BMJ Open

Inequalities in healthcare resources and outcomes threatening sustainable health development in Ethiopia: panel data analysis

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ABSTRACT

Objective To measure inequalities in the distributions of selected healthcare resources and outcomes in Ethiopia from 2000 to 2015.

Design A panel data analysis was performed to measure inequalities in distribution of healthcare workforce, infrastructure, outcomes and finance, using secondary data.

Setting The study was conducted across 11 regions in Ethiopia.

Participants Regional population and selected healthcare workforce.

Outcomes measured Aggregate Theil and Gini indices, changes in inequalities and elasticity of healthcare resources.

Results Despite marked inequality reductions over a 16 year period, the Theil and Gini indices for the healthcare resources distributions remained high. Among the healthcare workforce distributions, the Gini index was lowest for nurses plus midwives (GI=0.428, 95% CI 0.393 to 0.463) and highest for specialist doctors (SPDs) (GI=0.704, 95% CI 0.652 to 0.756). Inter-region inequality was the highest for SPDs (95.0%) and the lowest for health officers (53.8%). The GIs for hospital beds, hospitals and health centres (HCs) were 0.592 (95% CI 0.563 to 0.621), 0.460 (95% CI 0.404 to 0.517) and 0.409 (95% CI 0.380 to 0.439), respectively. The interaction term was highest for HC distributions (47.7%). Outpatient department visit per capita (GI=0.349, 95% CI 0.321 to 0.377) and fully immunised children (GI=0.307, 95% CI 0.269 to 0.345) showed inequalities; inequality in the under 5 years of age mortality rate increased overtime (P=0.048). Overall, GI for government health expenditure (GHE) was 0.596 (95% CI 0.544 to 0.648), and the estimated relative GHE share of the healthcare workforce and infrastructure distributions were 46.5% and 53.5%, respectively. The marginal changes in the healthcare resources distributions were towards the advantaged populations.

Conclusion This study revealed high inequalities in healthcare resources in favour of the advantaged populations which can hinder equal access to healthcare and the achievements of healthcare outcomes. The government should monitor and implement mechanisms to address inequalities based on the national healthcare standards.

Strengths and limitations of this study

► This study attempted to provide a comprehensive picture of the extent of healthcare resources and outcomes inequalities in relation to government health expenditure (GHE) within an under resourced country.

► The application of different inequality measures and Gini inequality decomposition models helped characterise the inequalities in healthcare resources and outcomes in a decentralised health system.

► The estimated Shapley value of the total GHE share of the selected explanatory variables indicated the priority resources, while the multidimensional Gini inequality decomposition provided the relative inequalities, the marginal changes and the elasticity values of the distributions.

► The regional overall Gini values for the distributions analysed are biased downwards around 10%.

► The analysis emphasised only the supply perspective of the health system.

INTRODUCTION

The concept of health has both moral and right elements. The central objective of many health systems is to ensure health equity among populations. Health equity may be viewed as the absence of systematic differences in health among populations regardless of their social, economic, geographical, power and prestige status.1–4 The guiding principle within this concept is health equality4 that may be achieved by making healthcare accessible and by addressing any socially unacceptable inequalities within healthcare, which are amenable to policy decisions.1–6 Thus the principle of health equality begins with creating equal opportunities for people to access needed healthcare resources,2,7 irrespective of their personal characteristics and ability to pay.8,9

The distinction between inequity and inequality can be blurred10,11 because both
concepts refer to unjust and socially unacceptable differences. The unfair inequities due to avoidable causes are specific forms of inequalities.\textsuperscript{12} Nevertheless, the two concepts are not synonymous. Inequality is viewed as the quantitative description of avoidable unfair differences without value judgements that do not belong to the legitimate occurrences from individual responsibility.\textsuperscript{13, 14} In the human rights field, the concept is used in a much broader sense to describe differences among individuals, of which some could be unavoidable, at least with current knowledge and approaches.\textsuperscript{15} Generally, the concept of inequality is dynamic, open to different interpretations and is highly linked to the socioeconomic structure of people.\textsuperscript{16} Like inequity, any measure of inequality involves normative judgements.\textsuperscript{17} We applied Braveman’s definition of inequality which refers to “differences in the distribution of resources or outcomes among people due to conditions that can be minimised or modified by policies”.\textsuperscript{5}

The success of equality policies in healthcare is subject to the influences of the political context,\textsuperscript{18} quality of information concerning the inequality\textsuperscript{19–21} and the appropriateness of the actions targeting identified unjust inequalities. However, government policies may favour the poor, especially when the share of the private sector is minimal,\textsuperscript{22} and the economic, political, moral or practical aspects may be used as criteria for the allocation of resources.\textsuperscript{13} Despite the unclear link between decentralisation and inequality, decentralised policies have been common practice to ensure social justice and address inequalities.\textsuperscript{23, 24} The local governments in decentralised systems are likely to vary in power, boundaries, capacity, socioeconomic and demographic factors, living conditions and healthcare needs of their constituencies.\textsuperscript{20, 25, 26} These conditions highlight the complexity and the likely occurrence of inequalities, and the coexistence of inequalities and judgements.

Ensuring fair allocation of human and material healthcare resources to people across regions contributes to better healthcare outcomes. Healthcare inequality is one of the conditions that hinders the success of healthcare systems and has been a concern to policymakers and planners. However, little evidence is available regarding

\begin{figure}
\centering
\includegraphics[width=\textwidth]{regions.png}
\caption{Regions in Ethiopia, proportion shares and selected indicators for the year 2015 (Source: Central Statistical Agency of Ethiopia, 2015 and Ethiopia Health and Demographic Surveys, 2016). IMR, infant mortality rate; LB, live born; U5MR, under 5 child mortality rate.}
\end{figure}
the extent of healthcare inequality in the decentralised system of Ethiopia. Our study, therefore, aims to measure inequalities in selected healthcare resources and outcomes from the year 2000 until 2015. The findings are anticipated to contribute to a better understanding of the effects of the existing health policies, provide information for action towards minimising unfair inequalities, contribute to policy decisions for strengthening the universal health coverage and eventually contribute to achieve the sustainable development goals (SDGs) for health in Ethiopia and perhaps beyond.

METHODS
Setting
Ethiopia is a federal democratic country that consists of nine national regional states and two chartered cities (hereafter regions). According to the Central Statistical Agency (CSA) of Ethiopia, 80.6% of the total population for the year 2015 resided in rural areas. The geographic location of the regions, population proportions and other indicators for the year 2015 are presented in figure 1.

Study design and data source
We performed panel data analysis to measure inequalities in the distribution of selected healthcare resources and outcomes in Ethiopia. Panel data analysis allows a better understanding of the trends and extent of inequalities in healthcare systems.27 The panel consisted of annual data for 11 regions (n=11) from the year 2000 to 2015. The data were related to government health expenditure (GHE), healthcare workforce, healthcare infrastructure, population and healthcare outcomes of each region. The regional data were retrieved from the Health and Health Related Indicators of Ethiopia. This bulletin has been published annually by the Policy Planning Directorate of the Federal Ministry of Health of Ethiopia since 1994. We also used census based annual population estimates for the regions by the CSA of Ethiopia, plus the 5 yearly reports of the Ethiopia Health and Demographic Surveys (EDHS) for 2000 to 2016.28–32

Patient and public involvement
We used data from the public domains and focused on the supply perspective of the healthcare system. There was no direct patient or public involvement in the data collection and analysis. This study intends to answer the following three basic distributional inequality questions in the context of Ethiopia:

- Are healthcare resources and outcomes fairly distributed across the regions?
- How were the trends and extent of the overall inequalities in the selected distributions, and which inequality component (inter-region, within region, interaction term Gini) dominantly explained the overall inequality of each distribution?
- Which healthcare resources had the dominant share of the GHE and what were the relative inequality changes with respect to the marginal change in the average GHE?

