



Health Personnel Inequality Trends in Türkiye: Theil Index and Gini Analysis

İlhan Kerem ŞENEL*

* Istanbul University-Cerrahpaşa, Faculty of Health Sciences, Department of Health Management, Istanbul, Turkey,
ORCID Number: 0000-0003-4496-5149.

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Abstract

Health workforce inequality affects equitable access to healthcare worldwide. Türkiye implemented major health system reforms in the 2000s through the Health Transformation Program (HTP) to address regional disparities in physician distribution.

Aim: To examine temporal trends in health personnel inequality across Türkiye's 81 provinces between 2002 and 2023, focusing on medical doctor distribution patterns.

Methods: Official data from the Turkish Statistical Institute (TÜİK) on physician counts and population figures for all provinces were analyzed. The Gini coefficient and Theil index were calculated annually to quantify changes in inequality. Although originally developed to measure income inequality, both metrics effectively capture disparities in the distribution of healthcare resources.

Results: Both indices showed major improvements in physician distribution equity during the 2000s, corresponding with HTP healthcare reforms. The Gini coefficient fell from 0.253 in 2002 to 0.146 in 2019, while the Theil index dropped from 0.103 to 0.034. After 2019, both measures showed modest increases, with 2023 values reaching 0.174 (Gini) and 0.048 (Theil).

Corresponding author: İlhan Kerem ŞENEL, e-mail: keremsenel@iuc.edu.tr

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Conclusion: Türkiye achieved substantial progress in reducing regional physician inequality through targeted policy interventions. Recent trends suggest the need for continued monitoring and adaptive strategies to maintain healthcare equity gains.

Keywords: Health Inequality, Gini Coefficient, Theil Index, Healthcare Policy, Türkiye

INTRODUCTION

Health workforce distribution is a critical determinant of service accessibility and equity. Classical frameworks such as Aday and Andersen's (1974) health service utilization model and Whitehead's (1991) equity framework emphasize that equal health outcomes require equitable spatial and professional alignment between resources and population needs. Within this context, evaluating inequality indices offers an empirical lens through which to assess systemic fairness in the distribution of health personnel.

Health workforce inequality, the uneven distribution of doctors and other health personnel across regions, is a critical issue affecting equitable access to healthcare. In many countries, doctors have historically been concentrated in major urban centers, leaving rural and less-developed regions underserved (De Looper & Lafortune, 2009). These regional disparities in health resources can pose major barriers to healthcare access (Ró, 2020). Recognizing this, Türkiye implemented major health system reforms in the 2000s to improve fairness in health service delivery (Mollahaliloglu et al., 2021). The Ministry of Health launched the Health Transformation Program (HTP) in 2003 with the explicit goal of achieving more effective, efficient, and equitable healthcare for all (Akdağ et al., 2003; World Bank, 2003). This analysis examines how inequality in the provincial distribution of doctors evolved over the period 2002–2023, using quantitative inequality measures. By analyzing Theil index trends alongside the more commonly used Gini coefficient, the analysis provides a detailed picture of temporal changes in health personnel distribution equity in Türkiye. The analysis reveals whether reforms and policies have narrowed the gaps between well-served and underserved provinces and highlights emerging trends in the 2020s. Key background literature, the methodological approach, a summary of findings, and the main implications for policy and research follow.

1. LITERATURE REVIEW

Research on geographic inequality of health personnel in Türkiye and other countries offers important background. Early studies found that Türkiye's healthcare resources were highly imbalanced across regions, with far higher physician densities in western metropolitan provinces than in eastern areas. This matches a worldwide trend where capital or wealthier regions attract more healthcare workers (Mollahaliloglu et al., 2021). Over time, policy interventions have had clear effects. For example, (Zeren et al., 2012) applied Theil index analysis to regional healthcare inequality in Türkiye from 1997 to 2006, finding that both inter-regional and intra-regional inequalities decreased over that decade. They also noted that inequality was more pronounced for specialist doctors than for general practitioners or total physician numbers, highlighting how different categories of health workers may experience different distribution patterns.

Subsequent studies have confirmed and extended these findings. (Mollahaliloglu et al., 2021) analyzed the distribution of health workers (including doctors, nurses, and midwives) for selected years between 2002 and 2016, using Lorenz curves and Gini coefficients. Their results showed considerable improvements in equity during the 15-year span: for instance, the Gini coefficient for specialist physicians fell from 0.33 in 2002 to 0.21 in 2016, while for general practitioners it dropped from 0.18 to 0.09. These sharp reductions in Gini values indicate that the distribution of health personnel became far more balanced, probably due to deliberate policies under the HTP. The HTP introduced measures such as incentive schemes for doctors to work in underserved areas (e.g. contract-based appointments with higher salaries) and a prioritization system to fill urgent staffing needs in less-developed provinces. Also, medical school enrollment was expanded to increase the overall supply of physicians. These diverse interventions have been credited with yielding positive results in reducing regional disparities.

The issue of health workforce inequality is not unique to Türkiye. Comparative studies have used Gini and Theil indices to assess doctor distribution in other countries, providing a methodological parallel and broader perspective. For example, a study in China examined the geographic equity of doctors from 2002 to 2017 and found that after health reforms in 2009, regional disparities in doctor distribution considerably decreased (as evidenced by declining Gini coefficients), although urban–rural gaps proved more persistent (Cao et al., 2020). Similar inequality monitoring exercises have been conducted in various contexts such as nursing workforce distributions in Poland and Iran and physician distribution in Brazil and Cameroon, all

using indices like Gini to quantify inequality (Kharazmi et al., 2023). These works highlight the importance of measuring and addressing the uneven geographic distribution of health professionals. Past literature shows that Türkiye made considerable progress in the 2000s in narrowing health personnel gaps. Yet, it is clear that continuous monitoring is needed, especially given potential new challenges like internal migration or external emigration of doctors that could affect the equity gains of prior years.

