DENTAL AMALGAM: UPDATE ON SAFETY CONCERNS

ADA COUNCIL ON SCIENTIFIC AFFAIRS

ABSTRACT

This report of the Council on Scientific Affairs reviews and discusses recent studies concerning the safety of dental amalgam, with an emphasis on studies that have been published since the 1993 review of dental amalgam by the U.S. Public Health Service Committee to Coordinate Environmental Health and Related Programs. The Council concludes that, based on currently available scientific information, amalgam continues to be a safe and effective restorative material.

Dental amalgam is an alloy composed of a mixture of approximately equal parts of elemental liquid mercury and an alloy powder.[1] The first use of amalgam was recorded in the Chinese literature in the year 659,[2] and for the last 150 years, amalgam has been the most popular and effective restorative material used in dentistry. The popularity of amalgam arises from its excellent long-term performance, ease of use and low cost.[1,3] Before the 1970s, amalgam accounted for more than 75 percent of all restorations.[4] In 1979, the total number of amalgam restorations placed by dentists in the United States was estimated at 157 million.[3,5] During the past 20 years, however, the use of amalgam in the United States has been declining, largely due to the decreasing incidence of dental caries, more frequent use of crowns and the availability of tooth-colored alternative restorative materials for certain applications.[3] In 1991, the total number of amalgam restorations placed was estimated at approximately 96 million, which accounted for about 50 percent of all restorations.[5]

Despite the long history and popularity of dental amalgam as a restorative material, there have been periodic concerns regarding the potential adverse health effects arising from exposure to mercury in amalgam.[6-10] As early as 1850, some U.S. dentists claimed that removing amalgam fillings could bring miraculous cures in patients with chronic disease.[11] Even today, some dentists remove amalgam restorations from patients as a result of claims that amalgam restorations result in serious adverse health effects.[12,13] Concerns in the public sector also were demonstrated in a 1991 survey conducted by the American Dental Association, which revealed that nearly half of the 1,000 American adults surveyed believed that health problems could develop as a result of dental amalgam.[14,15]

The safety of dental amalgam has been the subject of a number of previous publications, expert panel meetings and national and international conferences.[3,16,17,18] During 1991 and 1992, the National Institutes of Health and the U.S. Public Health Service, or PHS, separately convened panels of experts to review the current state of knowledge on amalgam safety. The expert panels were unable to

identify, in the general population, any human health detriments arising from the placement of dental amalgam restorations, and all concluded that amalgam was a safe and effective restorative material.[3,19]

This article reviews more recent studies on the safety of dental amalgams, with an emphasis on those that have been published since the 1993 report by the PHS Committee to Coordinate Environmental Health and Related Programs.[3] For reference, a brief summary on mercury toxicity and current safety guidelines also is provided.

MERCURY TOXICITY AND SAFETY GUIDELINES

Chemically, mercury exists in three major forms: elemental (valence 0), inorganic (valence +1 and +2) and organic (alkyl and aryl). These three forms are different in their physical and chemical properties, their rates of absorption and excretion, and their distribution patterns in tissues. The chemical form of mercury, therefore, determines its toxicological profile. Elemental mercury is the most volatile of the three, and mercury vapor in air is the predominant form of elemental mercury. Sources of mercury in drinking water and food are generally inorganic and organic mercury compounds, with organic compounds being particularly associated with seafood.[16,20,21] Total daily exposure to methylmercury (a prototype of organomercury), primarily stemming from the ingestion of food (> 98 percent), is estimated at 5.8 micrograms by the Environmental Protection Agency, or EPA,[20] and 2.3 µg by Clarkson and colleagues.[16] Other studies have reported values ranging from 2 to 15 µg/day.[22,23] Estimates of inhaled elemental mercury from air range from 40 to 120 nanograms per day.[16,20] Controversy still exists as to whether mercury from amalgam is a significant contributor to the total body mercury burden.

