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Oral Health Inequalities: A Global Cross-Sectional Ecological Assessment in the Light of Economic Indicators

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Research Article

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ABSTRACT

Objectives: Achieving the desired level of oral health requires identifying economic factors. The purpose of this research is to evaluate oral and dental health problems and service levels according to the economic variables of the countries.

Materials and Methods: This study evaluates oral health problems and service levels in 123 countries based on economic variables. Data on GDP per capita, Gini coefficient, unemployment, and inflation rates were obtained from the World Bank, while oral health data were sourced from the WHO. Kolmogorov-Smirnov, Skewness and Kurtosis, Mann-Whitney U, Spearman Correlation Analysis, Logistic Regression Analysis and Multiple Regression Analysis were used in the analysis of the data.

Results: GDP per capita increases the availability of oral health services and is negatively associated with caries prevalence at ages 1-9 years, and is positively associated with edentulism. The Gini coefficient is negatively associated with periodontal disease and edentulism. In addition, GDP significantly increased the availability of restorative dental treatments. However, the effect of the Gini coefficient was not significant.

Conclusions: Economic indicators seem to have an impact on the availability of oral health services. However, the lack of a significant improvement in toothlessness rates despite high GDP levels shows that not only economic indicators but also effective health policies and preventive services are determinants.

Keywords: Dental health services, health inequities, health services accessibility, health policy**.**

Ağız ve Diş Sağlığı Eşitsizlikleri: Ekonomik Göstergeler Işığında Küresel Kesitsel Ekolojik Bir Değerlendirme

Araştırma Makalesi

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ÖZ

Amaç: Ağız sağlığında istenen düzeye ulaşmak için ekonomik faktörlerin belirlenmesi önemlidir. Bu araştırmanın amacı, ülkelerin ekonomik değişkenlerine göre ağız ve diş sağlığı problemlerinin ve hizmet düzeylerinin değerlendirilmesidir.

Gereç ve Yöntem: Bu araştırma, 123 ülkenin ekonomik değişkenlerine göre ağız ve diş sağlığı problemlerini ve hizmet düzeylerini değerlendirmektedir. Kişi başına düşen GSYH, Gini katsayısı, işsizlik ve enflasyon oranları gibi ekonomik veriler Dünya Bankası'ndan; ağız sağlığına ilişkin veriler ise DSÖ'den elde edilmiştir. Verilerin analizinde Kolmogrov Smirnov, Skewness ve Kurtosis, Mann Whitney U, Spearman Korelasyon Analizi, Lojistik Regresyon Analizi ve Çoklu Regresyon Analizi kullanılmıştır.

Bulgular: Kişi başına GSYH, ağız sağlığı hizmetlerinin bulunabilirliğini artırmakta ve 1-9 yaş çürük yaygınlığıyla negatif, dişsizlikle pozitif ilişki göstermiştir. Gini katsayısı ise periodontal hastalık ve dişsizlikle negatif ilişkilidir. Ayrıca, GSYH restoratif diş tedavilerinin bulunabilirliğini anlamlı şekilde artırmış; Gini katsayısının etkisi anlamlı bulunmamıştır.

Sonuçlar: Ekonomik göstergelerin ağız sağlığı hizmetlerinin mevcudiyetinde bir etkisi olduğu görülmektedir. Ancak yüksek GSYİH düzeyine rağmen dişsizlik oranlarında anlamlı bir iyileşme sağlanamaması, yalnızca ekonomik göstergelerin değil, aynı zamanda etkili sağlık politikalarının ve koruyucu hizmetlerin de belirleyici olduğunu göstermektedir.

***Anahtar Kelimeler*:** diş sağlığı hizmetleri, sağlıkta eşitsizlikler, sağlık hizmetlerine erişilebilirlik, sağlık politikası.

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Introduction

Oral health, defined as the condition of the mouth, teeth and orofacial structures, enables individuals to perform basic functions such as eating, breathing and speaking. Oral health varies from early life to old age and is an integral part of overall health. It also encompasses psychosocial dimensions such as self-confidence, well-being and the ability to socialize and work without pain, discomfort or embarrassment.[1] It has been suggested that individuals' oral health has an impact on health-related quality of life.[2] Furthermore, oral health conditions have been found to be associated with non-communicable diseases.[3] In addition to treatment costs, oral health also has indirect costs that should be considered in terms of productivity losses due to absenteeism.[4] In its Global Oral Health Action Plan, the World Health Organization has set the goals that by 2030, 80% of the world's population will have access to basic oral health services and that these services will be included in universal health coverage. Additionally, there will be a relative reduction of 10% in the global combined prevalence of major oral diseases and conditions across the life course.[1]

The theoretical framework of this research is based on the Social Determinants Model. This model argues that health outcomes and access to health services are shaped not only by individual factors, but also by economic, social and environmental conditions. According to Solar and Irwin (2019), poor health conditions of the poor, health disparities within societies, and marked health inequalities between countries result from the inequitable distribution of power, income and resources at both global and national levels. These inequalities are manifested in the tangible and visible differences that individuals face in their daily lives - inequalities in access to health services, educational opportunities, working conditions, housing and environmental standards. When the structural arrangements of society and the environmental conditions in which individuals live are considered together, these are collectively referred to as the social determinants of health.[5] Marmot & Wilkinson (2004) state that health status is directly related to social position in society. It is emphasized that health status improves as one moves up the social hierarchy, while health indicators deteriorate as one moves down.[6] Differences between countries in oral and dental health service levels and access to these services are closely related to macro-level economic indicators such as per capita income, income inequality, unemployment and inflation.[7] Oral diseases and their conditions are affected by access to safe water, sanitation and hygiene, which are social, economic and political conditions that affect oral diseases. Oral diseases are also influenced by the strategies used by some private sector actors to promote products, such as tobacco, marketing and sale of sugary foods and choices that are harmful to health.[1]