2. RESEARCH METHODOLOGY

2.1. Data and Scope

This analysis focuses on provincial-level inequality in the distribution of total medical doctors in Türkiye from 2002 through 2023. The data on the number of doctors by province and year were obtained from official statistics of the Turkish Statistical Institute (TÜİK, 2025). Population figures for each province were also used in order to account for population size in measuring per-capita doctor availability. There were 81 provinces throughout the study period (the provincial boundaries remained unchanged after 1999). By analyzing a 21-year period, the analysis captures the long-term trends before and after major health reforms.

2.2. Inequality Measures

Two complementary indices, the Gini coefficient and the Theil index, were calculated to quantify inequality each year. The Gini coefficient and Theil index originated as measures to quantify income inequality.

The Gini coefficient, introduced by Corrado Gini in 1912 (Ceriani & Verme, 2012), is the most widely used inequality measure. The Gini coefficient ranges from 0 (perfect equality) to 1 (maximum inequality) (Catalano et al., 2009; Dorfman, 1979; Lambert & Decoster, 2005; Milanovic, 1997). It is derived from the Lorenz curve, depicting cumulative shares of a population against cumulative shares of income or other resources. In this context, the cumulative share of resources corresponds to the cumulative share of doctors across provinces. Hence, a lower Gini indicates a more equitable distribution of doctors relative to population. Below is the formula for Gini coefficient:

$$G = \frac{1}{2n^2\mu} \sum_{i=1}^n \sum_{j=1}^n |x_i - x_j|$$

- x_i, x_j : Individual observations (e.g., doctor-to-population ratios)
- μ : Mean of the observations
- n : Number of observations

The Theil index, developed by Henri Theil in 1967 (Theil, 1967), is a measure from information entropy family which also gauges inequality (Conceição & Ferreira, 2000; Conceição & Galbraith, 2000). Below is the formula for Theil Index:

$$T = \frac{1}{n} \sum_{i=1}^n \frac{x_i}{\mu} \ln \left(\frac{x_i}{\mu} \right)$$

- x_i : Individual observations
- μ : Mean of observations
- n : Number of observations

2.3. Why Employ Both Gini and Theil?

The Theil index offers key advantages over the Gini coefficient, most importantly its ability to decompose overall inequality into within and between group components. It is more sensitive to extreme disparities at the tails of the distribution, detecting changes among the very highest and lowest ratios more sharply than Gini (Lee, 2025). As an information-theoretic measure, Theil quantifies inequality as an entropy divergence from perfect equality. Being part of the generalized-entropy family, it allows researchers to tune its sensitivity parameter to focus on different parts of the distribution (Cowell, 2006). Finally, unlike Gini's 0–1 bound, Theil T is unbounded above, so it continues to rise in extreme scenarios of doctor-population concentration (Milanovic, 2013).

2.3.1. Decomposability

Theil's most celebrated property is additive decomposability, which splits total inequality into:

- Between-province inequality (variation in average doctor ratios across provinces) (World Bank Group, 2025)

- Within-province inequality (unevenness inside provinces, e.g. urban vs. rural areas) (Trapeznikova, 2019)

This breakdown helps pinpoint whether policy should target disparities across provinces or inside them, which is something Gini cannot do (Cowell, 2006). This feature allows researchers to isolate specific regional contributions to overall inequality, providing targeted insights for policy interventions.

While the Gini coefficient provides a comprehensive, single-value measure of inequality, it lacks decomposability. The Theil index adds analytical depth by enabling decomposition into “between-group” and “within-group” components, although this paper focuses on the overall Theil values.

2.3.2. Sensitivity to Extreme Values

Theil T places relatively more weight on large deviations at the top of the distribution, while Gini is most responsive around the median (Lee, 2025). In contexts where a few provinces are heavily doctor-rich or doctor-poor, Theil emphasizes those extremes and better shows changes at the extremes that matter for policy.

In Fiji, a study measuring inequalities in health worker distribution at the sub-national level used the Theil index alongside Gini coefficients to reveal greater inequalities in provinces with extreme doctor shortages or surpluses, highlighting how Theil captures disparities at the tails of the distribution more effectively, which is important for policy targeting (Wiseman et al., 2017). Research on the allocation of general practitioner resources in mainland China employed the Theil index to analyze regional disparities, showing that intra-regional differences (i.e., extremes within provinces) contributed more to overall inequality, indicating Theil’s sensitivity to tail disparities relevant for policy interventions (Fu et al., 2023).

Another study on health service development differences in China used the Theil index and variance decomposition methods to explore spatial and structural sources of inequality, emphasizing Theil’s ability to show disparities where some provinces are doctor-rich or doctor-poor, thus better informing policy to address these extremes (Jin et al., 2025).

2.3.3. Information- Theoretic Interpretation

Framing inequality in “bits” or “nats” can be intuitive in communicating how far a system is from uniformity (Costa & Pérez-Duarte, 2019). Derived from Shannon’s entropy, Theil T measures the “redundancy” or information divergence between the observed doctor distribution and perfect equality. Theil’s original conceptualization and subsequent applications describe the

Theil T index as based on Shannon's entropy, quantifying the difference between the observed distribution and a perfectly equal distribution, effectively measuring the "redundancy" or information divergence in the system. Studies applying Theil T in various fields such as income inequality and labor market disparities often emphasize that the index stems from Shannon's information theory, using entropy to capture inequality as the divergence from uniformity (Soares et al., 2016). This approach allows decomposition of inequality into within and between group components, useful in policy analysis.

More recent works in complex systems and financial time series also highlight the mathematical relationship between Theil's index and generalized Shannon entropy measures, showing how Theil T can be interpreted as an entropy-based measure of distributional heterogeneity or divergence (Abril-Bermúdez et al., 2024; Kopczewski & Bil, 2024).

2.3.4. Generalized-Entropy Flexibility

Theil belongs to the Generalized-Entropy class of measures indexed by a parameter α :

- $\alpha = 1$ yields Theil T (more sensitive to upper-tail disparities)
- $\alpha = 0$ yields Theil L or mean log deviation (more sensitive to lower-tail disparities) (Cowell, 2006).