The toxicological effects of various forms of mercury have been well-documented and investigated, mainly in populations with excessive occupational or environmental exposures.[9,20,21,24,25] Besides allergic reactions, symptoms associated with mercury toxicity include tremor, ataxia, personality change, loss of memory, insomnia, anxiety, fatigue, depression, headaches, irritability, slowed nerve conduction, weight loss, appetite loss, gastrointestinal problems, psychological distress and gingivitis.[16,20]

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Consequently, various guidelines to prevent excessive occupational exposure to mercury have been developed. Both the National Institute for Occupational Safety and Health, or NIOSH, and the Occupational Safety and Health Administration have adopted a threshold limit value, or TLV, of 50 µg mercury vapor per cubic meter of the breathing zone air for eight hours per day, 40 hours per week.[26,27] The World Health Organization, or WHO, on the other hand, has adopted the lower limit of 25 µg/m^3 as the TLV for occupational mercury exposure.[28]

In 1983, a study by Fawer and colleagues[29] reported that industrial workers who had occupational mercury exposure at a time-weighted average of 26 µg/m^3 in the workplace for an average of 15.3 years showed a significant increase in tremor when compared with a control group. Concerns about this study have been expressed by Mackert and Berglund,[30] who re-evaluated the hand tremors in this group of 26 occupationally exposed industrial workers. Concerns with the study design noted that the hand-tremor test apparently was not blinded, and the medical and previous exposure histories of the workers were not known. In addition, the researchers make no mention of any corrections for other sources of mercury intake or elimination. The sample pool was small, and no dose-response relation was found. Assuming that confounding factors were similar between the exposed and control groups, it can be estimated that the mercury level in the air for the control subjects was between 8 and 10 µg mercury/m^3, which is exceptionally high.

Furthermore, in a study by Nilsson and Nilsson,[31] urinary mercury concentrations found in Swedish dentists, dental assistants and the rest of the staff were 2.5, 3.6 and 1.8 nanomole mercury/millimole creatinine, respectively. These concentrations were similar to those found in the supposedly nonoccupationally exposed control subjects in the Fawer and colleagues[29] study, who exhibited an average of 3.4 nmol mercury/mmol crea-

tinine. It, therefore, can be inferred that the Fawer and colleagues study is unsuitable for determining an occupational exposure level at which preclinical symptoms can be established.

Nevertheless, using Fawer and colleagues' data as the lowest observed adverse effect level and a safety factor of 100, the Agency for Toxic Substances and Disease Registry set the minimal risk level, or MRL, at 0.3 µg/m^3 for long-term human exposure to mercury in ambient air.[24] (The MRL is defined as the level of mercury vapor below which a person can continuously be exposed with no harmful health effects.) The EPA also uses 0.3 µg/m^3 as the inhalation reference concentration for elemental mercury in air.[3,32]

DENTAL PROFESSIONALS AND EXPOSURE TO MERCURY FROM AMALGAM

It has long been recognized in dentistry that chronic exposure to mercury vapor owing to inappropriate handling of dental amalgam can be a potential health hazard in the workplace.[3,33] Recent studies, however, show that mercury exposure levels among dental professionals have been steadily decreasing,[34] probably as a result of improved mercury hygiene techniques. Average urinary mercury levels among dentists were 19.5 µg/liter in 1980 and 6.7 µg/L in 1986, as compared with 4.9 µg/L in 1991.[35] Ferracane and co-workers,[36] investigating exposure to elemental mercury vapor from mercury spills in the dental office, reported that elevated mercury vapor concentrations persisted only 10 to 20 minutes in well-ventilated dental operatories; even in poorly ventilated operatories, mercury vapor concentrations returned to levels below NIOSH's TLV within 20 to 30 min. The study concluded that mercury remained in vapor form for only limited periods, presumably because of its density and affinity for surfaces, and that a single accidental mercury spill probably would not be a significant source of mercury in a dental operatory.

Exposure to mercury vapor during the placement of amalgam restorations also was found to be minimal when appropriate hygiene procedures were followed.[37,38] Although significant concentrations of mercury may be generated during restorative procedures, approximately 90 percent can be eliminated by using high-volume evacuation.[39] A recently published study by Langworth and colleagues[40] found that the levels in the dental clinics averaged approximately 2 µg mercury/m^3, and no adverse health effects on the personnel could be seen. In addition, another study conducted in Sweden[38] showed the importance of practicing proper mercury hygiene measures. Mercury vapor in the breathing zone of the dentist was minimal (1 to 2 µg/m^3) when the high-volume evacuator was used; without high-volume evacuation, however, mercury vapor levels were two to 15 times higher than the TLV as defined by WHO. According to these investigators, however, the level of mercury fluctuated significantly, with peaks lasting for periods of only a couple of seconds during the removal procedure.

