

Dental amalgam and mercury in dentistry

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Abstract

Mercury in dentistry has re-emerged as a contentious issue in public health, predominantly because so many people are inadvertently exposed to mercury in order to obtain the benefits of dental amalgam fillings, and the risks remain difficult to interpret. This commentary aims to examine the issues involved in public policy assessment of the continued use of dental amalgam in dentistry. More than 30 per cent of Australian adults are concerned about mercury from dental amalgam fillings but only a small percentage report having their amalgam fillings removed. The placement of dental fillings nearly halved between 1983 and 1997, but many millions of dental amalgam fillings exist in the Australian community. These fillings release mercury (mercury vapour or inorganic ions) at a low level (about 2-5µg/day in an adult). Evidence on the health effect of dental amalgams comes from studies of the association between their presence and signs or symptoms of adverse effects or health changes after removal of dental amalgam fillings. More formal risk assessment studies focus on occupational exposure to mercury and health effects. Numerous methodological issues make their interpretation difficult but new research will continue to challenge policymakers. Policy will also reflect prudent and cautious approaches, encouraging minimization of exposure to mercury in potentially more sensitive population groups. Wider environmental concerns and decreasing tolerance of exposure to other mercury compounds (for example, methylmercury in seafoods) will ensure the use of mercury in dentistry remains an issue, necessitating dentists keep their patients informed of health risks and respect their choices.

Key words: Dental amalgam, mercury, health, risk assessment, public policy.

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Introduction

Water fluoridation and the use of mercury in dental amalgam attracted, not for the first time, the

attention of national health authorities in Australia in 1999.^{1,2} Given the substantial differences in their roles in dentistry, it may at first seem surprising that these are regarded as such contentious issues. However, they share characteristics that might help explain the attention they receive:

1. Fluoride and mercury are widespread in the natural environment.

2. When high levels of exposure occur, adverse health effects have been observed.

3. Fluoride in water and mercury vapour at low concentrations are colourless, tasteless and odourless, making it difficult to know if they're present or to what extent.

4. What is known is that very large numbers of people are deliberately or inadvertently exposed to each substance. Two-thirds of the Australian community live in fluoridated areas and possibly a greater proportion of people have or have had dental amalgam restorations.

5. While the benefits are self-evident to many, it is a view not shared by all.

6. Their use involves assessments about benefits and risks which are not always easily quantified.

7. There is an increasing volume of research literature relevant to the assessment of benefits and risks which leads to different interpretations. A vocal minority in the community uses differing interpretations to justify calls for changes in public policy.

The purpose of this commentary is to provide an overview of the assessment of dental amalgam and mercury in dentistry – it is not a literature review. Detailed discussion has recently been published² and a systematic review is currently underway as part of a further risk assessment by the National Health and Medical Research Council. This commentary aims to examine the issues involved in public policy assessment of the continued use of dental amalgam in dentistry.

Public opinion

All dentists in Australia are aware that some of their patients have concerns about dental amalgam

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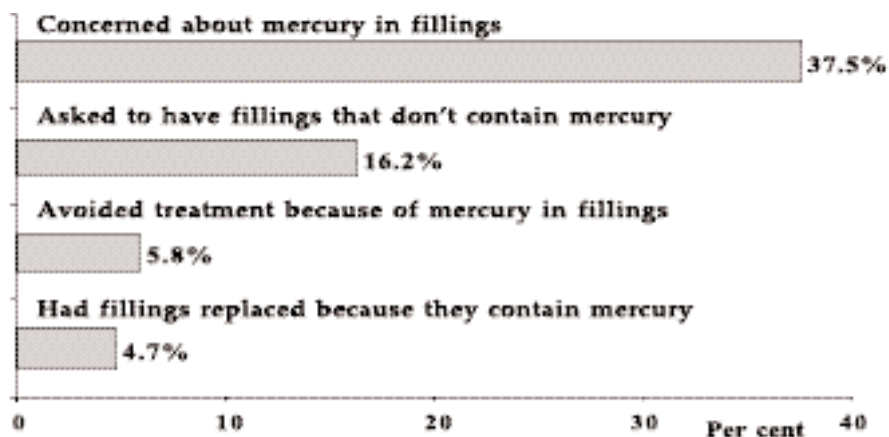


Fig 1. – Public opinion on dental amalgam and mercury in dentistry among a random sample of dentate Australian adults.

fillings and mercury. Just how often patients raise these concerns with Australian dentists is unknown. While researchers in Scandinavia sought information on patients' concerns through surveys of dentists,³ no such study has been conducted in Australia. Alternatively, such information may be sought directly from the public. In 1995, 5,101 people were interviewed by telephone on their access to dental care. A random sub-sample of the adults interviewed (n=1,185) were sent a follow-up questionnaire which included four focal questions on dental amalgam and mercury in dentistry.⁴ One thousand and ten adults responded. The key findings among dentate respondents are summarized in Fig 1.

Over one-third (37.5 per cent) expressed concern about mercury in fillings. Concern significantly decreased across older age groups and across groups with increasing numbers of missing teeth. Over 16 per cent reported asking for mercury-free fillings.