Researchers can thus select α to emphasize the policy-relevant segment of the distribution, which is a flexibility Gini lacks.

2.3.5. Unbounded Upper Range

While the Gini coefficient is strictly bounded between 0 and 1, Theil T can grow up to $\ln N$, where N is the number of provinces (Milanovic, 2013). In extreme doctor concentration scenarios, where a few provinces monopolize medical resources, Theil continues to rise, signaling intensifying inequality that Gini would understate.

2.4. Practical Calculation

Both indices were computed for each year using standard formulas and computational tools. Following established methods in health inequality research, provinces were ranked by doctor-to-population ratio, and calculations took into account population weights (so that larger

provinces have proportional influence on the national inequality measure). This approach provides that the indices truly demonstrate inequality in access to doctors per capita, rather than just absolute doctor counts. Using both the Gini and Theil indices allows cross-validation of trends and helps maintain robustness. Consistent movement in both metrics would build confidence in the direction of inequality change, whereas a divergence could signal subtle shifts in the distribution, since the Gini is more sensitive to the middle and the Theil to the tails.

Both indices were calculated annually using provincial doctor-to-population ratios. The data, sourced from TÜİK, included physician counts and population sizes for all 81 provinces. The calculation process involved:

1. Computing per capita physician ratios for each province annually.
2. Using these ratios to derive cumulative distributions.
3. Calculating the Gini coefficient using Lorenz curve approximations.
4. Computing the Theil index using direct substitution into the entropy formula.

See the appendix for the Python code that calculates the Gini coefficient and the Theil index and plots the Lorenz curves.

3. ANALYSIS

The temporal trend of the two indices was analyzed to identify phases of improvement or deterioration in equity. Key inflection points were noted in relation to policy timelines such as the rollout of HTP initiatives around 2003–2010. Formal statistical significance tests were not performed year-by-year because the dataset covers the entire population, making such tests less important. Where feasible, the findings were compared with those reported in the literature for overlapping periods. The analysis also involved visualizing the data through charts and curves for clearer communication, as described below.

Table 1: Gini and Theil Indices (2002–2023)

Year	Gini Coefficient	Theil Index
2002	0.253	0.103
2003	0.252	0.104
2004	0.246	0.0986
2005	0.238	0.091
2006	0.249	0.105
2007	0.242	0.104
2008	0.228	0.0907
2009	0.217	0.0798
2010	0.185	0.0581
2011	0.161	0.0428
2012	0.162	0.043
2013	0.163	0.0442
2014	0.162	0.0436
2015	0.157	0.0409
2016	0.16	0.0412
2017	0.149	0.0363
2018	0.155	0.0379
2019	0.146	0.0338
2020	0.154	0.0373
2021	0.158	0.0396
2022	0.169	0.0453
2023	0.174	0.0484

Over the study period 2002–2023, Türkiye experienced notable changes in the inequality of doctor distribution across provinces. At the start of the period, inequality was relatively high:

the Gini coefficient in 2002 stood at approximately 0.25, indicating a moderately unequal distribution of doctors (many provinces had far fewer doctors per capita than the national average). Theil's T index in 2002 was around 0.10, similarly showing considerable imbalance. As Türkiye's health reforms took effect in the mid-2000s, these measures showed an overall decline (with a brief uptick around 2006). By 2010, the Gini had fallen below 0.20, and the Theil index dropped to around 0.058, roughly half its initial level. See Figure 1 below.

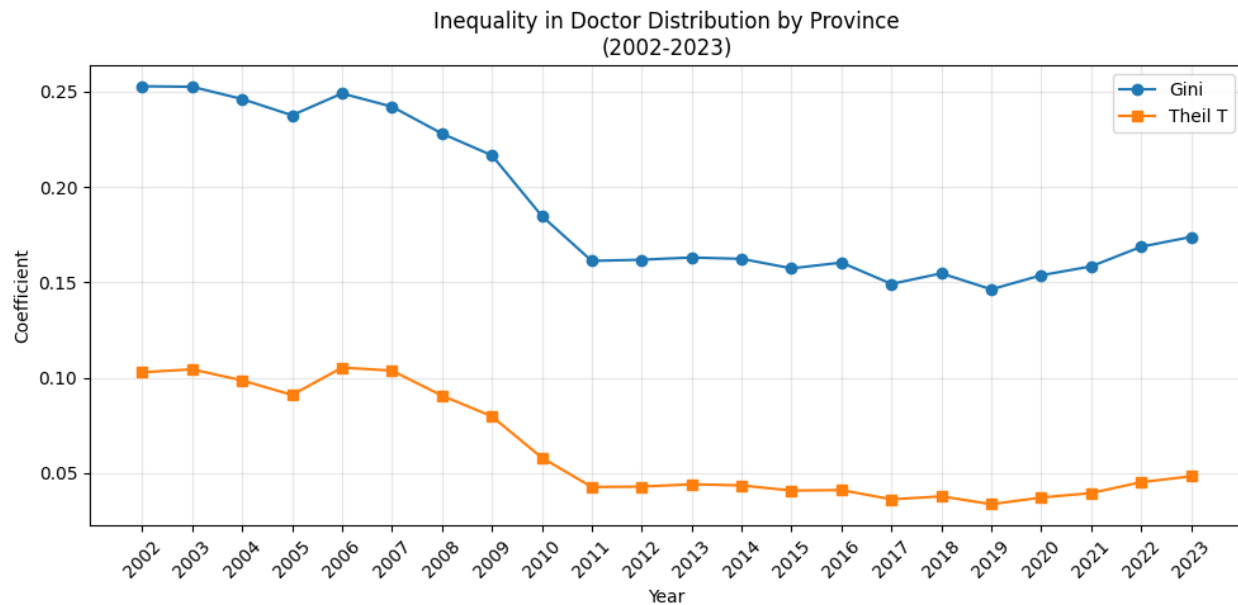


Figure 1: Temporal trend of inequality indices for physician distribution across Turkish provinces (2002–2023).

