

Title: Economic Burden of Periodontitis in the United States of America and Europe – an updated estimation

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Running title: Economic Burden of Periodontal Disease in 2018

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One-sentence summary describing the key finding(s) from the study

In 2018, periodontal disease caused a \$154.06B loss in the USA and a €158.64B in Europe. Periodontal disease has very significant direct and indirect costs.

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Authors' contribution statement: The authors' responsibilities were as follows — JB and VM designed the research; JB conducted the research; JB, VM and LP analyzed the data and performed the statistical analysis; JB, VM, YL, LP, LC, JJM wrote the manuscript; JB has primary responsibility for final content; and all authors contributed to critically reviewing the manuscript and read and approved the final manuscript. All authors declare no conflicts of interest.

ABSTRACT

Background: The aim of this study is to estimate the direct and indirect economic burdens of periodontal disease in the USA and in Europe.

Methods: We used the most recent data available for the USA and for Europe (32 European countries) to estimate the cost of periodontal disease. Global health, dental and periodontal expenditures were estimated. We tried to estimate the direct and the indirect costs of periodontitis. Indirect costs, those related to productivity losses, are a consequence of periodontal disease proper, plus edentulism and caries due to periodontal disease.

Results: In 2018, the aggregate cost in the USA was estimated at \$3.49B and €2.52B in Europe. Indirect costs due to periodontal disease amounted to \$150.57B (95% confidence interval [CI]: 103.32-189.87) in the USA countries and €156.12B (95% CI: 123.72-221.86) in Europe. The majority of the projected indirect costs were due to edentulism related to periodontal disease and periodontal disease. Indirect costs were the majority of the estimated economic impact with an average of 0.73% (95% CI: 0.50-0.93%) of annual gross domestic product in the USA and 0.99% (95% CI: 0.78-1.40%) in Europe.

Conclusions: Periodontal disease caused an estimated loss of \$154.06B in the USA and €158.64B in Europe, in 2018. These results show that the economic burden of periodontal disease is significant and its indirect costs are impactful.

Keywords: periodontitis; cost-benefit analysis; economic factors; periodontal diseases; dental scaling; root planning

Introduction

Periodontal disease is a major public health problem, with significant socio-economic impacts ¹⁻³. In 2010, periodontitis affected the majority of the adult population, considered the sixth-most prevalent health condition ². And severe periodontitis was estimated to affect 10.8% of the global population ².

Health care expenditures have been increasing in the recent decades (Organisation for Economic Co-operation and Development [OECD] 2015). A reliable estimation of the economic burden associated with a disease is also an estimation of the maximum amount of resources that would gain if the disease were partially or totally eradicated ⁴. Estimating the economic impact of periodontal disease in the United States of America (USA) and Europe, would help public health decision and policy makers in their choices.

Previous studies, published in 2010 ⁵ and 2015 ⁶ tried to estimate the direct and indirect costs of the three most common oral problems: untreated caries in permanent and deciduous teeth, severe periodontitis, and severe tooth loss. More recently, the Global Burden of Disease (GBD) study estimated the direct and the indirect costs of periodontitis at \$44.28B and \$20.50B, respectively, at world level ⁷.

Periodontitis has direct and indirect costs. The former are those associated with its treatment. The latter include both the oral consequences of periodontitis, and the productivity losses due to absenteeism from work. Oral consequences may be important. They include

root caries – 30% of root caries are thought to be associated with periodontal disease⁸ – tooth losses, and tooth rehabilitation.

This study aimed to make up-to-date of the direct and indirect economic burdens of periodontal diseases in the USA and in 32 European countries.

Methods

This economic burden study used a systematic approach to search and compute information regarding direct and indirect costs of periodontal disease in the USA and in 32 European countries. The direct costs were defined as overall (public and private) expenditures for periodontal care. As indirect costs, we computed the productivity losses due to collateral costs associated with periodontal disease, in particular absence from work, impact on edentulism and impact on root caries.

