Socio-Demographic and Medical Characteristics of Patients With Odontogenic Infection Admitted to the Adult University Hospital in Puerto Rico: A Cross-sectional Study

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Objective: We aimed to estimate the overall distribution of odontogenic infection by socio-demographic and medical characteristics in patients admitted to the Adult University Hospital (AUH) in Puerto Rico (PR).

Methods: A cross-sectional study was undertaken with the medical charts of 129 patients (≥21 years) with odontogenic infection who had been admitted (2011–2015) to the AUH and treated by the Oral and Maxillofacial Surgery Post - graduate Program of the University of PR. The patients were selected from the hospital's billing database after having been identified using the International Classification of Diseases (9th and 10th revisions). The study variables included age, gender, municipality of residence, medical insurance, infection etiology, surgical and antibiotic treatments, length of stay (LOS), and the presence of diabetes. Descriptive and frequency statistics were calculated for all the variables; chi-squared, Kruskal–Wallis, Kendall tau, and Mann–Whitney tests were performed. A *P* < .05 was considered statistically significant.

Results: The mean age of the subjects was 40.36 (SD: 14.74) years, and they ranged in age from 21 to 81 years; the majority were enrolled in the public health insurance plan of PR. The leading cause of infection was dental caries. Diabetes was associated with longer LOSs; *P* < .01.

Conclusion: In our study, the relative frequency of admitted patients with an odontogenic infection, most of them with low income, increased over time with dental caries being the principal cause of infection. [*P R Health Sci J 2022;41(4):210-216*]

Key words: Odontogenic infection, Caries, Adults, Health disparities, Puerto Rico

Odontogenic infections are oral cavity infections caused by indigenous bacteria that gain access to deeper tissues (1–3). At the early stages of infection, patients may develop edema, pain, and/or fever. An untreated infection can progress in severity and extend beyond the area of its origin. These infections often involve the deep facial and neck spaces and poses a risk for potentially life-threatening events as compromised airways, septicemia, brain abscesses, and mediastinitis (1–4). To prevent these potentially lethal complications, the source(s) of a patient infection must be removed. This involves treatment that usually consists of the administration of intravenous antibiotics, a hospital care procedure (2,5–9).

Several risk factors for odontogenic infection have been described. In terms of demographics, a study of Western Chinese patients, affected by severe odontogenic infection, showed that most (59.0%) of those patients were males with a mean age of 47.5 years and that 54.7% of them were farmers (10). In another study, in a public hospital in Brazil, the majority (64.7%) of the patients with odontogenic infections were women; the mean age of the study population was 28.3 years. This study did not assess any aspects of socio-economic status (SES) (11). In addition, immunocompromised individuals, such as people living with HIV, subjects suffering from malnutrition, patients undergoing chronic steroid therapy, and those with uncontrolled diabetes mellitus, are at the greatest risk of developing a severe odontogenic infection (3,5,10,12–15).

Dental caries is undoubtedly the leading cause of odontogenic infection in adults (2–5). Data from the National Health and Nutrition Examination Survey (NHANES, 2011–2012) on

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adults in the United States (US) demonstrated that 27% of these adults had untreated tooth decay and that almost all (96%) of those who were 65 years old and older had cavities (16). The burden of this disease is higher in ethnic minorities and low-income people. The prevalence of untreated dental caries is 42% in non-Hispanic blacks and 36% in Hispanics. In adults with incomes below the federal poverty level, the prevalence of untreated tooth decay is 44% (17).

Puerto Rico (PR) is a US territory; 43.5% of its population lives below the poverty level and consists mostly (98.7%) of Hispanics (18). The population of PR represents a social minority and has a higher prevalence of caries than does the population of the US mainland. There is a scarcity of information with regards to the oral health status of adults residing in PR.

We found a single relevant article that evaluated the effect of the implementation of a health reform on the prevalence of dental caries in 12-year-old Puerto Ricans (19); health reforms such as the one described by Elías-Boneta et al. attempt to provide health insurance to the medically indigent, decrease health disparities, and improve access to health care (19,20). The authors found that the 2011 prevalence of odontogenic infection in the population of interest represented a decrease compared to the prevalence reported in 1997 for that same population. Yet the prevalence of caries was higher in students enrolled in public schools (72%) than it was in those enrolled in private schools (55%), highlighting the need to tackle health disparities based on SES. In PR, a child's enrollment in either public or private school can be considered a proxy measure of the SES of that child's family (19,21,22). In another study in PR, assessing periodontal health in adults, the prevalence of gingivitis doubled the one reported in the U.S. for the same age group (23). In a representative sample of elderly patients in PR, the prevalence of moderate and severe periodontitis was 44.5%, compared to the 20.7% reported in the NHANES 1999–2004 survey for individuals aged 75 years and older and living on the U.S. mainland (24). The findings of various studies on Puerto Ricans oral health suggest the presence of an oral health disparity that may be associated with social and economic determinants of oral health.