The Gini coefficient (blue circles) and Theil index (orange squares) both declined markedly during 2002–2011, indicating improved equity in the geographic distribution of doctors following health system reforms. Inequality reached its lowest level around 2017–2019, after which a slight increase is observed through 2023. (Data based on TÜİK provincial statistics and author's calculations.)

This downward trend continued into the mid 2010s, with the inequality reaching its lowest levels around 2017–2019, a period when the Gini hovered in the 0.15–0.16 range and the Theil index in the 0.03–0.04 range. These values indicate relatively low inequality. For reference, a Gini between 0.20 and 0.35 is often considered “relatively equal” in resource distribution (Kharazmi et al., 2023). The improvements over this first decade and a half suggest that policies succeeded in

distributing the growing health workforce more evenly. This finding is consistent with earlier reports that documented major reductions in regional imbalance up to 2016 (Mollahaliloglu et al., 2021).

The trend after 2019 reveals a subtle reversal. Both indices show a rising tendency in the early 2020s: the Gini coefficient climbed to 0.174 by 2023, and the Theil index to about 0.048, representing an uptick from their historical lows. Although inequality levels in 2023 were still better than those in the early 2000s, the increase suggests emerging challenges. New observations support this concern. For example, in 2023 some eastern and southeastern provinces had only about 1 to 2 doctors per 1000 people, whereas the capital Ankara had about 4 per 1000. See Figures 2, 3, 4, and 5 below.

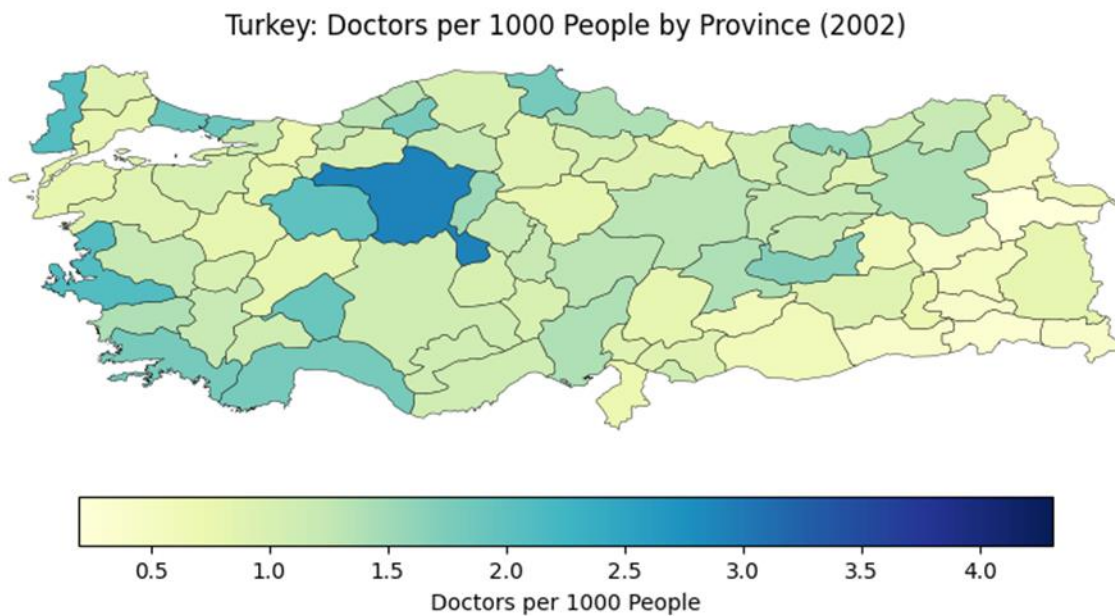


Figure 2: Türkiye: Doctors per 1000 People by Province (2002). (Data based on TÜİK provincial statistics and author's calculations.)

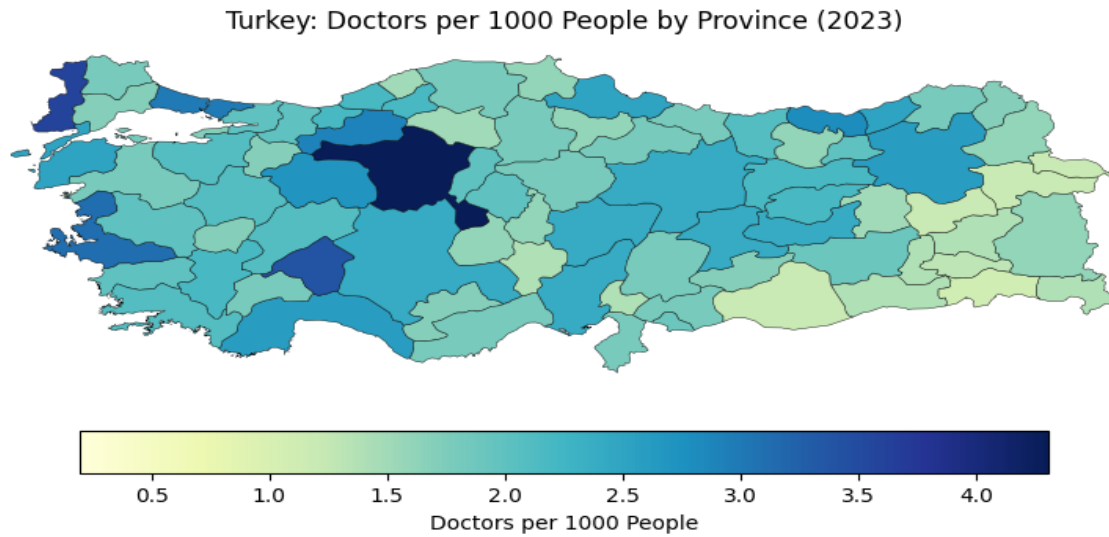


Figure 3: Türkiye: Doctors per 1000 People by Province (2023). (Data based on TÜİK provincial statistics and author's calculations.)

