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OBSERVANCE OF PROPER MERCURY HYGIENE PRACTICES BY JORDANIAN GENERAL DENTAL PRACTITIONERS

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Abstract
Objectives: To assess the knowledge and observance of proper mercury hygiene and amalgam waste management (AWM) among Jordanian general dental practitioners (GDPs). **Subjects and Methods:** Interviews were conducted with randomly selected 250 Jordanian GDPs, using a specially designed questionnaire. Out of the total of 250 GDPs, 228 (91.2%) agreed to participate. The questionnaire covered aspects related to professional information and total amalgam contact (TAC) of these practitioners. The second part focused on the degree of awareness of the protocols related to mercury hygiene and safe AWM. **Results:** Mean TAC was 3.2±3.6 hours per week. Of the Jordanian practitioners, 22.6% reported no undergraduate training in amalgam safety measures. Almost a quarter of GDPs did not have proper ventilation in their clinics, around 20–25% did not use protective clothing or eye protection, 5.3% were mixing amalgam manually, and 13.9% used their bare fingers for inserting the freshly mixed amalgam. Most of unused amalgam ends up through the drain or in trash; there are no recycling facilities to be used. **Conclusions:** Most Jordanian GDPs do not strictly follow the mercury hygiene and AWM guidelines. Promoting the American Dental Association (ADA) guidelines through undergraduate and postgraduate training will help GDPs acquire proper attitude towards the proper hygiene practices described in these recommendations.

Key words:
Amalgam, Dentist, Mercury hygiene recommendations, Jordan

INTRODUCTION

The use of amalgam as a direct restorative material dates back to A.D. 600 [1]. Starting from the 19th century, amalgam has been widely used as a major filling material. Amalgam has been described as the most complex metallurgical system to be used as a biomaterial; it contains a mixture of mercury with silver, tin, copper and zinc [2]. Mercury is a bio-accumulating heavy metal which comprises 50% by weight of dental amalgam [3,4]. Although there was a common belief among ancient civilizations that mercury has an excellent therapeutic potential, the practical applications had catastrophic results, including early death of ancient Chinese emperors [5]. Mercury inhalation during the hat making process was also associated with the so-called "mad hatter" condition [6]. It is now known that elemental mercury and its products have toxic effects on plants, animals and humans [3].

Amalgam waste can be generated from amalgam abrasion and from the placement and replacement of fillings. If amalgam waste is not managed properly, mercury can

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enter the environment. Although mercury vapour generated during amalgam filling preparation can be toxic, it is the organic mercury products, methyl and ethyl mercury, that have a higher toxic potential [1]. Organic mercury products can enter the environmental system due to biodegradation of amalgam waste [3]. It has been estimated that 3–70% of mercury load of wastewater management facilities is related to dentistry [3].

To reduce the health and environmental burden of amalgam waste, the World Dental Federation (FDI, Fédération Dentaire Internationale) has published guidelines for mercury hygiene [7]. In the same way, the ADA has published (latest version in 2003) the best management practice for handling dental amalgam waste and mercury hygiene, [8–11]. While these guidelines are important to reduce the burden of amalgam waste on the general population and environment, they are of paramount importance to dental staff, who are more likely to experience the detrimental effects of amalgam waste and mercury spillage accidents.

Both guidelines have met a global acceptance and the ADA 2003 recommendations have been used as the best practice and a reference for other regions of the world. The aim of this study was to investigate the adherence of Jordanian GDPs to these guidelines and to set out recommendations for further improvements, if needed.

SUBJECTS AND METHODS

A random sample of 250 GDPs (5% of GDPs in Jordan) working in four major districts (Amman, Zarqa, Irbid, and Madaba) was selected based on the Jordanian Dental Register to investigate the degree of the GDPs adherence to the ADA dental mercury hygiene recommendations [11]. Specialist practitioners were excluded from the study. Data were collected through field visits to the GDPs' clinics in the period between March and December 2008. The purpose of the study was explained to each GDP and his/her approval to participate was obtained.