Significantly more women than men asked for mercury-free fillings. Only 5.8 per cent reported avoiding treatment because of mercury in fillings. Such avoidance was significantly higher among those with secondary rather than tertiary education and household incomes less than or equal to \$30,000. A similar 4.7 per cent reported having fillings replaced because they contained mercury. This percentage was significantly higher among those with one to five missing teeth compared to those with no teeth or more than six missing teeth.

The high percentage reporting concern and the sizeable percentage asking for mercury-free fillings indicate widespread adverse public opinion. That far fewer people have had mercury fillings replaced may reflect the influential advice from the majority of dentists who still regard dental amalgam as the restorative material of choice in relatively common clinical circumstances. Even so, 4.8 per cent of the

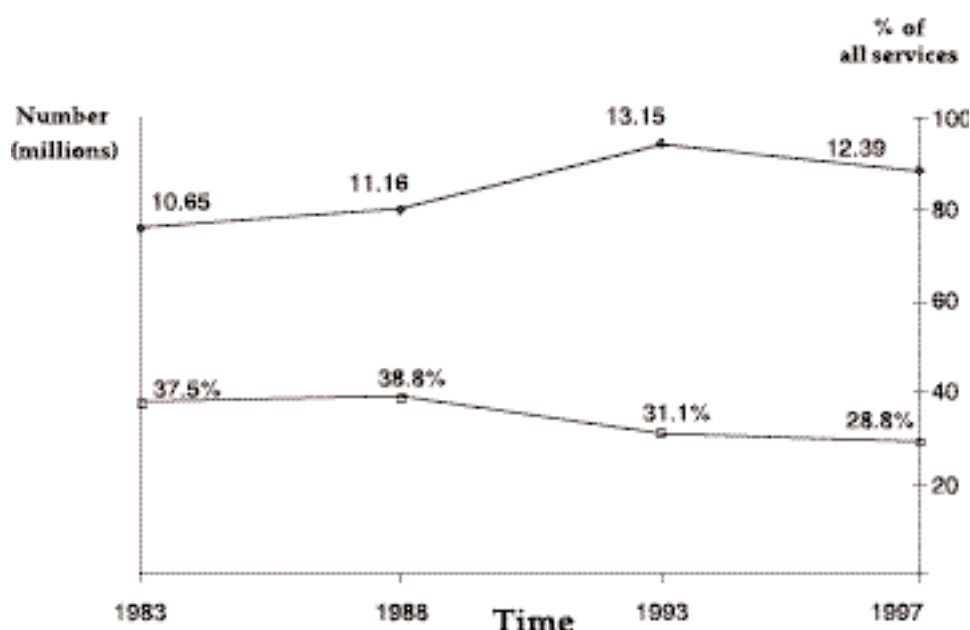


Fig 2. – Annual provision of restorative services in Australia; total number of restorative services in millions and per cent of all dental services.

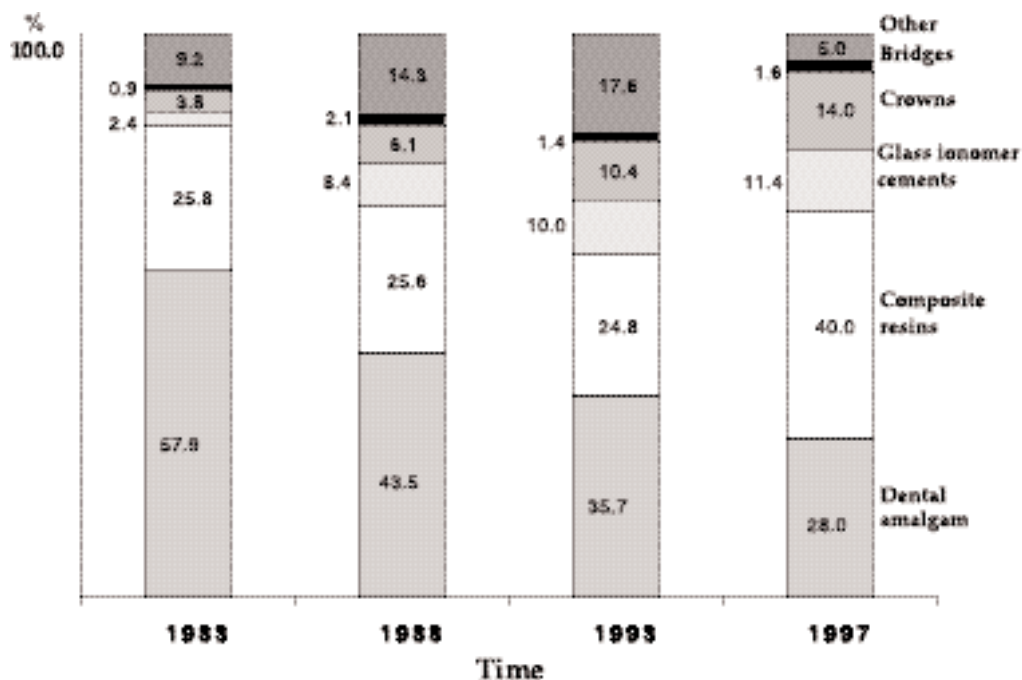


Fig 3. – Percentage of restorative services using different materials by time.

Australian adult dentate population represents a staggering 650,000 people who have had their dental amalgam fillings replaced.