There have been concerns that mercury vapor may be converted into highly toxic organomercury compounds by microorganisms in the mouth and gastrointestinal tract. To examine the potential of such a risk, Chang and co-workers[41] conducted a study in both dentists and nondentists. Although the investigation found that blood inorganic mercury levels were higher among dentists with poor mercury hygiene practices, blood organomercury levels were statistically insignificant between the two groups. Thus, researchers concluded that biotransformation of inorganic mercury to organomercury did not occur in vivo.

One human study[42] found that female dental assistants with high occupational exposure to mercury were less fertile than unexposed control subjects. Interestingly, however, subjects with low mercury exposure were more fertile than unexposed control subjects. In a 1994 study, Sundby and Dahl[43] found no differences in fertility and pregnancy outcome between female teachers and female dentists. This study offers a useful comparison, as dentists' mercury exposure generally exceeds mercury exposure in non–occupationally exposed people with amalgam restorations. Recently, Warfvinge[44] reported a case of a pregnant dentist with chronic occupational exposure to mercury vapor and elevated urinary levels. Ultrasound examination of the fetus at 20 weeks of gestation showed a mild bilateral hydronephrosis, which resolved at 32 weeks of gestation. The dentist gave birth to a normal baby who was clinically healthy at a two-year follow-up study. The clinical cause of the hydronephrosis is unknown.

Although mercury exposure

levels among dental professionals have been steadily decreasing during recent years, occupational exposure remains a safety concern. The risk is mainly associated with improper handling, repeated accidental spilling and skin contact with mercury. Subclinical adverse health effects, primarily in manual dexterity profiles, were reported in a group of 19 practicing dentists whose urinary mercury concentrations averaged 36 µg/liter.[45] Improper handling of amalgams, including the use of squeeze cloths to extract mercury from triturated amalgam, was found to be the primary source of mercury exposure in these dentists. Another study[34] examined personal, professional and office characteristics of dentists to determine factors that contribute to mercury exposure. The findings showed that dental professionals can minimize unnecessary exposure to elemental mercury simply by following recommended mercury hygiene procedures such as those recommended by the American Dental Association.[46,47]

DENTAL PATIENTS AND EXPOSURE TO MERCURY FROM AMALGAM RESTORATIONS

It is known that both the placement and removal of amalgam restorations can result in significant levels of intraoral mercury vapor.[39,48] An early study using copper amalgam and procedures that are no longer conventionally used in today's dental practices reported that intraoral mercury vapor can reach up to 388 µg/m^3 of air during the insertion of an amalgam restoration,[48] while an in vitro study by Engle and colleagues[39] using a small box to simulate the mouth found that dry polishing of amalgam restorations resulted in the release of 44 µg of mercury vapor per restoration. Removal of amalgam in vivo initiated the release of 15 to 20 µg of mercury vapor per restoration. The short duration of these exposures, however, is considered inadequate to cause any adverse health effects, and the placement and removal of amalgam restorations does not appear to constitute a significant health concern to patients.[3,16] In addition, studies have demonstrated that up to 90 percent of the mercury vapor generated during restorative procedures can be effectively eliminated by using a high-volume evacuator.[38,39]

With the development of highly sensitive techniques, measurement of mercury release from amalgam restorations has become possible.

In 1997, Bjorkman and colleagues[49] demonstrated that the removal of dental amalgam resulted in a considerable increase in soluble mercury concentrations in a group of 10 patients. The average median concentration in saliva was 130 nmol mercury/kg; in feces, the median was 280 µmol/kg dry weight two days after amalgam removal. Mercury in saliva was found to decline exponentially over a two-week period. Using the median value from each day and assuming a two-compartment model and common half-life for all people in this group, the α phase could be described by a half-life of 1.8 days and the β phase by a half-life of 24 days. A very similar decline pattern also was observed in fecal mercury levels. These data demonstrate the transitional nature of mercury derived from amalgam removal.[49]

Sällsten and colleagues[50] recently looked at the influence of long-term, frequent nicotine gum chewing on mercury levels in plasma and urine. Mercury levels were significantly higher in the gumchewers than in the control group and were found to be four times higher than was the median reported for Swedish dental personnel.[31] In fact, in three out of the 18 gumchewers examined, urinary mercury levels in excess of 10 nmol/mmol creatinine were observed; such levels are normally seen only among chloralkali workers (those in heavy industry who deal with strong acid). However, urinary mercury levels were still well below levels at which adverse health effects might be expected. This study also demonstrates the need for careful selection of a control group when setting baseline mercury exposure levels in clinical studies.