Out of the 250 GDPs selected, 228 (91.2%) agreed to participate in the study. Structured interviews were conducted with the GDPs using a specially designed questionnaire composed of 24 questions. Demographic and professional characteristics of the GDPs made up the first part of the questionnaire. This part also included data on workload (average number of working hours per week) and GDP's total amalgam contact (TAC) per week. TAC was measured as a weekly amount of the total number of new amalgam fillings multiplied by the average time needed for each filling plus the total number of removed old amalgam fillings multiplied by the average time needed for removal of each filling plus the total number of polished amalgam fillings multiplied by the average time needed to polish each filling.

The second part of the questionnaire focused on the general principles and measures used to minimize the release of mercury into the dental office environment. GDPs were asked if they were given instructions and training in the handling of dental amalgam and observance of good mercury hygiene during their undergraduate study and if they now provide respective training to their dental assistants. They were asked if they periodically check dental treatment room atmosphere for mercury vapour levels. Data on ventilation in the working area, floor covering, amalgam mixer used, and the use of different size amalgam capsules were written down. The third part included data on the safety measures used by the GDPs when working with dental amalgam. The GDPs were also asked how they deal with empty amalgam capsules, excess unused (non-contact) amalgam, and extracted teeth with amalgam fillings. In the last part, GDPs were asked if they personally think amalgam has any adverse effects on environment, on the patients' health, or their own health.

Statistical analysis was performed using SPSS for Windows release 16.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were generated and Chi-square tests, Independent-Samples T Test, One-Way-ANOVA test, and Spearman's rho test were used to examine differences between groups. When One-Way-ANOVA test was conducted, post hoc multiple comparisons were made to check which pairs of the means were statistically significant. Differences at the 5% level were regarded as significant.

RESULTS

The demographic and professional characteristics of GDPs surveyed are shown in Table 1.

More than three quarters (77.2%) of GDPs surveyed were males and the mean age was 35.8±9.9 years (age range: 23–63 years). Jordanian graduates represented 27.2% of GDPs surveyed. The vast majority (71.5%) of GDPs worked more than 8 hours per day and 88.6% worked 6 or 7 days per week. The mean workload was 46.5±12.1 hours per week (range: 4–84 hours) and the mean TAC was 3.2±3.6 hours per week (range: 0.09–23.8 hours). Out of the GDPs surveyed, 19 (8.3%) did not use amalgam as a restorative material in their clinics.

As shown in Table 1, male GDPs had significantly more working hours per week than female GDPs ($P < 0.001$); however, no significant gender r-related difference was noted for TAC. Although the differences were not significant, the results showed that male GDPs performed more amalgam fillings per week than female GDPs, but their mean time to finish the fillings was shorter than those of female GDPs. As the age of GDPs increased, the workload decreased significantly ($P < 0.05$) and, as post hoc multiple comparisons revealed, a significant difference was found between 20–29 years old GDPs and those > 50. Although not statistically significant, a linear age-dependent decrease in TAC was noted. Workload was significantly associated with the country of graduation ($P < 0.01$). GDPs graduating from Eastern European universities had the highest workload; the post hoc multiple comparisons revealed that it was significantly different from that of Jordanian or Western European graduates. In addition, a significant association was found between the country of graduation and TAC (P,0.001). Significant differences, as shown by post hoc multiple comparisons, were noted between GDPs graduating in Jordan and those from Arabian, Eastern European and Western European countries.

Table 1. Demographic and professional characteristics of GDPs surveyed.

Demographic and professional characteristics	n	%	Workload (hours/week) mean±SD	TAC* (hours/week) mean±SD
Total	228	100.0	46.5±12.1	3.2±3.6
Gender				
male	176	77.2	48.4±11.3	3.1±3.5
female	52	22.8	39.9±12.2	3.6±3.9
Age (years)				
20–29	67	29.4	48.8±12.6[a]	3.7±4.3
30–39	94	41.2	46.4±12.4	3.3±3.6
40–49	35	15.4	46.9±11.7	3.2±2.6
> 50	32	14.0	41.5±9.1[b]	2.1±2.8
Country of graduation				
Jordan	62	27.2	43.2±11.1[a]	5.1±4.7[a]
Arab countries	66	28.9	45.7±13.7	2.6±3.2[b]
Western Europe	74	32.5	41.0±9.6[a]	2.3±2.2[b]
Eastern Europe	11	4.8	50.4±10.2[b]	2.5±2.2[b]
Asian countries	15	6.6	48.3±13.6	3.6±3.5

* Total amalgam contact = (Number of new amalgam fillings/ week × time/filling) + (number of removed old amalgam fillings/ week × time/removal) + (number of polished amalgam fillings/ week × time/polish).