The placement of dental amalgam fillings

Placing restorations is a major, changing, area of dental services. There are useful data in Australia to track changes in dental services over time from the Longitudinal Study of Dental Practice Activity. This five-yearly study provides a representative picture of private general practice from 1983-93.⁵⁻⁷ A related study, the Study of Dental Services, provides data for 1997.⁸ The key trends are illustrated in Fig 2. From 1983-97, restorative services decreased as a percentage of all services from 37.5 to 28.8 per cent. However, as the volume of all provided services increased, there was a slight increase in the total number of restorative services provided from 10.7 to 12.4 million a year.

The use of dental amalgam as a material for those restorative services has decreased markedly. This is illustrated in Fig 3. In 1983, 57.9 per cent of restorative services used dental amalgam. By 1997, the use of dental amalgam had decreased to 28 per cent of all restorative services. The use of other restorative materials increased: composite resins from 25.8 to 40 per cent, glass ionomer cements from 2.4 to 11.4 per cent and crowns from 3.8 to 14 per cent. Bridges and restorations using other materials make up the remainder.

While the total number of restorative services using dental amalgam decreased from 6.1 to 3.5 million, the decrease was not even across all age groups.⁹ Estimates of the total number of dental

amalgam fillings placed annually indicated substantial decreases among 5-11 year olds (0.39 to 0.07 million), 12-17 year olds (0.75 to 0.08 million), 18-24 year olds (1.33 to 0.19 million) and 24-44 year olds (2.63 to 1.75 million). For both the middle-age and older adult age groups, the estimate of the total number of dental amalgam fillings placed increased between 1983 and 1997: 25-64 year olds from 0.96 to 1.12 million and 65+ year olds from 0.08 to 0.20 million. However, for both older age groups, a peak occurred in 1993 followed by a decrease in the placement of dental amalgam fillings through to 1997.

A further finding was the shift in number of surfaces involved in restorations.⁹ There was a decrease in the percentage of one-surface fillings from 31.4 to 20.8 per cent across 1983 to 1997. Two-surface fillings remained at a stable percentage (47.1 to 46.9 per cent), while three or more surface fillings increased from 21.5 to 32.3 per cent. There was a large reduction in the percentage of one-surface fillings using dental amalgam (57 to 19.5 per cent), but less dramatic decreases in the percentage of two-surface fillings (74.4 to 44.5 per cent) and three or more surface fillings involving dental amalgam (71.5 to 44.9 per cent).

The placement of restorations is likely to remain at a similar absolute volume, but a decreasing percentage, of all dental services. Fewer dental amalgam fillings are being placed in children, adolescents and young adults – this reflects both the overall decline in caries activity in these age groups and a movement away from dental amalgam toward composite resins and glass ionomer cements,

