SSM - Population Health 6 (2018) 259–275

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Article

Transnational wealth-related health inequality measurement☆

Mathieu J.P. Poirier[a,*], Michel Grignon[b], Karen A. Grépin[c], Michelle L. Dion[d]

[a] Department of Health Research Methods, Evidence, and Impact, McMaster University, Hamilton, Ontario, Canada
[b] Department of Economics, McMaster University, Hamilton, Ontario, Canada
[c] Department of Health Sciences, Wilfrid Laurier University, Waterloo, Ontario, Canada
[d] Department of Political Science, McMaster University, Hamilton, Ontario, Canada

ARTICLE INFO

Keywords:
Hispaniola
Health Inequalities
Transnational Analysis
Demographic and Health Surveys
Household Asset Index

ABSTRACT

The study of international differences in wealth-related health inequalities has traditionally consisted of country-by-country comparisons using own-country relative measures of socioeconomic status, which effectively ignores absolute differences in both wealth and health that can differ between and within countries. To address these limitations, we propose an alternative approach: that of constructing a transnational measure of wealth-related health inequality. To illustrate the limitations of the country-by-country approach, we simulate the impact of changes in wealth and health inequalities both between and within countries on cross-country measures of health inequality and find at least five errors that may arise using country-by-country methods. We then empirically demonstrate the transnational approach to wealth-related health inequalities between and within Haiti and the Dominican Republic, the two constituent countries of the island of Hispaniola, using data from their respective Demographic and Health Surveys. Transnational socioeconomic rankings reveal a large and increasing divergence in wealth between the two countries, which would be ignored using the county-by-country approach. We find that wealth-related inequalities in long-term children's health outcomes are larger than inequalities in short-term health outcomes, and decompositions of the influence of place-based variables on these inequalities reveal country of residence to be the most important factor for long-term outcomes, while urban/rural residence and subnational regions are more important for short-term health outcomes. The significance of this novel methodological approach in relation to conventional health inequality research, including hidden dimensions of wealth-related health inequalities, for example the urbanized "middle class" distribution of HIV and a hidden unequal burden of wasting among children uncovered by the transnational approach are discussed, and errors in gauging changes in inequality over time using a country-by-country approach are highlighted. Using the transnational approach can help to measure important trends in wealth-related health inequalities across countries that more commonly used methods traditionally overlook.

1. Introduction

Health inequality research has matured into a well-recognized field with dedicated journals, funding sources, and institutional support within governmental and non-governmental agencies. With the advent of the Sustainable Development Goals (SDG), reducing inequalities within and between countries as detailed in Goal 10 is now an explicitly recognized global objective demanding internationally standardized measurement techniques (United Nations, 2015). While some effort has been made towards developing indices to measure global convergence in health outcomes across countries (Sachs, Schmidt-Traub, Kroll, Durand-Delacre, & Teksoz, 2016), empirical research quantifying and comparing socioeconomic inequality in achieving SDG health targets at a multi-country level has been limited. There have been calls for additional research to investigate health inequalities at this level (GBD 2015 SDG Collaborators, 2016; Hosseinpoor & Bergen, 2016; McKinnon, Harper, Kaufman, & Bergevin, 2014), but the methodological foundation for international comparisons in health inequalities has yet to be formally developed. Given the limited attention that has been given to this topic in the global health inequality measurement field, there is a need for the development of new measures to compare health inequalities across countries and over time.

Most studies of wealth-related health inequalities are typically limited to a single country or subregion (i.e. province, state, district, etc.) and use summary measures such as the concentration index, relative index of inequality, slope index of inequality, generalized entropy index, or similar measure to quantify inequality (Kakwani, Wagstaff, & van Doorslaer, 1997; Marmot et al., 1991). The most common ranking measures of socioeconomic status (SES) that health inequality researchers have used include

☆ This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
* Correspondence to: McMaster University, 1280 Main St. W., Hamilton, Ontario, Canada L8S 4L8.
E-mail address: poiriemj@mcmaster.ca (M.J.P. Poirier).

https://doi.org/10.1016/j.ssmph.2018.10.009
Received 4 September 2018; Received in revised form 10 October 2018; Accepted 14 October 2018

years of education (Fortson, 2008), income (Mújica, Vázquez, Duarte, & Cortez-Escalante, 2014), and household expenditure (Mokdad et al., 2015), however, in global health the most commonly used measure across countries is the household asset index (Davidson R. Gwatkin et al., 2007; McKinnon et al., 2014; Van De Poel, Hosseinpoor, Speybroeck, Van Ourti, & Vega, 2008; Wang, 2003). This technique is based on an accounting procedure that records the presence of typical household assets and calculates an index, often using the method of principal components analysis (PCA) adapted for household SES ranking by Filmer and Pritchett (2001), to calculate the relative well-being of households. The wealth index is now included as a standard feature in all Demographic and Health Surveys (DHS) as both a raw score and as quintiles of households ranked by raw score (Rutstein, 2008).[1] The validity and implicit value judgements of each measure of inequality have been well described for single-unit studies (Harper et al., 2010), but an increasing number of researchers are now using these measures of SES to construct measures of health inequality across more than one country or subregion and over time.