Much recent research has focused on mercury released from amalgam restorations after insertion and, thus, chronic mercury exposure experienced by patients. Dental amalgam restorations used to be considered inert, and it was thought that little mercury release would occur after the material had set. Additionally, as mercury exists widely in our environment, including in various foods, air, paint and certain medications,[51] mercury from dental amalgam was considered

to contribute a relatively small portion of a person's total daily mercury exposure.[22,52,53] With the development of highly sensitive techniques, however, measurement of mercury release from amalgam restorations has become possible. Early estimates of average daily dose, in people without occupational exposure, range from 1.24 to 27 µg/day,[54-60] although more recent studies report a lower daily mercury dose from amalgam.[61-67] Using an improved technique, Halbach[66] showed that mercury release was linearly correlated to time and the surface area of restorations; in a study group of 20 people with between 1 and 46 amalgam surfaces, mercury dose ranged from 0.3 to 13.9 µg/day, with an average daily mercury dose of 4.5 µg /day in the study group. The same investigator reported essentially the same findings in another group of subjects, in which the daily mercury dose from amalgam averaged 4.8 µg.[67] Another recently published study, using an artificial mouth system, found an even lower average mercury dose—0.03 µg/day—from amalgam.[68]

The potential effects of mercury release from amalgam on the fetuses of pregnant women and on newborns also has been investigated.[69] Mercury content was determined in samples of liver, kidney cortex and cerebral cortex from deceased infants, and in liver and kidney cortex from fetuses. Mothers were interviewed to assess possible occupational, domestic and medical mercury exposures, and their dental status was recorded. The results showed that mercury content in the tissues correlated significantly with the number of amalgam restorations in the mothers. While these findings may seem significant, the study design and methods of data analyses are questionable. Study subjects reported no occupational mercury exposure or frequent consumption of seafood, yet the interview did not provide reliable information on the influence of other environmental and other dietary factors that may significantly influence the degree of mercury exposure in humans.[51] Furthermore, information important in assessing potential mercury exposure from amalgam restorations—such as the age, location and surface area of the restorations—was not available. Also puzzling is that the investigators grouped mothers with zero and up to two amalgam restorations together, resulting in no true control for the study. Well-designed studies are needed, not only to assess the extent to which amalgams are responsible for exposing the human fetus to mercury, but also to determine the clinical significance of this exposure, if any, with respect to ill health effects. To approach this question, information on the daily dose of mercury absorbed into the blood and the subsequent transfer of mercury through the body compartments[70] is of prime importance.

There are substantial differences in the methods and assumptions used for estimating the average daily mercury dose from amalgam restorations.[54-57,60,62-65,71,72] Many factors—including the number and age of restorations, type of amalgam material, surface area and quality of the restoration, methods of measuring mercury, individual variability in subjects and approaches for data analysis—may all be responsible for the reported differences in estimates of mercury exposure from dental amalgam. As an example, previous studies reported that chewing significantly increased mercury release from amalgam restorations. Consequently, many studies calculated daily mercury exposure by estimating the total chewing and nonchewing time in a 24-hour period. However, more recent studies indicate that the effect of meals and snacks on mercury release from amalgams is not consistent; some meals have been shown to actually reduce intraoral mercury vapor.[71,73] The daily mercury exposure from amalgam, therefore, would be overestimated if all chewing time is considered to cause increases in mercury vapor levels. Overestimation also may occur when baseline intraoral mercury is measured after eating and toothbrushing.[63]

In short, there is considerable controversy as to the extent to which mercury from amalgam contributes to our total daily exposure to mercury. Further refinement of measurement techniques, appropriate experimental design and judicious data analyses all will aid in reaching a consensus on this issue. It is doubtful, however, whether this is the vital question when considering the safety of dental amalgam. Rather, the more significant question is whether mercury released from dental amalgam results in significant adverse health effects, as mere exposure is not synonymous with ill effects to health.

DENTAL AMALGAMS, MERCURY AND THE HEALTH RISK DEBATE

Although the overwhelming body of scientific evidence demonstrates amalgam to be a

safe and effective restorative material, recent publications continue to debate not only the degree of mercury release, but also the clinical significance such release may have on the health of patients.[57,73-83] Literature reviews by Pleva[78] and Lorscheider and colleagues[82,83] both expressed concerns relating to the safety of amalgam. Concerns identified by Lorscheider and colleagues[82,83] include possible detrimental effects of mercury on the immune, renal, reproductive and central nervous systems, as well as on oral and intestinal bacteria. Other reviews of the literature, however, result in very different conclusions. Halbach[67] found that the combined mercury intake from food and amalgam did not exceed the acceptable daily intake and that blood and urinary mercury levels in patients with dental amalgams were below one-tenth of the critical concentrations usually associated with the onset of subclinical health effects attributable to mercury toxicity. Furthermore, a study by Langworth and colleagues[84] examined the immune systems of chloralkali workers, dental personnel, subjects allergic to mercury, subjects with alleged amalgam disease and control subjects. Nearly all values fell within the reference interval. No significant difference in the immune parameters was found, and no significant correlation between mercury exposure parameters and the immune parameters was noted.

