Dental amalgam restorations in nationally representative sample of US population aged ≥15 years: NHANES 2011–2016
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Abstract
Objectives: Estimate the proportion of amalgam restorations among the US population.
Methods: Data from ≥15 year old clinically examined dentate participants in three 2-year survey cycles (NHANES 2011–2016) were analyzed. The 2015–2016 data include restorative material type, allowing for the first time a US estimate of amalgam-restored teeth.
Results: The percent of the US population with at least one restoration (65.8±1.4) was relatively constant in 2011–2016. Among those with restored teeth, the mean number of teeth with amalgam restorations increased with age from 4.71 among 15–24 year olds to 7.03 among those ≥75 years. Non-Hispanic Whites with restored teeth had the highest mean of teeth with amalgam restorations (5.94), while non-Hispanic Blacks had the lowest (5.08).
Conclusion: In 2015–2016, about half (51.5 percent) of restored teeth in the US population contained amalgam. Amalgam presence varied by age, tooth type, and race/ethnicity, but not by sex. These estimates can be used to assess future US caries prevention and dental amalgam reduction efforts.

Introduction
Dental caries is the most prevalent chronic disease among children and adults in the United States.1 Treatment of primary caries and repair or replacement of existing restorations are commonplace in general dentistry.2 In terms of direct restorative materials used in the management of cavitated caries lesions, there are several options, among which are glass ionomer cement, composite material, and silver amalgam, alternatively referred to as “dental amalgam” or simply “amalgam.”3 Treatment planning regarding the material to be used can include consideration about the individual patient (i.e., their age, sex, caries risk assessment, tendency for bruxism, and occlusal loading)3 characteristics of the restorative materials (i.e., strength, longevity, and cost); esthetics (i.e., color, size)4 and details about the practice setting [i.e., availability of appropriate storage and specialty equipment (e.g., curing lights)].5 In addition, restoration material choice has been seen to be influenced by practice and practitioner characteristics.6

As of 2013, the United States is a Party to the Minamata Convention on Mercury, the objective of which is “to protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds.”7 The Minamata Convention specifically gives dental amalgam as its example of a “mercury-added product” and calls for phase down in its use.7 In 2017, sufficient Parties had ratified the Convention, entering it into force. This meant that the Parties were then bound to describe the measures and/or strategies implemented, “including a quantification of the reductions achieved” of mercury.7 A necessary step to comply with the Convention is to establish the current prevalence of dental amalgam which can then be used as a measure against which to evaluate the success of strategies taken to reduce its use. Previous estimates regarding the frequency of amalgam use in the United States have been limited because studies relied on administrative records or data from third party payers which may not have been representative of the population. The National Health and Nutrition Examination Survey (NHANES) 2015–2016 dataset included surface specific data by restoration material (e.g., amalgam, other),8 thus providing, for the first time, the opportunity to calculate an objective
and nationally representative rate of amalgam restored
caries for the US population.

**Methods**

The 2011–2012, 2013–2014, and 2015–2016 data sets of
NHANES, a stratified, multistage probability sample of the
civilian, non-institutionalized, population of the United
States, were used for this analysis. Oral health examinations
were conducted by trained and calibrated dentists for data
quality, and only natural teeth were scored for restorations.\(^8\)

The analyses were limited to participants aged ≥15 years
to focus on the permanent dentition. The NHANES 2011–
2012 and 2013–2014 data sets included the number and
placement of dental restorations. A tooth with a restora-
tion on any surface was considered to have a dental

| Two year cycles | US population represented (weighted) | Number of participants | Proportion of participants with ≥1 restored tooth | Proportion of restored teeth restored with silver amalgam on ≥1 surface | Ratio of number of teeth restored with silver amalgam to number of teeth restored with no silver amalgam |
|-----------------|-------------------------------------|------------------------|--------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| 2011–2012       | 244.5 million                       | 6,059                  | 65.9%                                             | NR                                                                        | NR                                                                                             |
| 2013–2014       | 249.8 million                       | 6,434                  | 64.4%                                             | NR                                                                        | NR                                                                                             |
| 2015–2016       | 254.5 million                       | 6,227                  | 67.1%                                             | 51.5%                                                                     | 1.1                                                                                             |

NHANES, National Health and Nutrition Examination Survey; NR, not recorded.