Due to the lack of data on oral health, especially infection data , we aimed to evaluate the distribution of odontogenic infection—overall, and by socio-demographic and medical characteristics—in patients who had been admitted to the Adult University Hospital (AUH) from 2011 through 2015.

Materials and Methods

A cross-sectional study of subjects aged 21 years old and older was conducted. Data were gathered from the medical charts of patients who had been admitted (from January 2011 through December 2015) to the AUH in PR with an odontogenic infection and who were, at some point during that period, under the care of oral–maxillofacial surgery (OMS) residents. The sampling group was selected from the OMS Department's annual procedure reports and billing database. A given patient was chosen for the study based on the International Classification of Diseases (ICD) code assigned to his or her case; individuals with the following diagnosis codes were deemed to be appropriate prospective study participants: (ICD-9 codes) 682.0, 522.5, and 528.3; and (ICD-10 codes) K12.2, K04.7, and L03.211.

A total of 217 patients' medical charts were evaluated. The medical charts of only those patients who presented an infection that originated in a tooth and involved the facial and neck spaces were included in this study (n = 129). Eighty-eight patients' records were excluded because 1) those records were incomplete (n = 56), 2) the patients described in those records were under 21 years old (n = 16), 3) the infections of the patients described in those records were of non-dental origin (n = 12), or 4) the patients described in those records were not admitted to the hospital's OMS or another specialist service (ENT [Ludwig angina; n = 3] and neurology [brain abscesses of odontogenic origin; n = 1]).

The medical charts were reviewed by the principal investigator. Data were entered into an EPI Info™ Version 7 database (25). The following variables were included in the study: age (years), gender (male or female), municipality of residence (based on the PR Health Department–designated geographic regions), medical insurance (public, private, Medicare, or none), symptom(s) (trismus, dysphagia, odynophagia, dysphonia, and/or dyspnea), surgical treatment (extraoral drainage, intraoral drainage, or intraoral/extraoral drainage), antibiotic treatment (clindamycin, ampicillin/sulbactam, ampicillin/sulbactam + metronidazole, or piperacillin/tazobactam), the etiology of the infection (caries or periodontal disease), diagnosis, the surgical treatment provided (if any), the length of stay (LOS) in days, the consulted services (OMS, ENT, internal medicine, ophthalmology, and infectious diseases), and whether the patient had diabetes.

This study was approved by the Institutional Review Board of the University of Puerto Rico Medical Sciences Campus (Protocol # B0880116).

Statistical analyses

For the descriptive analysis, absolute (n) and relative (%) frequencies were calculated for all the categorical variables. For continuous variables, means and standard deviations, as well as medians and interquartile ranges were computed. The normality of distribution of continuous variables (age and LOS) was formally tested using Shapiro-Wilk test of normality.

A bivariate analysis was conducted to address the relationship between age, sex, insurance, and (presence of) diabetes and multiple tooth extractions and LOS. To compare gender, medical insurance, and diabetes with multiple tooth extractions, Pearson's chi-squared or Fisher's exact test was done, as appropriate. Since normality was rejected for both age and LOS variables, non-parametric tests were preferred for analysis on these variables. Mann–Whitney test was used to evaluate the association between

age and multiple tooth extractions, as well as between diabetes and gender (as binary predictors), and LOS. Kruskal–Wallis test was conducted to relate medical insurance to LOS. Furthermore, we tested the relationship between age and LOS by using the Kendall tau test. The trend analysis for the number of cases by year was performed with Pearson's chi-squared test. Statistical analysis was conducted using SAS statistical software version 9.3 (SAS Institute, Cary, NC). All tests were two-sided; a P-value < .05 was seen as statistically significant.