In response to the increasing interest being paid to comparisons of inequalities in global health, some studies have begun compiling, comparing, and even averaging health inequality summary measures across countries using a country-by-country approach (Li, Li, Subramanian, & Lu, 2017; McKinnon et al., 2014; Strømme & Norheim, 2017). Although the need for such research to guide the SDGs is clear, the growing body of studies that have used this country-by-county method have generated somewhat counter-intuitive results; especially when there are large differences in disease prevalence and wealth levels between countries. As one illustrative example in Latin America and the Caribbean, researchers have either found that Haiti and Colombia have similarly very low inequalities in health (Arsenault et al., 2017; McKinnon et al., 2014; Paraje, 2009; Van De Poel et al., 2008), or are polar opposites of very high and very low inequality in health (Cardona, Acosta, & Bertone, 2013; Gakidou & King, 2000; Wagstaff, 2002a), with some even presenting conflicting conclusions within the same study. It is possible that these conflicting findings can be attributed to the use of different methods of combining absolute and relative health inequality measures between two countries with very different levels of absolute wealth and health but similar patterns of disease distribution. This is because if the poorer country has a high burden of disease throughout the SES spectrum of its population, a summary measure of wealth-related health inequality may still be quite low, and conversely, a rich country with a very low burden of disease may not result in a large summary measure due to semi-random dispersion in its distribution. The effects of ignoring these differences can be further exacerbated by comparing countries over time. If there are larger increases in absolute wealth in one country or changes in the distribution of wealth in either country, making comparisons with the assumption of relative wealth parity would become invalid; even if the distribution of health outcomes within each unit does not change (Hosseinpoor et al., 2016; Wagstaff, Bredenkamp, & Buisman, 2014). The effects of ever-changing living standards between countries and the varying levels in health inequalities both within and between countries have therefore been continually analyzed as distinct and unrelated phenomena.

In addition to the variety of measurement errors that can arise from different combinations of health and wealth inequalities, the method by which wealth is measured can also have a distortionary effect. Since household asset indices calculated using the most common method of PCA have no meaningful scale (Filmer & Pritchett, 2001), the magnitude of wealth inequality may appear to be different even if absolute wealth levels are equal, or else may appear to be the same even when vast differences in wealth present. If researchers use a scale-dependent measure of inequality or attempt to compare two countries with separately calculated asset indices, this illusion can lead to the appearance of differences in health inequalities even when none are present. Stated differently, it may be clear that a household earning $50,000 is qualitatively different than a household earning $10,000, even if both households are in the highest-earning quintiles of their respective countries, but this difference can be less apparent to researchers if both households have an identical 5.5 household asset index value in the survey data. In sum, depending on the method used to quantify SES and absolute inequalities in health and wealth, comparing the magnitude of wealth-related health inequalities across countries using a country-by-country approach can produce misleading results– a methodological blindness which we propose to address using a new approach.

In this paper, we develop a new methodology to compare estimates of wealth-related health inequalities between countries and over time, an approach we call the transnational approach. To demonstrate its usefulness and the limitations of the country-by-country approach, we first demonstrate the distortionary effects of differences in health and disease prevalence within and between countries on overall differences in health inequalities across countries using simulated survey data. Second, we empirically construct measures of health inequalities across two countries, Haiti and the Dominican Republic, using both the country-by-country approach and the transnational approach. To do so, we begin with a discussion of specific methodological and practical issues that affected our ability to compare these two countries including selecting which countries to compare, identifying an appropriate data source that is comparable across countries or subregions, measuring SES on a common scale across countries, and deciding on an appropriate health inequality measure for transnational health inequality measurement. Our main finding is that the transnational approach identifies very different trends in cross-country health inequalities and that the transnational approach allows us to observe important differences in health inequalities that we could not observe using the country-by-country approach. We discuss the limitations of this approach and instances when we believe it would be more appropriate than more commonly used approaches to measure differences in health inequalities across countries.

2. Approaches to comparing health inequalities across countries

Rather than combining disparate measures of wealth and health using a bottom-up country-by-country approach, a top-down transnational approach allows us to address confounders which have affected this emerging field. At the most basic level, the transnational approach is simply the analysis of wealth-related health inequalities with every person or household in the area of study ranked using one unified SES measure rather than attempting to compare two or more countries with separate and incomparable SES rankings. The utility of this type of analysis has previously been demonstrated in the decomposition of health inequalities into within- and between-provincial components in Canada (Jimenez-Rubio, Smith, & van Doorslaer, 2008).[2] The institutional design of Canada's federated health institutions means it can be treated as a proxy for the study of international health with provinces representing the same type of variation as might be seen in a country-by-country analysis, demonstrating that transnational health inequality analysis is theoretically possible. The primary obstacle to extending this style of analysis to the level of international health lies in the comparison of SES between countries, as one cannot simply use a common currency or an assumption of formal and relatively stable household incomes. However, it is possible to overcome this obstacle using common methods of household asset index creation to extend analysis from the within-country scale to the scale of multiple countries, bringing with it more significant health inequalities and greater policy diversity inherent in international research and leading to findings which are not apparent using any other method.

[1] An alternative approach of polychoric PCA offers the advantages of not requiring the creation of dummy variables, includes the lack of ownership of assets in the score, and has been demonstrated to perform at least as well as the original PCA methodology (Filmer & Scott, 2012; Kolenikov & Angeles, 2009).