Variables (indicators)
Total GHE and total number of each selected health professional were considered to analyse the finance and healthcare workforce dimensions of the healthcare system. These dimensions are vital for the proper functioning of the healthcare infrastructure. The total number of each functional healthcare infrastructure (health centres, the different levels of public hospitals together and public hospital beds) in each region were also healthcare resources related variables. The annual hospital outpatient department (OPD) visits per capita, the proportions of fully immunised (FIMM) children, and the Ethiopia Health and Demographic Surveys' 5 yearly reports on under 5 child mortality rates (U5MR) and infant mortality rates (IMR) per 1000 live births for each region were healthcare outcome related indicators.

GHE is a crucial determinant of healthcare, especially in countries like Ethiopia where the public sector is the main provider of healthcare services. Missing data for GHE for the years 2013 and 2014 and for physicians for the year 2015 for all the regions were estimated using the annual average growth rate of each distribution. The five central hospitals in Addis Ababa (AA), which were financed and managed by the Federal Government of Ethiopia, were included in the analysis for the AA region. The annual total of each distribution (variable) in a region was divided by the annual total population of that region. The ratio of each distribution was again weighted by a fixed number of people to ensure consistency of the indicator, because the regions differ in population size. A summary of the indicators used in the analysis is presented below.

### Dimension Indicator

| Finance: | Per capita government health expenditure (GHE) per annum |
| Healthcare workforce: | General medical practitioners (GPs) per 10 000 population |
| | Specialist doctors (SPDs) per 10 000 population |
| | All physicians (APHYs) per 10 000 population |
| | Health officers (HOs) per 10 000 population |
| | Nurses and midwives (NMWs) per 10 000 population |
| | Skilled health professionals (SKHPs) per 10 000 population |
| | Pharmacy personnel (PHARP) per 10 000 population |
| | Medical laboratory personnel (MLABP) per 10 000 population |
GI = \frac{2}{n} \sum_{i=1}^{n} Y_i P_i R_i - \mu: \text{ where } \mu \text{ is the mean value of the overall distribution, } n \text{ is the number of regions, } Y_i \text{ is the value of a distribution in the } i^{th} \text{ region, } P_i \text{ is a region’s population share and } R_i \text{ is the relative rank of the } i^{th} \text{ region.}

Despite the claim that the GI allows direct comparison of inequalities between units with different population sizes, the small number of regions (n=11), the wide difference in population size among the regions and the direct association between population size and GI may lead to biased results— that is, the comparison of Gini inequalities among the regions and the inequality changes over time can lead to bias. Therefore, we considered the simple first order bias correction term due to a small sample proposed by Deltas, which is expressed as follows:

\[ G_{i}^{adj} = \frac{n}{n-1} \cdot G_i \]

\[ G_{i}^{adj} \] represents the adjusted GI for small sample and \( n \) is the number of regions. Accordingly, the GIs for the regions in our study would be underestimated by about 10%. The values of the GI range from 0 (absolute equality) to 1 (absolute inequality). The extent of the Gini inequality was judged based on the five scale values categorised as absolute equality (GI <0.2), high equality (GI=0.2–0.3), inequality (GI=0.3–0.4), high inequality (GI=0.4–0.6) and absolute inequality (GI >0.6). A distribution with a Gini value above 0.5 can also be considered polarised. This scale was used only to create simplicity of interpretation because the extent of inequality is context specific and can be judged differently.

We further applied different Gini decomposition techniques. First, Pyatt’s overall Gini decomposition technique was applied to quantify the extent of the net between region Gini (\( G_B \)), within region Gini (\( G_W \)) and the interaction pseudo-Gini (\( G_I \)) inequality components of each distribution. The sum of these components provides the overall Gini of a distribution. This modelling approach utilises the values of observations >0. The interaction term (trans-variation, an overlap or crossover term) is a re-ranking effect that occurs when the highest distribution in one region overlaps with the lowest distribution of the same variable in another region. This method avoids the ambiguity that might arise from the interaction term in the Theil’s index of inequality decomposition and is more appealing to devise appropriate measures for reducing inequalities.

Second, we calculated the extent of the overall inequality change between the baseline and end of study period using the Jenkins and Van Kerms decomposition of inequality changes at two points in time. Third, the Shapley post-estimation statistics was done after running the logarithm of the overall GHE (logGHE) per capita regression model on the explanatory variables (healthcare resources) to estimate their relative share of the overall GHE per capita.
of the regression model to precisely quantify the estimates by handling the problem that could arise from the residual. The estimates additively yield the overall GHE and point those variables that require explanations. Finally, we applied the multidimensional decomposition of the overall GHE inequality (\(G_{GHE}\)) by the explanatory variables using the Lerman and Yitzhaki62 method of decomposition as follows:

\[G_{GHE} = \sum_{k=1}^{K} R_k \times G_k \times S_k\]

where \(K\) is a healthcare resource variable, which ranges from \(k=0, \ldots, K\), \(R_k\) is the Gini correlation of the ranked explanatory variable with the overall GHE inequality, \(G_k\) is the Gini of the explanatory variable and \(S_k\) is the GHE share of the explanatory variable.

This technique incorporates the concept of concentration index and was used to quantify the relative marginal change, the relative GHE inequality and the Gini elasticity of the explanatory variables with respect to the marginal change in the mean GHE and populations of the regions over time. The relative GHE inequalities and the elasticity values of the explanatory variables were calculated manually. These measures enabled us to explain the Gini of inequalities. We used the bootstrap and Jackknife techniques as appropriate to determine 95% CI for the indices. All analyses were performed using Stata Statistical Software Release 14 (StataCorp LP, College Station, Texas, USA). The interpretations and discussions of the findings were based on the Gini values.

RESULTS

The Theil and Gini indices consistently revealed high overall inequalities in the GHE per capita, healthcare workforce, healthcare infrastructure and in some of the healthcare outcome indicators from 2000 to 2015 in Ethiopia. The aggregate inequality values of at least two of the three indices of all the indicators except for the SPDs and OPD visit per capita had intersection points in common. Despite considerable inequality reductions between the baseline and end of the study period, the GIs of many of the indicators remained strongly correlated with the overall GHE per capita inequality. The marginal increase in the mean GHE per capita resulted in a relative marginal increase in the distributions in favour of the advantaged populations of the regions. The elasticity value of <1 for all the indicators suggests the shortages. The net between region inequality dominantly explained the overall inequality of each distribution, and the interaction term was >0.

Inequality in GHE

The average overall GI for the GHE per capita was 0.596 (95% CI 0.544 to 0.648), and marked reduction in the inequality was observed after 2006 (figure 2A). The overall GI for the regions ranged from 0.317 (95% CI 0.252 to 0.381) for HA to 0.624 (95% CI 0.526 to 0.722) for SNNP. The net inter-region inequality and the interaction term accounted for 54.4% and 37.9% of the overall GHE per capita inequality, respectively (table 1).