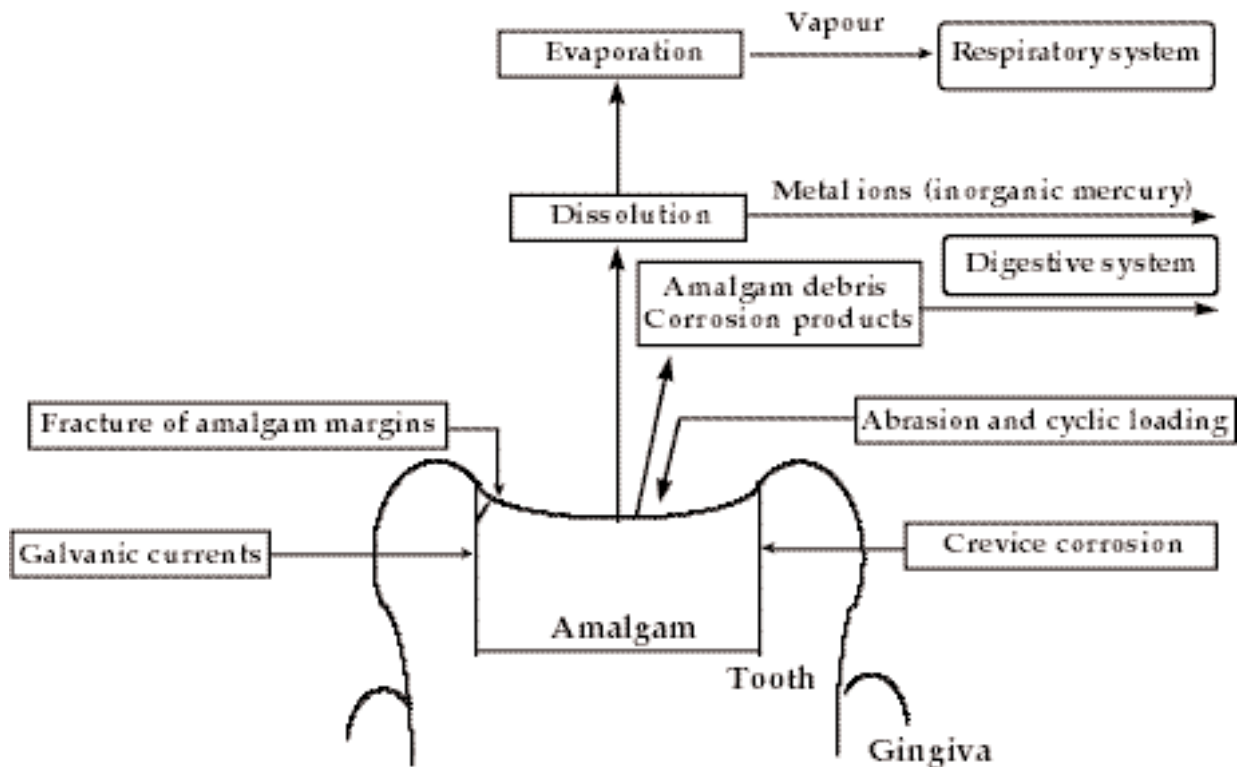


Fig 4. – Release of mercury from dental amalgam fillings (adapted from Marek).¹³

especially for one-surface fillings. More dental amalgam restorations are being placed in late middle-aged and older adults – this reflects the higher caries activity and restoration replacement rates in these now predominantly dentate age groups and a greater percentage of fillings involving two- and three-or-more-surfaces where the physical properties and handling characteristics of dental amalgam for load bearing fillings on molar teeth are still frequently regarded as superior to alternative materials.¹⁰

While the annual placement of dental amalgam fillings may have decreased, many people have existing dental amalgam fillings. On the basis of an overall mean of six filled teeth per Australian¹¹ and 50 per cent of those filled teeth being dental amalgam fillings,¹² then there were approximately 50 million dental amalgam fillings in the Australian community in the later part of the 1980s. This number will slowly decrease, but there will still be a large number of dental amalgam fillings in the Australian population. These trends in the use and estimates of the burden of dental amalgam for fillings create the context in which both benefits and risks need to be considered.

Release of mercury from dental amalgam fillings

Given appropriate apportioning of the constituents of dental amalgam, mixing or trituration, condensing into the cavity preparation and removal of excess

surface material, it was considered that all available mercury was bound up in a matrix of mercury-silver-copper-tin compounds. Further, after the initial set and hardening of the dental amalgam, it was considered inert. While it was known that dental amalgam debris could be swallowed or become lodged in periodontal tissues, and that corrosion at the interface with the tooth and abrasion of amalgam under masticatory load occurred, it was not known that mercury, in either the vapour or metal ion form, was released from dental amalgam. However, dissolution of mercury does occur,¹³ as illustrated in Fig 4. Mercury is either released from the material as metal ions or evaporates to mercury vapour. Metal ions may pass into the oral fluids to be ingested via the digestive system – it is suggested that 40 per cent of mercury exposure from dental amalgam is via ingestion of metal ions.¹⁴ Mercury vapour in the oral cavity may be exhaled or inhaled into the lungs and absorbed via the respiratory system – it is suggested that 60 per cent of mercury exposure from dental amalgam is via the inhalation of mercury vapour.¹⁴

The amount of mercury released will vary with the number of restorations, their surface area, particularly the load-bearing surface area, the galvanic currents, mastication habits (for example, bruxism), eating habits, chewing gum and toothbrushing habits. Estimates of mercury released and absorbed initially varied markedly, but are generally accepted to lie between 2-5µg/day for the average adult.¹⁵⁻¹⁷ On the assumption that the average Australian adult has approximately eight teeth with dental amalgam

fillings,¹¹ 2-5µg/day exposure to mercury from those fillings is in keeping with data published by Richardson and Allan.¹⁴ However, on the assumption that a 12 year old child has only 0.5 tooth with a dental amalgam filling,¹¹ exposure would be about 0.3µg/day.

In recognizing the release and absorption of mercury from dental amalgam fillings, it is important to place this absorption in the context of total mercury absorbed per day. The most recent Australian data on dietary mercury estimated the average daily intake of dietary mercury in food at 15µg.¹⁸ Approximately 40 per cent of dietary mercury will be bio-available,¹⁹ indicating that absorbed dietary mercury will be approximately 5.8µg/day. Mercury from dental amalgam fillings represents an average 25-50 per cent of total mercury absorbed per day. This is comparable to other reports.¹⁴ For a 12 year old child, average dietary mercury intake is about 8µg/day, with absorbed dietary mercury approximately 3.2µg/day and mercury from dental amalgam fillings make up about 9 per cent of total mercury absorbed per day.

Mercury absorption and adverse health effects

Mercury vapour is rapidly absorbed in the respiratory tract and distributed by blood to a number of key target organs. Mercury vapour is oxidized to inorganic mercury and elimination is by exhaled air or as inorganic mercury by urine from the kidneys, sweat and saliva. The key target organs are the central nervous system, which appears to be the most sensitive toxicological endpoint observed following exposure to mercury vapour, and the kidneys. Inorganic mercury (metal ions) is much less readily absorbed in the gastrointestinal tract. Approximately 15-20 per cent of available inorganic mercury may be absorbed,²⁰ hence the majority of ingested inorganic mercury is excreted through the faeces. Inorganic mercury has limited capacity to penetrate blood-brain or placental barriers, thus the most sensitive toxicological endpoint observed following exposure to inorganic mercury is kidney function.