Health inequalities represent preventable disparities in disease burden and the ability to achieve a healthy life among socially disadvantaged groups. Globally, variations in socioeconomic conditions are a major factor influencing health inequalities. Factors such as occupation, income level, and education are closely interconnected. Disparities in oral health arise from imbalances in other social determinants of health, including education, financial status, social standing, and minority status. Communities with the worst oral health typically have lower levels of education and higher poverty rates.[8-9] The effects of poor social conditions during childhood have lasting consequences not only on general health but also on chronic oral diseases.[10] Individuals from lower socioeconomic backgrounds are more prone to engaging in harmful oral health practices than those from higher socioeconomic groups.[11] The inequitable distribution of economic, social, political and environmental resources is one of the causes of oral health inequalities. Addressing oral health inequalities requires global collaboration that brings together all stakeholders. Furthermore, the ethical responsibility to address health inequalities has resulted in scientific research on resource distribution and societal trends.[8]

Most studies have been conducted at the individual level, and the relationship between socioeconomic and demographic characteristics of individuals and oral health has been investigated. Studies have examined the relationship between oral health status and factors such as the Human Development Index, education level, ethnicity, and age. Lalloo et al.[12] showed an association between dental caries and socioeconomic development. Yfantopoulos et al.[13] in Greece examined self-reported oral health inequalities by analyzing demographic and socioeconomic factors such as age, gender, income and education. The findings revealed statistically significant differences in oral health between different socioeconomic groups in the country. Poorer oral health outcomes were particularly associated with financial hardship, older age and lower levels of education. Elani et al.[14] found a clear trend of social inequalities in oral health in Canada and the United States, with inequalities based on place of birth, education and income tending to decrease over time. Corbet[15] investigated the links between social, economic and behavioral factors and oral diseases such as cancer, dental caries and severe periodontal disease and found significant associations with some variables. Dugmore et al.[16] noted that oral health is influenced by ethnicity, which is inherently associated with factors like poverty.

Hosseinpoor et al.[17] found that across 52 countries, oral health services exhibit a bias towards wealthier individuals, with low-income countries facing higher levels of relative inequality than their high-income counterparts. In another study conducted in the Netherlands, Verlinden et al.[11] found that children from low socioeconomic backgrounds have a higher risk of dental caries. The study highlights the overconsumption of processed and carbohydrate-rich foods in low-income households and the need for policy interventions to reduce this. Tickle et al.[18] found in the UK that children from low-income families were more likely to have dental extractions. Yousaf et al.[19] suggested that high sugar consumption, low

maternal education and low and high socioeconomic status (SES) increase the risk of dental caries in Low and Middle Income Countries (LMICs).

Limited number of studies have analyzed data at the ecological level by making cross-country comparisons. Bencze et al.[20] found an association between early childhood caries, socioeconomic status and sugar consumption in European Union (EU) member countries. Palencia et al.[21] reported that socioeconomic inequalities in the use of dental care services are higher in countries without public dental care coverage than in countries with some degree of public coverage. Keller Celeste et al.[22] found that data collected from 40 high-middle and low-income countries between 2007 and 2018 showed thatedentulism prevalence was consistently higher among individuals in the lowest wealth quintile. The study suggests that policies in some welfare regimes can reduce inequalities while improving oral health.

Significant findings on the social, economic and demographic determinants of inequalities in oral health have been revealed. In particular, studies conducted at the individual level explain the impact of variables such as education level, income, ethnicity, and age on oral and dental health. However, in the few ecological studies with cross-country comparisons, the presence of socioeconomic inequalities in the distribution of oral health services have become evident. However, ecological studies on the link between economic indicators and coverage of oral health services across countries are limited. This research addresses the gap in the existing literature that oral health inequalities have not been systematically addressed at the country level with macroeconomic indicators. The literature on global studies involving multiple countries regarding the socioeconomic factors behind oral health inequalities is limited. To achieve the desired global standards of oral health, it is essential to identify not only behavioral risk factors but also the economic elements contributing to these inequalities. Oral health is not only related to teeth and gums but is also has an impact on overall health. Therefore, research on the relationship between differences in oral health and overall health provides valuable information. This study aims to evaluate dental health problems and service levels in relation to countries' economic variables. In doing so, it will highlight potential areas for intervention and necessary steps to improve oral health outcomes.

The following research hypotheses were developed within the scope of the study:

H1: There is a significant association between per capita GDP and the availability of oral health services, including oral screening, urgent treatments, restorative procedures, oral health workforce capacity, and public health responses to Noma.

H2: There is a significant association between the Gini coefficient and the availability of oral health services, including oral screening, urgent treatments, restorative procedures, oral health workforce capacity, and public health responses to Noma.