Following a previously defined a priori protocol and with overall consensus among all authors, the most suitable methods were employed via detailed and best practice-based approaches. Considering that 2018 was the most recent year with a comprehensive set of data available, this year was defined as reference for estimation of the economic burden of periodontal disease. This choice had the extra advantage of aligning with the GBD data for 2018. Aggregate data for the countries was gathered from both national and international sources, following previous approaches ^{5,9}.

Estimation of direct costs

Country-specific aggregate health and dental expenditure data was sourced from: the WHO Global Health Expenditure Database ¹⁰. Annual Gross Domestic Product (GDP) was sourced from the Statistical Office of the European Communities (EUROSTAT) ¹¹, the International Labour Organization (ILOSTAT) ¹² and the Organisation for Economic Cooperation and Development (OECD) Data ¹³.

For most countries, it was not possible to obtain the percentage of periodontal expenditures in dental care expenditures. We had the information from a representative German statutory health insurance, which covers around 80% of the country's population, and puts periodontal therapy as 3.45% of dental treatment costs (500 m€ out of 14.492 m€) ²⁹. Without better alternative, we applied these 3,45 percentages to each national dental care expenditure to get an estimate of the national periodontitis care expenditures.

Because we had insufficient national data for overall health and dental costs, we did not try to use data imputation techniques.

Estimation of Indirect Costs

We followed the approach of Listl et al. ⁵, based on the previous suggestions of the WHO's Commission on Macroeconomics and Health ¹⁵. In this approach, one disability-adjusted life year (DALY) was valued at one year of per capita GDP, to estimate productivity losses.

Country-specific data on health and dental expenditure was sourced from: the WHO Global Health Expenditure Database ¹⁰. To estimate country-specific data on mean daily earning we divided the mean annual earning by 250 (5 days of work per week x 50 weeks of work). Mean annual earning information was sourced from the EUROSTAT (*European Commission*, 2021), ILOSTAT, ¹² and OECD data ¹³.

Country-specific data on the prevalence of periodontal disease cases for 2018 were obtained from the Global Health Data Exchange online tool ¹⁶.

To estimate edentulism due to periodontal disease, we attributed 70% of edentulism to periodontal disease according to a previous estimate by the European Federation of Periodontology (EFP) ¹⁷. For caries due to periodontal disease, we projected costs by multiplying a reported prevalence of 30% of caries patients having periodontal disease ⁸ by a 82% prevalence of root caries in periodontitis patients ¹⁸.

All proportion analyses were carried out with a spreadsheet software package*.

Results

Direct costs

The overall estimation of dental health expenditure is set out in Table 1. The USA and Europe spent \$3.5 trillion and €1.7 trillion in health expenditures, respectively. Health expenditures represent an average of 8.40% of GDP in Europe, 16.88% in the USA. The aggregate direct dental treatment costs in Europe were estimated at €72.95B, with two-thirds of the estimated expenditures (66.21%; €48.29B) occurring in the largest countries, Germany, France, Italy, United Kingdom and Spain. In the USA, dental treatment costs amounted to \$101.26B. As a percentage of GDP, dental treatment costs are roughly similar in Europe and the USA, at 0.4% in Europe and 0.5% in the USA. Also, the dental expenditure cost paid out-of-pocket was €34.62B in Europe, \$40.50B in the USA.

Concerning the direct costs of periodontal disease, the aggregate cost in 2018 was estimated at \$3.49B in USA and €2.52B in Europe (Table 2).