Results

There was an equal distribution of male (49.61%, n = 64) and female (50.39%, n = 65) patients in the study group. The study subjects ranged in age from 21 to 81 years, with their average being 40.36 (SD: 14.74) years. Most (53.49%, n = 69) of the individuals in our sample either were enrolled in the government health insurance program or had a private insurance plan (27.13%, n = 35); 13 patients had Medicare and 12 had no insurance. Figure 1 shows the increase in the percentage of patients admitted from 2011 through 2015 with an odontogenic infection; P = .01. In addition, mainly, the patients lived in the metropolitan area of PR, as can be seen in Figure 2 (26).

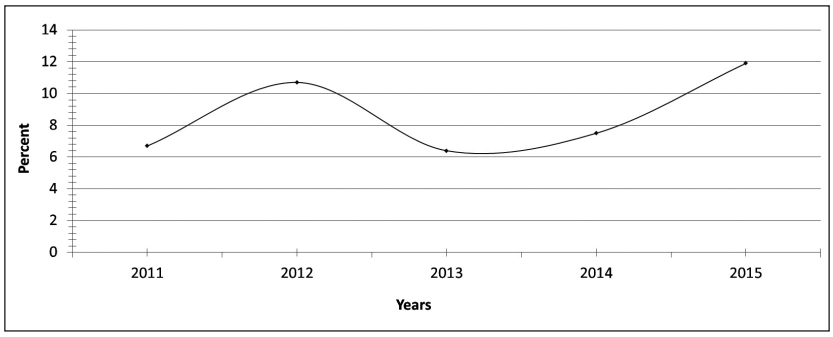

Figure 1. Percentage of patients admitted (2011–2015) to the Adult University Hospital with an odontogenic infection; P = .01

Ninety-one percent (n = 117) of the cases of odontogenic infection in this study were diagnosed as having been caused by dental caries, followed by periodontal disease (n = 12). Additionally, the most common symptoms reported by individuals suffering from odontogenic infection were trismus (68.99%), odynophagia (17.05%), and dysphagia (16.28%). The surgical treatments required by the patients included tooth extraction, incision, and drainage. Out of the 129 included patients, 96.12% (n=124) required incision and drainage: 59.69% (n = 77) extraorally, 25.58% (n = 33) intraorally, and 10.85% (n = 14) both extra- and intraorally. In terms of medical procedures, all the participants in the sample required at least 1 tooth to be extracted. Additionally, 55.04% (n = 71) of the individuals had multiple teeth extracted, which were identified as being non-restorable. Ampicillin/sulbactam (41.86%) and clindamycin (35.66%) were the most prevalent antibiotic treatments used in our sample (see Table 1).

Furthermore, in 30 cases, other specialty services were consulted. The most consulted specialties were internal medicine (9.3%) and otorhinolaryngology (9.3%). The causes for the consultations were the presence of uncontrolled systemic disease, such as hypertension or diabetes mellitus, and the need to evaluate a patient with impending signs of respiratory failure due to airway obstruction. Eleven (8.53%) of the 129 patients admitted with an odontogenic infection were diabetic. In addition, the average LOS was 5.47 days (SD: 8.66), with the median of 4 days (see Table 1).

No associations were found between gender, age, health insurance, and diabetes, and the distribution of multiple extractions in the admitted patients; *P* > .05. Likewise, there was no correlation between age and LOS. Nevertheless, the LOS was longer for diabetic patients (Mean: 9.18 [SD: 7.22]; median: 7 days) than it was for non-diabetic patients (mean: 5.12 [SD: 8.73]; median: 4 days); *P* = .002. Similarly, LOS was associated statistically significantly with gender; *P* = .04.

