, the European Council, and the Haute Autorité de Santé.

The new important aspect of this second conference edition is the participation of more than 10 Patient Safety Champions representatives of the World Alliance for Patient Safety. Every session of the conference will commence with a testimony their experiences.

The main challenge and factor of success of the event is to create a bridge between the world of healthcare practioners and the world of specialists in human factor and ergonomics.

More than 300 abstracts from all over the world have been turned in, and many clinicians, experts and academics from 28 different countries have already decided to attend.

Registrations to the event are still open! This congress is a great occasion to get in touch with people who are trying to conjugate human factor ergonomics and patient safety in the world of healthcare.

For further information please visit the HEPS 2008 website, www.heps2008.org or contact the Organizing Secretariat (heps2008@newtours.it -
Tel. +39 055 3361.1 - Fax +39 055 3033895).

We look forward to seeing you in Strasbourg!
The Organizing Board

6. 13th Annual Conference of the Biofeedback Foundation of Europe

co-sponsored by the Technische Universiteit, Eindhoven, University of Technology.

Date: February 24-28, 2009

Location: Technische Universiteit, Eindhoven, University of Technology, The Netherlands.

Submission deadlines:
July 1, 2008: Workshop proposals
October 10, 2008: Symposia, Papers, Posters, and Short Courses

Download Submission Forms: www.bfe.org

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7. IEA'2009 Triennial Congress

Information about the conference, including deadlines and the template for abstracts is available on IEA website. The deadline for submitting abstracts is November 15, 2008.

For more information, please go to the website of the IEA'2009 congress: www.iea2009.org
Pascale Carayon,
Secretary General of the IEA
www.iea.cc

8. 3rd International Conference on Rail Human Factors

We are pleased to inform you of the 3rd International Conference on Rail Human Factors. It will be held in Lille, France on 3-5 March 2009. All details about the conference are posted on the website: www.railhumanfactors.co.uk

The conference is organised by the European Railway Agency, Rail Safety and Standards Board, Network Rail and University of Nottingham. This will be in association with the Ergonomics Society, Société d'Ergonomie de Langue Française (SELF) and Rail Research UK.

As with the first two conferences in the series it will be THE forum for human factors practitioners and researchers to discuss their latest work, and for the rail industry and regulators to describe their current use of ergonomics and human factors and to identify their future needs.

A number of leading authorities will be keynote and invited speakers. There will be workshop and open discussion sessions as well as technical paper presentations, and there will also be a number of technical visits available.

Please register your interest in the conference as early as possible, with stella.Okezie@rssb.co.uk. For information about submission of abstracts, please contact ECRHF@nottingham.ac.uk

We look forward to seeing you in Lille in March 2009.
Jane Rajan, Ann Mills, Theresa Clarke, John Wilson
www.railhumanfactors.co.uk

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9. HFESA 44th Annual Conference
Sustainable Performance: Human Factors, Ergonomics and the Work Environment.

17–19 November 2008

A human-centred approach considers people first in the design of the work environment. It improves the performance of both individuals and the organisation. Sustainable work performance means sound business development and profitability. The current business context is full of stressors, demands, and pressures. The economy is booming and businesses are positively financially geared. But there are barriers to sustainable performance: threat of a slowing economy in the US, a skilled-labour shortage, community demands for family-work-life balance, a shortage of infrastructure and the ever-present government red tape! In this conference we will explore the relationship between sustainable performance and the health and safety of workers, as well the impact on the wider community. Come and join us in analysing sustainability at work in a changing workplace and changing work environment. Make your contribution. Challenge your thinking – and challenge others.

University of South Australia - City East Campus.
Adelaide, South Australia
www.hfesaconference.org.au
Jennie Window
Assistant Secretary,
HFESA SA Branch

44th ANNUAL HFESA NATIONAL CONFERENCE 2008

Sustainable Performance: Human Factors, Ergonomics & Work Environment

UniSA, Adelaide, South Australia.
17-19 November, 2008

Conference Calendar

2008

25–27 June
2008—HEPS International Conference
Health Ergonomics and patient Safety
Strasburg
For further information please visit the HEPS 2008 website, www.heps2008.org or contact the Organizing Secretariat
(heps2008@newtours.it - Tel. +39 055 3361.1 - Fax +39 055 3033895).

14–17 July
2008—2nd International Conference on Applied Ergonomics (AE International 2008)
Jointly with 12th International Conference on Human Aspects of Advanced Manufacturing (HAAMAHA)
Caesars Palace • Las Vegas, Nevada USA
Under the auspices of 7 distinguished international boards of 167 members from 29 countries
Conference Chair: Gavriel Salvendy
salvendy@purdue.edu
Program Chair: Waldemar Karwowski
karwowski@louisville.edu
Conference Administrator: Laura Abell
laurajere@peoplepc.com
Fax: + 1 502 852 7397
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URL: www.AEI2008.org

15 September—15 October
Fifth International Cyberspace Conference on Ergonomics (CybErg'08)
Local Knowledge, Global Applications
Contact:
CybErg 2008: http://www.cyberg2008.org.
Ms. D'oria Islamiah (CybErg'08 Secretary)
E: secretariat@cyberg2008.org) or
A/P Alvin Yeo (Conference Chairman) E:
alvin@fit.unimas.my).

17th - 19th November
44th Annual HFESA Conference
Human Factors and Ergonomics Society of Australia.
Sustainable Performance: Human Factors, Ergonomics and the Work Environment.
University of South Australia - City East Campus.
Adelaide, South Australia
www.hfesaconference.org.au

2009

24–28 February 2009
13th Annual Conference
Biofeedback Foundation of Europe
co-sponsored by the Technische Universiteit, Eindhoven, University of Technology.
Technische Universiteit, Eindhoven, University of Technology, The Netherlands.
Erik Peper, Ph.D.
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Biofeedback Foundation of Europe
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www.bfe.org

3–5 March 2009
3rd International Conference on Rail Human Factors
Lille, France
All details about the conference are posted on the website: www.railhumanfactors.co.uk
Please register your interest in the conference as early as possible, with stella.Okezie@rssb.co.uk.
For information about submission of abstracts, please contact ECRHF@nottingham.ac.uk
Jane Rajan, Ann Mills, Theresa Clarke, John Wilson
www.railhumanfactors.co.uk

9–14 August 2009
17th World Congress on Ergonomics
IEA 2009 Beijing, China
Congress Secretariat:
Tel: +86 10 8280 1728
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Articles published in Ergonomics Australia are subject to peer review.

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The intended deadline for issues in 2008:

March edition	February 1
June edition	May 1
September edition	August 1
December edition	November 1

Contributions

Any inquiries about contributions should be directed in the first instance to the Editor.

Information for Advertisers

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Contact

The Human Factors and Ergonomics Society of Australia Inc
PO Box 7848 Balkham Hills BC NSW 2153
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Email: secretariat@ ergonomics.org.au

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Enclosure requiring folding	$462.00

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Edition	Submission Deadline
March	February 1
June	May 1
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Circulation

The Journal is published four times a year and is received by approximately 620 professionals Australia wide working in the areas of ergonomics, occupational health and safety, and design.

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Advertising and sponsorship opportunities also exist in the electronic version of this journal (EAOL) which is managed by Dr Robin Burgess-Limerick at Department of Human Movement at Queensland University. It is downloaded by more than 100 Australian and International readers each week.

To view EAOL: http://www.uq.edu.au or enter via the HFESA website.

Caveats

The views expressed in the Journal are those of the individual authors and contributors and are not necessarily those of the Society.

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Editor

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Notes

Notes