Indirect Costs

The estimates of indirect costs, in other words productivity losses, are presented in Table 2. Indirect costs due to periodontal disease amounted to \$150.57B (95% CI: 103.32-189.87B) in the USA and \$197.09B (95% CI: 155.71-279.26B) in European countries. The majority of the projected indirect costs were because of edentulism due to periodontal disease, to periodontal disease and to untreated caries in permanent teeth due to periodontal disease (root caries). In the USA, the majority of the projected indirect costs were also due to edentulism, related to periodontal disease (\$50.42B, 48.8%) and periodontal disease (\$50.15B, 95% CI: 19.82-103.88B). The highest productivity losses were found for Germany (€34.79B, 95% CI: 26.53-43.91B), France (€23.83B, 95% CI: 19.13-33.74B), Italy (€18.05B, 95% CI: 14.41-25.15B), United Kingdom (€17.98B, 95% CI: 15.89-30.50), Netherlands (€9.55B, 95% CI: 7.83-14.06B) and Spain (€7.64B, 95% CI: 6-60-12.91B).

As with the impact on GDP, indirect costs were indeed the majority of the estimated economic impact with an average of 0.73% (95% CI: 0.50-0.93%) of GDP in the USA and 0.99% (95% CI: 0.78-1.40%) in Europe.

Discussion

We estimated the total cost of periodontal disease, in 2018, across the USA and 32 European countries to be approximately \$154.06B and €158.64B, respectively. From these approximations, the majority were incurred by indirect costs due to periodontal disease. Among the indirect costs, periodontal disease and edentulism due to periodontal disease were the most impactful determinants. Furthermore, this approximation calculated the impact of indirect costs at 0.73% of the USA GDP and 0.99% of the European GDP.

As a percentage of GDP, the USA expends twice as much as Europe in health (16.88% vs. 8.40%). (16.88% vs. 8.40%). We found that the indirect cost of periodontal disease is lower in the USA than in Europe. We cannot deduce an association, but a preventive attitude towards periodontal disease may be a reason for this fact. The USA Office of Disease Prevention and Health Promotion, based on Centre for Diseases Control figures, has set a target of reducing the prevalence of periodontal disease by 6.7%¹⁹. Prevention and early detection of periodontitis have both become a public health focus²⁰⁻²², and this may help explain the lower impact on indirect costs compared to European countries. Vigorous actions have also been carried out by the European Federation of Periodontology^{23,24}, but to reach this level of impact a closer collaboration with European official organizations (i.e. the European Centre for Disease Prevention and Control) may be required.

Regarding the precision of our results, the quality and availability of data are decisive to attain comparable periodontal disease-related data across countries ^{25,26}. Considering that thirty-three countries were analyzed (32 European countries and the USA), we required a number of sources and have experienced insufficiencies in available information to compute costs, and for this reason assumptions had to be made. Such approach is common and has been previously reported ^{9,25-28}. Yet, both health and dental expenditures were mostly available in European official databases which increase the reliability of these results. As the 2019 data is still scarce and estimates by regional comparison with socioeconomically similar countries would have to be made, we decided to focus on the 2018 data. Nevertheless, these projections are novel and demonstrate a growing economic burden of periodontal disease in Europe compared to 2010 estimates ⁵.

Importantly, the estimated direct costs due to periodontal disease are imprecise due to the nonexistence of national statistics on the overall economic cost of periodontal treatments. Thus, we decided to use data from a representative German statutory health insurance (which encompasses around 80% of the country's population) that reported 3.45% of treatment costs being due to periodontal therapy (500 m€ out of 14.492 m€ for dental health costs) ²⁹. Indeed, this result presents some limitations, however future national information is crucial to estimate precisely the direct costs involved with periodontal disease. As for the indirect cost, the approach used has been validated in the past ¹⁵.

This study presents some other limitations worth mentioning. There can be some level of underestimation as some categories directly associated with periodontal disease were not recorded as health statistics (such as, periodontal surgical therapy, implant therapies after tooth extraction due to periodontitis, peri-implantitis therapies, orthodontic treatments due to periodontal disease or restorative dentistry to mitigate soft tissue esthetic defects). These categories of expenditure were not included due to scarcity of data and for this reason we highlight the need for further collection in the future. Also, because of this hypothetical lack of information, and as far as we may estimate, these overall costs may be significantly superior. Furthermore, the direct costs estimates were based on a private insurance company from Germany. While the extrapolation may be acceptable for European countries, for the USA estimates it might lead to off-centered results, though in our view this shows the need for this data to compute more reliable results in the near future.