There is a reasonable understanding of the pharmacokinetics of mercury, its absorption, distribution and elimination.²⁰ It is also clear that very high levels of mercury absorption, for instance urinary levels of mercury above 100µg/g creatinine, are associated with adverse health effects, predominantly with the central nervous system and the kidneys. What is less certain is the level of mercury absorption at which the first adverse effects occur or whether the level of mercury absorbed from dental amalgam fillings leaves some appropriate safety margin for the lowest level of exposure to mercury with an established adverse health effect.

In considering dental amalgam and mercury in dentistry, three lines of investigation are relevant to the issue of adverse health effects:

1. Is the presence of dental amalgam fillings associated with signs or symptoms of adverse health effects?
2. Is the removal of dental amalgam fillings associated with better health outcomes?
3. Can risk assessments establish that the level of mercury absorbed from dental amalgam fillings leaves an adequate safety margin for the lowest level of mercury exposure with an adverse health effect?

These questions are considered below.

Dental amalgam fillings and signs and symptoms of adverse health effects

The claimed association between dental amalgam fillings and a range of diseases or symptoms of unknown aetiology has been the starting point for much concern over mercury absorption from dental amalgam.²¹ A long list of possible adverse symptoms has been incorporated into questionnaires for practitioners to use. Certainly patients with dental amalgams do report symptoms such as irritability, depression, numbness and tingling in the extremities, frequent night urination, chronic fatigue, cold hands and feet, bloating, memory loss, anger and constipation. However, this does not establish causation.

The problem with observing symptoms of unknown aetiology in patients with dental amalgam restorations is confusing commonality with causality. Both the symptoms and dental amalgam fillings are commonplace, thus one being observed with the other is not unexpected. This is what one researcher called the menace of daily life.²² Further, the selection of practitioners who have an 'amalgam-free practice' by patients who have such symptoms and think their dental amalgam fillings may be the cause, only accentuates the apparent commonality.

A much higher level of evidence about causality is required. The basis for much of this consideration of evidence was developed by Hill²³ and has been applied to commonplace exposures.²⁴ More recently, a hierarchy of strength of evidence for clinical interventions has been adopted by the National Health and Medical Research Council and this can also guide the assessment of evidence on causality.²⁵ Stronger evidence can only come by moving away from one-time reports of a series of 'cases' to more complex designs. A small step forward is made in cross-sectional comparisons of a sub-sample of the population with and without (or with few) dental amalgam fillings. This was the approach of Ahlqwist et al who compared the prevalence of 30 specified symptoms and complaints in dentate women with

equal to or greater than 20 and 0-4 tooth surfaces with dental amalgam fillings.²⁶ They found no symptom or complaint to be more common in those with higher numbers of dental amalgam fillings. Instead, chest pain, over-exertion, abdominal pain, poor appetite and loss of weight were significantly less common in those with more tooth surfaces filled with dental amalgam. A similar study by Saxe et al among US nuns found no association between dental amalgam surface area and eight different tests of cognitive function.²⁷

Studies like those by Ahlqwist et al can be further improved to support or refute causality. Their cross-sectional design leaves the issue of time precedence unaddressed. The next higher level of evidence on the link between dental amalgam fillings and adverse health effects would be cohort studies, where individuals exposed and not exposed to dental amalgam fillings are measured and followed over time for a range of adverse health effects. Even higher level evidence comes from randomized controlled trials. Here, the use of dental amalgam for fillings is on a random basis. This reduces the risk of bias in who receives and does not receive dental amalgam fillings. However, the issue of participants knowing whether they receive dental amalgam fillings or not remains problematic. Alternatively, a randomized controlled trial could be conducted on the removal of dental amalgam fillings from patients with claimed mercurialism. This leads into the second type of evidence, the outcome of the removal of dental amalgam fillings.

Health outcomes after the removal of dental amalgam fillings

When a patient claims symptoms or complaints caused by mercurialism from dental amalgam fillings, some practitioners remove the amalgam fillings. Detailed protocols have been developed for the removal process to protect the patient, dentist and staff from what would otherwise be a high single mercury exposure. Protocols involve rubber dam, evacuation behind the dam, special systems for evacuation over the tooth, cutting away rather than drilling out the dental amalgam filling, rinsing the working area with water, shielding, oxygen-rich air supplies, filters and negative ion generators. Staging and timing of removal by quadrants is considered important. Adjunctive therapies are also common – these include chelation agents to reduce body load of mercury and nutritional support involving zinc, vitamin C, antioxidants and other preparations.²

It has been reported that high percentages of patients with symptoms or complaints claimed to be from mercurialism show improvements as a result of dental amalgam filling removal. Equally, dramatic testimonies are available from individuals whose

lives appear to be changed by their dental amalgam filling removal. However, the circumstantial evidence should be examined as such case reports frequently lack independent, objective assessment. There is a strong likelihood of non-specific treatment (placebo) and undefined effects from the adjunctive therapies. After removal, when a high number of symptoms and complaints are generally being monitored, the probability that some patients will improve by chance alone is high. The long-term benefits are unknown as follow-up is often short-term and incomplete.²

While dental amalgam removal does lead to reduced mercury concentrations in blood and urine, no differences have been observed in organ function before and after amalgam filling removal.²⁸ In Sweden, a three-year follow-up study of dental amalgam removal among people claiming mercurialism found the amalgam removal did not result in any significant effect on general health.²⁹ Overall, there is a lack of supportive scientific evidence of improved health outcomes following removal of dental amalgam fillings.³⁰