Inequality in healthcare workforce

The overall GI ranged from 0.428 (95% CI 0.393 to 0.463) for NMWs to 0.682 (95% CI 0.646 to 0.718) for the SPDs (table 1). Including zero values in the analysis of the time series observations, the GI for the SPDs was 0.704 (95% CI 0.652 to 0.756). The net inter-region inequality ranged from 53.8% for the HOs to 95.0% for the SPDs, and the interaction term was the lowest for the SPDs (1.6%) and the highest for the HOs (38.7%). Over the 16 year time period, AM (GI=0.387, 95% CI 0.281 to 0.493) and OR (GI=0.319, 95% CI 0.193 to 0.444) among the agrarian regions and BG (GI=0.368, 95% CI 0.248 to 0.487), GA (GI=0.356, 95% CI 0.233 to 0.478) and AF (GI=0.323, 95% CI 0.223 to 0.424) among the pastoral/semi-pastoral regions showed inequality in the SPDs. The inequality in the distribution of the HOs was common to all regions, while SO (GI=0.638; 95% CI 0.435 to 0.841) and AA (GI=0.633, 95% CI 0.494 to 0.771) were the regions with absolute inequality. There were inequalities in NMWs and SKHPs in SO and in all the agrarian regions, except for TG, PHARP in GA, and MLABP in BG and HA regions were fairly equally distributed. GA and all the urban/urban dominated regions had inequality in the distribution of the EVT’THP. Including zero values in the analysis, the overall GI for PHARP and EVT’THP were 0.541 (95% CI 0.492 to 0.590) and 0.467 (95% CI 0.402 to 0.531), respectively. The magnitude and trend of the overall inequalities in the distributions of the GHE and the healthcare workforce at the national level is indicated in figure 2A,B.

Inequality in healthcare infrastructure

The overall GI for the HC, PHP and HPB distributions, and the net between region inequality of the same distributions accounted for 0.409 (95% CI 0.380 to 0.439), 0.460 (95% CI 0.404 to 0.517) and 0.592 (95% CI 0.563 to 0.621), and 44.7%, 94.0% and 92.1% of the overall inequality of each distribution, respectively (table 2). The interaction term was the highest for the HC distributions (47.7%). The overall inequality trend for the healthcare infrastructure is illustrated in figure 2C. BG (GI=0.223, 95% CI 0.168 to 0.278), HA (GI=0.290, 95% CI 0.244 to 0.336) and AA (GI=0.242, 95% CI 0.150 to 0.335) regions had equally distributed HCs. All the regions had GIs for the PHP and HPB distributions <0.3 except for the GI for HPBs in the SO (GI=0.314, 95% CI -0.120 to 0.748) and SNNP (GI=0.598, 95% CI -0.185 to 1.380) regions, which were insignificantly high. The regional disparities in the distributions of selected healthcare resources is graphically illustrated in figure 3. For example, the bottom 50%, middle 40% and the top 10% of the populations in TG had access to 31.2%, 50.5% and 18.3% of the total NMWs in the region, respectively.

Inequality in healthcare outcomes

The overall GIs for hospital OPD visits per capita (GI=0.349, 95% CI 0.321 to 0.377) and FIMM children...
Figure 2  Aggregate inequality trends in selected healthcare resource distributions in Ethiopia from 2000 to 2015. Note: this figure presents the Gini index (GI) for government health expenditure (GHE), general medical practitioners (GPs), specialist doctors (SPDs), health officers (HOs), nurses and midwives (NMWs), all physicians (APHYs), pharmacy personnel (PHARM), medical laboratory personnel (MLABP), environmental health personnel (ENV'THP), health centres (HCs), public hospitals (PHPs), hospital beds (HPBs), hospital outpatient department visits (OPDV) and fully immunised children (FIMM).
Table 1  National level Theil and Gini indices for government health expenditure per capita and healthcare workforce, and Gini index decomposition into its components and by region (with 95% CI for the indices) from 2000 to 2015

| Measure/region | Overall index* | GHE | GPs | SPDs | APHYs | HOs | NMWs | SKHPs | PHARP | MLABP | ENV'THP |
|----------------|----------------|-----|-----|------|-------|-----|------|-------|-------|-------|--------|
| $\theta_L$     | 0.707          | 0.643| 1.066| 0.711| 0.708| 0.345| 0.360| 0.590| 0.440| 0.377 |
|                | (0.566 to 0.848)|   | (0.524 to 0.763)| (0.951 to 1.181)| (0.619 to 0.803)| (0.604 to 0.812)| (0.289 to 0.402)| (0.306 to 0.414)| (0.454 to 0.726)| (0.380 to 0.501)| (0.282 to 0.471)|
| $\theta_T$     | 0.596          | 0.591| 0.682| 0.612| 0.577| 0.428| 0.437| 0.539| 0.491| 0.457 |
|                | (0.544 to 0.648)|   | (0.545 to 0.638)| (0.646 to 0.718)| (0.578 to 0.646)| (0.544 to 0.610)| (0.393 to 0.463)| (0.402 to 0.473)| (0.484 to 0.593)| (0.457 to 0.524)| (0.399 to 0.515)|
| $\theta_L$     | 0.645          | 0.653| 0.864| 0.682| 0.572| 0.299| 0.313| 0.517| 0.414| 0.388 |
|                | (0.511 to 0.779)|   | (0.517 to 0.798)| (0.740 to 0.988)| (0.578 to 0.786)| (0.499 to 0.646)| (0.247 to 0.351)| (0.261 to 0.366)| (0.397 to 0.636)| (0.351 to 0.476)| (0.256 to 0.521)|

Gini decomposition (%)

| Measure/region | G B | G I | G W | Overall GI |
|----------------|-----|-----|------|-----------|
|                | 0.324 (54.4) | 0.540 (91.3) | 0.648 (95.0) | 0.596 (100) |
|                | (0.544 to 0.648) | (0.545 to 0.638) | (0.646 to 0.718) | (0.578 to 0.646) |
|                | 0.226 (37.9) | 0.028 (4.6) | 0.011 (1.6) | 0.226 (100) |
|                | (0.184 to 0.268) | (0.009 to 0.056) | (0.011 to 0.022) | (0.226 to 0.226) |
|                | 0.046 (7.7) | 0.024 (4.1) | 0.023 (3.4) | 0.046 (100) |
|                | (0.009 to 0.084) | (0.009 to 0.056) | (0.011 to 0.022) | (0.046 to 0.046) |

Gini by region

| Measure/region | Agrarian | Pastoral/semi-pastoral | Urban/urban dominated |
|----------------|----------|------------------------|-----------------------|
|                | TG       | AM                     | HA                    |
|                | 0.406    | 0.580                  | 0.317                 |
|                | (0.306 to 0.506) | (0.508 to 0.672) | (0.252 to 0.381) |
|                | 0.206    | 0.192                  | 0.281                 |
|                | 0.406    | 0.192                  | 0.197                 |
|                | 0.317    | 0.192                  | 0.187                 |
|                | 0.317    | 0.192                  | 0.187                 |
| Overall GI     | 0.596    | 0.591                  | 0.547                 |
|                | (0.511 to 0.779) | (0.517 to 0.798) | (0.523 to 0.585) |
|                | 0.596    | 0.591                  | 0.547                 |
|                | (0.511 to 0.779) | (0.517 to 0.798) | (0.523 to 0.585) |

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...GI=0.307, 95% CI 0.269 to 0.345) revealed inequalities. The net between region inequality of the same indicators accounted for 75.1% and 59.0% of the overall inequality, respectively (table 2). We observed a continuous reduction in the overall inequality in FIMM children throughout the 16 year time period (figure 2C). The GIs for OPD visits per capita in AF (GI=0.341, 95% CI 0.249 to 0.432) and GA (GI=0.427, 95% CI 0.303 to 0.550), and for FIMM children in the regions SO (GI=0.524, 95% CI 0.384 to 0.665), AF (GI=0.393, 95% CI 0.219 to 0.566) and BG (GI=0.311, 95% CI 0.217 to 0.405) were higher than the GIs in the other regions. The net between region inequality of U5MR and IMR accounted for 47.1% and 49.5% of the overall inequality of each indicator, respectively.

The overall Gini inequality changes between baseline and the end of the study period for GHE per capita indicated a 31.2% reduction in inequality (P=0.030). The GIs for GPs, APHYs, HOs, NMWs, SKHPs and MLABP were each reduced by more than a third (P<0.01) (table 3). The reductions in GIs for SPD, PHARP and ENV'THP distributions were insignificant (P>0.05). The GIs for the overall distributions of HCs and the coverage of FIMM children were reduced by 60.3% and 63.8% (P<0.001), respectively. The inequalities in U5MR increased by 64.5% (P=0.048).