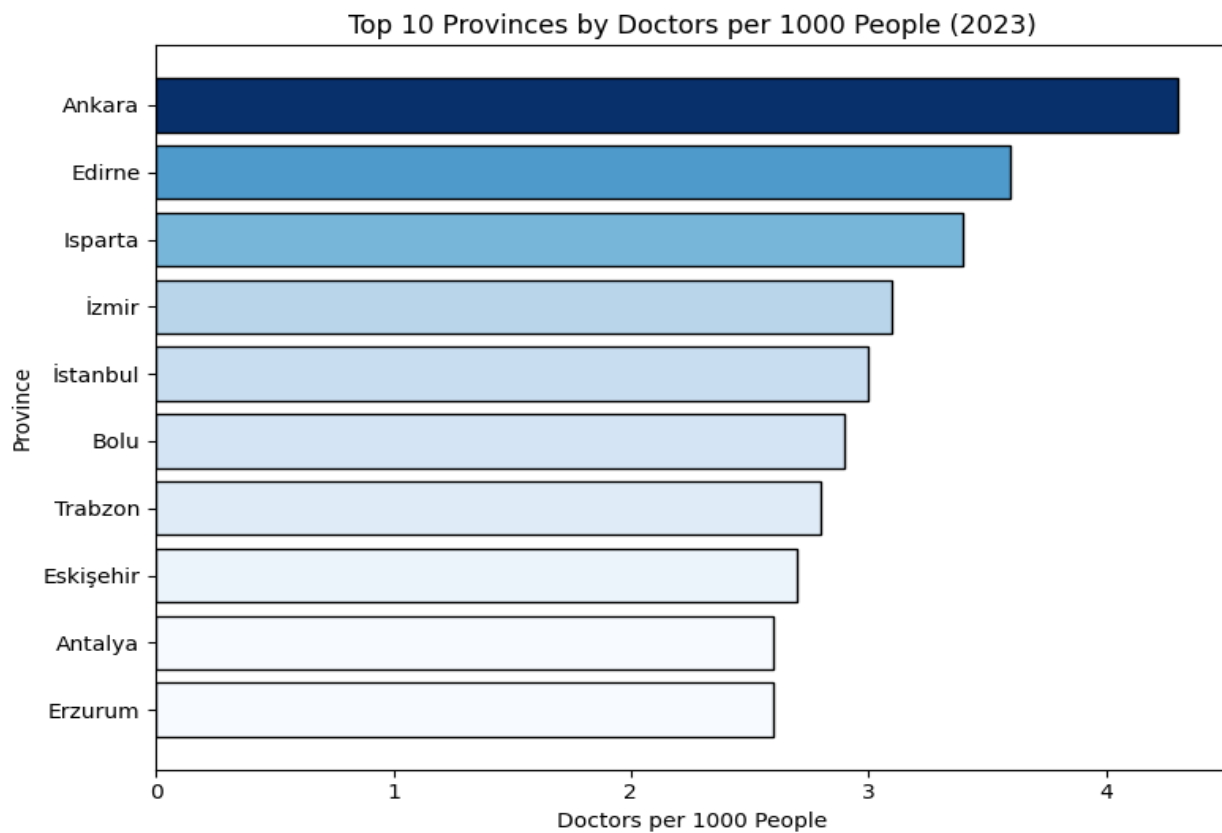


Figure 4: Top 10 Provinces by Doctors per 1000 people. (Data based on TÜİK provincial statistics and author's calculations.)