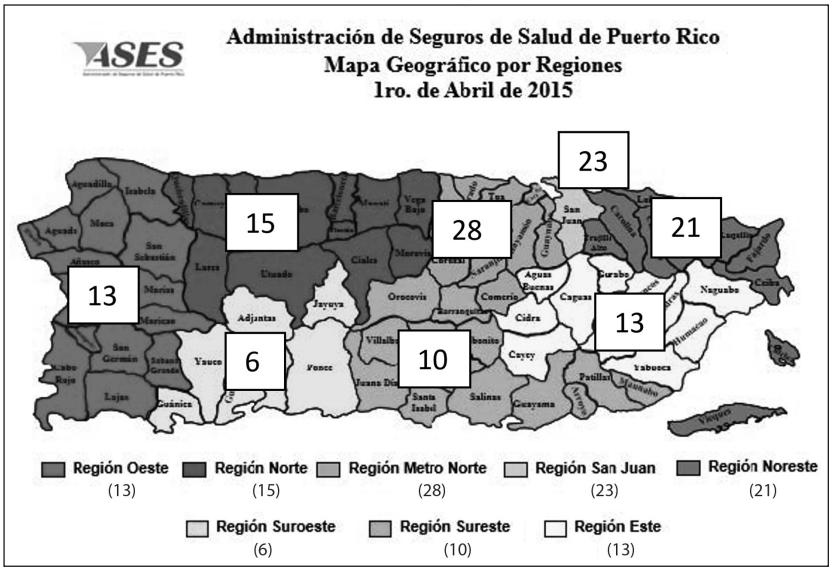

Figure 2. Map of the geographic distribution (by PRHIA geographic region) of the locations of the residences of patients admitted (2011–2015) to the Adult University Hospital with an odontogenic infection.

Table 1. Description of the clinical variables in patients admitted (2011–2015) to the Adult University Hospital with an odontogenic infection (n = 129).

Characteristic		N	%
Symptom			
Trismus		89	68.99
Dysphagia		21	16.28
Odynophagia		22	17.05
Dyspnea		2	1.55
Dysphonia		1	0.78
Etiology			
Caries		117	90.70
Periodontal disease		12	9.30
Surgical Treatment			
Extraoral drainage		77	59.69
Intraoral drainage		33	25.58
Intraoral/extraoral drainage		14	10.85
None		5	3.88
Antibiotic Treatment			
Clindamycin		46	35.66
Ampicillin/sulbactam + metronidazole		14	10.85
Ampicillin/sulbactam		54	41.86
Piperacillin/tazobactam		15	11.63
Consulted Service			
Ear, nose, throat		12	9.30
Internal medicine		12	9.30
Ophthalmology		2	1.55
Infectious diseases		4	3.10
Diabetes		11	8.53
Multiple Extractions		71	55.04
Age (in years)			
Mean (±SD)	40.36 (±14.74)		
Median (Q1-Q3)	39 (28 – 52)		
LOS (in days)			
Mean (±SD)	5.47 (±8.66)		
Median (Q1-Q3)	4 (3 - 6)		

infection by gender, no such differences were observed in the present study. The previously noted differences may have arisen because our sample and those of the other studies are not the same.

The most common etiology for our patient's odontogenic infections was dental caries; generally, this has been found to be the case for all low-income patients who rely on the government's health insurance plan. These findings are consistent with those of the NHANES (2011–2012), which reported that individuals with low incomes had the highest prevalence of untreated caries (16). In 2011, the Centers for Disease Control and Prevention (CDC) Health Disparities and Inequalities Report stated that people of a low SES were at the greatest risk of engaging in unhealthy behaviors and of having limited access to care (27). Data from the NHANES confirmed that 41.6% of US adults (35–44 years) with untreated tooth decay had attained an education level of less than high school (28). Our results may be attributed to the high level of poverty in PR, which is higher than that of the US mainland (29). Factors linked to low SES factors play an important role in both the low usage of preventive health services and the increase in unhealthy behaviors, both of which may have an impact on the worsening of the overall health of a population.

According to the National Diabetes Statistics Report (CDC, 2014), 29.1 million Americans suffer from diabetes (30). In PR, diabetes is the third highest cause of death and accounts for 14.8% of the deaths among individuals 20 years old and older and who dwell on the island (31). Our results showed that complicated infections required longer hospitalizations. Moreover, diabetes (in our patients) was associated with longer LOSs. Some studies have suggested that patients

Discussion

The aim of the present study was to address the distribution of odontogenic infection, overall and by socio-demographic and medical characteristics, among a sample of patients admitted to the AUH from 2011 through 2015. With regards to demographic variables, the mean age of the sample population was 40.36 (SD: 14.75) years. This was higher than the mean age reported in a cross-sectional study in Brazil (10) but lower than the reported age for a study that took place in western China (11). The mean ages of the subjects in all 3 studies ranged from 30 to 50 years. In addition, although some studies have found differences in the proportion of subjects suffering odontogenic

Table 2. Associations between the demographic variables and diabetes and multiple extraction and length of stay (LOS) in the patients admitted (2011–2015) to the Adult University Hospital with an odontogenic infection.