H3: There is a significant association between unemployment rates and the availability of oral health services, including oral screening, urgent treatments, restorative procedures, oral health workforce capacity, and public health responses to Noma.

H4: There is a significant association between inflation rates and the availability of oral health services, including oral screening, urgent treatments, restorative procedures, oral health workforce capacity, and public health responses to Noma.

H5: Economic variables (GDP per capita, Gini coefficient, unemployment rate, and inflation rate) are significantly associated with the prevalence of oral and dental health problems.

H6: GDP per capita and the Gini coefficient are significantly associated with the likelihood of countries providing basic restorative dental procedures.

H7: GDP per capita and the Gini coefficient are significantly associated with the prevalence of edentulism in individuals aged 20 and over.

Materials and Methods

This study was designed and reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for cross-sectional studies. The STROBE guidelines aim to provide guidance on how to report observational studies well. It provides a 22-item checklist.[23]

Study Design

This research employed a cross-sectional ecological study design, utilizing secondary data collected from publicly available international sources (World Health Organization and World Bank database).

Variables and Data Sources

The study population consists of 218 countries, with data obtained from the World Bank website. The study was conducted on 123 countries that do not have missing data among the variables analyzed. The data and data sources used in this study are presented in Table 1. Data on economic indicators such as GDP per capita, Gini coefficient, unemployment rate, and inflation were obtained from the World Bank database. Data related to oral health, such as edentulism and availability of basic restorative dental services, prevalence of oral diseases, and the number of oral health personnel were obtained from the World Health Organization. In this study, there was no participant recruitment, follow-up and direct data collection from individuals because the study relied on secondary data sources.

Table 1. Data source in the research

Variables	Abbreviation	Sources
"Gross Domestic Product (GDP) per capita*"	GDP_pc	World Bank
"Gini coefficient"	Gini	World Bank
"Unemployment rate"	Unemp_rate	World Bank
"Inflation**"	Inf_rate	World Bank
"Prevalence of untreated caries of deciduous teeth in children 1-9 years"	Caries_1-9	World Health Organization
"Prevalence of untreated caries of permanent teeth in people 5 years"	Caries_5+	World Health Organization
"Prevalence of severe periodontal disease in people 15 years"	Perio_15+	World Health Organization
"Prevalence of edentulism in people 20 years"	Edent_20+	World Health Organization
"Oral health screening for early detection of oral diseases"	Oral_Screen	World Health Organization
"Urgent treatment for providing emergency oral care and pain relief"	Urgent_Treat	World Health Organization
"Basic restorative dental procedures to treat existing dental decay"	Restorative_Procedures	World Health Organization
"Presence of dedicated staff for oral health working on NCDs at the Ministry of Health"	Oral_Staff	World Health Organization
"Noma recognized as a national public health problem"	Noma_Public_Health	World Health Organization

*Current US$ **Concumer prices (annual%)

Bias

To reduce selection bias in this study, only countries with complete and consistent data on both economic indicators and oral health measures were included. This ensured comparability across the sample. To minimize measurement bias, data were obtained from reputable and standardized international databases (World Bank and World Health Organization) using validated data collection and reporting methodologies. The use of multiple statistical methods (correlation analysis, logistic regression and multiple regression) helped to cross-validate the findings and reduce the possibility of spurious associations.

Study Scope

Countries were eligible for inclusion if data on all key economic and oral health variables were available. Economic indicators such as GDP per capita, Gini coefficient, unemployment rate and inflation are for 2022. Prevalence data on oral health are based on data from 2019 (Caries_1-9, Caries_5+, Perio_15+, Edent_20+). Oral health service delivery and policy indicators are derived from data for 2021 (Oral_Screen, Urgent_Treat, Restorative_Procedures, Oral_Staff, Noma_Public_Health). The final sample consisted of 123 countries. Data sources included the World Bank and World Health Organization Global Health Observatory.

Statistical Methods

The study was conducted at the ecological level (country-based) without any stratification by regional, income group or similar categories, and therefore no specific subgroup or interaction analyses were conducted. However, by including economic variables simultaneously in the regression models, the independent effects of each variable on oral health outcomes were analyzed. Only countries that provided complete data for all key variables were included in the analysis, minimizing bias due to missing data. The variables determined in the study were analyzed with Microsoft Excel and SPSS (IBM SPSS Statistics 26) software. Data were presented using mean, median as measures of central tendency, standard deviation, as well as frequency, percentage, minimum, and maximum values. Various statistical methods such as correlation, logistic regression, and multiple regression were used to increase the reliability of the findings. A multiple correlation analysis was performed to explore the relationship between the prevalence of oral and dental health issues and economic variables. The significance level was set at 0.05.

The normality of the distribution was evaluated using the Kolmogorov-Smirnov test. To assess skewness and kurtosis, the skewness and kurtosis tests were conducted. The normality of the data distribution was confirmed through skewness and kurtosis values, ensuring that the independent variables adhered to a normal distribution. Additionally, z-scores were calculated and used in the analyses to standardize the variables. Multivariate normality was examined using scatter plots, while linearity was assessed through residual plots in regression analysis, A non-parametric 'Mann-Whitney U' test was used for data analysis. To control for potential confounding effects between economic indicators, multiple linear regression analysis was used when assessing continuous outcomes such as the prevalence of edentulism. Similarly, logistic regression analysis was used to examine the impact of GDP per capita and Gini coefficient on the availability of basic restorative dental treatments while controlling for other economic variables.