Lastly, these results present disturbing evidences about the undeniable impact that periodontal disease has on the economy. Aware of the time we live in, with the COVID-19 pandemic, worrisome economic decline and consequently less financial capacity, health in general, and consequently oral health (including periodontal) will certainly deteriorate. For

this reason, we can conjecture that periodontal disease may grow even more with presumable higher economic impact. More than ever, it is fundamental to reinforce periodontal public health measures and articulate with national and continental entities.

In conclusion, our report offers a view of the economic costs posed by periodontal disease in the USA and in 32 European countries in 2018. Periodontal disease caused a \$154.06B loss in the USA and €158.64B in Europe, that year.

FOOTNOTES

* Microsoft Office Excel

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Table legends

Table 1. Costs of health, dental health and paid out-of-pocket (\$ billion and % GDP) for the United States of America and 32 European countries in 2018.

Table 2. Estimated direct and indirect cost by periodontal disease (\$ billion and % GDP) for the United States of America and 32 European countries in 2018.

Table 1. Costs of health, dental health and paid out-of-pocket (\$ or € billion and % GDP) for the United States of America and 32 European countries in 2018.

Country	Health expenditure (€B)	% GDP	Dental expenditure (€B)	% GDP	% Dental expenditure on Health expenditure	Dental expenditure cost paid out-of-pocket (€B)
Austria	38,53	10.33	2.22	0.6	5.77	1.16
Belgium	45.92	10.32	1.51	0.3	3.28	0.87
Bulgaria	3.99	7.35	0.16	0.3	4.01	0.15
Croatia	3.41	6.83	0.23	0.5	6.84	0.23
Cyprus	1.38	6.77	0.07	0.4	5.21	0.07
Czech Republic	15.36	7.65	0.78	0.4	5.08	0.41
Denmark	29.47	10.07	1.31	0.4	4.45	0.89
Estonia	1.68	6.69	0.16	0.6	9.61	0.12
Finland	20.45	9.04	0.97	0.4	4.75	0.66
France	257.36	11.26	11.16	0.5	4.34	2.46
Germany	371.51	11.43	25.02	0.8	6.74	6.26
Greece	13.80	7.72	0.67	0.4	4.82	0.67
Hungary	8.67	6.70	0.34	0.3	3.87	0.25
Iceland	1.80	8.47	0.12	0.6	6.73	0.09
Ireland	21.74	6.93	0.32	0.1	1.47	0.27
Israel	22.84	7.52	1.86	0.6	8.13	1.67
Italy	148.24	8.67	5.03	0.3	3.40	4.78
Latvia	1.75	6.19	0.11	0.4	6.05	0.10
Lithuania	2.88	6.57	0.26	0.6	9.18	0.22
Luxembourg	3.07	5.29	0.17	0.3	5.60	0.07
Malta	1.07	8.97	0.03	0.2	2.67	0.03
Netherlands	74.76	9.98	2.58	0.3	3.45	0.57
Norway	35.78	10.05	1.76	0.5	4.93	1.27
Poland	30.48	6.33	1.00	0.2	3.30	0.71
Portugal	18.69	9.41	0.63	0.3	3.40	0.62

Romania	11.01	5.56	0.37	0.2	3.37	0.33
Slovakia	5.80	6.69	0.27	0.3	4.72	0.10
Slovenia	3.68	8.30	0.18	0.4	4.93	0.04
Spain	104.69	8.98	3.56	0.3	3.40	3.48
Sweden	49.64	10.90	2.76	0.6	5.56	1.68
Switzerland	68.67	11.88	3.79	0.7	5.52	2.95
United Kingdom	239.10	9.98	3.52	0.1	1.47	1.43
Europe (Total)	1,657.24	8.40	72.95	0.4	2.91	34.62
Country	Health expenditure (\$B)	% GDP	Dental expenditure (\$B)	% GDP	% Dental expenditure on Health expenditure	Dental expenditure cost paid out-of-pocket (\$B)
United States of America	3,475.02	16.88	101.26	0.5	5.77	40.50

Table 2. Estimated direct and indirect cost by periodontal disease (\$ or € billion and % GDP) for the United States of America and 32 European countries in 2018.