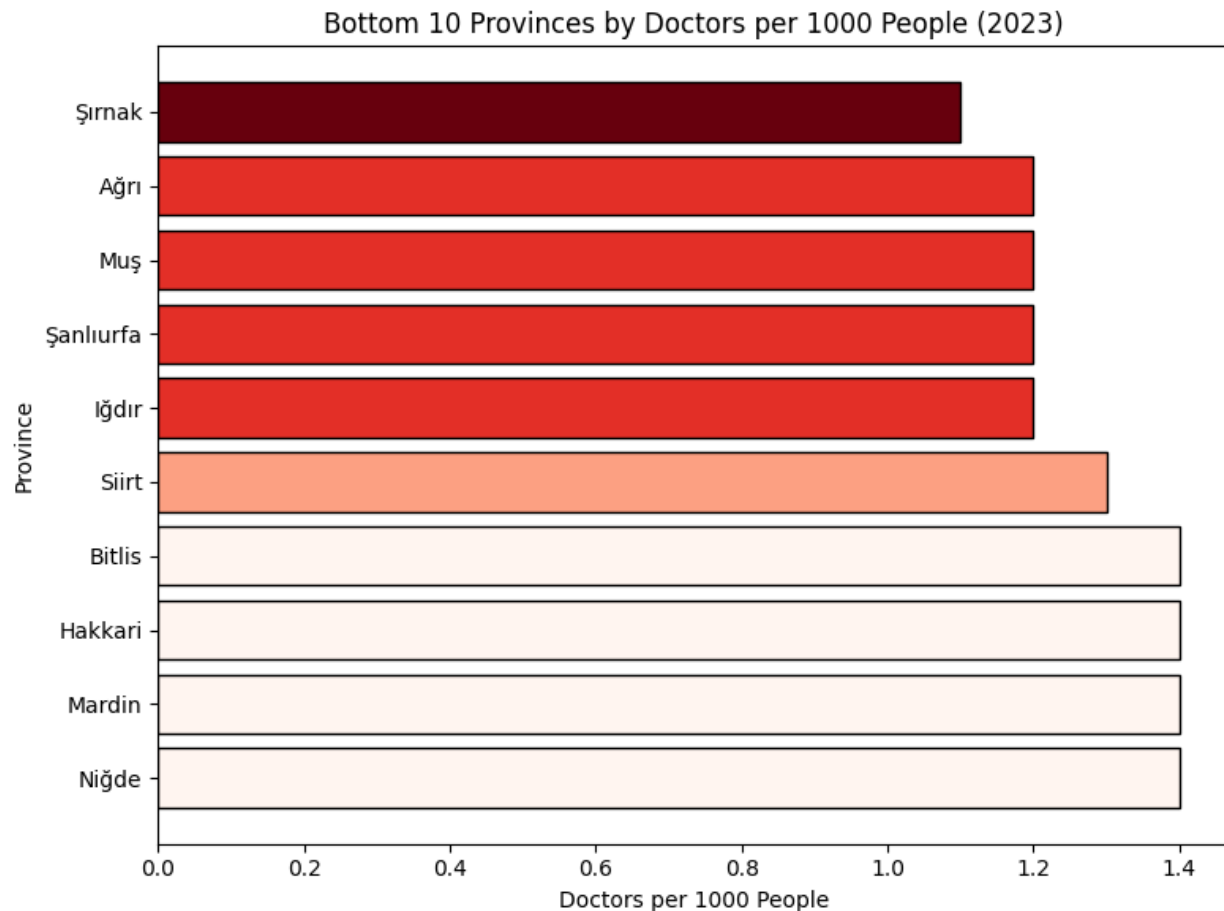


Figure 5: Bottom 10 Provinces by Doctors per 1000 people. (Data based on TÜİK provincial statistics and author's calculations.)

These disparities have been widening recently due to factors like physician migration (both from less developed regions to big cities, and from Türkiye to abroad) and the concentration of new private facilities in wealthier urban centers (Önal, 2023; Pekdemir, 2017). Thus, while the 2002–2019 period was marked by improving equity, the early 2020s call attention to emerging challenges that require further investigation. Figure 6 shows the Lorenz curves that are used for the calculation of Gini coefficients for 2002, 2019, and 2023. As the area between the line of equality and the Lorenz curve increases (decreases), the Gini coefficient (hence, the inequality) increases (decreases). This area decreases markedly from 2002 to 2019 and then increases slightly from 2019 to 2023.

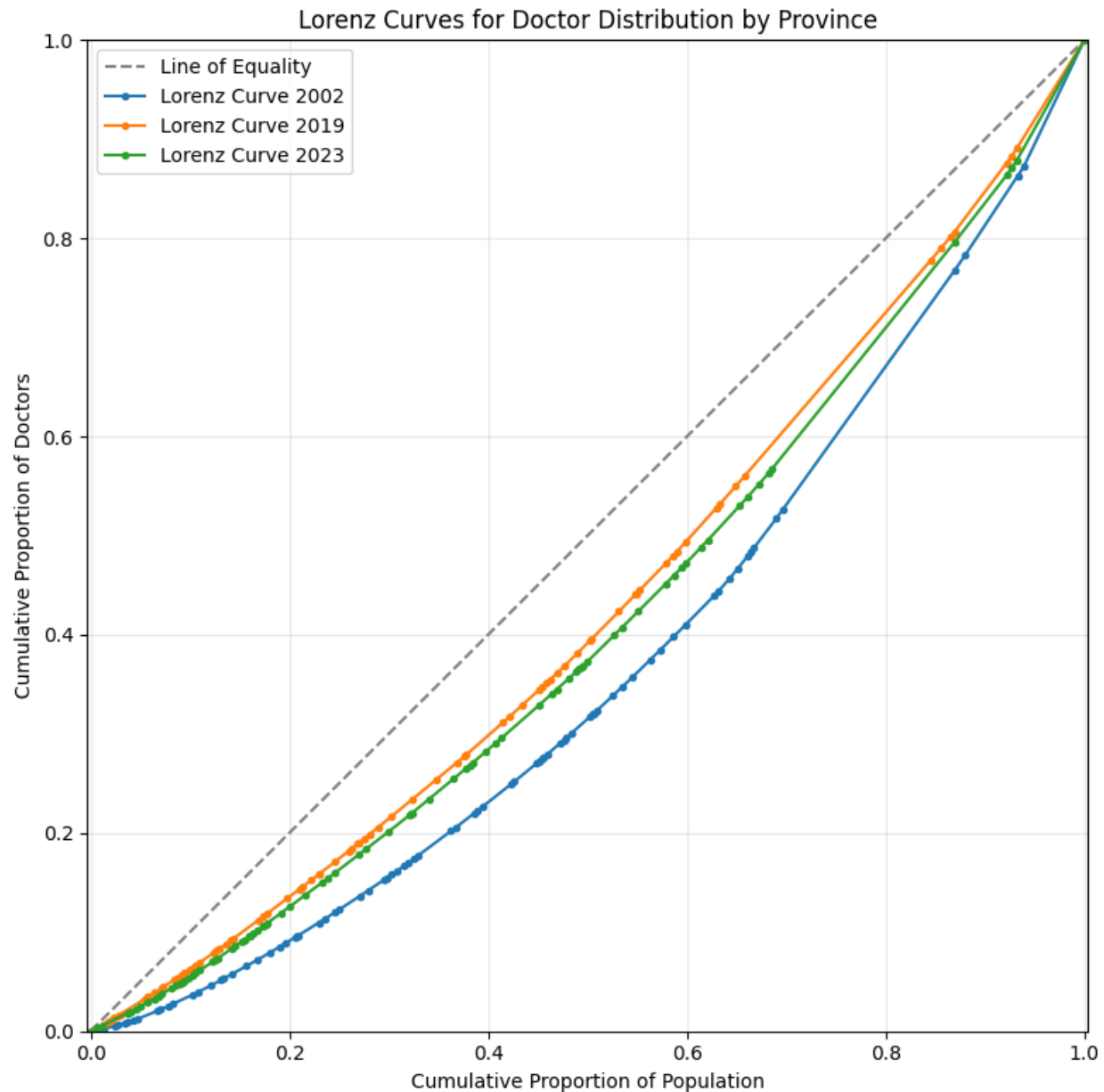


Figure 6: Lorenz Curves for Doctor Distribution by Province. (Data based on TÜİK provincial statistics and author's calculations.)