**Table 2** Restored Teeth by Demographics and Tooth Location Among Those with at Least One Restoration, NHANES 2015–2016 (N = 6,227)

| Characteristic | n     | Mean number of teeth with amalgam restorations (SE) | Mean number of teeth with non-amalgam restorations (SE) | Ratio of restored teeth with amalgam to restored teeth without amalgam |
|----------------|-------|-----------------------------------------------------|--------------------------------------------------------|-----------------------------------------------------------------------|
| Age in years*  |       |                                                    |                                                        |                                                                       |
| 15–24          | 1174  | 4.71 (0.28)                                         | 5.32 (0.34)                                            | 0.89                                                                  |
| 25–34          | 988   | 5.39 (0.31)                                         | 5.75 (0.29)                                            | 0.94                                                                  |
| 35–44          | 915   | 5.72 (0.24)                                         | 5.76 (0.35)                                            | 0.99                                                                  |
| 45–54          | 927   | 6.08 (0.33)                                         | 5.35 (0.34)                                            | 1.14                                                                  |
| 55–64          | 921   | 6.14 (0.38)                                         | 5.28 (0.87)                                            | 1.16                                                                  |
| 65–74          | 728   | 5.67 (0.65)                                         | 6.24 (0.90)                                            | 0.91                                                                  |
| ≥75            | 574   | 7.03 (0.93)                                         | 4.79 (1.10)                                            | 1.47                                                                  |
| Sex            |       |                                                    |                                                        |                                                                       |
| Male           | 3004  | 5.55 (0.23)                                         | 5.12 (0.24)                                            | 1.08                                                                  |
| Female         | 3223  | 5.93 (0.18)                                         | 5.84 (0.21)                                            | 1.02                                                                  |
| Race/ethnicity*|       |                                                    |                                                        |                                                                       |
| Non-Hispanic White | 1992 | 5.94 (0.25)                                         | 5.63 (0.23)                                            | 1.06                                                                  |
| Non-Hispanic Black | 1333 | 5.08 (0.28)                                         | 5.58 (0.27)                                            | 0.91                                                                  |
| Hispanic       | 1923  | 5.46 (0.20)                                         | 5.35 (0.36)                                            | 1.02                                                                  |
| Non-Hispanic Asian | 735  | 5.18 (0.39)                                         | 4.93 (0.22)                                            | 1.05                                                                  |
| Other race/ethnicity | 244 | 5.70 (0.64)                                         | 5.62 (0.60)                                            | 1.01                                                                  |

**Dental group**

| Proportion with amalgam restorations | Proportion with nonamalgam restorations | Ratio of restored teeth with amalgam to restored teeth without amalgam |
|-------------------------------------|-----------------------------------------|-----------------------------------------------------------------------|
| Incisors                           | 0.32%                                   | 4.13%                                                                | 0.08                                                                  |
| Canines                            | 0.59%                                   | 2.67%                                                                | 0.22                                                                  |
| Premolars                          | 7.63%                                   | 6.87%                                                                | 1.11                                                                  |
| Molars                             | 19.01%                                  | 12.80%                                                               | 1.49                                                                  |

* ANOVA test P-value <0.05.

SE, standard error.
restoration. In addition to number and placement, the NHANES 2015–2016 data set indicated whether the dental restoration was “amalgam” or “other” material. If a tooth had any surface restored with amalgam, that tooth was considered to contain amalgam; if a tooth had surfaces restored with “other” materials and no amalgam, that tooth was considered to contain “other” materials.