[2] Similar work comparing within- and between-jurisdictional inequalities in health have been conducted in both high-income (Allanson, 2017) and low- and middle-income countries (Chalasani, 2012; Pulok, Uddin, Enemark, & Hossin, 2018), but Jimenez-Rubio et al. (2008) provide a useful framework for understanding the general approach.

Although the lack of income or expenditure data in most household health survey of low- and middle-income countries may seem to be a significant challenge, the common practice of using a household asset index to rank SES can be used to generate a transnational ranking. The asset index measures a different dimension of SES than income or household expenditure that is more indicative of long-term SES than short- or medium-term income, and as such may not yield the same relative rankings (Howe, Hargreaves, Gabrysch, & Huttly, 2009). However, since they are derived from household assets, these indices can be easily measured, remain relatively stable over time, and can be directly compared across national boundaries – all major advantages over income or expenditure data which can fluctuate dramatically and can be difficult to measure accurately in developing contexts (Bollen, Glanville, & Stecklov, 2002; Sahn & Stifel, 2003). The main challenge in using this measure comes from the fact that although asset indices effectively rank each household relative to others in the sample, the numeric value of each index has no inherent value – it is an ordinal, but not an interval variable. Nevertheless, with care to ensure all household assets are directly comparable, one can pool two or more household surveys together, create a new transnational asset index using common methods such as PCA, and then analyze the within- and between-country components of health inequalities, as demonstrated by Jimenez-Rubio et al. (2008). While the fundamental approach is straightforward, the consequences of using the transnational approach in place of the currently accepted practice of country-by-country comparisons of international health inequalities are far from trivial.

To demonstrate the differences between the country-by-country approach and transnational approaches to estimating differences in health inequalities, we simulate the theoretical impact of changes in both income[3] and disease inequality within and across countries using simulated survey data. A "poorer" country (mean income $30,000) and a "richer" country (mean income $40,000) with normally distributed and overlapping incomes were randomly assigned different prevalence levels of a disease according to transnational quintile, representing the entire SES distribution of both countries divided into five equal parts. Individuals were randomly assigned a hypothetical disease outcome varying randomly from a 0.65–0.75 level in the poorest transnational SES quintile to 0.25–0.35 in the richest transnational quintile. This disease distribution is meant to represent disease outcomes which are more prevalent both in poorer countries and among lower SES status within countries. Parameters of both between- and within-country income inequalities and health inequalities were then varied to observe the relative effect of both transnational and country-specific income-related health inequalities.[4]

In Table 1, we present the differences that each of these effects have on the direction of both within- and between-country health inequalities, several of which would be undetectable or produce counterintuitive results using country-by-country methods. For example, error #1 identifies a situation in which reducing between-country health inequality by improving health outcomes in the poorer country increases health inequality within that country but decreases transnational inequality. Therefore, if a researcher were to use a country-by-country approach and simply count the number of countries that had experienced increases in health inequalities or take an average of country-level health inequalities – a method which has been used in published literature – one would conclude that overall inequality in the two countries had increased rather than decreased. An increase or decrease of between-country income inequality with disease prevalence staying the same, as described in errors #2 and #3, would result in changes to transnational inequality, but country-by-country inequality remaining exactly the same. Similarly, increasing within-country income inequality in either the poorer or richer country, as described in errors #4 and #5, would decrease transnational inequality, but be completely

Table 1
Simulated transnational composition effects for increases and decreases in both within- and between-country health and income inequality.

Variable modified	Direction of modification	Poor country inequality	Rich country inequality	Country-by-country inequality	Transnational inequality	Error #
Health inequality between countries	Convergence (poor reduces disease prevalence more than rich country)	Increase	No change	Increase	Decrease	1
	Divergence (rich reduces disease prevalence more than poor country)	No change	Increase	Increase	Increase	
Income inequality between countries	Convergence (poor catches up to rich)	No change	No change	No change	Decrease	2
	Divergence (rich becomes even wealthier than poor)	No change	No change	No change	Decrease	3
Health inequality within countries	Decrease in richer country	No change	Decrease	Decrease	Decrease	
	Increase in richer country	No change	Increase	Increase	Increase	
	Decrease in poorer country	Decrease	No change	Decrease	Decrease	
	Increase in poorer country	Increase	No change	Increase	Increase	
Income inequality within countries	Decrease in richer country	No change	Decrease	Decrease	Decrease	4
	Increase in richer country	No change	No change	No change	Decrease	
	Decrease in poorer country	Decrease	No change	Decrease	Decrease	
	Increase in poorer country	No change	No change	No change	Decrease	5

[3] Although most transnational wealth-related inequality issues are related to the use of household asset indices, income is used as the ranking measure in the simulation for ease of understanding.

[4] Appendix Table 1 presents concentration indices for each scenario.

undetected using country-by-country methods. Given the many threats to validity demonstrated in the simulated survey data, there is clearly justification for the use of transnational health inequality research, but the feasibility of doing so using real-world data must first be considered.

3. Empirical example: Wealth-related health inequalities in Hispaniola

To best demonstrate the utility of the transnational approach, case selection for our empirical demonstration was guided by three factors – a clearly demarcated jurisdictional or physical boundary for each individual jurisdiction and for the transnational unit, a most-different (i.e. extreme case) case selection approach, and data availability. These criteria were chosen to explore cases which most closely match the simulated composition effects identified in Table 1 while reducing the influence of confounding effects such as differing cultural contexts, conflict zones, or environmental/ecological differences. The contrast afforded by an "extreme case" and "most different case" selection logic has the advantage of highlighting transnational inequalities that may be overlooked using country-by-country methods of analysis (Seawright & Gerring, 2008).[5] These considerations led to the selection of Haiti and the Dominican Republic, which together constitute the island of Hispaniola.