Country	Direct costs (€B)	Estimated Indirect Costs (95% CI)				% of total GDP Indirect costs (95% CI)
		Periodontal disease (€B)	Predicted edentulism due to periodontal disease (€B)	Predicted untreated caries in permanent teeth (€B)	Total indirect costs (€B)	
Austria	0.08	1.31 (0.52-2.77)	2.89 (1.84-3.68)	0.09 (0.05-0.16)	4.29 (3.20-5.93)	1.14 (0.85-1.58)
Belgium	0.05	1.95 (0.81-4.08)	3.06 (2.14-4.28)	0.08 (0.04-0.16)	5.10 (3.91-7.09)	1.17 (0.89-1.62)
Bulgaria	0.01	0.09 (0.03-0.19)	0.22 (0.15-0.34)	0.01 (0.00-0.02)	0.32 (0.25-0.53)	0.60 (0.47-1.00)
Croatia	0.01	0.17 (0.07-0.35)	0.31 (0.21-0.42)	0.01 (0.01-0.02)	0.50 (0.37-0.69)	1.00 (0.75-1.39)
Cyprus	0.00	0.08 (0.03-0.16)	0.11 (0.08-0.17)	0.01 (0.00-0.01)	0.20 (0.15-0.28)	0.97 (0.77-1.41)
Czech Republic	0.03	0.58 (0.24-1.21)	1.25 (0.83-1.67)	0.05 (0.02-0.09)	1.89 (1.45-2.71)	0.95 (0.73-1.37)
Denmark	0.05	1.79 (0.74-3.64)	1.61 (1.01-2.22)	0.06 (0.03-0.10)	3.46 (2.20-4.00)	1.20 (0.77-1.39)
Estonia	0.01	0.08 (0.03-0.16)	0.14 (0.09-0.19)	0.00 (0.00-0.01)	0.22 (0.16-0.32)	0.90 (0.64-1.27)
Finland	0.03	0.97 (0.40-2.00)	1.58 (1.11-2.21)	0.05 (0.02-0.09)	2.60 (2.00-3.65)	1.15 (0.89-1.62)
France	0.39	7.23 (2.86-14.67)	15.93 (11.15-20.71)	0.66 (0.34-1.30)	23.83 (19.13-33.74)	1.05 (0.84-1.48)
Germany	0.86	15.71 (6.52-32.1)	18.37 (13.78-25.26)	0.72 (0.33-1.30)	34.79 (26.53-43.91)	1.06 (0.81-1.34)