Post hoc multiple comparisions shared statisticaly significant differences between the groups marked "a" and those marked "b".

Table 2 shows the general principles and measures used by GDPs to minimize the release of mercury in the dental office environment. Only 13.2% of GDPs reported no undergraduate training in safe handling of dental amalgam fillings and wastes. The percentage of Jordanian graduates (22.6%) who reported having no training of this kind was higher than that of other graduates. A significant proportion of GDPs did not train their dental assistants in proper mercury hygiene practices and only 2.2% periodically checked the dental room atmosphere for mercury vapour level. One quarter of GDPs worked in poorly ventilated clinics and 4.8% of the clinics had absorbent floors. Out of the 209 GDPs using amalgam as a restorative material, 11 (9 males and 2 females) (5.3%) were mixing amalgam manually, and this technique was not limited to the older generations of GDPs; six GDPs (54.5%) were below 40 years of age. Out of the 11 GDPs, 7 graduated in Arab countries and 4 in Eastern Europe. Nearly one quarter of GDPs used exposed arm amalgamator and one size of amalgam capsules.

Table 2. General principles and measures used to minimize the release of mercury into the dental office environment

Principles and measures		n	%
Undergraduate training in mercury hygiene	Yes	198	86.8
GDP training in mercury hygiene for dental assistants*	Yes	102	51.8
Periodic MVL measurements in dental room atmosphere	Yes	5	2.2
Type of ventilation in working area	Passive	100	43.9
	Air-conditioned	128	56.1
Periodic replacement of air-conditioning filters	Yes	108	84.4
Well-ventilated working area	Yes	170	74.6
Non-absorbent flooring	Yes	217	95.2
Amalgam mixing method**	Amalgamator	198	94.7
	Manual	11	5.3
Use of enclosed arm rather than exposed arm amalgamators	Yes	155	78.3
Use of amalgam capsules of different size	Yes	152	76.8

MVL — mercury vapour level.
* 31 (13.65) GDPs working without dental assistants.
** 19 (8.3%) GDPs not using amalgam as a restorative material in their clinics.

Table 3. Safety measures undertaken by the GDPs when working with dental amalgam

Safety measures	Positive response (%)*							
	Total	Gender of GDP		Country of graduation of GDP				
		male	female	Jordan	Arabian	Eastern E	Western E	Asian
Wearing lab coat	79.9	75.0	95.9	93.2	81.4	67.6	66.7	85.7
Wearing dental gloves	81.8	78.1	93.9	98.3	72.9	76.5	77.8	78.6
Wearing face mask	75.1	72.5	83.7	88.1	74.6	63.2	88.9	71.4
Wearing protective eyeglasses	59.3	58.8	61.2	61.0	64.4	51.5	55.6	71.4
Use of high-volume suction	29.7	31.2	24.5	42.4	37.3	13.2	0	42.9
Water spray during amalgam removal	93.3	92.5	95.9	93.2	94.9	92.6	8.9	92.9
Water spray during amalgam polishing	36.4	36.9	34.7	44.1	37.3	23.5	55.6	50.0
Air evacuation during amalgam removal	0.5	0.6	0	1.7	0	0	0	0
Air evacuation during amalgam polishing	0.5	0.6	0	1.7	0	0	0	0
Use of bare fingers**	13.9	16.9	4.1	0	20.3	20.6	11.1	14.3

E — European.
* Out of 209 GDPs; 19 did not use amalgam as a restorative material in their clinics.
** During insertion of freshly mixed amalgam restorative material.

The safety measures undertaken by GDPs when working with amalgam, and the relationship of these measures with the GDP's gender and country of graduation, are shown in Table 3. About 20–25% of GDPs did not wear white coats, dental gloves or facemasks while working with amalgam. This behaviour was noted less frequently among female GDPs and Jordanian graduates ($P < 0.05$). Many GDPs were not following the recommended ADA guidelines regarding the use of protective eyeglasses, high-volume suction, or air evacuation during working with dental amalgam. Unexpectedly, a significant proportion of GDPs, particularly those who graduated in Arabian or Eastern European countries ($P < 0.01$), were found to use bare fingers during the insertion of the freshly mixed amalgam fillings.

