ORIGINAL ARTICLE

Analyzing Global Dentist Distribution Using the Gini Coefficient

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Abstract

Background: Each country's health system is tasked with providing services to ensure the health of its population. Dental services are among these essential services. However, dental service utilization is unevenly distributed worldwide. This study's findings will give health sector officials and policymakers valuable insights to enhance system performance.

Methods: This descriptive-analytical study, conducted in 2021, aimed to determine the distribution of dentists worldwide. The analysis utilized the Pareto curve, the dentist-to-population ratio (DPR), the Gini Coefficient (GC), and the Lorenz curve. The goal was to identify the countries with the highest number of dentists.

Results: There are over 2,500,000 dentists globally, averaging 3.6 dentists per 10,000 people. However, the ratios vary significantly, with about 6.8 per 10,000 in countries with very high Human Development Index (HDI) groups and 0.19 per 10,000 in low HDI groups. The data indicates that more than 80% of dentists work in countries with very high and high HDI.

Conclusion: This study suggests that job concentration is higher in areas with superior welfare and facilities, and dentistry is no exception. Therefore, creating better welfare in more disadvantaged areas, implementing mandatory government plans, and strategic government planning can help mitigate distribution inequality.

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Introduction

Health and healthcare systems are integral components of any society, and their governing laws should be tailored to meet that society's specific needs. Decisions in this field carry significant weight as they directly impact societal health, equitable access to healthcare services, and more.[1]

Each country's health system is tasked with providing services to ensure the health of its population. Primary Health Care (PHC) is a key part of health systems[2] and has been recognized as a crucial component of health systems since the early 20th century. Despite significant progress, a substantial gap remains between the needs of individuals and communities and the quality and effectiveness of the care provided.[3]

People often face challenges in accessing basic PHC services. Access to such care frequently encounters numerous additional barriers, including discrimination and racism. Secure access necessitates more services than those readily available.[4] The availability of healthcare providers is influenced by demographic factors, particularly population size and income.[5]

The health workforce is a critical component of any healthcare system. Without people to provide services, there can be no healthcare. Thus, the health workforce plays a fundamental role in addressing health inequalities.[6] The health system should invest significantly in medicine, nursing, and other

specialized educational fields. Planning for the health workforce requires comprehensive strategies that address all aspects, including the number, skills, and gender distribution, to meet society's health needs and achieve the goals.[7]

An essential factor in healthcare systems is planning for the correct number and combination of health workforce at the right place and time. A significant part of health workforce costs includes salaries, wages, fees, and contracts. Health workers constitute the largest financial input of these systems. There is growing concern about whether the supply of health workers can meet the current population's needs and handle the health system's future demands.[8]

A robust workforce for any organization should function constructively to achieve its goals. More than two-thirds of an organization's expenses are consumed by human resources, which have always been the main asset of any system or organization. Human resource planning aims to ensure that the right number of personnel with the right skills and competencies are available at the appropriate place and time. Health services rely heavily on personnel to the extent that 60-75% of the health sector's budget is spent to maintain this particular resource.[9]

The World Health Organization (WHO) estimates that approximately 59.2 million health providers are working worldwide, with a reported shortage of about 4.3 million service providers. This shortage is particularly severe in the 57 poorest countries, especially sub-Saharan Africa. On World Health Day in 2006, this situation was declared a "crisis in the health workforce", resulting from decades of underinvestment in education, wages, work environments, and management of health workers.[10]

The "human resource crisis" in the health sector has been described as one of the most pressing global health issues. This global shortage threatens the quality and sustainability of health systems worldwide. Opportunities for health workers to seek work overseas have led to the migration of health professionals from low-income countries to high-income ones. This global migration pattern has sparked extensive international debate on the consequences for health systems, including questions about sustainability, equity, and global social responsibilities.[11]

Given the shortage of a skilled workforce in the health sector, properly distributing human resources is crucial to improving people's health. It is essential to have information about the level of equality in the distribution of the health workforce and their time trends for better planning and optimal use of these resources. Inequality in the distribution of resources has increased in the health sector over time. With the development of the private sector and depending on the activity trend of this sector in more developed regions, health policymakers should continuously evaluate the distribution of human resources and organize a specific plan for allocating human resources in the health sector.[12]

The health system is responsible for providing dental services. Oral and dental health directly influence overall health and quality of life.[13] Scientific research in the field of medicine consistently indicates that health begins in the mouth. Nowadays, oral and dental health not only targets dental health but also serves as the starting point for our body's general health and well-being.[14]