Characteristic	Multiple Extractions (%)		*P* value	LOS (days) Mean (±SD) Median (Q1-Q3)	*P* value
Gender					
Male (n = 65)	59.38		.33*	5.33 (±3.75) 4.5 (3 – 6)	.04§
Female (n = 64)	50.77			5.62 (±11.75) 4 (3 – 5)	
	Multiple extractions	No Multiple extractions			
Age (in years) (n = 71)					
Mean (± SD)	40.73 (±14.67)	39.91 (±14.93)	.74§	-0.01§§	.82§§
Median (Q1-Q3)	40 (28 – 54)	37 (28 – 51)			
Type of Medical Insurance					
Public (n = 69)	56.52			6.06 (±11.30) 4 (3 – 6)	
Medicare (n = 13)	53.85		.98*	5.92 (±7.08) 4 (3 – 5)	.74**
Private (n = 35)	54.29			4.37 (±2.14) 4 (3 – 5)	
None (n = 12)	50.00			4.82 (±2.56) 4 (3 – 7)	
Diabetes (n = 11)	72.73		.34	9.18 (±7.22) 7 (5 – 11)	.002§
No diabetes (n = 118)	53.39			5.12 (±8.73) 4 (3 – 6)	

*Pearson's chi-squared test; **Kruskal–Wallis test; §Mann–Whitney–Wilcoxon test; §Fisher's exact test; §§Kendall tau correlation coefficient and test

with uncontrolled diabetes mellitus are at increased risk of complicated infection, dealing with which, in turn, increases treatment cost (32). It has been reported that a hyperglycemic environment affects immune function, thereby increasing the morbidity and severity of infectious processes (32).

It is now recognized by policymakers that access to medical and dental care, especially preventive treatment and screenings that keep people healthy, are a luxury for many in the U.S. as well as in other countries (33–35). There have been some efforts by the PR government to reduce the burden of disease: "Mi Salud" is a program of public health insurance in PR that includes oral health coverage. In 2015, it was estimated that a total of 1.3 million low-income individuals were insured by the program. The oral health coverage of Mi Salud provided (and still provides) preventive dental care, including periodic oral evaluations, prophylaxis, and fluoride application.

However, more needs to be done to prevent the development of oral infections. Indeed, data provided by the PR Health Insurance Administration revealed that in 2015, only 48.8% of the beneficiaries of PR's government-funded health insurance (i.e., Mi Salud) took advantage of preventive dental services (36). Health care reforms (such as the Affordable Care Act signed in 2010 in the US) have been established to increase access to and the quality of services, as well as to ensure that health insurance plans are reasonably priced (37). To match the Medicaid and Medicare benefits of Puerto Ricans with those of the citizens on the mainland, some benefits of this law were extended to PR in 2011, but—in the presence of the fiscal and debt crisis occurring on the island and in light of the reduction of federal funds—this allowance only minimally mitigated the extant health care disparity (38).

Preventive care is accepted as an effective strategy for reducing both emergency room visits and their attendant health costs. Studies have demonstrated the effect that the lack of covered preventive dental treatment by government insurance programs can have. Salomon et al. reported a 48% increase in emergency room visits treating dental infections after the preventive dental care benefits provided by Medicaid were eliminated in Illinois in 2012 (SMART Act) (39). Regarding the financial burden of being treated for acute odontogenic infection as an inpatient, an Australian study found the average cost per patient to be AUD 12,228 (USD 8,381.27) versus AUD 181 (USD 124) for early primary care such as a dental extraction (40). On average, the cost to a patient admitted to our institution for odontogenic infection treatment is more than $2,000 (~$600 per day of hospital stay, ~$70 for surgical tooth extraction, and ~$100 for incision and drainage), excluding radiographic images, intravenous medications, or consultations. Nonetheless, the cost for preventive dental treatment is approximately $100 per year, which includes an oral evaluation, radiographs, and dental prophylaxis (41).

The unprecedented exodus of island dentists to the US mainland is having the inevitable result of restricting access to primary dental prevention and will further aggravate the health inequalities currently plaguing the Puerto Rican population. In PR, both the high cost of operating a dental office and low insurance reimbursements contribute to causing this large movement of professionals (42). This situation may perpetuate the usage of the emergency room for the treatment of preventable odontogenic infections, as well as increasing the morbidity and costs of treatment associated with the disease.

Besides (lack of) access to dental care and the social determinants of health, (lack of) fluoride exposure and sugar ingestion are among the factors that may influence the occurrence of dental caries in PR (43). Ironically, water fluoridation in PR was discontinued in the 1980s, although it remains not only government mandated but also recommended by the US Department of Health and Human Services to reduce the prevalence of dental caries (44–45).