SAS version 9.4 (Cary, NC) survey procedures were used to generate means, frequencies, and regression calculations using the NHANES examination subsample weights for 2 year nationally representative estimates and Taylor series linearization to compute variance estimates. Differences between weighted means of restored teeth were compared by participants’ demographic characteristics with the SAS SURVEYREG procedure, with statistical significance set at P < 0.05. Collection of each NHANES data set used in this research was approved as protocol #2011-17 or as a continuation of protocol #2011-17 through the National Center for Health Statistics Research Ethics Review Board.

Results

The rate of the US population with at least one restoration of any material has varied only 2.7 percent, ranging from 64.4 to 67.1 percent, in the three data sets examined (Table 1). In 2015–2016, the only data set in which restoration material was reported, 51.5 percent of teeth with restorations included amalgam. As expected, more molars and premolars had at least one restoration when compared to canines and incisors; and restorations in molars and premolars more commonly utilized amalgam than other restorative materials (Table 2). Among those with restored teeth, the weighted mean number of teeth that included an amalgam restoration increased with age (Table 2), from 4.71 [standard error (SE): 0.28] among 15–24 year olds to 7.03 (SE: 0.93) among those 75 years or older (P value: 0.01). For those with restored teeth, there was no statistically significant difference in weighted mean number of teeth that included an amalgam restoration between the sexes (P value: 0.08), but there were significant differences by race/ethnicity (P value: 0.03) (Table 2). Non-Hispanic Whites had the highest mean of teeth that included an amalgam restorations, while non-Hispanic Blacks had the lowest mean (Table 2).

Discussion

To our knowledge, this is the first study to report the mean number of teeth restored and the proportion of such teeth restored with silver amalgam in a nationally representative sample of the non-institutionalized US population. We found that in 2015–2016, about half (51.5 percent) of restored teeth in the US population contained amalgam. Amalgam presence varied by age, tooth type, and race/ethnicity, but not by sex. A strength of this study is that it is based on data collected upon clinical assessment of the presence and material of restoration per surface by trained and calibrated dentists. Interpretation of demographic differences observed are limited by the lack of data evaluating access to dental care over time, differences in personal preferences regarding dental care, and specifics on restoration materials. It is possible that the differences among groups may, in part, reflect systemic health care inequities. Differences which appear age related may be exacerbated by age-related tooth loss, access to care issues, and may be an artifact of when new restorative materials were approved for use. The findings presented can be used as a baseline against which to assess effectiveness of efforts to prevent dental caries and reduce use of dental amalgam in accordance with the Minamata Convention. Furthermore, these results confirm the observation of others, namely that premolars and molars more often have restorations than do other types of teeth. We cannot determine whether this was due to clinicians’ choice of material, availability of alternative materials to amalgam, or other issues. We identified significant differences in a number of teeth restored with silver amalgam; future research that evaluates number of amalgam-restored surfaces or amount of restoration per tooth may further elucidate these differences. Given that amalgam is used more frequently than other materials for restorations in premolars and molars, prioritizing research and development of materials particularly suited to meet the structure and force requirements to restore surfaces in these teeth has the greatest potential to reduce the use of dental amalgam. Since caries risk is reported to be the predominant factor in choosing to use amalgam, additional reductions in use of amalgam for restorations may be achieved by focusing on caries management efforts, first and foremost prevention.

Conclusion

In 2015–2016, about half (51.5 percent) of restored permanent teeth in the US population contained amalgam. Amalgam presence varied by age, tooth type, and race/ethnicity, but not by sex. These estimates can be used to assess future US efforts to prevent caries and reduce dental amalgam in accordance with the Minamata Convention.

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How to cite this article: Estrich CG, Lipman RD, Araujo MWB. Dental amalgam restorations in nationally representative sample of US population aged ≥15 years: NHANES 2011–2016. J Public Health Dent. 2021;1–4. https://doi.org/10.1111/jphd.12456