Logistic regression was performed to assess how GDP and the Gini coefficient influence the availability of basic restorative dental treatments for addressing existing dental decay. To examine the impact of GDP and the Gini coefficient on the prevalence of edentulism in individuals aged 20 or older, multiple linear regression analysis was conducted. To assess the validity of the model, multicollinearity, residual analysis, outliers, and influential observations were examined. In multiple linear regression analysis, correlations among independent variables were analyzed to identify high correlations, and variance inflation factor (VIF) values were calculated. Since the VIF valueswere below 5, it was determined that multicollinearity was not an issue. The distribution of residuals was analyzed using scatter plots, confirming a random distribution in the range of -2 to +2. In logistic regression analysis, the linear relationship of independent variables with the logit transformation was examined, and thus, the assumption of logistic regression analysis was met. The model's fit was assessed by analyzing influential observations using Cook's distance measure, and no highly influential observations were identified.

Results

Table 2 presents descriptive findings related to oral and dental health variables and economic variables. Among the 123 countries examined, the minimum per capita GDP was $238.4, while the maximum was $126,426. The average Gini coefficient across these countries was 37.78 ± 7.95. The unemployment rate ranged from a minimum of 0.7% to a maximum of 28.8%, while the average inflation rate was recorded as 14.30 ± 28.23.

A flowchart summarizing the data selection and analysis process is provided in Figure 1.

Moreover, the average prevalence of untreated caries in primary teeth in children aged 1-9 years was 41.75 ± 5.81%. In individuals aged 5 years and older, the prevalence of untreated caries in permanent teeth was 32.22 ± 4.69%. In individuals aged 15 years and older, the prevalence of severe periodontal disease was 18.55 ± 7.09%. Lastly, the prevalence of edentulism in people aged 20 years ranged from a minimum of 1.24% to a maximum of 16.85%, with an average of 7.56 ± 4.13%. Table 2.

Table 2. Descriptive statistics of oral and dental health variables and economic variables

Variables	*n*	Min	Max	x̄	*σ*
GDP_pc	123	238.4	126426	14250	21503
Gini	123	24	63	37.78	7.95
Unemp_rate	123	0.7	28.8	7.11	5.18
Inf_rate	123	-6.7	254.9	14.30	28.23
Caries_1-9	123	20.2	52.73	41.75	5.81
Caries_5+	123	21.8	49.53	32.22	4.69
Perio_15+	123	2.26	33.48	18.55	7.06
Edent_20+	123	1.24	16.85	7.56	4.13

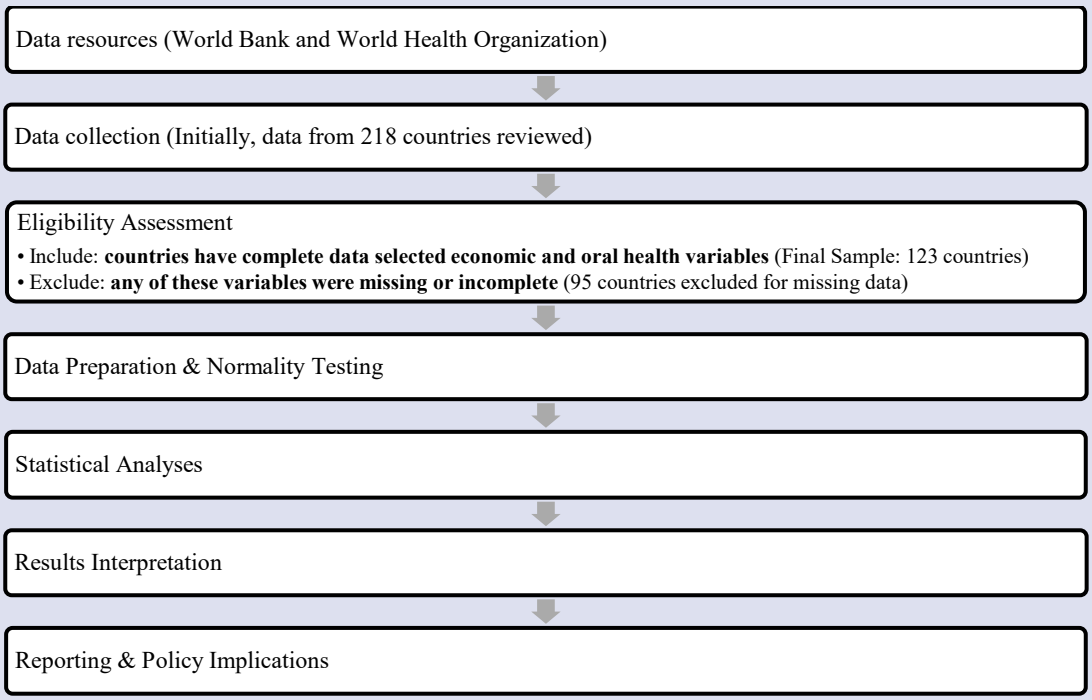

Figure 1. Flowchart for research.