The physical boundary formed by the limits of the shared island provide an ideal and intuitive delimitation for the frame of analysis. The shared terrain has shaped the economic development and the public health challenges faced by both countries, but despite their shared geography, each country has undergone remarkably divergent paths of development. Whether the measure is gross national income (GNI) per capita, human development index, life expectancy, or infant mortality rate; Haiti has long endured the lowest quality of life measures in the Western Hemisphere, and has consistently fared worse than the neighboring Dominican Republic with an 11 year gap in life expectancy and a GNI per capita more than eight times lower than its richer neighbor in 2016 (The World Bank, 2017). The disparity between these countries has not gone unnoticed among health inequality researchers. More than fifteen years ago, Adam Wagstaff posed a prescient question - why is it "that the two countries that occupy the Caribbean island of Hispaniola-the Dominican Republic and Haiti-have such markedly different levels of inequality in child malnutrition and mortality?" (Wagstaff, 2002a, p. 10). He concluded that Hispaniola is an illustrative case of the tendency for health inequalities to increase as per capita incomes increase and as concomitant gains in health outcomes begin to take root among those benefiting from economic growth – the same effect identified in our transnational composition effect simulation.

Several studies have investigated health inequalities in Haiti (Arsenault et al., 2017; Danquah et al., 2015; Fenn, Kirkwood, Popatia, & Bradley, 2007; Gwatkin et al., 2007a) and in the Dominican Republic (Gwatkin et al., 2007b; Wagstaff, 2002b) separately. In addition, a number of studies have also contrasted measures of health inequalities across the two countries using country-by-county methods. One study found Haiti to have the largest inequities in health of any country in the Latin American and Caribbean (LAC) region using an index of health and socioeconomic factors, while the Dominican Republic was ranked sixth worst out of 20 total countries in the same analysis (Cardona et al., 2013). In contrast, another cross-country comparison using DHS data noted that although Haiti had the lowest levels of inequality in child malnutrition in the LAC region, this obscured the fact that it had one of the highest absolute levels of child malnutrition in the region (Paraje, 2009). These seemingly contradictory findings can be explained by the limitations in making comparisons across countries using different reference points for both wealth and health; the best performing country in the first case, and own population in the second case. Thus, depending on the reference point, completely contradictory findings can be obtained due to a fundamental tension that cannot be resolved using a country-by-country frame of analysis – more examples of the errors we identified in our simulation. Absolute differences in health inequalities across countries and inequalities within countries can be compared, but the magnitude of wealth-related inequalities among the population of Hispaniola as a whole cannot be measured using the current paradigm.

Having selected cases for analysis, the challenge of identifying an appropriate data source to pool over the two countries was solved using DHS data, which offer seven waves of more than 300 household surveys in over 90 countries with directly comparable health outcomes collected over three decades by international researchers in conjunction with country officials (Corsi, Neuman, Finlay, & Subramanian, 2012). Health outcomes included in these datasets are mainly focused on maternal and child health, but certain countries have chosen to add country-specific modules. Directly measured outcomes always include children's height and weight, and sometimes include laboratory test results for other outcomes such as anemia, human immunodeficiency virus (HIV), and malaria. These direct measures are complemented by self-reported health outcomes regarding child mortality, cough, diarrhea, and fever. An additional advantage of using DHS data is the availability of georeferenced data, which have been previously used to map children's health outcomes across several African countries (Burke, Heft-Neal, & Bendavid, 2016; Kazembe & Mpeketula, 2010).[6] Using these techniques, subregional differences within countries can point to environmental or political determinants of health that would be overlooked using summary indicators, and more relevant to this study, sharp discontinuities across national boundaries can be suggestive of country-specific determinants of health (Burke et al., 2016).

The Dominican Republic has participated in every wave of DHS since its inception in 1986 (DHS-I to DHS-VI), while Haiti has participated since 1994 (DHS-III to DHS-VI). The analysis was restricted to women of reproductive age and their children, because adult men are only sampled as a subsample of the women's household surveys and the sample is therefore relatively underpowered and non-representative (ICF International, 2012). To capture a variety of distributions of inequalities in health, every health outcome (excluding healthcare utilization variables) present in surveys for both countries were analyzed (Appendix Table 2). Children's nutritional health outcomes are widely recognized to be crucial to public health and are generally more sensitive to living standards than adult health outcomes (Marmot, 2005). Therefore, the directly measured outcomes of underweight, stunting, and wasting were all converted to binary outcomes (z-scores two standard deviations below zero), because of the limited and uncertain influence of positive z-scores on children's health in this context.[7] Self-reported outcomes of children's fever, cough, and diarrhea in the last two weeks were also included as indicators of short-term children's health. From the women's dataset, a ratio of self-reported children's deaths to live births was included as a proxy for infant mortality, and blood tests for HIV status were included to observe whether infectious diseases exhibited a different pattern of inequality.[8] All calculations were performed using STATA version 13 (StataCorp LP, College Station,

[5] While this case selection method is inappropriate for generalizing findings to countries not selected for analysis (Lieberson, 1992), it is appropriate for a study demonstrating the utility of a novel methodology.