There are several shortcomings in this study . We were not able to capture information about dental insurance benefit coverage in the privately insured group. In addition, this is a study from a public health facility were all patients that were admitted and treated by OMS had severe infections ; thus, the results cannot be generalized to the PR population. Therefore, the study has sampling bias because the population served by the AUH are more likely to have low income and lower access to care, in contrast to the access enjoyed by the members of higher status groups, which individuals tend to use private hospitals and dentists. To develop tailored interventions for the island's underserved population, there is a need for more studies in PR that would evaluate odontogenic infection and overall oral health, and to reduce the burden of the disease (especially in those populations in need), these interventions should be based on the social determinants of health framework and should explore the underlying causes of oral diseases.

Conclusion

The relative frequency of adult patients admitted to the OMS-UPR (2011-2015) for the treatment of an odontogenic infection increased. Most of the patients were low-income and had government-provided public health insurance. Dental caries was the leading cause of these odontogenic infections.

Resumen

Objetivo: Estimar la distribución general de infecciones odontogénicas por variables sociodemográficas y características médicas en el Hospital Universitario de Adultos (HUA) en Puerto Rico (PR). Métodos: Se realizó un estudio transversal con 129 expedientes médicos de pacientes (≥21 años) con infecciones odontogénicas, admitidos en el HUA, tratados por el Programa Graduado de Cirugía Oral y Maxilofacial de la Universidad de PR, 2011-2015. Los pacientes fueron seleccionados de la base de datos de facturación, utilizando los códigos de Clasificación Internacional de Enfermedades (9 y 10) para infecciones odontogénicas. Las variables que se incluyeron en el estudio

fueron: edad, género, municipio de residencia, seguro médico, etiología, tratamiento quirúrgico y antibióticos, largo de estadía y la presencia de diabetes. Se calcularon estadísticas descriptivas y frecuencias para todas las variables. También se realizaron pruebas chi cuadrado, Kruskal-Wallis, Kendall Tau, y Mann–Whitney. Se consideró significativo un p<.05. Resultados: La media de edad de los sujetos del estudio fue 40.36 (DE: 14.74) años con rango de 21 a 81 años de edad; mayormente personas en seguro médico público. La causa principal de las infecciones fue la caries dental. La diabetes se asoció con un largo de estadía prolongado en nuestra muestra, con un p<.01. Conclusión: En nuestro estudio, la frecuencia relativa de pacientes ingresados con una infección odontogénica, la mayoría de bajos ingresos, aumentó con el tiempo, siendo la caries dental la principal causa de infección.