Table 4. The practices used by GDPs to deal with excess unused amalgam, excess carved amalgam, and extracted teeth with amalgam fillings

Type of amalgam	Trash or sink		Open dry container		Open container, under liquid		Sealed dry container		Sealed container, under liquid	
	n	%	n	%	n	%	n	%	n	%
Excess unused amalgam*	176	84.2	3	1.4	6	2.9	10	4.8	14	6.7
Extracted teeth with amalgam fillings	214	93.4	3	1.3	6	2.6	3	1.3	3	1.3

* 19 GDPs did not use amalgam as a restorative material in their clinics.

Table 5. GDP's personal beliefs regarding amalgam toxicity to environment, patient's health and his/her own health

GDPs believing that amalgam has	Yes		No		Do not know	
	n	%	n	%	n	%
Adverse effects on environment	161	70.6	51	22.4	16	7.0
Adverse effects on patient's health	86	37.7	137	60.1	5	2.2
Adverse effects on dentist's health	141	61.8	83	36.4	4	1.8

Only 14 GDPs (7.1%) of those who used amalgam capsules in their clinics (n = 198) reported to recap it after use and store it in a closed container, while the majority admitted that they threw them away in trash, either capped (99 GDPs, 50%) or uncapped (80 GDPs, 40.4%). Five GDPs (2.5%) stored the empty amalgam capsules uncapped in closed containers. Regrettably, a vast majority of GDPs threw the excess unused (non-contact) amalgam or extracted teeth with amalgam fillings in the trash bins or sinks, and did not follow respective ADA guidelines (Table 4).

A significant proportion of GDPs believed that amalgam could be toxic not only to the environment but also to the patient's and their own health (Table 5). Interestingly, a higher proportion of GDPs thought that amalgam is health possibly more harmful to the environment or to their own health than to their patients' health. These beliefs were not significantly affected by gender, age group, or country of graduation of the GDPs. Interestingly, GDPs who thought that amalgam can have adverse effects on their own health, were found to work significantly more with amalgam (TAC: 3.8±3.9 hours/week) than those who assumed it did not produce adverse effects (2.4±2.8 hours/week) or those who had no idea whether it is harmful or not (1.7±1.4 hours/week) ($P < 0.05$).

DISCUSSION

Although the contribution of dentistry to environmental mercury contamination is negligible compared to other sources [12], the adverse effects of mercury spurred a lively debate about the so-called "amalgam toxicity" [1], and gave rise to the "amalgam war" [13] continuing for decades. The debate started in the media, and was soon transferred to the World Wide Web where multiple sites are dedicated to the banning of amalgam use. The anti-amalgam provocative groups have linked the use of amalgam to localized allergic reactions [14] and systemic complications, such as brain damage and Alzheimer disease [15], reproductive disorders [16], and even fetal disorders related to maternal exposure to amalgam [17].

Although the use of amalgam has been banned in some countries, it is still used all over the world [12]. The ADA Council on the Scientific Affairs in its July 2009 meeting reaffirmed that amalgam is still a valuable, viable and safe choice for dental patients [18]. This was also supported by the Food and Drug Administration (FDA) final resolution [19] on dental amalgam which, although classified amalgam as class II drug similar to composite and other restorative materials, has confirmed the safety of amalgam use [20]. The FDA resolution stated

that, while elemental mercury has been associated with adverse health effects at high exposures, the levels released by dental amalgam fillings are not high enough to cause harm in patients [20]. The potential health risks from dental amalgam use were identified as: (1) exposure to mercury; (2) toxicity and adverse tissue reaction; (3) corrosion and mechanical failure; (4) contamination; and (5) improper use. The document recommends measures to mitigate these risks that are similar to those set by the ADA, but it also implements new regulations for the labelling of amalgam capsules. These regulations have also been supported by the Scientific Committee on Emerging and Newly Identified Health Risks that was established by the European Commission [4]. By not implementing these guidelines, the dentists and other dental professionals are potentially at a higher risk of exceeding their time-weighted long-term Threshold Limit Value for mercury (50 μg Hg m^3, 8 h/day, 40 h week) [21]. This has been shown to make them more at risk for developing systemic adverse health effects [21].