[6] Actual global positioning system (GPS) coordinates are offset by up to five kilometers in rural clusters and up to one kilometer in urban clusters while remaining inside the administrative boundary to protect confidentiality, however, on aggregate, these random displacements do not affect the results (ICF International, 2012).

[7] Reference standards developed by the DHS for children's height and weight were used rather than the World Health Organization's (WHO) standards to allow direct comparability throughout all survey waves (WHO standards only available for DHS wave 6).

[8] Corrections using Heckman-type selection models have been suggested for use in analyzing HIV status using DHS data due to selection issues associated with nonparticipation rates being higher for HIV testing in particular, however, since bias has been found to only significantly impact male prevalence rates (Bärnighausen, Bor, Wandira-Kazibwe, & Canning, 2011), a correction was not performed in this case.

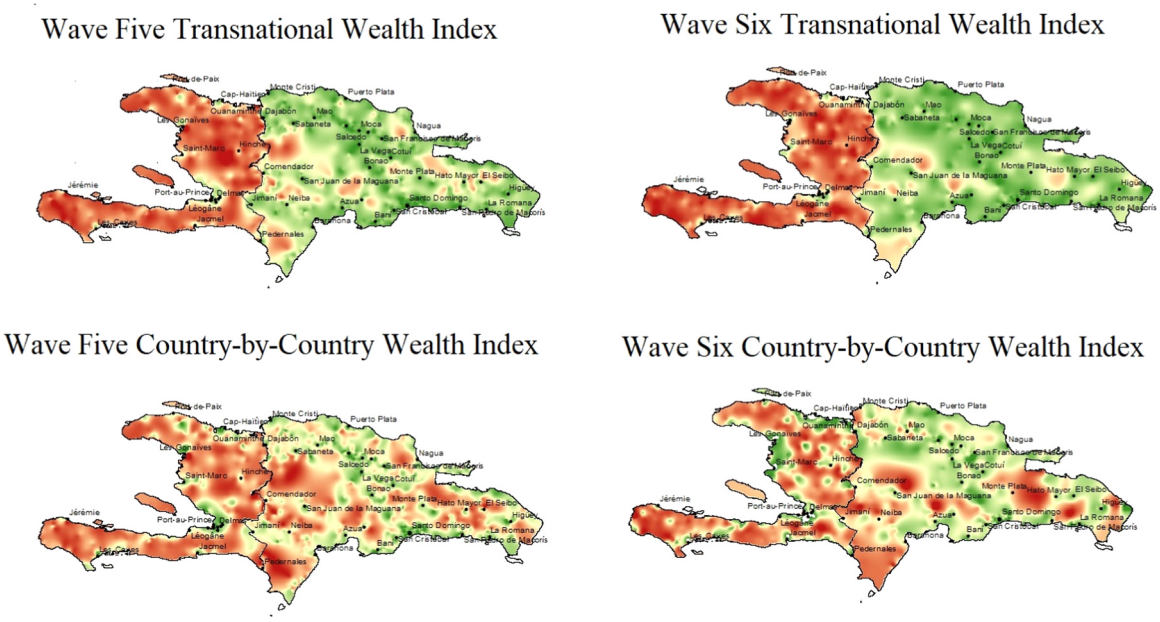


Fig. 1. Transnational and country-by-country wealth index spline interpolation for waves five and six.

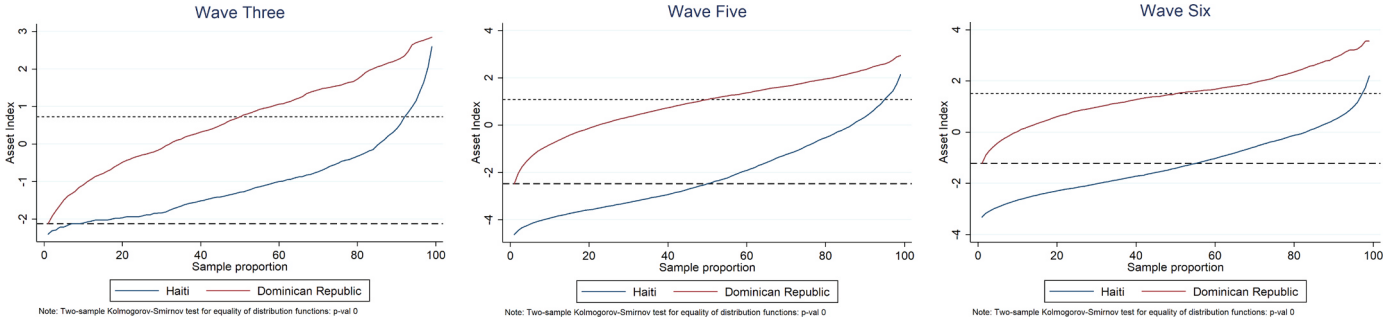


Fig. 2. Pen's Parades of polychoric PCA wealth indices for waves three (left), five (center) and six (right).