The computation of the Theil index alongside the Gini coefficient provided valuable incremental insights into the evolution of inequality over the 2002-2023 period. While both measures showed similar overall trends, declining from their peaks in the early 2000s to reach minimum values around 2019 before rising again, the Theil index demonstrated greater sensitivity to changes in the distribution, particularly at the extremes. For instance, between 2009 and 2011, the Gini coefficient declined by 25.8% (from 0.217 to 0.161), but the Theil index showed a more

dramatic 46.4% reduction (from 0.0798 to 0.0428), suggesting that the Theil index better captured improvements in equality during this period, especially among the lowest and highest segments of the distribution. This shows how Theil zeroes in on gains in the most underserved provinces. This enhanced sensitivity of the Theil index, which gives more weight to extremes of the distribution due to its logarithmic properties, provides a more detailed understanding of how inequality changed over time and reveals that the most major improvements occurred not just in overall distribution but particularly in reducing extreme disparities. Theil not only enriches the analysis with tail-focused perspectives but also delivers a more detailed narrative of how doctor distribution inequality evolves over time. The complementary use of both measures thus strengthens the robustness of the findings and offers a more complete picture of inequality dynamics than either measure could provide alone.

4. DISCUSSION

While the Theil and Gini indices demonstrate measurable convergence among regions, these quantitative patterns represent structural redistribution rather than full equality in access or quality of care. In other words, numerical parity in physician density does not necessarily imply uniformity in service outcomes or patient satisfaction.

The observed temporal trends have important implications and align with the context provided by earlier studies. The sharp decline in inequality from 2002 to the mid 2010s demonstrates the success of Türkiye's health workforce redistribution policies. During this period, the government's deliberate strategies, part of the Health Transformation Program, clearly helped bring more doctors to historically underserved provinces. Measures like offering higher salaries and career incentives for postings in eastern Türkiye, implementing a needs-based placement system for new health workers, and expanding medical training capacity all contributed to a fairer allocation of human resources (Mollahaliloglu et al., 2021). These efforts not only reduced the Gini coefficient, but likely also improved health outcomes by increasing healthcare access in poorer regions. Though outcomes are beyond the scope of this analysis, other research has linked improved resource distribution to better service utilization and health indicators (Akdağ, 2015; Aran et al., 2015; Caner & Cilasun, 2019; Tirgil et al., 2018).

In addition to the Gini and Theil indices employed in this study, several investigations have examined health resource inequality in Türkiye using alternative analytical frameworks. For

instance, Caner & Cilasun (2019) analyzed disparities in health service utilization across different population groups through ratio-based and regression methods rather than inequality indices, while Çiftçi (2022) applied the Atkinson inequality index to assess inter-provincial disparities in the distribution of health workers serving older adults. Although these studies relied on different methodological approaches, their findings similarly revealed notable regional disparities. This convergence across diverse methods reinforces the appropriateness and robustness of using the Gini and Theil coefficients for evaluating health-workforce inequality in the Turkish context.

The findings confirm that policy intervention can mitigate regional health inequalities. Türkiye's experience in the 2000s shows how strong political will and systematic reforms moved the country toward greater equity in healthcare provision.

The recent uptick in inequality (post 2019), albeit modest so far, is a cautionary sign. It suggests that initial gains may be lost without ongoing efforts. Several possible explanations exist. One factor is the strain on the health system and workforce dynamics in the late 2010s and early 2020s, such as the impact of COVID-19, which may have disproportionately affected certain regions. The rapid expansion of private hospitals in big cities as part of healthcare commercialization without equivalent investment in rural healthcare has also likely contributed to widening the gap. These developments might explain why the analysis shows a rise in the Gini and Theil indices after a long period of decline. It is an example of how structural and socioeconomic changes can impact resource distribution even after successful reforms.

Beyond the structural and policy factors discussed above, several socioprofessional dynamics may also be influencing the recent rise in inequality. In recent years, physician migration abroad has accelerated, with reports indicating that thousands of doctors have sought professional opportunities outside Türkiye (Önal, 2023). Although systematic data on the regional origins of emigrating physicians are limited, such outflows may indirectly worsen staffing shortages in less-favored provinces by reducing the national pool of available doctors. In parallel, increasing incidents of violence against healthcare workers have contributed to deteriorating working conditions, particularly in high-pressure public facilities, which may discourage physician retention in certain regions (TTB, 2024). Considering these contextual elements alongside structural determinants provides a more comprehensive understanding of the factors that may be driving renewed regional disparities in the physician workforce.

From a methodological viewpoint, the use of both Gini and Theil indices proved useful in confirming trends. Both indices moved in tandem (both decreasing then increasing), which lends confidence that the changes observed are robust. The Theil index also offers the possibility to delve deeper. Future analysis could decompose the Theil index into “between-region” and “within-region” components to quantify how much of the inequality is due to disparities between broad regions such as East vs West as opposed to within regions. Prior research on earlier periods suggested that inequality reduction occurred at both the inter-regional and intra-regional levels (Zeren et al., 2012), so it would be informative to see if the recent uptick is driven mainly by certain regions falling behind. Such an analysis could guide targeted policy responses. For example, if eastern vs. western disparity is the main culprit, interventions can focus on that gap specifically. Sustained policy attention is required to maintain equitable distribution of health personnel. Türkiye’s progress through the 2000s demonstrates that government policies can reduce inequality in healthcare resources. At the same time, the slight backsliding in the 2020s reminds policymakers that equity gains are not permanent. They must be reinforced in the face of new challenges like healthcare worker migration. These findings contribute to the broader literature on health systems by showing how inequality metrics can be used to monitor and evaluate the spatial equity of health service delivery over time.

The observed improvements in regional distribution should also be viewed within the broader framework of the Health Transformation Program, which encompassed reforms in financing, service delivery, and health infrastructure. Workforce policies likely interacted with these systemic changes to produce the overall reduction in regional disparities.

As this study relies exclusively on quantitative inequality indices, it does not capture contextual influences such as physician migration, workplace conditions, or qualitative dimensions of equity.