Table 3 presents descriptive statistics on the prevalence of oral and dental health services. Among the 123 countries included in the study, 74% (n = 91) conduct oral health screenings for the early diagnosis of oral diseases, whereas 26% (n = 32) do not implement such measures. Emergency oral care and pain management services are available in 80.5% (n = 99) of the countries, while 19.5% (n = 24) lack these services. Additionally, basic restorative dental treatments for managing dental decay are provided in 70.7% (n = 87) of the countries, whereas 29.3% (n = 36) do not offer these treatments. In 73% (n = 90) of the examined countries, the Ministry of Health has specialized personnel working on oral health within the department for communicable diseases, while 26.8% (n = 33) do not have such personnel. Furthermore, only 8 countries (6.5%) officially recognize Noma disease as a national public health concern.

Table 3. Availability of oral and dental health services

Variables	n	%
Oral_Screen		
Available	91	74
Not Available	32	26
Urgent_Treat		
Available	99	80.5
Not Available	24	19.5
Restorative_Procedures		
Available	87	70.7
Not Available	36	29.3
Oral_Staff		
Yes	90	73.2
No	33	26,8
Noma_Public_Health		
Yes	8	6.5
No	115	93.5
Total	123	100

Table 4 presents the distribution of per capita GDP based on oral and dental health variables. A significant statistical difference was observed between countries that have oral health screenings for the early detection of oral diseases and those that do not ($p = 0.001 < 0.05$). Countries with oral health screenings had a higher per capita GDP ($17,657) compared to those without ($4,561). There was a statistically significant difference between countries with and without emergency treatment in terms of emergency oral care and painkiller supply ($p = 0.016 < 0.05$). Countries with such emergency services had a higher per capita GDP ($23,242) than those without ($8,239).

A significant statistical difference was observed between the GDP per capita of countries that had oral health screening for early diagnosis of oral diseases and the GDP per capita of countries that did not ($p = 0.001 < 0.05$). Countries providing these services had a higher GDP per capita ($17,849) compared to those lacking these services ($5,553). Additionally, a statistically significant disparity in GDP was observed between countries that have specialized oral health personnel working on non-communicable diseases within the Ministry of Health and those that do not ($p= 0.045 < 0.05$). Additionally, a notable difference was identified between countries where noma is recognized as a national public health issue and those where it is not ($p= 0.001 < 0.05$).

Table 5 presents the distribution of the Gini coefficient in relation to oral health variables. No statistically significant difference was found in the Gini coefficient between countries with and without oral health screenings for early detection of oral diseases ($p = 0.206 > 0.05$). Similarly, there was no significant difference in the Gini coefficient between countries with and without emergency oral care and pain management services ($p = 0.440 > 0.05$). However, a significant difference in the Gini coefficient was found between countries that provide basic restorative dental procedures for treating existing dental caries ($p= 0.017 < 0.05$). The median Gini coefficient in countries with basic restorative dental procedures (35.2) was lower than in those without such procedures (38.6). No significant statistical differences were found in the Gini coefficient between countries with and without specialized personnel in the Ministry of Health's Communicable Diseases department focusing on oral health ($p = 0.227 > 0.05$), or between countries that classify Noma disease as a national public health concern and those that do not ($p = 0.415 > 0.05$).

Table 6 illustrates the distribution of the unemployment rate based on oral health variables. No significant difference in the unemployment rate was found between countries that conduct oral health screenings for early detection of oral diseases and those that do not ($p = 0.851 > 0.05$). Similarly, there were no significant differences in the unemployment rate between countries that provide urgent oral care and pain relief services and those that do not ($p = 0.858 > 0.05$), between countries offering basic restorative dental procedures for existing dental decay and those that do not ($p = 0.809 > 0.05$), between countries with and without specialized oral health personnel involved in Ministry of Health's Communicable Diseases (CD) department ($p = 0.237 >$

0.05), or between countries that recognize Noma as a national public health issue and those that do not (p= 0.112 > 0.05).

Table 7 presents the distribution of inflation rates based on oral and dental health variables. No statistically significant differences in inflation rates were identified between countries that conduct oral health screenings for early detection of oral diseases and those that do not (p = 0.588 > 0.05). Similarly, no significant differences were found between countries that offer urgent oral care and pain relief services and those that do not (p = 0.542 > 0.05); between countries that provide basic restorative dental procedures for treating dental decay and those that do not (p = 0.322 > 0.05); between countries with and without specialized oral health personnel within the Ministry of Health (p = 0.376 > 0.05); and between countries that acknowledge noma as a national public health issue and those that do not (p = 0.460 > 0.05).

The results of the correlation analysis examining the relationship between the prevalence of oral health problems and economic factors are presented in Table 8. According to the analysis, there is a statistically significant and negative correlation between GDP per capita and the prevalence of untreated dental caries in children aged 1-9 years (r = -0.488; p = 0.001). A significant positive correlation was also found between GDP per capita and the prevalence of edentulism in individuals aged 20 years and older (r = 0.477; p = 0.001). Additionally, a significant negative correlation was observed between the Gini coefficient and the prevalence of severe periodontal disease in individuals aged 15 years (r = -0.249; p = 0.005), as well as between the Gini coefficient and the prevalence of edentulism in individuals aged 20 years (r = -0.237; p = 0.008).