The estimated Shapley value indicated that the relative share of the healthcare workforce and healthcare infrastructure distributions were 46.5% and 53.5% of the overall GHE, respectively. HOs (18.09%), NMWs (17.20%), MLABP (10.65%), PHARP (9.58%) and HCs (32.32%) had higher relative shares of GHE (table 4).

The highest and lowest relative GHE inequality and Gini elasticity were for HOs (0.8525 vs 0.8513) and environmental health personnel (0.3750 vs 0.3612), respectively. The marginal increase in the average GHE resulted in a marginal increase in the distributions of all the explanatory variables (column 6) towards the privileged people among the regions (the negative sign indicated the concentration of the indicator among the advantaged populations). Ceteris paribus, a 1% increase in the GHE per capita, resulted in a 0.0027% increase in the distribution of the GPs towards the most affluent people among the regions.

**DISCUSSION**

This study analysed the trend and degree of inequalities in the distributions of selected healthcare resources and outcomes from 2000 to 2015 in Ethiopia. Our findings revealed a high degree of overall inequalities in
Table 2  National level Theil and Gini Indices for healthcare infrastructure and outcomes and Gini decomposition into its components and by region (with 95% CI for the indices) from 2000 to 2015

| Measure/region | Healthcare infrastructure, index (95% CI) | Healthcare outcomes, index (95% CI) |
|----------------|------------------------------------------|-------------------------------------|
|                | HCs | PHPs | HPBs | OPD | FIMM | U5MR | IMR |
| Overall Index* | $\theta_L$ | 0.310 (0.268 to 0.351) | 0.362 (0.279 to 0.444) | 0.673 (0.593 to 0.752) | 0.239 (0.195 to 0.283) | 0.264 (0.175 to 0.352) | 0.072 (0.048 to 0.096) | 0.046 (0.026 to 0.067) |
|                | GI  | 0.409 (0.380 to 0.439) | 0.460 (0.404 to 0.517) | 0.592 (0.563 to 0.621) | 0.349 (0.321 to 0.377) | 0.307 (0.269 to 0.345) | 0.208 (0.175 to 0.241) | 0.163 (0.130 to 0.195) |
|                | $\theta_T$ | 0.274 (0.234 to 0.314) | 0.419 (0.310 to 0.527) | 0.616 (0.540 to 0.693) | 0.196 (0.164 to 0.228) | 0.166 (0.124 to 0.209) | 0.068 (0.047 to 0.089) | 0.043 (0.025 to 0.060) |

Gini decomposition (%)

| G_i | 0.183 (44.7) | 0.433 (94.0) | 0.545 (92.1) | 0.262 (75.1) | 0.181 (59.0) | 0.098 (47.1) | 0.081 (49.5) |
| G_i | 0.195 (47.7) | 0.014 (3.1) | 0.034 (5.7) | 0.069 (19.7) | 0.105 (34.2) | 0.095 (45.7) | 0.068 (41.5) |
| G_W | 0.031 (7.8) | 0.013 (2.9) | 0.013 (2.2) | 0.018 (5.2) | 0.021 (6.8) | 0.015 (7.2) | 0.015 (9.0) |
| Overall GI | 0.409 (100) | 0.460 (100) | 0.592 (100) | 0.349 (100) | 0.307 (100) | 0.208 (100) | 0.163 (100) |

GI by region

Agrarian

| Region | $\theta_L$ | GI | $\theta_T$ | Overall GI |
|--------|------------|---|------------|------------|
| TG     | 0.380 (0.330 to 0.431) | 0.080 (−0.029 to 0.190) | 0.089 (−0.011 to 0.190) | 0.084 (0.061 to 0.107) | 0.061 (0.025 to 0.096) | 0.061 (0.057 to 0.362) | 0.029 (0.080 to 0.316) |
| AM     | 0.432 (0.341 to 0.524) | 0.108 (0.131) | 0.214 (0.121 to 0.307) | 0.210 (0.146 to 0.273) | 0.210 (0.082 to 0.239) | 0.210 (0.069 to 0.149) | 0.109 (0.080 to 0.316) |
| OR     | 0.419 (0.340 to 0.498) | 0.142 (0.011 to 0.227) | 0.149 (0.015 to 0.248) | 0.155 (0.121 to 0.307) | 0.155 (0.146 to 0.273) | 0.155 (0.082 to 0.239) | 0.155 (0.069 to 0.149) |
| SNNP   | 0.339 (0.304 to 0.373) | 0.159 (0.061 to 0.258) | 0.598 (−0.185 to 1.380) | 0.146 (0.090 to 0.202) | 0.250 (0.150 to 0.350) | 0.157 (0.052 to 0.263) | 0.129 (0.058 to 0.199) |

Pastoral/semi- pastoral

| Region | $\theta_L$ | GI | $\theta_T$ | Overall GI |
|--------|------------|---|------------|------------|
| SO     | 0.493 (0.426 to 0.561) | 0.051 (0.037 to 0.065) | 0.314 (−0.120 to 0.748) | 0.197 (0.113 to 0.281) | 0.524 (0.384 to 0.665) | 0.153 (0.015 to 0.290) | 0.099 (0.051 to 0.146) |
| AF     | 0.427 (0.354 to 0.500) | 0.186 (0.156 to 0.217) | 0.219 (0.099 to 0.340) | 0.341 (0.249 to 0.432) | 0.393 (0.219 to 0.566) | 0.132 (−0.073 to 0.338) | 0.153 (0.048 to 0.128) |
| BG     | 0.223 (0.168 to 0.278) | 0.113 (0.077 to 0.149) | 0.118 (0.082 to 0.155) | 0.147 (0.102 to 0.192) | 0.311 (0.217 to 0.405) | 0.125 (−0.004 to 0.255) | 0.145 (0.038 to 0.253) |
| GA     | 0.308 (0.308) | 0.161 (0.161) | 0.143 (0.143) | 0.427 (0.427) | 0.293 (0.293) | 0.195 (0.195) | 0.115 (0.115) |

Continued
most of the distributions included in our analysis. The net between region inequality in GHE accounted for 54.4% of the average overall GHE inequality in Ethiopia. Although better economic position of a country and sufficient allocation of GHE can positively influence health system outcomes,67 decentralisation in under resourced countries may lead to more interregional inequalities.68 Nevertheless, evidence from high income countries with decentralised governance revealed no increased inter-regional inequalities in health expenditure per capita.69 The high overall GHE inequality observed in our study could be due to multiple factors, including the regional differences in prioritising health, development priorities or compliance to the national health policies.70 Like the evidence from other studies, the small allocation of GHE, the difference in the roles of the regional governments with respect to spending on health,71 differences in economic performances of the regions and the weak balancing mechanisms 34 72 could have contributed to the GHE inequalities shown in our findings.

The significant reduction in the GHE inequality observed in our study could be related to an increased fair allocation of the GHE due to the progressive improvement of the national GDP during the past decade.73 Also, the reduction in GHE inequality might imply the increased regional governments’ commitments to spending more on health,74–76 improvements in governance 77 78 or increased commitment of the development partners to health. Nevertheless, the overall GHE inequality remained too high and sufficient enough to contribute to the regional inequalities in healthcare. The strong correlation between the overall GHE inequality and the inequalities in some of the healthcare resources may indicate the prioritisation of healthcare resources by national and regional governments, whose success depends on the rational distribution of healthcare resources.79 Evidence from a study in South Africa showed that regions with a better capacity to use the health budget also had better opportunities to receive, allocate and spend more.80 A region with a high density of fairly distributed healthcare workforce is more likely to serve the healthcare needs of its people than a low healthcare workforce.35 The high net between region inequalities in the healthcare workforce observed in our findings might imply the shortage and maldistribution of the limited available healthcare workforce. This was reflected by the relative marginal increase in the distributions of the healthcare resources towards the advantaged populations among the regions and the elasticity values of <1 in all the healthcare resources analysed.