5. CONCLUSION

The examination of temporal trends in Türkiye’s physician distribution inequality (2002–2023) provides a comprehensive overview of how health workforce equity can evolve under the influence of policy reforms and socioeconomic forces. The Theil index analysis, complemented by Gini coefficient comparisons, revealed that Türkiye achieved a major reduction in region inequality of doctor distribution in the first decade of the 21st century, coinciding with major health system reforms. By the mid 2010s, the distribution of doctors across provinces had become more

equitable than in the early 2000s, a positive outcome reflecting deliberate policy actions. This improvement carries an important implication. Other countries facing similar disparities might draw lessons from Türkiye's interventions such as incentive-based deployments and increased training of health professionals to reduce their own internal inequalities.

At the same time, the analysis demonstrates that achieving equity is an ongoing process. The slight rise in inequality indices after 2019 indicates that new challenges are emerging. Maintaining equitable access to healthcare will require continuous monitoring and adaptive strategies. Policymakers should be vigilant about factors that can reintroduce imbalances such as the concentration of healthcare infrastructure in certain cities and the loss of medical talent in underserved areas. They can address these factors through targeted measures such as retention programs for rural doctors, protection against workplace violence, and balanced investment in health facilities nationwide.

The temporal analysis using Theil and Gini measures not only shows the past and present state of health personnel inequality in Türkiye but also provides a quantitative foundation for future decision making. Regularly calculating these indices can serve as an early warning system for emerging disparities, helping ensure that the goal of "health for all" is pursued not just in terms of overall resources but in their fair distribution across regions. Türkiye's experience confirms that equity in healthcare is attainable through coordinated policy effort, but it must be protected carefully. Future research could build on this work by exploring the causes of recent trends, for instance through qualitative studies or regional case analyses, and by evaluating the impact of inequality in doctor distribution on health outcomes. Ultimately, targeting a low Gini or Theil index in health workforce distribution is not about the numbers per se, but about what they represent, i.e. a more just health system where every citizen, regardless of location, has reasonable access to a doctor.

Future studies could expand this analysis by incorporating other categories of health personnel, such as nurses, midwives, and allied health professionals, to provide a more comprehensive picture of workforce inequality. Applying decomposed Theil analyses could also help differentiate between inter-regional and intra-regional disparities, identifying whether inequality stems primarily from differences between large geographic regions or within them. In addition, qualitative or mixed-methods studies could explore the underlying causes of recent inequality trends, including workforce migration patterns, workplace violence, or policy-

implementation gaps. Such multidisciplinary approaches would deepen understanding of the dynamics influencing the equitable distribution of health resources in Türkiye.

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Appendix: Python Code That Computes the Gini Coefficient and the Theil Index and Plots the Lorenz Curves

```
import pandas as pd

import numpy as np

import matplotlib.pyplot as plt

# -----

# 1. READ and CLEAN the DATA

# -----

pop = pd.read_csv('ToplamNufus.csv') # population
docs = pd.read_csv('ToplamDoktor.csv') # doctor

for df in (pop, docs):
    for col in df.columns[1:]: # years after the first column
        # "1 234 567" → "1234567" → int
        df[col] = (df[col].astype(str)
                    .str.replace(r'\s+', '', regex=True)
                    .replace('', np.nan)
                    .astype(float)
                    .fillna(0)
                    .astype(int))

pop = pop.set_index('il')
docs = docs.set_index('il')

years = pop.columns.tolist()

gini, theil = [], []

# -----
```

```
# 2. COMPUTE GINI and THEIL for EACH YEAR
# -----

for y in years:

    P = pop[y].values          # population
    D = docs[y].values         # doctor
    total_P, total_D = P.sum(), D.sum()

    # Sort doctor per capita in increasing order for Lorenz curve
    order = np.argsort(D / P)
    P_sorted, D_sorted = P[order], D[order]

    cumP = np.cumsum(P_sorted) / total_P
    cumD = np.cumsum(D_sorted) / total_D
    cumP = np.insert(cumP, 0, 0)    # (0,0)
    cumD = np.insert(cumD, 0, 0)

    # Gini = 1 - 2 * (Area Under the Lorenz Curve)
    area = np.trapz(cumD, cumP)    # trapezoid integral
    gini.append(1 - 2 * area)

    # Theil-T (Weighted Entropy)
    share_D = D / total_D
    share_P = P / total_P
    theil.append(np.sum(share_D * np.log((share_D / share_P) + 1e-12)))

# -----

# 3. PLOT THE RESULTS
# -----

plt.figure(figsize=(10,5))
```

```
plt.plot(years, gini, marker='o', label='Gini')
plt.plot(years, theil, marker='s', label='Theil T')
plt.title('Inequality in Doctor Distribution by Province\n(2002-2023)')
plt.xlabel('Year')
plt.ylabel('Coefficient')
plt.xticks(rotation=45)
plt.grid(alpha=.3)
plt.legend()
plt.tight_layout()
plt.show()

# -----
# 4. PLOT LORENZ CURVES
# -----

years_to_plot = ['2002', '2019', '2023']

plt.figure(figsize=(8, 8))

# Plot the line of equality
plt.plot([0, 1], [0, 1], color='gray', linestyle='--', label='Line of
Equality')

for y in years_to_plot:
    if y in years:
        P = pop[y].values
        D = docs[y].values
        total_P, total_D = P.sum(), D.sum()

        order = np.argsort(D / P)
```

```
P_sorted, D_sorted = P[order], D[order]
cumP = np.cumsum(P_sorted) / total_P
cumD = np.cumsum(D_sorted) / total_D
cumP = np.insert(cumP, 0, 0)
cumD = np.insert(cumD, 0, 0)

plt.plot(cumP, cumD, marker='.', linestyle='-', label=f'Lorenz
Curve {y}')
else:
    print(f"Year {y} not found in the data.")

plt.title('Lorenz Curves for Doctor Distribution by Province')
plt.xlabel('Cumulative Proportion of Population')
plt.ylabel('Cumulative Proportion of Doctors')
plt.grid(alpha=.3)
plt.legend()
plt.axis('equal') # Ensure the plot is square
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.tight_layout()
plt.show()
```