The efficacy of the adjunctive therapies, especially chelation agents such as dimercapto-propane sulfonate (DMPS) or 2,3 dimercapto-succinic acid (DMSA), is a separate issue. Concern has been expressed about the efficacy and safety of these agents,² as there are few higher level studies on their use. Grandjean et al, in a randomized clinical trial involving 50 patients who claimed mercurialism symptoms or complaints, showed no difference in health outcome between active and placebo chelation treatment groups.³¹ Another trial of 23 patients undergoing dental amalgam filling removal showed no benefit of a chelating agent compared with a placebo and was terminated prematurely due to the occurrence of hypersensitivity to the chelation agent.³² Clearly, care is required in the use of chelating agents.

The mix and proportions of mercury absorption from different sources present a potentially confounding problem in establishing either a causal association between the presence of dental amalgam fillings and various symptoms and complaints or improved health outcomes upon their removal. Earlier estimates were that mercury absorption from dental amalgam fillings may be as low as 25-50 per cent of total mercury absorbed daily in an adult. Unless patients undergo marked dietary changes away from a range of fish and seafoods, green vegetables and other foods, total mercury absorption per day is likely to remain high. Researchers will need to take account of the confounding effect of other mercury exposures.

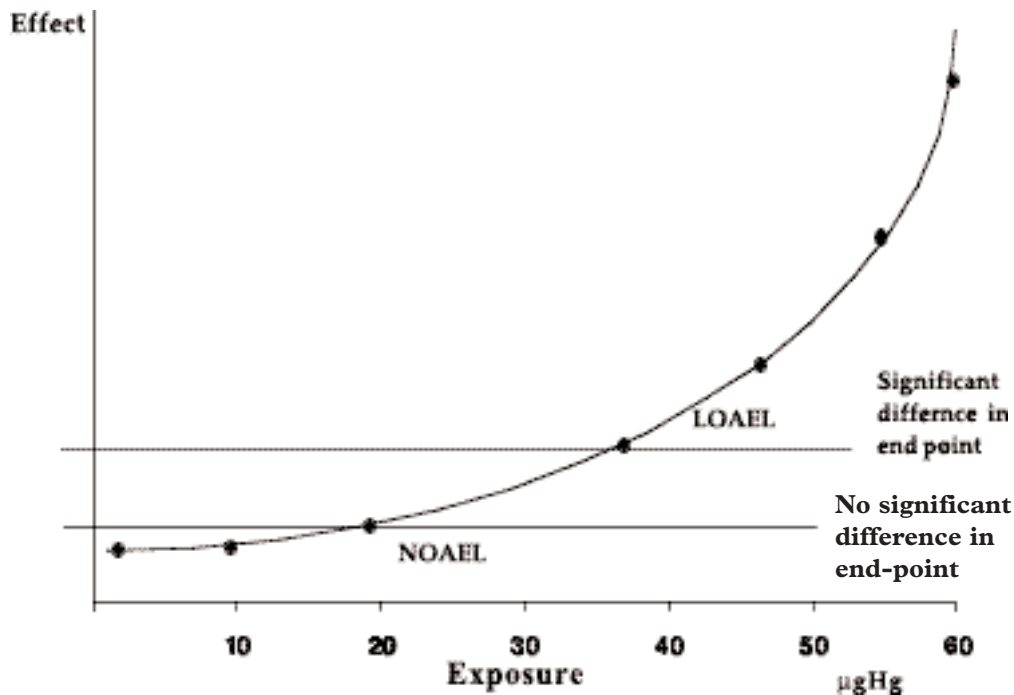


Fig 5. – Dose-response relationship between mercury exposure and effects, illustrating the key toxicological doses, the NOAEL and LOAEL.

Risk assessment

The third area of investigation concerning the possible adverse health effects of mercury from dental amalgam fillings is formal toxicological risk assessment. Risk assessment initially focuses well away from the direct clinical or epidemiological study of individuals with dental amalgam fillings to the area of occupational exposures.

Risk assessment involves four processes: hazard identification, dose-response assessment, exposure assessment and risk characterization.^{33,34}

Mercury has a long history as an identified health hazard. There is no doubt that mercury at high levels of absorption causes severe adverse health effects. Attention then shifts to the dose-response assessment, essentially to answer the question of the effects of low levels of mercury absorption. Two points on the dose-response curve crucial to risk assessment are illustrated in Fig 5.³³ The first is the level of dose up to which no adverse health effect is observed – a No Observed Adverse Effect Level (NOAEL) – and the second is the level of dose down to which an adverse health effect is observed – a Lowest Observed Adverse Effect Level (LOAEL). Which of these is known is subsequently important in establishing an uncertainty factor, because a factor of 10 is assumed in extrapolating a LOAEL to a NOAEL if a NOAEL is not known. Other uncertainty factors can also be applied, for instance for assumed variation in sensitivity in the population. Toxicologists use the NOAEL or LOAEL divided by uncertainty factors to estimate a Tolerable Daily Intake (TDI). A level of mercury absorbed from

dental amalgam fillings which exceeds the TDI would raise concerns but does not imply that an adverse effect will occur. Public policy might have to weigh those concerns against any possible benefits from the exposure, for example, the restoring of tooth function and avoidance of pain and suffering through the use of the material when alternatives are not either available or as cost-effective.