TX) and survey weights were included in all relevant calculations with poststratification adjustment according to each country's population.[9] In addition to these summary measures, georeferenced data was available for both Haiti and the Dominican Republic in waves five and six. Using these georeferenced data, the geography of health inequality throughout Hispaniola was investigated using ArcGIS (ESRI, Redlands, CA). The prevalence of disease for each survey cluster was mapped using global positioning system coordinates, and both spline interpolation and kriging methods were used to produce smoothed disease outcome maps (Auchincloss, Gebreab, Mair, & Diez Roux, 2012; Auchincloss, Diez Roux, Brown, Raghunathan, & Erdmann, 2007). Although waves three and four did not include georeferenced data, the earliest available shared survey (wave three) was analyzed for both countries to track the evolution of inequalities over time.

Despite the DHS offering a rich source of information for health outcomes in both countries, the surveys generally do not contain income or household expenditure data – a common challenge present in many household health surveys. This led us to create a new household asset index for the entire transnational sample for each of DHS waves three (1994–1996), five (years 2005–2007) and six (2012–2013). Household asset data was first closely examined and recoded to ensure direct comparability between both countries before a transnational asset index was calculated for each wave.[10] With socioeconomic ranking of the transnational dataset complete, quantification of wealth-related health inequalities was conducted using the concentration index. We calculated the concentration index using methods described by O'Donnell, van Doorslaer, Wagstaff, and Lindelow (2008) and concentration indices for all binary variable outcomes were corrected using the Wagstaff (2005) method.[11] Concentration indices are represented graphically as concentration curves, which represent all individuals ranked in order of lowest to highest SES along the x axis, with the cumulative share of disease plotted on the y axis, usually contrasted against a 45-degree diagonal line of equality for

[9] Postweights based on population under 5 for children's recode and women aged 15–49 for women's recode variables using United Nations population data.

[10] Only assets included in both country surveys were included for analysis, resulting in a range of 26 (wave three) to 52 (wave six) assets included for analysis. One wealth index was created with the same methodology used by the DHS Program (Filmer & Pritchett, 2001; Rutstein, 2008), including rescaling of rural and urban households with a secondary regression, and another wealth index was calculated using polychoric PCA. Given the more desirable statistical properties of polychoric PCA (Kolenikov & Angeles, 2009) and minimal difference between the two indices, polychoric PCA wealth index values are used as the default in this analysis.

[11] An alternative method of addressing binary outcome variables is the Erreygers method (Erreygers, 2009; Erreygers & Ourti, 2012). Since we are more interested in relative inequality of health than absolute inequality and compare only outcomes of ill health rather than good health the Wagstaff correction is appropriate (Kjellsson & Gerdtham, 2013) and represents the more widely used method in global health literature.

reference. The concentration index has a value ranging between -1 and 1 which corresponds to two times the area between the line of equality and the concentration curve; or the percentage of the total outcome of interest that would have to be redistributed from the richest half to the poorest half of the population to reach a state of equality (Koolman & van Doorslaer, 2004; O'Donnell et al., 2008; Wagstaff, Paci, & van Doorslaer, 1991). We therefore exploit the fact that the concentration index is unaffected by a non-interval SES variable and proceed to decompose the index into its constituent parts.

The decomposition of the concentration index has been used to tease out factors which contribute to social inequalities in health as well as whether the factors contribute to larger or smaller inequalities. Studies using this approach do so for two main reasons. The first type attempts to identify possible causal factors which determine population social inequality in health, such as education, national income growth rates, or healthcare system characteristics (Goesling & Firebaugh, 2004; McGrail, van Doorslaer, Ross, & Sanmartin, 2009; Sahn & Younger, 2006). The second approach does not attempt to identify causal factors that explain patterns of inequality, but investigates the relative distribution of inequality among groups, often investigating the degree to which inequalities are distributed *within* geographical regions or *between* geographical regions (Pradhan, Sahn, & Younger, 2003). Within the Canadian context, for example, studies have decomposed health outcomes and healthcare use inequalities into both causal (Allin, 2008) and distributional (Jimenez-Rubio et al., 2008) types. With respect to our empirical demonstration, using the distributional decomposition approach means that besides removing the possibility of analytical errors demonstrated in the simulation, the transnational approach can identify the ways in which disadvantaged regions shift over time and the degree to which they are distributed between and within countries. Our concentration indices were therefore decomposed into three principal geographical constituents – the cross-country component, the within-country subregional component, and the urban-rural component.[12,13] Having addressed the major challenges of justifying cases for inclusion, using high-quality comparable data, ranking households according to a common SES scale, quantifying the magnitude of inequalities in health on a transnational scale, and decomposing these inequalities according to their distributional components, we proceed to describe the results of the first empirical demonstration of transnational health inequality decomposition in Haiti and the Dominican Republic.

4. Results

A map of transnational household asset index values (Fig. 1, top) from highest (green) to lowest (red) clearly demonstrates a sharp disparity in wealth between the two countries.[14] It is important to note that borders are presented for visual aid only and did not affect wealth index calculation or interpolation in any way. This makes the sharp divide which nearly identically coincides with the Haitian-Dominican border all the more striking. Going past this clear contrast, there are, nonetheless, areas of relative wealth and deprivation in both countries. The Dominican Republic's pockets of relative deprivation are observed in mountainous and rural areas and are fewer in number in wave six. Haiti's pockets of relative affluence are nearly all concentrated around major cities of Port-au-Prince, Cap-Haïtien, Saint Marc, Gonaïves, and Les Cayes. In contrast, mapping country-specific values of the same index values (Fig. 1, bottom) displays no such contrast. While the areas of relative wealth within each country are the same, there is no discernible wealth disparity between countries, an effect which is guaranteed by the use of country-by-country methods, and which could produce counterintuitive results if interpreted naively. In effect, the country-by-country maps are a visual representation of how wealth data can be misleadingly used to erase real and meaningful differences in household SES.