Table 2

| Measure/region | Infrastructure, index (95% CI) | Outcomes, index (95% CI) |
|----------------|-------------------------------|-------------------------|
|                | HCs                           | PHPs                    | HPBs                    |
|                | (0.262 to 0.354)              | (0.081 to 0.241)        | (0.095 to 0.191)        |
|                | OPD                           | FIMM                    | U5MR                    |
|                | (0.303 to 0.550)              | (0.189 to 0.397)        | (0.061 to 0.329)        |
|                | IMR                           |                         | (0.073 to 0.157)        |

Urban/urban dominated

| Measure/region | Infrastructure, index (95% CI) | Outcomes, index (95% CI) |
|----------------|-------------------------------|-------------------------|
|                | HA                            |                         |
|                | (0.244 to 0.336)              |                         |
|                | AA                            |                         |
|                | (0.242 to 0.335)              |                         |
|                | DD                            |                         |
|                | (0.237 to 0.413)              |                         |

*See text for explanation of index.

AA, Addis Ababa; AF, Afar; AM, Amhara; BG, Ben-Gumuz; DD, Dire-Dawa; FIMM, fully immunised children; GA, Gambella; GI, Gini index; HA, Harari; HCs, health centres; HPBs, hospital beds; IMR, infant mortality rate; OPDs, hospital outpatient departments; OR, Oromia; PHPs, public hospitals; SO, Somali; SNNP, Southern Nations, Nationalities and Peoples; TG, Tigray; U5MR, under 5 child mortality rate.
The overall inequalities in GPs and NMWs in our study were more than threefold (GI=0.591 vs GI=0.191) and about twofold (GI=0.428 vs GI=0.267), respectively, compared with the inequalities reported from China. The absolute inequality in the distribution of SPDs across the years observed in our study coupled with the prolonged time required to train and produce the qualified GPs and SPDs, plus the turnover of the SPDs for different reasons in Ethiopia, ranging from 21.4% in DD to 43.3% in the AM region, could make the inequality reduction more challenging. The overall inequality in APHY distribution in our study (GI=0.612 vs GI=0.532) was slightly higher than that reported from a study in Fiji and extremely higher than the reports from Japan and Mongolia. The relatively homogenous but small Gini values for APHYs across the regions may imply the hidden inequity phenomenon.

Figure 3  Regional inequalities in selected healthcare resource distributions in Ethiopia from 2000 to 2015. Note: this figure indicates the extent of Gini index for the nurses and midwives, all physicians, pharmacy personnel, health centres, public hospitals and hospital beds by region. The share of each resource was classified based on the bottom 50%, middle 40% and top 10% of the population ranks of each region. Regions: AA, Addis Ababa; AF, Afar; AM, Amhara; BG, Ben-Gumuz; DD, Dire-Dawa; GA, Gambella; HA, Harari; OR, Oromia; SO, Somali; S/P, Southern Nations, Nationalities and Peoples; TG, Tigray.
The overall healthcare infrastructure distributions (HCs, PHPs, and HPBs) were also highly unequal compared with the findings reported from China. Nevertheless, the continuously marked reduction in the inequality of the HC distributions and the two-thirds (60.3%) reduction in inequality indicate the efforts.

Table 3
Overall Gini decomposition of inequality change between 2000 and 2015 (and 95% bootstrap CI for the inequality change)

| Indicator            | Gini Index (95% CI) Change (Δ) | Change (Δ) (%) | P value |
|----------------------|---------------------------------|----------------|---------|
| **Finance**          |                                 |                |         |
| Per capita GHE       | 0.446 (0.324 to 0.567)           | −0.139 (−0.265 to −0.014) | 31.2    | 0.030 |
| GPs                  | 0.560 (0.323 to 0.798)           | −0.196 (−0.316 to −0.076) | 35.0    | 0.001 |
| SPDs                 | 0.679 (0.485 to 0.873)           | −0.042 (−0.177 to 0.093)  | 6.2     | 0.543 |
| APHYs                | 0.581 (0.415 to 0.746)           | −0.226 (−0.366 to −0.085) | 38.8    | 0.002 |
| HOs                  | 0.461 (0.345 to 0.577)           | −0.173 (−0.292 to −0.054) | 37.5    | 0.004 |
| NMWs                 | 0.433 (0.320 to 0.546)           | −0.164 (−0.292 to −0.054) | 37.9    | 0.001 |
| SKHPs                | 0.448 (0.305 to 0.592)           | −0.172 (−0.263 to −0.081) | 38.3    | 0.002 |
| PHARP                | 0.492 (0.349 to 0.636)           | −0.084 (−0.215 to 0.047)  | 17.0    | 0.210 |
| MLABP                | 0.519 (0.220 to 0.819)           | −0.204 (−0.315 to −0.094) | 39.3    | <0.001 |
| ENV'THP              | 0.450 (0.252 to 0.648)           | 0.072 (−0.204 to 0.060)   | 16.0    | 0.284 |
| **Healthcare Infrastructure** |                                |                |         |
| HCs                  | 0.313 (0.156 to 0.470)           | −0.189 (−0.242 to −0.136) | 60.3    | <0.001 |
| PHPs                 | 0.506 (0.134 to 0.879)           | 0.016 (−0.146 to 0.179)   | 3.2     | 0.843 |
| HPBs                 | 0.541 (0.444 to 0.639)           | −0.098 (−0.310 to 0.115)  | 18.0    | 0.367 |
| **Healthcare outcomes** |                                |                |         |
| OPD visit            | 0.343 (0.242 to 0.445)           | −0.050 (−0.141 to 0.042)  | 14.4    | 0.286 |
| FIMM                 | 0.408 (0.264 to 0.553)           | −0.261 (−0.392 to −0.130) | 63.8    | <0.001 |
| U5MR                 | 0.082 (0.022 to 0.142)           | 0.053 (0.000 to 0.105)    | 64.5    | 0.048 |
| IMR                  | 0.075 (0.027 to 0.123)           | 0.041 (−0.015 to 0.097)   | 54.6    | 0.150 |

APHYS, all physicians; ENV'THP, environmental health personnel; FIMM, fully immunised children; GHE, government health expenditure; GPs, general medical practitioners; HCs, health centres; HOs, health officers; HPBs, hospital beds; IMR, infant mortality rate; MLABP, medical laboratory personnel; NMWs, nurses and midwives; OPDs, hospital outpatient departments; PHARP, pharmacy personnel; PHPs, public hospitals; SKHPs, skilled health professionals; SPDs, specialist doctors; U5MR, under 5 child mortality rate.
In the central and regional governments in improving access to primary healthcare among rural residents. In contrast, the increasing tendency in the overall inequality of the PHPs may also imply an increasing inequality in the healthcare workforce, especially among GPs and SPDs. Similarly, others reported a wide disparity in the geographic distribution of healthcare workforce, health facilities and hospital beds. The high inequalities in the distributions of the healthcare infrastructure in our study might inform the regional differences in development, management, institutional capacity, priorities and strategies followed by the regions to meet the healthcare needs of the local people.

The high overall inequalities in the distributions of the healthcare resources in the context of Ethiopia, where most people live in rural areas, can challenge the uniform achievement of the health sector goals in the country. As Atkinson stated, “a smaller cake more fairly distributed may be preferable to a bigger one with high levels of inequality”. Thus the high inequality in the GHE across the regions might challenge the reduction of inequalities for other healthcare resources. It is pivotal to minimise the existing inequalities among the regions, yet success may depend on the government’s commitment to improve financing, allocation of healthcare resources in addition to identification of other context specific opportunities and barriers to reduce the inequalities.