However, while the prevalence of oral diseases is on the rise in many low—and middle-income countries, oral and dental health has received little attention in other countries. Access to and use of dental services depend on factors such as lifestyle, social rank, region, and social inequalities.[15]

Dental services are heavily distributed unequally among different social, ethnic, economic, and educational groups. This unequal and inequitable use of dental services likely leads to or exacerbates existing inequalities in dental health.[16]

Studies show that the majority of the 1.6 million dentists in the world reside in Europe and America, with 69% of dentists providing services to 27% of the global population. Only 1% of the global workforce belongs to Africa; therefore, there are certain inequalities in the availability of dental personnel, as indicated by the population-to-dental workforce ratio.[17]

To date, no systematic attempt has been made to quantify inequalities in the use of dental services.[16] Since the cases above are the harm caused by the unequal distribution of dentists worldwide, this study attempts to quantitatively report the distribution of dentists in different countries using the Gini coefficient (GC). It is expected that the results obtained in this study will be available to officials and policymakers in the health sector, providing an effective step to improve the performance of this system.

Methods

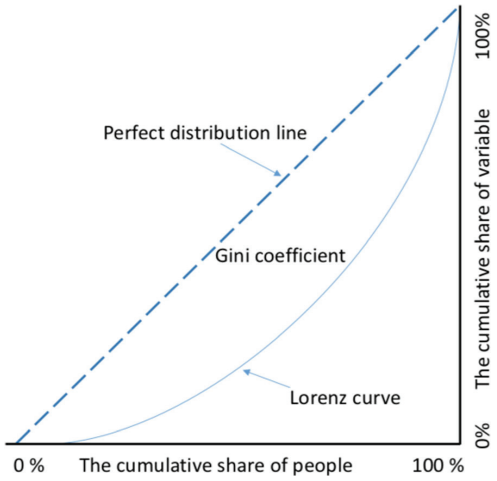
In this retrospective and descriptive-analytical research, the basic data about the number of dentists and the population of countries were obtained from the World Health Organization (WHO) and the United Nations (UN) databases. In each case, the most recent data approved by the countries were included in the calculations. Accordingly, the latest data regarding the population and the Human Development Index (HDI) were obtained in 2020, and the number of dentists was collected in 2019 and 2018. If data for some indices were unavailable in the main databases, attempts were

made to obtain data from the reliable databases of each country, such as the website of the Ministry of Health in that country. If data for a country could not be obtained from all sources, that country was excluded from the research population. All methods followed the Ethical Guidelines of the Declaration of Helsinki. This study was also approved by the Ethics Committee of the Shiraz University of Medical Sciences (Code: 25908). All participants provided written informed consent to participate in this study.

The Human Development Index (HDI) is utilized to classify countries. The data for this index are extracted from United Nations databases. The HDI considers life expectancy, literacy level, and Gross Domestic Product (GDP). The HDI is between zero and one, with a higher index indicating a more developed country. Accordingly, the world's countries are divided into four categories: very high HDI, high HDI, medium HDI, and low HDI.

The distribution of dentists in each of the categories above was determined using calculations and analyses of the "Pareto curve", the "dentist-to-population ratio (DPR)", the "Gini Coefficient (GC)", and the "Lorenz curve". The DPR determined the distribution of dentists per 10,000 population in each country. The Lorenz curve, Pareto curve, and GC calculated the distribution of dentists among different countries.

In this research, the GC was used in three different modes: the GC of the countries of the same group in the four HDI groups, the GC between the four groups, and the GC in all the countries of the world. The GC represents the area ratio between the Lorenz curve and the equality line to the whole area below the equality line. This coefficient ranges from 0 (indicating perfect equality) to 1 (indicating perfect inequality). Typically, a GC of 0.2–0.35 is considered a relatively fair distribution, 0.35–0.5 is a relatively unequal distribution, and 0.5–0.7 is a highly unequal distribution.[18] To draw the curves, the population of countries and the number of dentists were represented on the horizontal and vertical axes, respectively.



Source: Reda et al.[16]

The following formula calculated the GC:

$$G = 1 - \sum_{i=0}^{n} (Y_{i+1} + Y_i) * (X_{i+1} + X_i)$$

n: Total number of groups

Yi: Cumulative percentage of dentists in the in the group

Xi: Cumulative percentage of the population in the group

The cumulative distribution of dentists across various countries was determined by Pareto analysis, which was based on the population of those countries. This analysis aimed to identify the group of countries with the highest number of dentists worldwide. For consistency and ease, all calculations and formulas related to the Lorenz curve, Gini Coefficient (GC), Dentist-to-Population Ratio (DPR), Pareto analysis, ratios, and cumulative percentages were implemented using Excel 2019 software.