References

1. Abubaker O. Orofacial Infections and Antibiotic Use. In: Abubaker O, Benson KJ, eds. Oral and Maxillofacial Surgery Secrets. 3rd ed. Mosby/Elsevier; 2001:290-317.
2. Flynn TR. Principles of Management of Maxillofacial Infections. In: Miloro M, Ghali GE, Larsen PE, Waite P, eds. Peterson's Principles of Oral and Maxillofacial Surgery. 3rd ed. People's Medical Publishing House; 2012:841-859.
3. Huang TT, Liu TC, Chen PR, Tseng FY, Yeh TH, Chen YS. Deep neck infection: analysis of 185 cases. Head Neck. 2004;26(10):854-860. doi:10.1002/hed.20014
4. Caccamese JF Jr, Coletti DP. Deep neck infections: clinical considerations in aggressive disease. Oral Maxillofac Surg Clin North Am. 2008;20(3):367-380. doi:10.1016/j.coms.2008.03.001
5. Parhiscar A, Har-El G. Deep neck abscess: a retrospective review of 210 cases. Ann Otol Rhinol Laryngol. 2001;110(11):1051-1054. doi:10.1177/000348940111001111
6. Shanti RM, Flynn TR. Principles of Antimicrobial and Surgical Infection Management. In: Hupp JR, Ferneini EM, eds. Head, Neck, and Orofacial Infections: An Interdisciplinary Approach. Elsevier Science; 2015:121-140.
7. Lee JK, Kim HD, Lim SC. Predisposing factors of complicated deep neck infection: an analysis of 158 cases. Yonsei Med J. 2007;48(1):55-62. doi:10.3349/ymj.2007.48.1.55
8. Sethi DS, Stanley RE. Deep neck abscesses--changing trends. J Laryngol Otol. 1994;108(2):138-143. doi:10.1017/s0022215100126106
9. Flynn TR, Shanti RM, Hayes C. Severe odontogenic infections, part 2: prospective outcomes study. J Oral Maxillofac Surg. 2006;64(7):1104-1113. doi:10.1016/j.joms.2006.03.031
10. Zhang C, Tang Y, Zheng M, et al. Maxillofacial space infection experience in West China: a retrospective study of 212 cases. Int J Infect Dis. 2010;14(5):e414-e417. doi:10.1016/j.ijid.2009.08.002
11. Sette-Dias AC, Maldonado AJ, Aguiar EG, et al. Profile of patients hospitalized with odontogenic infections in a public hospital in Belo Horizonte, Brazil. J Clin Exp Dent. 2012;4:e271-e274. http://www.medicinaoral.com/odo/volumenes/v4i5/jcedv4i5p271.pdf
12. Mathew GC, Ranganathan LK, Gandhi S, et al. Odontogenic maxillofacial space infections at a tertiary care center in North India: a five-year retrospective study. Int J Infect Dis. 2012;16(4):e296-e302. doi:10.1016/j.ijid.2011.12.014
13. Opitz D, Camerer C, Camerer DM, et al. Incidence and management of severe odontogenic infections-a retrospective analysis from 2004 to 2011. J Craniomaxillofac Surg. 2015;43(2):285-289. doi:10.1016/j.jcms.2014.12.002
14. Rao DD, Desai A, Kulkarni RD, Gopalkrishnan K, Rao CB. Comparison of maxillofacial space infection in diabetic and nondiabetic patients. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;110(4):e7-e12. doi:10.1016/j.tripleo.2010.04.016
15. Bali RK, Sharma P, Gaba S, Kaur A, Ghanghas P. A review of complications of odontogenic infections. Natl J Maxillofac Surg. 2015;6(2):136-143. doi:10.4103/0975-5950.183867
16. Dye B, Thornton-Evans G, Li X, Iafolla T. Dental caries and tooth loss in adults in the United States, 2011-2012. NCHS Data Brief. 2015;(197):197. https://www.cdc.gov/nchs/products/databriefs/db197.htm.
17. Hinton E, Paradise J. Access to Dental Care in Medicaid: Spotlight on Nonelderly Adults. The Henry J Kaiser Family Foundation. March 17, 2016. Accessed May 9, 2017. http://www.kff.org/medicaid/issue-brief/access-to-dental-care-in-medicaid-spotlight-on-nonelderly-adults/
18. U.S. Census Bureau. Quick Facts Puerto Rico. Accessed: July 25, 2021. https://www.census.gov/quickfacts/fact/table/PR#
19. Elias-Boneta AR, Toro MJ, Rivas-Tumanyan S, et al. Persistent oral health disparity in 12-year-old Hispanics: a cross-sectional study. BMC Oral Health. 2016;16:10. Published 2016 Feb 1. doi:10.1186/s12903-016-0162-7
20. Elías-Boneta AR, Crespo Kebler K, Gierbolini CC, Toro Vizcarrondo CE, Psoter WJ. Dental caries prevalence of twelve year olds in Puerto Rico. Community Dent Health. 2003;20(3):171-176.
21. Elías-Boneta AR, Toro MJ, Garcia O, Torres R, Palacios C. High prevalence of overweight and obesity among a representative sample of Puerto Rican children. BMC Public Health. 2015;15:219. doi:10.1186/s12889-015-1549-0
22. Torres R, Santos E, Orraca L, Elias A, Palacios C. Diet quality, social determinants, and weight status in Puerto Rican children aged 12 years. J Acad Nutr Diet. 2014;114(8):1230-1235. doi:10.1016/j.jand.2014.01.011
23. Elías-Boneta AR, Encarnación A, Rivas-Tumanyan S, et al. Prevalence of Gingivitis in a Group of 35- to 70-Year-Olds Residing in Puerto Rico. PR Health Sci J. 2017;36(3):140-145.
24. Montero-Aguilar M, Muñoz-Torres F, Elías-Boneta AR, Dye B, Joshipura KJ. High levels of periodontal disease among the older adult population in San Juan, Puerto Rico. Community Dent Health. 2012;29(3):224-228.
25. Carstensen B, Plummer M, Laara E, Hills M. Epi: A Package for Statistical Analysis in Epidemiology. R package version 2.44. Accessed July 25, 2021. https://CRAN.R-project.org/package=Epi
26. Centers for Disease Control and Prevention. Fact Sheet—CDC Health Disparities and Inequalities Report—United States, 2011. January 25, 2011. Accessed January 9, 2017. https://www.cdc.gov/minorityhealth/chdir/2011/factsheet.pdf
27. Healthy People 2020. National Health and Nutrition Examination Survey. Disparities Details by Educational Attainment for 2011-12. OH-3.1: Adults with untreated dental decay (percent, 35–44 years). Accessed January 9, 2017. http://www.healthypeople.gov/2020/data/disparities/detail/Chart/5020/5.1/2012
28. Puerto Rico Report. U.S. Census Shows Continued Decline in Puerto Rico's Population. September 21, 2015. https://www.puertoricoreport.com/u-s-census-data-show-continued-decline-puerto-ricos-population/#.YP3IZOhKh3i. Accessed July 25, 2021.
29. Centers for Disease Control and Prevention. National Diabetes Statistics Report, 2014. Accessed January 9, 2017. https://www.cdc.gov/diabetes/data/statistics/statistics-report.html
30. Administración de Servicios Médicos de Puerto Rico. Plan de Acción de Enfermedades Crónicas para Puerto Rico (2014-2020). Accessed October 24, 2021. https://www.asem.pr.gov/sites/default/files/pdf_docs/plan_de_accion_de_enfermedades_cronicas_espanol.pdf
31. Casqueiro J, Casqueiro J, Alves C. Infections in patients with diabetes mellitus: A review of pathogenesis. Indian J Endocrinol Metab. 2012;16 Suppl 1(Suppl1):S27-S36. doi:10.4103/2230-8210.94253
32. Centers for Disease Control and Prevention. Disparities in Oral Health. May 17, 2016. Accessed November 11, 2019. https://www.cdc.gov/oralhealth/oral_health_disparities/index.htm
33. Healthy People 2020. Access to Health Services. Accessed November 11, 2019.https://www.healthypeople.gov/2020/topics-objectives/topic/Access-to-Health-Services
34. World Health Organization. Oral health. Accessed November 11, 2019. https://www.who.int/oral_health/en/