The economic, social, political and infrastructural positions of a country or a region are fundamental to determine the success in healthcare outcomes. The expansion of the PHPs in Ethiopia are believed to have created an opportunity for people to use hospital services. However, the net between region inequality in OPD visits per capita was considerably high (75.1%), and the reduction in inequality over time was insignificant. Over a 16 year period, two of the four pastoral/semi-pastoral regions (AF and GA) had high inequality in OPD visits per capita. In Ethiopia, this inequality might be explained by low access to the hospital services among the majority of rural residents, the shortage of qualified providers, the weak referral linkage between the primary healthcare units and PHPs and other individual factors, such as low awareness of the benefits of hospital services and financial constraints. A recent study in Ethiopia also reported the practice of daily or weekly rationing of laboratory tests, hospital drugs prescriptions, radiological investigations and the provision of the second best treatment, all of which might contribute to the low utilisation of hospital services. People living in remote areas, those who were poor, and of ethnic minorities, were also reported to have a low hospital services use.

Despite the marked reduction in the overall inequalities in FIMM children (63.8%) over the study period, the U5MR presented a significant inequality. Micro-level studies in Ethiopia identified the association between hospital inaccessibility and death from a vaccine preventable disease (measles) as well as the association between HC inaccessibility and a high child mortality. Others also reported an increasing tendency in socioeconomic inequality in neonatal and under 5 child mortality rates. Due to the possible occurrence of unavoidable contextual and individual differences, such as the biological factors, it would be difficult to further reduce the small degrees of overall inter-regional inequalities in the U5MR and IMR.

### Strengths and limitations of this study

This study provided a comprehensive understanding of the extent and trend of inequalities in selected healthcare resources and outcomes over a 16 year period in Ethiopia. Application of the different econometric models helped us describe the inequalities in the decentralised system. The comprehensive use of data from the annually published Health and Health Related Indicators bulletin of the Federal Ministry of Health of Ethiopia, the CSA of Ethiopia census based population estimates for the regions and data from the 5 yearly EHDS reports could have contributed to the reliability and credibility of the findings. The analysis was based on a small number of regions, which could lead to a downward biased GIs for the regions with small populations. Despite this, we observed relatively higher inequalities for some of the indicators among the regions with smaller population sizes; the Gini values of the regions

### Table 4 Estimated Shapley value of overall logGHE share of selected healthcare resources from 2000 to 2015 in Ethiopia

| Factor | Value | % | Group |
|--------|-------|---|-------|
| GPs    | 0.0173| 2.24 | Group 1 |
| SPDs   | 0.0155| 2.01 |
| HOs    | 0.1398| 18.09 |
| NMWs   | 0.1330| 17.20 | 0.3594 | 46.48 |
| PHARM  | 0.0741| 9.58 |
| MLABP  | 0.0823| 10.65 |
| ENV’THP| 0.0171| 2.21 |
| HCs    | 0.2499| 32.32 | Group 2 |
| PHPs   | 0.0198| 2.57 | 0.4138 | 53.52 |
| HPBs   | 0.0242| 3.13 |

Total 0.7731 100.00 0.7731 100.00

ENV’THP, environmental health personnel; GHE, government health expenditure; GPs, general medical practitioners; HCs, health centres; HOs, health officers; HPBs, hospital beds; MLABP, medical laboratory personnel; NMWs, nurses and midwives; OPDs, hospital outpatient departments; PHARP, pharmacy personnel; PHPs, public hospitals; SKHPs, skilled health professionals; SPDs, specialist doctors.
Table 5  Relative marginal effects of overall government health expenditure inequality and elasticity of selected healthcare resources over time, from 2000 to 2015 in Ethiopia

| Explanatory variable (K) | GHE share (S_k) | Gini of component (G_k) | Correlation with GHE (R_k) | Share of GHE inequality (l_k) = (R_k * G_k * S_k) / G_{GHE} | Relative GHE inequality (l_k/S_k) | Relative marginal change (l_k - S_k) | Elasticity (η_k) = (R_k * G_k) / G_{GHE} % (95% bootstrap CI) |
|------------------------|----------------|------------------------|---------------------------|------------------------------------------------------------|--------------------------------|-------------------------------------|----------------------------------|
| GPs                    | 0.0048         | 0.5913                 | 0.4430                    | 0.0021                                                      | 0.4375                      | −0.0027 (-0.0036 to −0.0018)        | 0.4395                           |
| SPDs                   | 0.0026         | 0.7036                 | 0.4032                    | 0.0013                                                      | 0.5000                      | −0.0014 (-0.0019 to −0.0008)        | 0.4760                           |
| HOs                    | 0.0061         | 0.5771                 | 0.8792                    | 0.0052                                                      | 0.8525                      | −0.0009 (-0.0013 to −0.0005)        | 0.8513                           |
| NMWs                   | 0.0674         | 0.4281                 | 0.7967                    | 0.0386                                                      | 0.5727                      | −0.0288 (-0.0340 to −0.0237)        | 0.5723                           |
| PHARP                  | 0.0082         | 0.5413                 | 0.8166                    | 0.0061                                                      | 0.7439                      | −0.0021 (-0.0027 to −0.0015)        | 0.7417                           |
| MLABP                  | 0.0093         | 0.4909                 | 0.8061                    | 0.0062                                                      | 0.6667                      | −0.0031 (-0.0038 to −0.0025)        | 0.6640                           |
| ENV’THP                | 0.0040         | 0.4665                 | 0.4615                    | 0.0015                                                      | 0.3750                      | −0.0026 (-0.0033 to −0.0018)        | 0.3612                           |
| HCs                    | 0.0068         | 0.4092                 | 0.8107                    | 0.0038                                                      | 0.5588                      | −0.0030 (-0.0036 to −0.0024)        | 0.5566                           |
| PHPs                   | 0.0109         | 0.4605                 | 0.5459                    | 0.0046                                                      | 0.4220                      | −0.0063 (-0.0076 to −0.0050)        | 0.4218                           |
| HPBs                   | 0.0764         | 0.5920                 | 0.4889                    | 0.0371                                                      | 0.4856                      | −0.0393 (-0.0511 to −0.0275)        | 0.4856                           |

ENV’THP, environmental health personnel; GHE, government health expenditure; GPs, general medical practitioners; HCs, health centres; HOs, health officers; HPBs, hospital beds; MLABP, medical laboratory personnel; NMWs, nurses and midwives; OPDs, hospital outpatient departments; PHARP, pharmacy personnel; PHPs, public hospitals; SKHPs, skilled health professionals; SPDs, specialist doctors.
generated by Pyatt’s Gini decomposition technique might be underestimated. We also acknowledge that the decomposition of the inequality change in two points in time cannot provide information about the whole story of the inequality dynamics over time. Also, the analysis was based on aggregate level data that emphasised the supply perspective of the health system.

Policy implications

The success of the healthcare system as a whole and the SDGs for health in the context of Ethiopia require a continuous and coordinated effort to further reduce the observed inequalities in healthcare access. This study highlighted not only the magnitude and trend of the inequalities in the distributions of the healthcare resources, but also an overall shortage of the healthcare resources. The relatively higher GHE share of the healthcare infrastructure also shows the regional and central governments’ greater emphasis on the expansion of healthcare facilities, rather than meeting the healthcare workforce standards of the facilities. This situation calls for a more coordinated effort to meet the healthcare needs of all people across all regions, especially those living in the pastoral and semi-pastoral areas. The healthcare resource gaps identified in this study imply the need for:

- Implementing healthcare standards and certifying the health facilities on the fulfilment of predetermined minimum healthcare workforce and material requirements, and strengthening mechanisms for monitoring inequalities in basic healthcare access in all regions.
- Building the institutional capacity of the regional health bureaus to closely track and address inequalities in distributions within each region.
- Introducing mechanisms to raise sufficient health budget without increasing the burden of cost on poor citizens.