Greece	0.02	0.48 (0.19-1.01)	1.13 (0.75-1.63)	0.05 (0.02-0.08)	1.66 (1.29-2.61)	0.93 (0.72-1.45)
Hungary	0.01	0.15 (0.06-0.35)	0.71 (0.45-0.98)	0.03 (0.01-0.05)	0.90 (0.71-1.52)	0.70 (0.56-1.19)
Iceland	0.00	0.09 (0.04-0.18)	0.13 (0.09-0.18)	0.01 (0.00-0.02)	0.23 (0.17-0.31)	1.08 (0.79-1.44)
Ireland	0.01	0.33 (0.12-0.76)	2.14 (1.50-2.99)	0.09 (0.05-0.17)	2.56 (2.31-4.57)	0.84 (0.76-1.49)
Israel	0.06	1.12 (0.44-2.37)	2.12 (1.49-2.76)	0.12 (0.05-0.22)	3.36 (2.62-4.60)	1.11 (0.86-1.52)
Italy	0.17	5.78 (2.35-11.7)	11.89 (8.33-15.46)	0.37 (0.17-0.72)	18.05 (14.41-25.15)	1.06 (0.85-1.48)
Latvia	0.00	0.08 (0.03-0.17)	0.12 (0.08-0.16)	0.01 (0.00-0.01)	0.21 (0.15-0.27)	0.73 (0.53-0.96)
Lithuania	0.01	0.13 (0.05-0.28)	0.18 (0.12-0.24)	0.01 (0.00-0.02)	0.32 (0.23-0.42)	0.74 (0.53-0.96)
Luxembourg	0.01	0.02 (0.01-0.05)	0.04 (0.03-0.05)	0.00 (0.00-0.00)	0.06 (0.05-0.09)	1.14 (0.88-1.52)
Malta	0.00	0.04 (0.02-0.09)	0.07 (0.05-0.09)	0.00 (0.00-0.01)	0.11 (0.09-0.16)	0.96 (0.76-1.30)
Netherlands	0.09	2.55 (1.00-5.34)	6.81 (4.72-8.91)	0.18 (0.09-0.33)	9.55 (7.83-14.06)	1.28 (1.05-1.88)
Norway	0.06	1.88 (0.77-3.93)	2.25 (1.50-3.00)	0.11 (0.05-0.02)	4.24 (2.96-5.25)	1.19 (0.83-1.47)
Poland	0.03	1.78 (0.72-3.72)	2.35 (1.68-3.36)	0.09 (0.05-0.18)	4.23 (3.17-5.71)	0.88 (0.66-1.19)
Portugal	0.02	0.06 (0.03-0.13)	0.12 (0.08-0.18)	0.00 (0.00-0.01)	0.19 (0.14-0.29)	0.98 (0.74-1.47)

Romania	0.01	0.48 (0.19-0.99)	0.96 (0.69-1.38)	0.05 (0.02-0.09)	1.49 (1.20-2.25)	0.76 (0.61-1.14)
Slovakia	0.01	0.25 (0.1-0.53)	0.49 (0.31-0.67)	0.02 (0.01-0.04)	0.76 (0.55-1.11)	0.87 (0.63-1.26)
Slovenia	0.01	0.18 (0.08-0.36)	0.37 (0.25-0.50)	0.01 (0.01-0.02)	0.57 (0.44-0.81)	1.27 (0.98-1.82)
Spain	0.12	1.57 (0.61-3.57)	5.73 (4.09-8.18)	0.34 (0.14-0.61)	7.64 (6.60-12.91)	0.65 (0.56-1.10)
Sweden	0.10	1.83 (0.75-3.77)	2.85 (1.90-3.80)	0.13 (0.07-0.25)	4.81 (3.53-6.42)	1.06 (0.78-1.42)
Switzerland	0.13	0.00 (0.00-0.01)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.01 (0.00-0.01)	0.95 (0.69-1.24)
United Kingdom	0.12	4.42 (1.69-9.87)	12.99 (9.74-19.48)	0.56 (0.29-0.98)	17.98 (15.89-30.50)	0.77 (0.69-1.31)
Europe (32 countries)	2.52	53.21 (21.5-110.5)	98.96 (70.22-135.16)	3.95 (1.9-7.27)	156.12 (123.71-221.86)	0.99 (0.78-1.40)
		Estimated Indirect Costs (95% CI)				% of total GDP
Country	Direct costs (\$B)	Periodontal disease (\$B)	Predicted edentulism due to periodontal disease (\$B)	Predicted untreated caries in permanent teeth (\$B)	Total indirect costs (\$B)	Indirect costs (95% CI)
United States of America	3.49	50.15 (19.82-103.88)	86.08 (57.38-114.77)	14.35 (1.52-6.10)	150.57 (103.32-189.87)	0.73 (0.50-0.93)