Exposure to low levels of mercury in air can be an occupational hazard in a number of industries. While traditionally these have included industrial sites such as chloralkali factories,³⁵ there is now an increasing trend to assess risk of exposure to mercury in dental office staff.³⁶

There are numerous methodological issues in such research that add confusion and disquiet.² First, such studies are frequently case:control studies. In terms of the evidence provided, case:control studies are considered to be of a low quality because there is no researcher control over who is a case or control (individuals with and without exposure to mercury). In a factory, cases may be the less educated or skilled, possibly interfering with measurement of neurobehavioural health effects. Case:control type studies are one-time snapshots, so there can be doubt whether the health effect preceded or followed exposure or the length and level of exposure. Second, there are many end-points which might be selected to represent an adverse health effect. The most sensitive systems or organs for mercury exposure are thought to be the central nervous system or kidney, but what specific change or end-point should be used? Most end-points are not clear

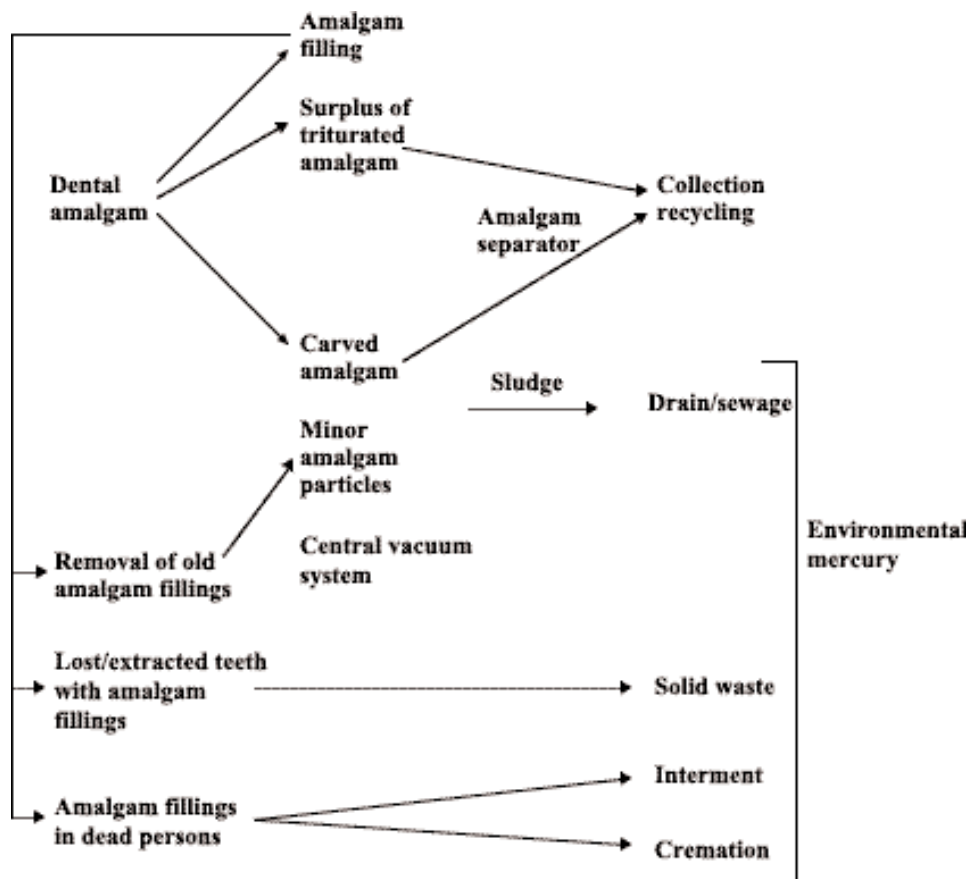


Fig 6. – Mercury cycle and environmental mercury sources in dentistry (after Horsted-Bindslev et al).⁵⁰

clinical health changes, but subtle signs of function that may or may not be indicative of an adverse health effect. An example is the release of N-acetyl- β -glucose amidase (NAG) in urine which has been variously regarded as a biomarker of exposure to mercury³⁷ through to an indicator of impaired renal function.³⁸ Third, many end-points are not only affected by mercury but many other heavy metals or substances. Is exposure to other possible risks known and appropriately accommodated for in any analysis? Fourth, there can be difficulty in equating an occupational exposure to mercury in air ($\mu\text{g}/\text{m}^3$) to exposure to mercury from dental amalgam fillings ($\mu\text{g}/\text{l}$ urine or $\mu\text{g}/\text{g}$ creatinine).

This is not an exhaustive list of the methodological issues. However, it serves as a rationale for why some groups have been unwilling on the basis of available research to even estimate a TDI and why there is debate when particular research results are used.³⁹ This occurred after Richardson⁴⁰ used Fawer et al's³⁵ research on hand tremor among chloralkali factory workers.³² The debate about the quality of the evidence will continue; however, there is increasing research activity on occupational exposure to mercury especially among dentists and their office staff.³⁶ This will make the systematic review of such research crucial and it will also ensure that risk assessments become common.