Hultman and colleagues,[85] studying the effects of amalgam on the immune system, reported that chronic hyperimmunoglobulinemia, among other immune irregularities, developed in a time- and dose-dependent manner after implantation of amalgam or silver alloy in genetically sensitive mice. These effects, however, could not be attributed directly to mercury from amalgam, as similar immune irregularities were observed in mice that received silver alloy without mercury. Indeed, another study using human subjects failed to detect any immune irregularities attributable to mercury from amalgam.[86] This study found that, while there was a direct correlation between the number of dental amalgams and plasma mercury concentrations, neither the number of amalgams nor the plasma mercury concentration had any significant influence on a wide range of immune factors, including B and T lymphocytes; T4 and T8 monocytes; neutrophilic, eosinophilic and basophilic granulocytes; large unstained cells; and a range of humoral factors.

A recent study of Swedish twins revealed no negative effects from dental amalgam on physical or mental health or memory functions.

The renal and central nervous systems also are considered susceptible to the effects of mercury toxicity.[45,87-91] A study by Herrstrom and colleagues[92] investigated the association between the number of amalgam restorations, urinary mercury and proteinuria in 48 male students. The presence of certain proteins (albumin, α-1-microglobulin, κ and λ light chains or *N*-acetyl-—D glucosaminidase) in two urine samples was considered to be indicative of a tubular or glomerular lesion that might be related to mercury toxicity. The study found no significant relationship between proteinuria and amalgam or urinary mercury, and therefore did not suggest that mercury from amalgam results in kidney dysfunction in humans. Other studies have confirmed this finding.[93]

In investigating the possible toxicological effects of mercury from amalgam on the CNS, Tulinius[94] studied the potential relationship between amalgam and intellectual abilities in schoolchildren. Mercury concentration in the hair of study subjects was recorded and compared with the subjects' scores in selected school subjects. Although a weak trend (no significant correlation) was detected between the number of amalgam fillings and mercury content in hair, no correlation between hair mercury content and school performance was noted. The significance of this finding, however, is doubtful; mercury concentrations in hair are generally not considered a reliable parameter for determining exposure to mercury vapor,[16,25] and estimating intellectual abilities by merely measuring school performance is likely an inadequate measure.

Another investigation examined the effect of amalgam on the cognitive function of Roman Catholic nuns.[95] The number and surface area of occlusal amalgams were measured, and cognitive function was evaluated using a battery of eight established tests. The results

from this relatively homogeneous population found no correlation between amalgam restorations and lower cognitive ability. A recent study of Swedish twins came to the same conclusion, revealing no negative effects from dental amalgam on physical or mental health or memory functions, even after the researchers controlled for age, sex, education and number of remaining teeth.[96]

The placement of amalgams also has been suggested to result in a host of nonspecific symptoms, such as personality change, insomnia, anxiety, fatigue, depression, headaches, irritability, weight loss and psychological distress.[16,20] Berglund and Molin,[73] in studying such reports, found that patients reporting nonspecific symptoms had neither a higher estimated daily uptake of inhaled mercury vapor or a higher blood or urinary mercury concentration than patients reporting no such symptoms.

To date, there is no evidence to suggest that mercury released from dental amalgams results in any adverse effects to health in the general population. However, several recent studies[97-99] support earlier work suggesting that a very small percentage of people—less than 1 percent—may have allergic reactions to mercury, as well as other metals, from amalgam. Research would indicate that these allergic reactions to metals in amalgam may be linked to certain major histocompatibility complex genotypes.[100]

DISCUSSION

For more than 150 years, dental amalgam has provided excellent clinical service with few documented adverse effects in either dental patients or dental professionals. While occupational exposure may be of a concern, recent data have suggested that if recommended mercury hygiene procedures are followed, the risks of any adverse health effects arising from mercury exposure in the dental office are minimal. However, controversy persists concerning potential adverse health effects that patients may experience as a result of chronic exposure to mercury released from amalgam restorations. While the overwhelming body of scientific evidence demonstrates amalgam to be a safe restorative material, debate continues regarding not only the degree of mercury exposure, but also—and more importantly—whether this exposure results in any ill effects on health.