Table 9 presents the results of a logistic regression analysis examining the impact of GDP and income inequality (Gini coefficient) on the availability of basic restorative dental procedures to treat existing dental caries. The analysis showed that the explanatory power of the model for the dependent variable was 16.3% and statistically significant (p < 0.001). This suggests that the independent variable (GDP) significantly contributes to explaining the availability of dental procedures. However, a negative relationship was observed between the Gini coefficient (income inequality) and the availability of dental procedures, although it was not statistically significant. An increase of one unit in the Gini coefficient decreases the likelihood of the availability of dental procedures (B = -0.218). In other words, as income inequality increases, the likelihood of dental procedures being available decreases. Specifically, a one-unit increase in the Gini coefficient results in approximately a 19.6% decrease in the likelihood of dental procedures being available (Exp(B) = 0.804; 1-0.804 = 0.196). This suggests that income inequality has a negative impact on the availability of dental procedures. However, this effect is not statistically significant.

An increase in GDP increases the probability of the availability of dental procedures (B = 1.379). In particular, a one-unit increase in GDP increases this probability by about four times (Exp(B) = 3.972). The increase in GDP has a statistically significant effect on the availability of dental procedures (p = 0.016).

Table 10 presents the results of the regression analysis evaluating the impact of GDP and income Gini coefficient on the prevalence of edentulism among individuals aged 20 and older. GDP has a positive effect on the prevalence of edentulism in people aged 20 years and older, meaning that each unit increase in GDP leads to an increase in the prevalence of edentulism (Beta = 1.824; Standardized Beta = 0.441). The effect of GDP on edentulism prevalence is statistically significant (p < 0.001). Therefore, we can conclude that the impact of GDP is significant. No strong correlations exist between the independent variables, and no multicollinearity issue is present (VIF = 1.102).

Table 4. Distribution of per capita GDP based on the availability of oral health services

Variables	n	$\bar{x}$	median	*p*
Oral_Screen				
Available	91	17657	7125	0.001
Not Available	32	4561	1918	
Urgent_Treat				
Available	99	23242	6267	0.016
Not Available	24	8239	2335	
Restorative_Procedures				
Available	87	17849	7014	0.001
Not Available	36	5553	2093	
Oral_Staff				
Yes	90	15921	6510	0.045
No	33	9694	3741	
Noma_Public_Health				
Yes	8	1336	6153	0.001

Table 5. Distribution of Gini coefficient based on the availability of oral health services

Variables	n	x̄	median	*p*
Oral_Screen				
Available	91	37.58	36.0	0.206
Not Available	32	38.34	37.6	
Urgent_Treat				
Available	99	37.6	36.0	0.440
Not Available	24	38.3	37.1	
Restorative_Procedures				
Available	87	36.8	35.2	0.019
Not Available	36	40.1	38.6	
Oral_Staff				
Yes	115	37.1	36.0	0.227
No	8	39.4	37.5	
Noma_Public_Health				
Yes	8	38.4	36.0	0.415
No	115	37.7	37.6	

Table 6. Distribution of unemployment rate based on the availability of oral health services

Variables	n	x̄	median	*p*
Oral_Screen				
Available	91	6.9	5.2	0.851
Not Available	32	7.5	5.8	
Urgent_Treat				
Available	99	7.1	5.4	0.858
Not Available	24	6.8	5.4	
Restorative_Procedures				
Available	87	7.1	5.6	0.809
Not Available	36	7.1	5.1	
Oral_Staff				
Yes	33	6.8	5.0	0.237
No	90	7.8	6.3	
Noma_Public_Health				
Yes	8	4.6	3.6	0.112
No	115	7.2	5.7	

Table 7. Distribution of inflation rate based on the availability of oral health services

Variables	n	*x̄*	median	*p*
Oral_Screen				
Available	91	14.1	8.2	0.588
Not Available	32	14.6	8.9	
Urgent_Treat				
Available	99	15.1	8.2	0.542
Not Available	24	10.8	9.3	
Restorative_Procedures				
Available	87	14.9	8.4	0.322
Not Available	36	12.8	7.0	
Oral_Staff				
Yes	90	16.0	8.8	0.376
No	33	13.6	8.1	
Noma_Public_Health				
Yes	8	14.7	6.6	0.460
No	115	8.2	8.3	

Table 8. Examination of the relationship between the prevalence of oral and dental health problems and economic variables

	GDP_pc	Gini	Unemp_rate	Inf	Caries_1-9	Caries_5+	Perio_15+	Edent_120+
GDP_pc	1							
Gini	r = -0.328**	1						
	p = 0.001							
Unemp_rate	r = -0.156	r = 0.316**	1					
	p = 0.084	p = 0.001						
Inf	r = -0.830	r = 0.121	r = 0.101	1				
	p = 0.362	p = 0.182	p= 0.265					
Caries_1-9	r = -0.488**	r = 0.003	r = 0.013	r = -0.009	1			
	p = 0.001	p = 0.974	p = 0.884	p = 0.918				
Caries_5+	r = 0.090	r = -0.114	r = 0.132	r = -0.031	r = 0.204*	1		
	p = 0.321	p = 0.208	p = 0.146	p = 0.730	p = 0.024			
Perio_15+	r = 0.087	r = 0.249**	r = 0.126	r = 0.049	r = -0.359**	r=-0.213*	1	
	p = 0.340	p = 0.005	p = 0.165	p = 0.594	p = 0.001	p = 0.018		
Edent_120+	r = 0.472**	r = -0.237**	r = 0.103	r = 0.033	r = -0.060	r = 0.335**	r = -0.110	1
	p = 0.000	p = 0.008	p = 0.258	p = 0.718	p = 0.508	p = 0.001	p = 0.225	