Interpretation of risk assessments for public policy

Even if risk assessment helps provide a clearer picture on low level exposure to mercury and adverse health effects, the way forward to public policy on the use of dental amalgam in dentistry is not straightforward. Two issues that need to be addressed pull policy in different directions – variation in sensitivity and cost-benefit, especially in comparison with alternatives.

Risk assessment, like most population research, seeks to derive a general understanding; however, individuals will vary in their sensitivity to exposure to mercury. In a quantitative sense, this is accommodated by applying an uncertainty factor to the findings available from research among adults. However, there is an as yet unquantifiable, but accepted, variation in sensitivity among certain population subgroups – foetuses (and, therefore, pregnant women) and the young developing child. As a matter of principle, the higher sensitivity of the developing foetus or child takes on special significance in framing prudent public policy. Hence, beginning with Health Canada,³⁹ a number of bodies and reports have recommended that exposure to mercury from dental amalgam fillings be minimized whenever possible by using alternative materials in the teeth of children and not placing or

removing dental amalgam fillings in the teeth of pregnant women.^{2,41,42} Further, because mercury may not be eliminated well, dental amalgam fillings are best avoided for people with impaired kidney function.^{2,39} However, such recommendations reflect prudent or cautious approaches and not direct evidence of any harm.^{2,39,41-43} The criterion of 'whenever possible' is also crucial. These recommendations accept that dental amalgam fillings should still be used when clinical circumstances indicate no alternative material is available.

The benefit of the use of dental amalgam fillings is a counterbalancing factor. Such a benefit cannot be judged in the absolute sense against no filling being placed, but in a relative sense against the alternative filling materials. While there has been great technological development in composite resin and glass ionomer cement materials, it is generally accepted they both have higher initial cost and shorter longevity,^{10,44-46} however, relative risks also need to be entertained. Very little research has been published on the toxicology of either composite resins or glass ionomer cements,⁴⁷⁻⁴⁹ and this needs to be rectified as it would be shortsighted policy to encourage a move from the use of dental amalgam to alternative materials that later may be found to present their own risks.

Other issues surrounding mercury which impinge on dental amalgam fillings

The Australian focus on the use of dental amalgam fillings has been strongly individualistic. The concern has been with the risks and benefits to the individual in whose teeth dental amalgam fillings have been placed. This is in contrast to two wider, collective concerns about mercury.

First, the mercury cycle in dentistry,⁵⁰ as illustrated in Fig 6, describes the pathways by which surplus triturated or carved dental amalgam along with minor particles of removed old dental amalgam fillings may be evacuated to waste in a dental practice. Depending on the fate of such waste, for example the presence of amalgam separators, there can be concern over the dental amalgam entering drains or the sewage system. Extracted teeth with dental amalgam fillings contribute to solid waste and dental amalgam fillings in deceased people are disposed of in the process of interment or cremation. Through these pathways, an individual's dental amalgam fillings can contribute to environmental mercury exposure. In Scandinavia and Europe, considerable concern about dental amalgam fillings has its genesis in this environmental exposure to mercury.^{51,52}

Second, there is a heightened concern about exposure to mercury in the food chain, particularly methylmercury from fish and seafoods. Recent

downward-revised TDI or RfD estimates from the US Environmental Protection Agency indicate a trend toward lower levels of exposure being linked to adverse health effects.^{53,54} These estimates reflect community concern about mercury in general and will ensure dental amalgam fillings remain a contentious community issue for the foreseeable future.

As a consequence, patients will continue to raise their concerns with dentists, so there is a need for dentists to provide concise, authoritative information to their patients. With the changed emphasis on patient autonomy and informed consent, all dentists will need to inform, advise and then support their patients in choices made about the use of restorative materials, including dental amalgam.²

Conclusion

A minority of the public has expressed concern about the use of dental amalgam in dentistry. While dental amalgam use has decreased markedly overall and in age groups up to late middle-aged adults, a vast number of dental amalgam fillings exist in the population. Mercury is released at very low levels from dental amalgam fillings and mercury vapour is absorbed in the lungs and inorganic mercury is absorbed in the gastrointestinal tract. However, there is no evidence that mercury absorbed from dental amalgam fillings is associated with signs or symptoms of adverse health effects or that the removal of dental amalgam fillings is associated with better health outcomes. Risk assessments, while clouded with uncertainty, have not established an inadequate safety margin between the level of mercury absorbed from dental amalgam fillings and the lowest levels associated with adverse health effects among people with occupational exposure to mercury. Despite this lack of evidence, it is a principle in toxicology to accept there are more sensitive groups in the community, especially foetuses and young children, and as a result to recommend minimization of exposure among pregnant women and young children. The trend in dental amalgam use is toward minimization, but there is still widespread opinion that dental amalgam is the material of choice in certain clinical situations. This clinical benefit and the lack of risk assessments of alternative materials are counterbalancing factors in the continued use of dental amalgam. However, wider environmental issues with dental amalgam use and disposal and increasing concern over methylmercury exposure will maintain community concerns. Dentists and their patients will need to be well informed and patient autonomy and choice respected.

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