Pen's Parades presented in Fig. 2 order each country's households from lowest to highest SES from left to right according to each wave's transnational asset index values – a comparison which would be impossible using country-by-country analysis.[15,16] Although the units of the index are not inherently meaningful, the relative standing of each household within each wave reveals that Dominican respondents are consistently wealthier than their Haitian counterparts.[17] Even more revealing, Dominicans are increasingly wealthier as time goes on. In wave three, both the "poorest" and the "wealthiest" Haitian respondents were almost as wealthy as the equivalent Dominican respondents. In wave five, however, the poorest Dominican respondents were about at wealthy as the median Haitian respondents, and the wealth disparity only worsened in wave six, recreating several conditions identified as potential confounding in the simulated survey data.

Moving from wealth to health, maps of health outcomes (Fig. 3) represent higher prevalence of each outcome with red shading.[18] The acute children's health outcomes seen in the top three rows of Fig. 3 are fairly evenly dispersed throughout both countries, with the exception of cough, which appears to be slightly more prevalent in Haiti. In contrast, there are clearly more high-prevalence clusters for the three long-term outcomes of underweight, stunting, and wasting on the Haitian side of the border. Health outcomes from the women's surveys, however, display two very different distributions of disease. Just as long-term children's health outcomes, child deaths are clearly more prevalent on the Haitian side of the border, but high-prevalence clusters of HIV appear to be spread evenly throughout the island.[19]

Delving deeper into these outcomes, Haitian survey respondents more frequently reported higher rates for every negative health outcome than respondents in the Dominican Republic.[20] Concentration indices for each of these outcomes are presented in Table 2. Country-by-country concentration indices indicate a significant difference between Haiti and the Dominican Republic at the 95% level in only eight of 23 outcomes analyzed, with child deaths and HIV status most likely to be significantly different. In contrast, the transnational sample consistently results in higher concentration indices, which is caused both by the disparities in wealth between the two countries and by the higher prevalence of each outcome in Haiti – yet another hidden effect predicted in the simulation exercise. This effect can be more clearly

[12] Subregions were recoded in waves five and six to be directly comparable using ten Haitian departments and nine Dominican health regions, however wave three only contained three Haitian divisions (north, metropolitan, south).

[13] Rather than only using within- and cross-country variables to decompose following Jimenez-Rubio (2008), urban-rural status was added to account for a possibly significant confounding factor. Subregions were used as fixed effect variables, while urban-rural and country were used as the primary decomposition variables.

[14] Alternative specifications of PCA wealth index and kriging interpolation are presented in Appendix Figs. 1 and 2, but do not affect these results significantly.

[15] PCA and polychoric PCA wealth indices performed very similarly overall, and closely matched the original wealth index calculated by DHS staff (Appendix Table 3). For example, the spearman's rho between the wave six transnational PCA wealth index and DHS wealth index are for the Dominican Republic (0.92) and Haiti (0.90). The same values between the polychoric PCA index and the original DHS index are 0.90 and 0.88 for the Dominican Republic and Haiti respectively, and PCA and polychoric PCA wealth indices reached a spearman's rho of 0.97 for the transnational sample. Differences due to dropping variables not present in both datasets were therefore minimal, and transnational PCA and polychoric PCA wealth indices were more similar to each other than to the DHS indices in every wave.

[16] Two reference lines have been added at the level of the lowest wealth index centile and the median wealth index value for the Dominican Republic.

[17] Reference lines within each survey wave can be used to compare countries, but cannot be used to compare other survey waves.

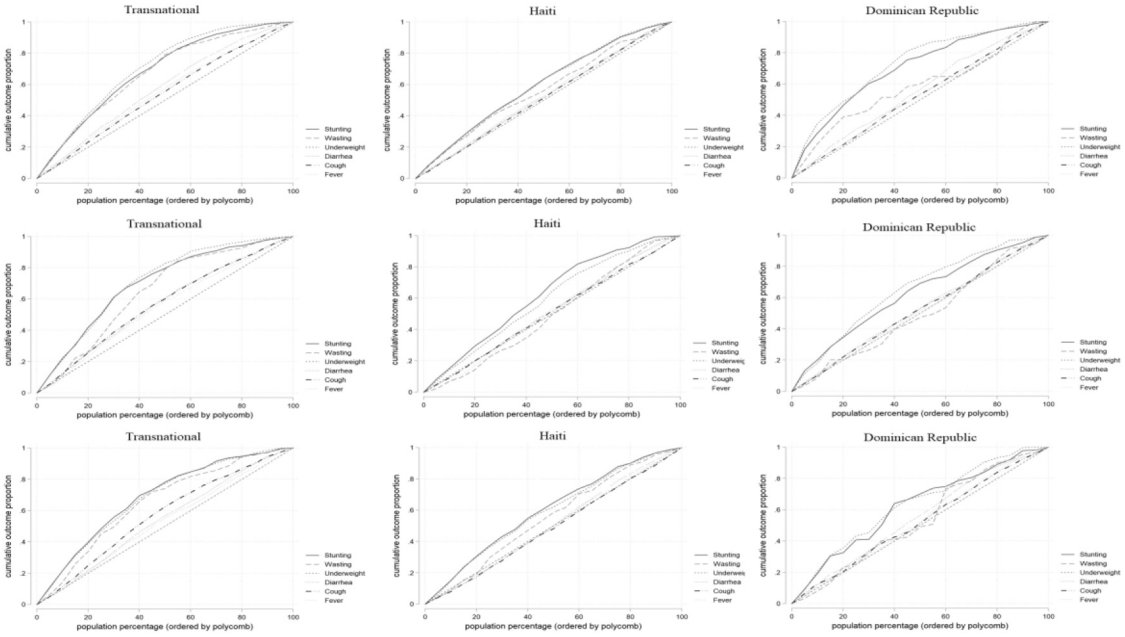
[18] Wave three data were not georeferenced. Borders are presented for visual aid only and did not affect interpolation.