Table 9. The effect of GDP and income inequality on the availability of basic restorative dental procedures

Dependent Variable	Variable	B	S.E.	Wald	Sig.	Exp(B)	95%C.I. for EXP(B)	
							Lower	Upper
Restorative_Procedures	Gini	-0.218	0.212	1.056	0.304	0.804	0.821	1.884
	GDP_pc	1.379	0.575	5.754	0.016	3.972	1.287	-
R^2 = 0.163 (Cox & Snell R Square), R^2 = 0.163 (Nagelkerke R Square), Chi-Square = 14.98, p < 0.001								

"Available (1) and Not Available (0); Reference Variable: Not Available"

Table 10. GDP and Gini coefficient effects on edentulism prevalence in individuals aged 20 and over

Dependent Variable	Independent Variable	Beta	Standart Error	Standart ßeta	t	p	VIF
Edent_20+	GDP_pc	1.824	-0.350	0.441	5.205	0.001	1.102
	Gini	0.382	0.350	-0.092	-1.090	0.278	1.102
R = 0.687, R^2 = 0.472, F = 53.58, p = 0.001, Durbin-Watson = 1.883							

Discussion

This study examined the relationship between macroeconomic indicators and oral health outcomes at the country level. The research results highlight substantial disparities in access to oral health services across different countries. The study found that countries screening for early detection of oral diseases have significantly higher GDP per capita than those that do not. Emergency treatment, restorative procedures, and recognition of Noma as a public health problem also differ significantly by GDP levels. Regarding the Gini coefficient, a significant difference was found only between countries offering basic restorative procedures and those that did not; no significant relationship was observed with other indicators. Significant differences in the Gini coefficient and inflation rate were found based on the provision of restorative procedures. GDP per capita was negatively associated with untreated caries and positively with edentulism in children aged 1-9. The Gini coefficient was negatively associated with severe periodontal disease and edentulism. Moreover, GDP significantly increases the availability of dental treatments, while the Gini coefficient's effect is negative but not significant. Finally, GDP significantly increases edentulism prevalence at age 20 and above.

The influence of socioeconomic status on dental health has been examined in numerous studies. These studies primarily focus on how an individual's income affects oral health at the micro level. In this regard, it is essential to consider that economic indicators, not only at the individual level but also at both micro and macro levels, may impact dental health in various ways. Aguiar et al.[24] found that individuals living in municipalities with fewer dental care services had a higher risk of dental caries (OR = 1.36). Timiş and Dănilă[9] stated that higher income leads to outcomes such as better housing, access to medical services, and engagement in behaviors that promote oral health. This justifies the effort to identify the factors that contribute to and sustain inequalities in both general and oral health.

Verlinden et al.[11] mentioned that lower socioeconomic status also affects dietary patterns, which in turn affect dental health. They emphasized the need for policy measures to reduce the consumption of highly processed, carbohydrate-rich foods at the societal level, noting that these measures would significantly reduce dental diseases. Other factors contributing to these inequalities include the skills of dental professionals, lower levels of oral health literacy, and the lack of guidelines for preventive dental care.

Yfantopoulos et al.[13] identified socioeconomic factors such as the availability of dentists, income, and insurance as determinants of individuals' ability to afford dental care. Watt & Sheidam[25] highlighted differences in the consumption patterns of sugar and fluoride toothpaste as major causes of inequalities. One study found that higher levels of education positively affect oral hygiene and that lower income levels are associated with poor oral hygiene. This emphasizes the relationship between health and education and the impact of economic factors on individuals' health habits.[26] Factors such as insurance status, education level, income and occupation have been identified as the main causes of inequalities in Iran. These factors are important determinants that affect individuals' access to and utilization of oral health services.[27] According to a review on the variables leading to inequalities in dental health, individual factors associated with inequality in dental service use include age, and dealing with diseases or functional impairments, while social factors include living in rural or urban areas, employment and types, migration, and education. Economic crises at the national level and regional disparities contribute to social inequalities. It is suggested that high-income groups with high socioeconomic status seek dental services more frequently and that the frequency of annual dental visits is significantly higher than those in low-income groups.[28]

In their meta-analysis of 83 studies, Schwendicke et al.[29] found that individuals from lower socioeconomic backgrounds had notably higher dental caries rates compared to those from higher socioeconomic backgrounds. A lower socioeconomic status was linked to an increased risk of either caries lesions and dental caries experiences. Another study revealed that students with parents who had lower education levels and those with lower per capita income experienced a higher prevalence of dental pain compared to their peers. Students residing in areas with a low Human Development Index experienced dental pain more frequently than those in more developed regions, regardless of individual factors.[30] Research that addresses economic indicators at the macro level has also been conducted. Fidan and Fidan[31] compared dental terms (tooth decay, toothache, dentist, tooth whitening and toothbrush) in Google Trends with the GDP and population of countries. They find that individuals in countries with higher GDP are less likely to search online for terms such as toothache and tooth decay.