Results

According to the United Nations classification, the countries of the world are categorized into four groups based on the Human Development Index (HDI): very high (66 countries), high (53 countries), medium (37 countries), and low (33 countries). In addition, the UN did not assign six countries to any of the above groups due to a lack of data. Norway, with an HDI of 0.957, and Niger, with an HDI of 0.394, hold the highest and lowest development positions among all countries, respectively. China and Palau, as the most and least populous countries, fall into the high and very high HDI groups, respectively (Table 1).

HDI levels above and below the world average (0.682) are observed in 58.52% and 41.48% of the world's population, respectively.

There are more than 2,500,000 dentists worldwide. With about 19% of the world's population, China has more than 25% of the world's dentists. India, with a similar population to China, has about 11% of the world's dentists. However, Sweden has the highest Dentist-to-Population Ratio (DPR), valued at 17.86 per 10,000 people.

On average, there are 3.6 dentists per 10,000 people worldwide. However, ratios of approximately 6.8 and 0.19 per 10,000 are reported in countries located in very high and low HDI groups, respectively (Figure 1).

In very high- and low-HDI countries, 20% and 12% of the world's population have about 40% and about 1% of the world's dentists, respectively. The findings indicate that over 80% of dentists work in the two groups of very high and high HDI countries (Figure 2).

Table 1: Distribution of dentists in different countries based on HDI indicator

	Factor	Very high	High	Medium	Low	
HDI	Max num.	0.957	0.796	0.697	0.546	
	Average num.	0.879	0.747	0.618	0.487	Ave:0.682
	Min num.	0.804	0.703	0.554	0.394	
Population	Max num.	332,915,073	1,444,216,107	1,393,409,038	211,400,708	
	Average num.	24,224,955	58,641,460	64,283,712	29,515,895	
	Min num.	18,169	53,544	116,254	1,002,187	
	Total num.	1,574,622,110	2,990,714,471	2,269,929,924	965,508,671	Sum:7,800,775,176
	%Of total	20.185	38.339	29.099	12.377	Sum:100
Dentist	Max num.	203,078	644,120	284,255	9,386	
	Average num.	158,25	22,100	10,949	756	
	Min num.	29	8	8	5	
	Total num.	1,012,800	1,105,018	372,270	23,460	Sum:2,513,550
	%Of total	40.295	43.962	14.810	0.933	Sum:100
	%Male	46.778	46.233	50.3	49.45	Ave:48.190
	%Female	53.221	53.766	49.7	50.55	Ave:51.809
	%Age:<25	1.825	4.454	0.731	0.057	Ave:1.766
	%Age:25-34	23.892	31.674	66.679	11.273	Ave:33.379
	%Age:35-44	24.914	27.859	18.864	35.727	Ave:26.841
	%Age:45-54	24.669	24.022	11.019	0.333	Ave:15.010
	%Age:>55	24.697	11.989	2.704	52.608	Ave:22.999
Gini in each group		0.136	0.270	0.241	0.627	
Gini between groups		0.563				
Gini total		0.687				

HDI: Human Development Index

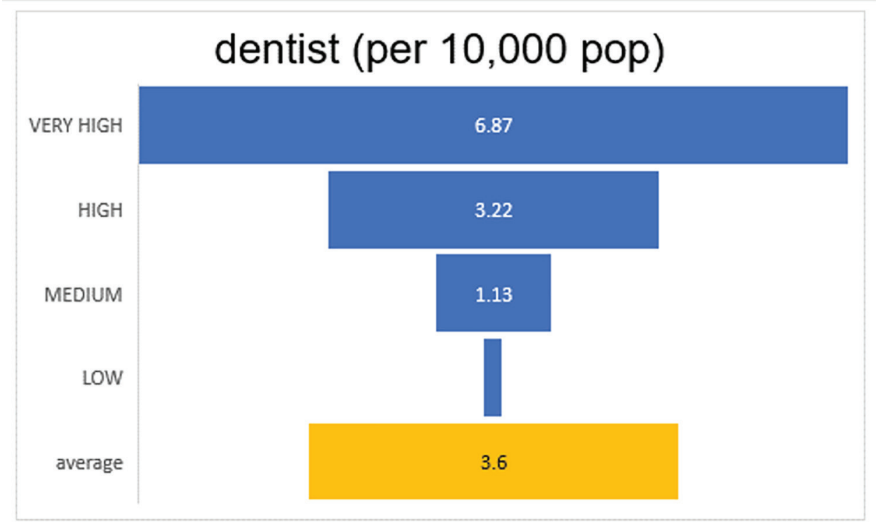


Figure 1: Distribution of dentists per 10,000 population in the 4 Human Development Index (HDI) groups countries.