The findings of the present study showed that mercury could be considered a potential hazard to most of Jordanian GDPs. These GDPs have a high workload and TAC, which were shown to be positively associated with increased level of mercury in urine [22]. Although the majority are aware of the possible harmful effects to their staff, the patients and the environment, this awareness was not reflected in their own practice of handling amalgam fillings. They failed to follow the ADA recommendations, some to an alarming extent. A significant proportion was unconcerned about training their assistants in proper mercury hygiene or in providing optimal ventilation in dental rooms, both of which are necessary to reduce mercury burden. A problem of more concern is the outdated manual on the mode of amalgam mixing procedure, which is still used by some dentists. This practices could lead to mercury inhalation at doses well above the acceptable limits [23]. It is also associated with mercury sensitization which may lead to skin eczema and other systemic symptoms [24]. A less serious, but a potentially dangerous routine practised by a quarter of the surveyed dentists was the use of exposed arm amalgamators.

Again, almost one fourth of GDPs did not follow the ADA guidelines which require the use of protective clothing and eyeglasses when handling amalgam. An expected behaviour if one considers the fact that almost 40% of these GDPs thought that amalgam had no adverse effects on their own health. Although a minority, some GDPs even dared to insert fresh amalgam fillings with bare hands, with no glove protection. This dangerous practice has been shown to significantly deteriorate the health of a group of dental nurses as reported by a 30-year observational study from New Zealand [16]. The fact that most of Jordanian dentists who were aware that amalgam poses a potential risk to their own health had a higher score on TAC is difficult to explain. Nevertheless, these observations highlight an urgent need for an educational campaign to make the GDPs familiar with the safety protocols for using amalgam restorations. Most dental authorities share the view that amalgam is a safe and viable option as a direct restoration once proper mercury hygiene and AWM protocols are strictly observed.

The overall picture is even gloomier when it comes to the management of non-contact amalgam. Although most of the surveyed GDPs were aware of the environmental burden of amalgam, the majority admitted throwing excess amalgam away either as trash, which leads to increased mercury pollution of general landfills, or dropping it into the sink, which results in an increased contamination of the sewage system. The same procedure was also reported in the Nablus [25] and Ramallah [26] districts of the Palestinian West Bank and by half of the dentists in southern Thailand [27]. This practice is against the ADA guidelines [11] which state that depleted amalgam capsules should be recapped, stored in a closed container and recycled. Only 11% of GDPs do follow these recommendations apart from recycling. To our best knowledge, there are no recycling agencies, whether governmental or private, to recycle amalgam waste or depleted amalgam capsules in Jordan. Besides, no protocols for mercury recovery from dental amalgam have been implemented [28]. A report based on the outcomes of this survey, with recommendations, will be sent to a relevant department at the Ministry of Health in Jordan to increase the awareness and implement new regulations in the public and private dental clinics.

The high percentage of graduates from Jordanian dental schools surveyed in this study who reported that they had no instructions or training in best AWM and mercury hygiene practice mandates immediate changes in the curriculum of our dental schools. The ADA guidelines are now taught to our undergraduate students in their preclinical and clinical training at the Department of Conservative Dentistry. The study results also showed that the GDPs who graduated in Jordan had the highest TAC index. This might be related to two factors. Firstly, the patients may choose an amalgam filling for economic reasons; an amalgam restoration costs less than a similar composite filling. The other factor might be related to the undergraduate training curriculum in Jordanian dental schools where more emphasis is on amalgam as the first choice for the treatment of moderate to large cavities in posterior teeth.

CONCLUSION

Although most of Jordanian GDPs are aware of the potential hazards related to the mercury present in dental amalgam, a substantial percentage were found not to adequately observe the ADA mercury hygiene and AWM guidelines. An urgent action should be undertaken to educate dental students and qualified dentists on the importance of observing these guidelines. The health authorities in Jordan should be contacted to issue guidelines and directives regarding dental surgery settings and equipment, AWM, and education of professionals that would be complementary to dentistry training. Another survey will be necessary to assess the future commitment of GDPs to these guidelines.

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