GDP was found to be associated with higher life satisfaction, and the absence of physical pain.[32] Low GDP and Human Development Index (HDI) has been linked to tooth pain.[33] Moreover, people tend to focus more on health inequalities when there aren't large differences in basic health and living conditions.[34] It has been suggested that the utilization of dental services may decrease as the national income level increases.[35] There are considerable disparities in access to primary dental care and emergency oral health services between high and low-income nations. Fewer dentists are practicing in lower-income countries compared to middle- and high-income countries. In addition to the shortage of dental professionals, low-income countries are also disadvantaged in terms of access to water fluoridation and toothpaste.[36] Especially in these countries, it is important to inform the public. Although information on dental hygiene requires an initial cost, it can save money in the long run.[37]

A significant statistical difference was found in the GDPs of countries with oral health specialists in the Ministry of Health compared to those without oral health specialists in the Ministry of Health, as well as between countries that recognize Noma as a national public health issue and those that do not. These findings are supported by other studies suggesting that national health systems and policies have a decisive impact on oral health.[28,36,38-40] There are underserved populations in both developed and developing regions. Oral health is treated as a separate area from general health services and is often not sufficiently integrated. It is emphasized that promoting the use of affordable fluoride toothpaste is crucial in developing nations, especially given the changes in dietary patterns and nutritional conditions. In low- and middle-income countries, particularly in impoverished and remote areas, encouraging the use of natural, nutritious products over processed foods, along with promoting healthy diets and reducing tobacco use, is a vital strategy.[41]

This study identified a statistically significant association between the Gini coefficient and the prevalence of severe periodontal disease in individuals aged 15 and older, as well as between the Gini coefficient and the prevalence of edentulism in individuals aged 20 and older. The findings align with previous research linking financial difficulties to lower levels of oral health.[11,13,14,17,18] Studies indicate that dental services are used more frequently in countries with lower income inequality. An analysis of 66 countries found a negative correlation between the Gini coefficient and dental service use, with a 10% increase in the Gini coefficient linked to a 15% decrease in service utilization.[35] Sabbah et al.[42] highlighted that income inequality is a significant contextual factor in periodontal disease. Income inequality may influence oral health behaviors .This study suggests that healthcare investment can influence the relationship between income inequality and dental service usage. It also supports the behavioral model that healthcare utilization is shaped by both individual and contextual factors (e.g., income inequality).[43]

Limitations

The inclusion of inflation as an economic indicator represents a limitation, as its direct impact on oral health services remains unclear. Further studies are needed to clarify this relationship. Additionally, the data used in the analyses were derived from the most recent available years. However, the use of data from different time points may have influenced the precision of the associations observed, as economic and health conditions can evolve over time. In addition, due to data availability constraints,

countries with missing information for key variables were excluded from the analysis. Differences in health policies, health infrastructure, and cultural practices across regions may also affect the applicability of the results to specific contexts. It should also be noted that due to the ecological study design, the relationships identified at the country level may not directly reflect the relationships at the individual level.

Conclusions

This study shows that economic factors influence oral health services. Higher GDP leads to increased early diagnosis, restorative treatments, and urgent interventions. The results indicate that in countries with higher GDP, oral and dental health interventions are more prominent. Additionally, a negative relationship was found between GDP levels and oral and dental health problems. The regression analysis revealed that the effect of GDP is significant, suggesting that as economic development increases, dental health services are expected to become more accessible. As the GDP level of countries increases, it is likely that more resources will be allocated to treatments such as oral health screenings for early detection of oral diseases, basic restorative dental procedures for existing caries, and emergency dental treatments. The increased provision of these treatments, combined with the holistic effects of factors such as dietary habits associated with lower income levels, oral health literacy, access to medical services, and lack of behavior that promote oral health, is likely to influence the occurrence of oral and dental health problems.

The study shows that higher GDP per capita significantly increases the likelihood of the availability of services such as oral health screenings, emergency oral care, basic restorative dental procedures, and the presence of specialized personnel in oral health. Conversely, increasing income inequality (Gini coefficient) negatively impacts access to oral and dental health services. Additionally, it was found that GDP has a positive effect on the prevalence of edentulism, meaning that economic development alone may not be sufficient to reduce tooth loss. To increase access to oral health services, public dental health programs should be developed in low-income countries, and international funding should be leveraged. In economically weaker countries, the widespread implementation of oral health screenings and basic restorative procedures can strengthen early diagnosis and treatment opportunities. While a high GDP positively influences oral health services, it may not lead to a decrease in edentulism rates. Therefore, oral health policies should focus not only on economic growth but also on raising health awareness within the community. Especially in low-income countries with high income inequality, social and economic policies for accessible and inclusive oral health services should be approached holistically.

Considering the relationship between income and access to products for basic dental care, it is clear that income level is a contributing factor to inequalities in oral and dental health. To universal access to oral and dental health services, these services must reach the poorest population groups. Equity-focused policies are needed in this area. This research may shed light on global and national oral and dental health policies. It is hoped that upcoming research and public health policies will contribute to the fair distribution of resources for oral and dental health while also reducing oral and dental health inequalities.

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Conflicts of Interest Statement

The author declares that there is no conflict of interest.

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