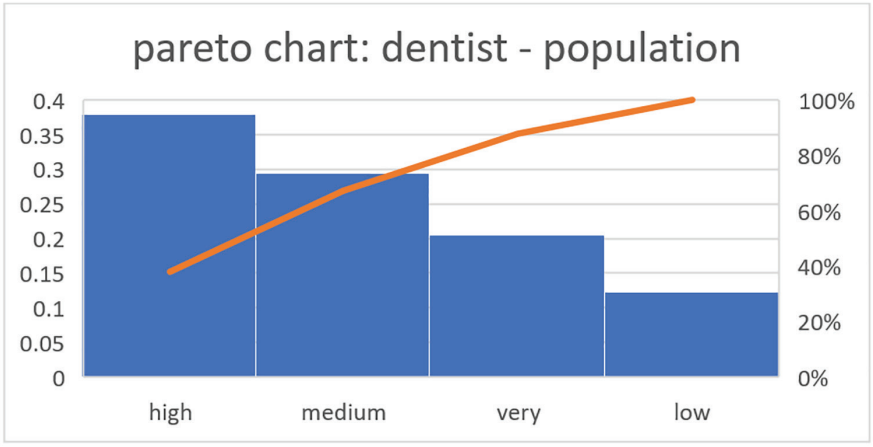


Figure 2: Pareto curve of dentists distribution to the population in 4 groups of countries