There is little doubt that minute levels of mercury are released from amalgam, but the extent to which this release contributes to the total daily exposure has yet to be ascertained. It is crucial to remember that mere exposure is not synonymous with adverse health effects. As stated in the 16th century by Paracelsus, an eminent Swiss alchemist and physician, "[A]ll substances are poisons; there is none which is not a poison. The right dose differentiates a poison and remedy."[101] On this basis, therefore, the question of degree of exposure only becomes important when it is directly related to adverse health effects.

Thus, two major factors support the continuing controversy over the safety of amalgam: first, the lack of a consensus as to how daily exposure to mercury from amalgam can be reliably estimated; and second, the fact that most toxic signs and symptoms suggested as being attributable to mercury from amalgam are nonspecific, difficult to define and often reported by subjects themselves without documentation of any physical or mental characteristics that can be directly measured or observed.[73,99-105] So far, few large-scale human studies have been conducted that have the statistical power to investigate any direct correlation between amalgam and ill effects to health. One study conducted in Sweden involving 1,462 women[102-104] provided no evidence of a correlation between dental amalgam and cardiovascular disease, diabetes, cancer, death rate or various subjective symptoms such as irritability, depression, fatigue and readiness to cry. Various biochemical parameters of blood and urine also were not affected by the presence of more than 20 amalgam surfaces. Interestingly, among the group of 50-year-old women, subjects with 20 or more amalgam restorations reported fewer subjective symptoms (such as irritability, depression, fatigue and readiness to cry) than those with four or fewer restorations. Unfortunately, these data are not able to provide any definitive conclusions, particularly regarding potential neurological and psychological effects of amalgam, as these subjective symptoms also are common in women experiencing menopausal stress.

So is amalgam safe? The FDA, in defining safety, requires that an ingredient or a material have a low incidence of adverse reactions or significant side effects when used according to adequate warnings and

directions. Inherent in this definition are considerations of the risk-vs.-benefit relationship of the material.[106,107] In relation to mercury exposure from dental amalgam, available data have not identified any significant side effect(s), other than the rare allergic reaction, after more than 150 years of use. Based on this overwhelming body of scientific data supporting the safety and efficacy of dental amalgam, and the absence of any similar database attesting to the safety and efficacy of an alternative material, there appears to be no justification for discontinuing the use of amalgam. Responsible public policy-making must be grounded in science and requires a thorough accounting of the benefits and detriments arising from the use of any technology. Failure to conduct such an analysis results in unbalanced risk assessment and can lead to the waste of limited health resources. Most importantly, it can deny the public access to beneficial therapies. In this light, the benefits of dental amalgam as a durable and cost-effective restorative material are well-documented.

SUMMARY AND CONCLUSIONS

Millions of people have amalgam restorations in their mouths, and millions more will receive amalgam for restoring their carious teeth. Over the years, amalgam has been used for dental restorations without evidence of major health problems. Newly developed techniques have demonstrated that minute levels of mercury are released from amalgam restorations; but no health consequences from exposure to such low levels of mercury released from amalgam restorations have been demonstrated. Given the available scientific information and considering the demonstrated benefits of dental amalgams, unless new scientific research dictates otherwise, there currently appears to be no justification for discontinuing the use of dental amalgam. Carefully designed, comprehensive research is encouraged to investigate potential biological effects resulting from low-level mercury exposure from amalgam restorations. The ADA's Council on Scientific Affairs will continue to review and evaluate scientific data on the safety of amalgam and make recommendations to the dental profession that are grounded in sound science. ■

This report was approved by the Council on Scientific Affairs in January 1998. The report was prepared on behalf of the Council by Dr. Yuming Li, Professor, Department of Restorative Dentistry, School of Dentistry, Loma Linda University, Loma Linda, Calif.; Chakwan Siew, Ph.D., Director, Department of Toxicology, Council on Scientific Affairs, American Dental Association; and Brian G. Shearer, Ph.D., Director, Department of Information and Policy, Council on Scientific Affairs, American Dental Association.
Address reprint requests to Brian G. Shearer, Ph.D., Director, Department of Information and Policy, ADA Council on Scientific Affairs, 211 E. Chicago Ave., Chicago, Ill. 60611.

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