CONCLUSION

Despite the progressive reductions in inequalities, there are still significant inequalities in the distributions of some healthcare resources and outcomes in Ethiopia. The small GHE per capita coupled with high inequalities make the situation more challenging. Similar to most member states, Ethiopia has committed to achieving SDGs by 2030. Unless Ethiopia significantly scales up its efforts to increase the GHE per capita and implement inequality reduction mechanisms, the proportional progress towards achieving the health related SDGs across the regions may become less feasible. Further investigation of context specific barriers to more equitable access in healthcare and their root causes is of paramount importance to contribute to the inequality reduction in healthcare in Ethiopia, and perhaps similar low income settings.

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Contributors AW contributed in developing the concept, analysing the data and interpreting the findings, and in the write up of the manuscript. AT contributed from the beginning in the development of the concept, in shaping the entire work and in intellectual development and continuous review of the manuscript. He is the guarantor. AAS participated in developing and refining the methodology, and revising the manuscript. AP participated in developing the methodology and interpretation of the findings.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement The study was based on publicly available data. The retrieved datasets are available from the corresponding author on reasonable request.

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REFERENCES

1. Whitehead M. The concepts and principles of equity and health. Health Promot Int 1991;6:217–26.
2. O’Donnell O, Propper C. Equity and the distribution of UK National Health Service resources. J Health Econ 1991;10:1–19.
3. Braveman P. Defining equity in health. J Epidemiol Community Health 2005;57:254–8.
4. Culyer AJ, Wagstaff A. Equity and equality in health and health care. J Health Econ 1993;12:431–57.
5. Braveman P. Health disparities and health equity: concepts and measurement. Annu Rev Public Health 2006;27:167–94.
6. Asthana S, Gibson A. Health care equity, health equity and resource allocation: towards a normative approach to achieving the core principles of the NHS. Radiat Stat 2008:96:6.
7. Morris S, Sutton M, Gravelle H. Inequality and inequality in the use of health care in England: an empirical investigation. Soc Sci Med 2006;60:1251–66.
8. van Doorslaer E, Wagstaff A, Calonge S, et al. Equity in the delivery of health care: some international comparisons. J Health Econ 1992;11:389–411.
9. Wagstaff A, Van Doorslaer E, Paci P. Equity in the finance and delivery of health care: concepts and definitions. Oxford Rev Econ Policy 1989;5:89–112.
10. Woodward A, Kawachi I. Why reduce health inequalities? J Epidemiol Community Health 2000;54:923–9.
11. Asada Y. A framework for measuring health inequality. J Epidemiol Community Health 2005;59:700–5.
12. Kawachi I, Subramanian SV, Almeida-Filho N. A glossary for health inequalities. J Epidemiol Community Health 2002;56:647–52.
13. Arcaya MC, Arcaya AL, Subramanian SV. Inequalities in health: definitions, concepts, and theories. Glob Health Action 2015;8:2106–12.
14. Fleurbaey M, Schokkaert E. Unfair inequalities in health and health care. J Health Econ 2009;28:73–90.
15. Starfield B. The hidden inequality in health care. Int J Equity Health 2011;10:15.
16. Atkinson AB. INEQUALITY: What Can Be Done? Cambridge, Massachusetts: Harvard University Press, 2015.
17. Harper S, King NB, Meersman SC, et al. Implicit value judgments in the measurement of health inequalities. Milbank Q 2010;88:4–29.
18. Beckfield J, Olafsdottir S, Sosnau B. Healthcare systems in comparative perspective: classification, convergence, institutions, Gini coefficients, and health outcomes. Ann Rev Sociol 2013;39:127–46.
19. Kjellsson G, Geratham UG, Petrie D, Lies, dammed lies, and health inequality measurements: understanding the value judgments. Epidemiology 2015;26:673–80.
20. Sadana R, Blas E. What can public health programs do to improve health equity? Public Health Rep 2013;128 Suppl 3:12–20.
21. Skaftun EK, Ali M, Norheim OF. Understanding inequalities in child health in Ethiopia: health achievements are improving in the period 2000–2011. PLoS One 2014;9:e106460.
22. Costa i Font J. Inequalities in self-reported health within Spanish regional health services: devilution re-examined? Int J Health Plann Manage 2005;20:41–52.
23. Jiménez D, Smith PC. Decentralisation of health care and its impact on health outcomes. Discuss Pap Econ 2005;10.
24. Nuti S, Vola F, Bonini A, et al. Making governance work in the health care sector: evidence from a ‘natural experiment’ in Italy. Health Econ Policy Law 2016;11:17–38.
25. Azfar O, Kakhonen S, Lanyi A, et al. Decentralization, governance and public services: the impact of institutional arrangements. Devolution Gov Prospect Decentralizing States (contemporary perspectives). Dev Sec 2004:19–62.
26. Bossert TJ, Mitchell AD. Health sector decentralization and local decision-making: Decision space, institutional capacities and accountability in Pakistan. Soc Sci Med 2011;72:39–48.
27. Bago d’Uva T, Jones AM, van Doorslaer E. Measurement of horizontal inequality in health care utilisation using European panel data. J Health Econ 2009;28:280–9.
28. MoH of Ethiopia. Health and Health Related Indicators. Annual publications from 1992–2007 E.C (2000 – 2015 G.C). Addis Ababa, Ethiopia. http://www.cnhde.org.et/
29. Central Statistical Agency. Ethiopia DHS 2000. 2001:1–299 http://www.dhsprogram.com/pubs/pdf/FR118/FR118.pdf
30. Central Statistical Agency, ICF International. Ethiopia Demographic and Health Survey 2005, 2006:1–430. http://www.measuredhs.com
31. Central Statistical Agency [Ethiopia] and ICF International. Ethiopia Demographic and Health Survey 2011. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International, 2012. http://www.measuredhs.com
32. Central Statistical Agency (CSA) (Ethiopia) and ICF. Ethiopia Demographic and Health Survey 2016. Rockville, Maryland, USA: CSA and ICF. Addis Ababa, Ethiopia, 2016. www.DHSprogram.com.
33. Cantarero D. Decentralization and health care expenditure: the Spanish case. Appl Econ Lett 2005;12:963–6.
34. Prieto DC, Lago-Perás A. Decomposing the determinants of health care expenditure: the case of Spain. Eur J Health Econ 2012;13:10–27.
35. Anand S. Measuring health workforce inequalities: methods and application to China and India. Geneva. World Health Organization, 2010.
36. Anand S, Fan VY, Zhang J, et al. China’s human resources for health: population, quantity, and distribution. Lancet 2008;372:1774–81.
37. Muszyńska J, Ocziķi J, Wdowski E. Income inequality in Poland and the United Kingdom. Decomposition of the Theil index. Folia Oeconomica Stetinensia 2018;18:108–22.
38. Tao Y, Henry K, Zou Q, et al. Methods for measuring horizontal equity in health resource allocation: a comparative study. Health Econ Rev 2014;4:10.
39. Zhou Y, Qin Y. Empirical analysis on income inequality of Chinese residents. New York: Springer, 2012.1.
40. Camilo D. A new approach to the decomposition of the gini income inequality ratio. Empir Econ 1997;22:15–31.
41. Toyabe S. Trend in geographic distribution of physicians in Japan. Int J Equity Health 2009;8:5.
42. Erednie O, Paramita SA, Yamazaki C, et al. Distribution of health care resources in Mongolia using the Gini coefficient. Hum Resour Health 2017;15:56.