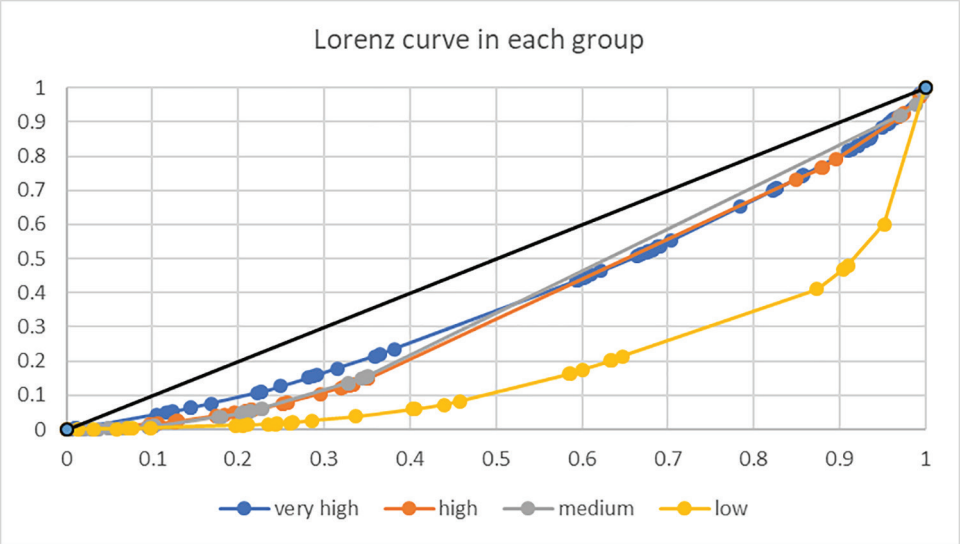


Figure 3: Dentist Lorenz curve in each group

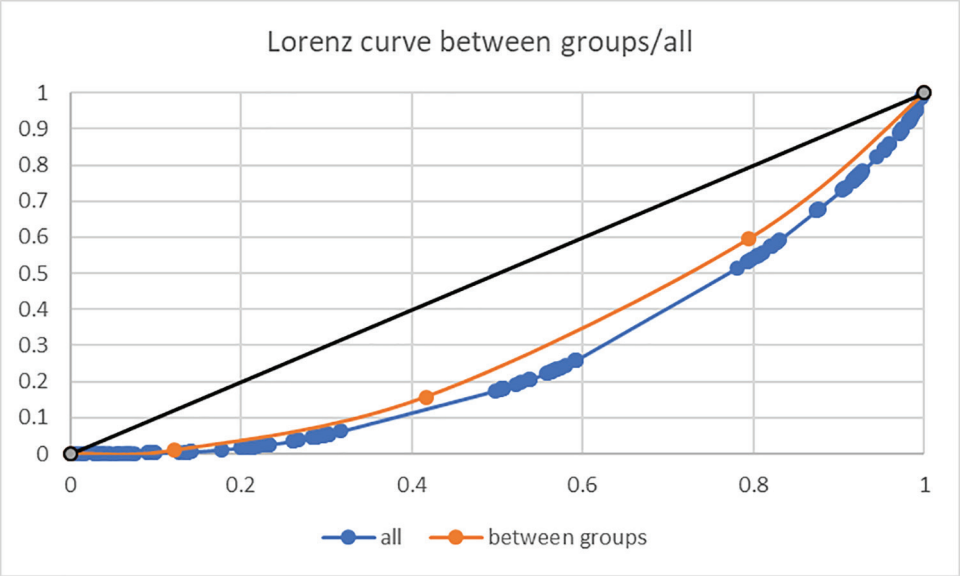


Figure 4: Dentist Lorenz curve between groups/all

Globally, women comprise 51.8% of dentists, and the percentage of female dentists increases with the HDI level. The highest percentage of dentists aged over 55 is observed in very high HDI countries. However, dentists in the 25-34 age range account for the highest average percentage among all countries.

The Gini Coefficient (GC) and Lorenz curve calculations do not show significant differences between the countries in the three groups of very high, high, and medium Human Development Index (HDI). However, this index suggests a strong difference between the countries of the low HDI group. Due to the increase of the GC exceeding a value of 0.5, different groups worldwide have very different distributions of dentists per 10,000 people (Figures 3 and 4).

Discussion

In addition to other resources in the health sector, there is a need for specialized and skilled human resources, such as doctors, paramedics, pharmacists, and dentists, to provide a qualified and appropriate service.[19] Although positive relationships are reported between access to healthcare resources (human and physical resources) and the health level of the population, the distribution of these resources is also considered one of the health-affecting social factors.[20, 21]

Currently, there are less than five dentists per 10,000 people in more than 68% of World Health Organization (WHO) member countries (less than one is reported in about 37%).[22] The special conditions in the health sector make the law of supply and demand unable to result in an equitable and need-based allocation of resources.[23] On the other hand, the treatment methods for oral diseases are very expensive, so dental treatments account for about 5-10% of the annual expenses of the health sector in industrialized countries.[24]

Inequality in oral and dental health varies significantly across countries, largely due to socioeconomic factors.[25] Oral and dental diseases, which are among the most common chronic diseases, pose significant challenges to public health due to their prevalence, treatment costs, and impact on individuals and society. Most countries' dental care systems are ill-equipped to meet their populations' oral health care needs. Therefore, more efforts and strategies are needed to integrate oral and dental health into general health policies.[22] The UN classifies the world's countries into four categories based on the Human Development Index (HDI), and the results of this study are reported accordingly.

Very High HDI

The largest number of dentists, particularly those in the 45-54 age group, are found in countries within this category. In Japan, Hashimura et al. (2020) reported an average of 273.8, 79.9, and 59.6 dentists per 100,000 population in primary medical care areas with dental schools, adjacent areas, and other areas, respectively. The distribution of dentists is highly unequal, primarily due to the presence of dental schools.[26] In Austria, Gochter et al. (2014) found a significant negative relationship between the density of private and public dentists, suggesting a substitution effect between the two groups. A significant positive relationship was also observed between private and public dentists in adjacent areas. Despite the strong negative relationship between private and public dentists across different regions, it is not appropriate to conclude that private dentists are close substitutes for public dentists in Austria.[27]

With a population growth rate exceeding 2% annually, Oman has historically relied on a foreign dental workforce. In 2010, only 24% (n=160) of the dental workforce was Omani. However, as Gallagher et al. (2015) reported, the annual growth of the dental workforce increased after the Oman Dental College (ODC) began educating qualified dentists (BDS) in 2012. Assuming all future ODC graduates have the opportunity to work and practice in Oman, the growth rate of Omani dentistry would increase from 2012 onwards, starting at 28% annually. This would enhance capacity towards global (n=1711) and regional levels.[28]