35. Puerto Rico Health Insurance Administration (PRHIA) geographic regions. Available at: https://www2.pr.gov/agencias/ASES/Documents/. Accessed February 9, 2017.
36. Puerto Rico Health Insurance Administration. Total insured population and preventive dental care utilization, 2011 to 2015. Planning and Quality Affairs Division of the PRHIA. 2016.
37. U.S. Department of Health and Human Services. About the Affordable Care Act. Accessed February 13, 2017. https://www.hhs.gov/healthcare/about-the-law/read-the-law/
38. Michelson S. On Life Support: The Puerto Rico Healthcare Crisis. New Oak. November 2015. Accessed February 13, 2017. https://newoak.com/municipal-insights/life-support-puerto-rico-healthcare-crisis/
39. Salomon D, Heidel RE, Kolokythas A, Miloro M, Schlieve T. Does Restriction of Public Health Care Dental Benefits Affect the Volume, Severity, or Cost of Dental-Related Hospital Visits? J Oral Maxillofac Surg. 2017;75(3):467-474. doi:10.1016/j.joms.2016.10.019
40. Han J, Liau I, Bayetto K, et al. The financial burden of acute odontogenic infections: The South Australian experience. Aust Dent J. 2019. Available at: https://doi.org/10.1111/adj.12726. Accessed April 21, 2021.
41. Manual del Odontólogo Participante, Triple S Salud, Edición 2017. Accessed March 21, 2017. https://pdfslide.net/reader/f/manual-del-odontologo-participante-de-triple-s-salud-con-sus-participantes
42. Rodríguez Caraballo H. Bajas tarifas disparan el éxodo de dentistas. Metro. June 13, 2018. Accessed July 25, 2021. https://www.metro.pr/pr/estilo-vida/2018/06/13/bajas-tarifas-disparan-exodo-dentistas.html
43. LexJuris. Ley Núm. 266 del 11 de septiembre de 1998. Para crear la Ley de Fluoración del Agua Potable en Puerto Rico. Accessed April 13, 2017. Url: http://www.lexjuris.com/LEXLEX%5CLEY1998%5Clex98266.htm
44. U.S. Department of Health and Human Services Federal Panel on Community Water Fluoridation. U.S. Public Health Service Recommendation for Fluoride Concentration in Drinking Water for the Prevention of Dental Caries. Public Health Rep. 2015;130(4):318-331. doi:10.1177/003335491513000408
45. Autoridad de Acueductos y Alcantarillado. Estado Libre Asociado de Puerto Rico. Ambiente. Informe de la Calidad del Agua, San Juan, Puerto Rico. 2011.