43. Wu J. Measuring inequalities in the demographical and geographical distribution of physicians in China: Generalist versus specialist. Int J Health Plann Manage 2018;33:660–79.
44. Kunga MA, Maestad O. Measuring inequalities in the distribution of health workers: the case of Tanzania. Hum Resour Health 2009;7:1–12.
45. Williams RF, Doessel DP. Measuring inequality: tools and an illustration. Int J Equity Health 2006;5:5.
46. Weich S, Lewis S, Jenkins SR. Income inequality and the prevalence of common mental disorders in Britain. Br J Psychiatry 2001;178:222–7.
47. Skaftun EK, Verguet S, Norheim OF, et al. Geographic health inequalities in Norway: A Gini analysis of cross-county differences in mortality from 1980 to 2014. Int J Equity Health 2018;17:64.
48. Wiseman V, Lagarde M, Bature N, et al. Measuring inequalities in the dissipation of the Fiji Health Workforce. Int J Equity Health 2017;16:115.
49. Deltas G. The small-sample bias of the Gini coefficient: results and implications for empirical research. Rev Econ Stat 2003;85:226–34.
50. Hu SY, Lin W, Tian JL, et al. Measuring inequality in physician distributions using spatially adjusted Gini coefficients. Int J Qual Health Care 2016;28:657–64.
51. Miao CX, Zhuo L, Gu YM, et al. Study of large medical equipment allocation in Xuzhou. J Zhejiang Univ Sci B 2007;8:881–4.
52. Pryt G. On the interpretation and disaggregation of Gini coefficients. Econ J 1976;86:243–52.
53. Silber J. Factor components, population subgroups and the computation of the Gini index of inequality. Rev Econ Stat 1989;71:107–15.
54. Ogwang T. A convenient method of decomposing the Gini index by population subgroups. J Off Stat 2014;30:91–105.
55. Lambert PJ, Aronson JR. Inequality decomposition analysis and the Gini coefficient revisited. Econ J 1993;103:1221–7.
56. Poddar N. A new decomposition of the Gini coefficient among groups and its interpretations with applications to Australia. Sankhyā Indian J Stat Ser B 1993;55:29–71.
57. Jenkins S, Van Kempen P. ‘$g' = Gini – Decomposition of inequality change into pro-poor growth and mobility components’. Luxembourg: Differdange, 2009.
58. Manna R, Regoli A. Regression-based approaches for the decomposition of income inequality in Italy, 1998-2008. Riv di Stat Uff 2012;1:1998–2008.
59. Shiroros AF. Inequality decomposition by factor components. Econometrica 1982;50:193–211.
60. Shiroros AF. Inequality decomposition by population subgroups. Econometrica 1984;52:1387–85.
61. Shiroros AF. Decomposition procedures for distributional analysis: a unified framework based on the Shapley value. J Econ Inequality 2013;11:99–126.
62. Lerman RI, Yitzhaki S. Income inequality effects by income source: a new approach and applications to the United States. Rev Econ Stat 1985;67:151–6.
63. Garner TI. Consumer expenditures and inequality: an analysis based on decomposition of the Gini coefficient. Rev Econ Stat 1993;75:134–8.
64. López-Feldman A. Decomposing inequality and obtaining marginal effects. Stata J 2006;6:106–11.
65. Davidson R. Reliable inference for the Gini index. J Econom 2009;150:30–40.
66. Biewen M. Bootstrap inference for inequality, mobility and poverty measurement. J Econom 2002;108:317–42.
67. Furr P, Sinha SC. Understanding the evolution of the health system outcomes in Central and Eastern Europe and their association with social, economic and political factors: an analysis of 25 years of transition. BMC Health Serv Res 2016;16:95.
68. Lessmann C. Regional inequality and decentralization: an empirical analysis. Environment and Planning A 2012;44:1363–88.
69. Costa-Font J, Turati G. Regional healthcare decentralization in unitary states: equal spending, equal satisfaction? Reg Stud 2018;52:974–85.
70. Glionno M, Hitiris T. The regional impact of health care expenditure: the case of Italy. Appl Econ 2002;34:1829–36.
71. Willis K, Khan S. Health reform in Latin America and Africa: decentralisation, participation and inequalities. Third World Q 2009;30:991–1005.
72. Cantarero D, Lago-Perás A. The determinants of health care expenditure: a reexamination. Appl Econ Lett 2010;17:723–6.
73. Abegaz KH, Mohammed AA. Healthcare expenditure and GDP in Ethiopia from 1995 to 2014: a time-series analysis. Agric Food Security 2018;7:47.
74. Lu C, Schneider MT, Gubbins P, et al. Public financing of health in developing countries: a cross-national systematic analysis. Lancet 2010;375:1375–87.
75. King A, Hansen P. Aggregate health care expenditure in the United States: evidence from cointegration tests: a comment. Appl Econ Lett 1996;3:37–9.
76. Parkin D, McGuire A, Yule B. Aggregate health care expenditures and national income. Is health care a luxury good? J Health Econ 1987:6:109–27.
77. Gregorio LE, Gregorio DI. Polity and health care expenditures: the association among 159 nations. J Epidemiol Glob Health 2013;3:49–57.
78. Liang LL, Mirelman AJ. Why do some countries spend more for health? An assessment of sociopolitical determinants and international aid for government health expenditures. Soc Sci Med 2014;114:161–8.
79. Krengkap VB, Yang CT. The equality of resource allocation in health care under the National Health Insurance System in Taiwan. Health Policy 2011;100:203–10.
80. Stuckler D, Basu S, McKee M. Health care capacity and allocations among South Africa’s provinces: infrastructure-inequality traps after the end of apartheid. Am J Public Health 2011;101:165–72.
81. Li D, Zhou Z, Si Y, et al. Unequal distribution of health human resource in mainland China: what are the determinants from a comprehensive perspective? Int J Equity Health 2018;17:29.
82. costa-font J. Does devolution lead to regional inequalities in welfare activity? Environment and Planning C: Government and Policy 2010;28:435–49.
83. Zhou K, Zhang X, Ding Y, et al. Inequality trends of health workforce in different stages of medical system reform (1985–2011) in China. Hum Resour Health 2015;13:94.
84. Assefa T, Haile Mariam D, Mekonnen W, et al. Physician distribution and attrition in the public health sector of Ethiopia. Risk Manag Healthc Policy 2016;9:285–95.
85. Ishikawa T, Fujiwara K, Ohba H, et al. Forecasting the regional distribution and sufficiency of physicians in Japan with a coupled system dynamics-geographic information system model. Hum Resour Health 2017;15:64.
86. Zhang T, Xu Y, Ren J, et al. Inequality in the distribution of health resources and health services in China: hospitals versus primary care institutions. Int J Equity Health 2017;16:42.
87. Admassie A, Abebaw D, Gatzweiler J von B, Rural poverty and marginalization in Ethiopia: a review of development, in marginality. The Netherlands: Springer, 2014:269–300.
88. Defaye FB, Desalegn D, Danis M, et al. A survey of Ethiopian physicians’ experiences of bedside rationing: extensive resource scarcity, tough decisions and adverse consequences. BMC Health Serv Res 2015;15:467.
89. Poletti P, Parlamento S, Fayyisaa T, et al. The hidden burden of measles in Ethiopia: how distance to hospital shapes the disease mortality rate. BMC Med 2018;16:177.
90. Okwaraji YB, Cousens S, Berhane Y, et al. Effect of geographical access to health facilities on child mortality in rural Ethiopia: a community based cross sectional study. PLoS One 2012;7:e33564.
91. Kakwani N, Wagstaff A, van Doorslaer E. Socioeconomic inequalities in health: Measurement, computation, and statistical inference. J Econom 1997;77:87–103.