High HDI

Countries in this category have the world's largest population, the highest percentage of female dentists, and the greatest number of dentists aged under 25 years. According to Rezaei et al. (2014), the highest Gini Coefficient (GC) values in Iran were attributed to dentists (0.25) in 2001, pharmacists (0.32) in 2015, and dentists (0.27) in 2010. The highest per capita growth in human resources was reported for dentists (77%) and medical specialists (61%), respectively, in 2011 compared to 2001. In Iran's public health system, dentists per 10,000 population increased from 0.18 in 2001 to 0.32 in 2011. The GC results for dentists indicated that their per capita increased quantitatively in 2011 compared to 2001, but the level of inequality also rose in 2011 compared to 2001. The GC values were 0.25 and 0.26 in 2001 and 2011, respectively.[29] Yahivi Dizj et al. (2019) reported a GC of 0.41 for the distribution of dentists in 2012, which slightly decreased to 0.40 in 2017.[30]

Medium HDI

Countries in this category have the highest percentage of male dentists and the largest age group of 25-34 years. In South Africa, the budget for oral health is generally limited due to a fourfold disease burden, which includes the human immunodeficiency virus, tuberculosis, maternal and child mortality, and non-communicable diseases.[31] A study by Tiwari et al. (2021) highlighted the imbalanced distribution of dentists across provinces, districts, and urban versus rural areas and an additional inequality in access between the public and private sectors.[32]

In Egypt, Tantawi et al. (2020) observed that dentists were randomly distributed per 1000 people throughout the country, with this ratio reaching 0.18 in 2014. This indicates a shortage despite the increased number of dental graduates (667.1%) since 1995. Although the number of dental graduates in Egypt has increased over the past 20 years, about 75% of the population resides in provinces with a shortage of dentists. The country is generally facing a shortage in dentistry, which the increased number of dental graduates has not compensated. This may be attributed to the high attrition rate. Providing financial incentives to dentists to encourage them to practice in disadvantaged areas and including healthcare in the national development program may improve this situation.[33]

Low HDI

Countries in this category have the largest number of dentists aged 35-44 years and over 55 years. They also have the highest Gini Coefficient (GC) values, indicating the worst distribution of dentists among the world's countries. As reported by Ismail (2020), health resources are distributed very asymmetrically in Sudan, showing significant differences among the 18 states in Sudan. Based on GC values, the inequality in the distribution of health facilities ranged from moderate to high. Regarding human resources, inequality was very high for physicians (specialists, dentists, and general practitioners) and ranged from low to very high for allied health personnel. To achieve an equal distribution of health resources among Sudanese governments, the study's results

indicate that 16-28% of health facilities and 18-44% of human resources must be redistributed among regions. Additionally, the findings strongly confirm the importance of equal geographical distribution of human resources between regions due to a significant positive relationship between the density of human resources and health outcomes.[34]

The UN Commission on Health, Employment, and Economic Growth recently reported a shortage of 18 million personnel by 2030, particularly in middle- and low-income countries. It stated that developing countries' situation is even worse.[35] Overall, since the GC did not exceed 0.3 in the first three groups, it can be argued that no considerable inequality is observed in the distribution of dentists in these groups (relatively equitable). Furthermore, the classification of countries based on the development index and the calculated results of the GC in each first group suggest a direct relationship between the development index and the unequal distribution of dentists in the four groups. However, the crossing of the GC from the limit of 0.5 in the fourth group indicates considerable inequality in this group compared to all groups.

Conclusion

The dependence of dental services on raw materials and equipment, as well as the introduction of new technologies, results in the high price of dental services. This reduces the demand for this group of services, thereby decreasing the income of dentists and their motivation to reside in outlying areas and government departments. The government should intervene in such cases that do not provide social welfare. This study, however, is subject to several limitations. The primary limitation was insufficient statistics and information about some countries. Hence, the authors were forced to exclude those countries from the calculations. Furthermore, there was a delay in the release of the updated data of the countries, so the authors tried to make calculations using the latest published data. In general, this study and previous studies demonstrate that the concentration of people in any job is higher in areas with better and higher welfare and facilities, and dentists are not exempt from this rule. Therefore, inequality in distribution can be prevented by creating better welfare in more disadvantaged areas, mandatory government plans, and, in principle, the government's planning and intervention in this issue.

Authors' Contribution

E.KH and SH.B contributed to the design and implementation of the research. E.KH performed the analysis of the results. SH.B and A.J. were involved in writing the manuscript. N.B. raised the research idea and contributed to drafting and reviewing the manuscript. All authors have read and approved the final manuscript.

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