[19] An effect similar to the one seen in Fig. 2 would be observed for health outcomes if interpolation was conducted separately for each country, but since this would be an artifact of interpolation methods rather than data analysis (anthropometry is always measured on the same scale), no additional maps or analysis were conducted.

[20] Descriptive statistics for health outcomes and wealth indices in waves three, five, and six are available in Appendix Tables 4–9.

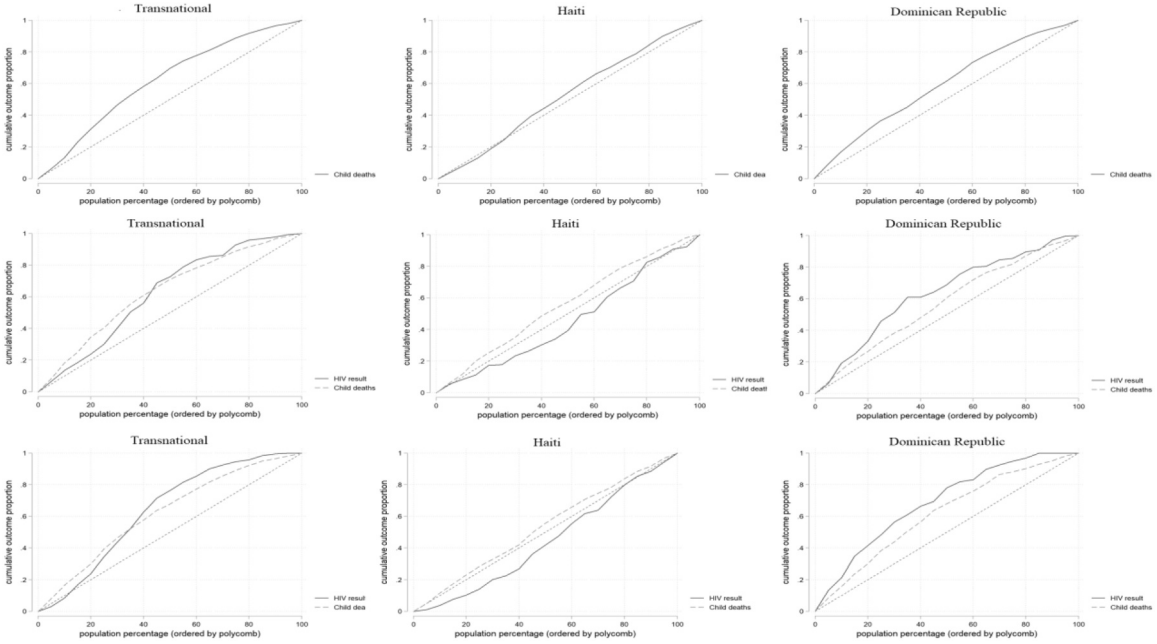
seen by plotting the concentration curves. For example, Fig. 4 shows that for the outcome of wasting in wave five, both Haiti and the Dominican Republic have no significant wealth-related inequalities in the distribution of wasting within their borders, however, due to the much higher prevalence in the lower SES country, the transnational sample has a highly significant pro-rich inequality of distribution for the island as a whole. Finally, changes in wealth-related health inequalities over time for both the country-by-country approach and for the transnational approach result in diametrically opposite conclusions in eight out of the fifteen measures that can be compared from wave to wave, and there are large differences in magnitude for those that are at least aligned in direction.

.



Panel 1. Concentration curves for children's health outcomes in wave three (top), wave five (middle), and wave six (bottom) for transnational sample, Haiti, and Dominican Republic.

.



Panel 2. Concentration curves for child deaths and HIV status in wave three (top), wave five (middle), and wave six (bottom) for transnational sample, Haiti, and Dominican Republic.

Concentration curves for both countries and for Hispaniola are presented for children's health outcomes in Panel 1, and women's health outcomes in Panel 2. For the transnational analysis, every outcome is disproportionately concentrated among the poor, with underweight, stunting, and wasting consistently being the most inequitably distributed outcomes, while fever, cough, and diarrhea are relatively more equitably distributed throughout the socioeconomic spectrum of Hispaniola. For example, in wave five more than 60% of underweight children were found within the poorest third of the population of Hispaniola and over 80% of underweight children were within the poorest half of the population. These wealth-related inequalities in child health outcomes worsened between waves three and five, but

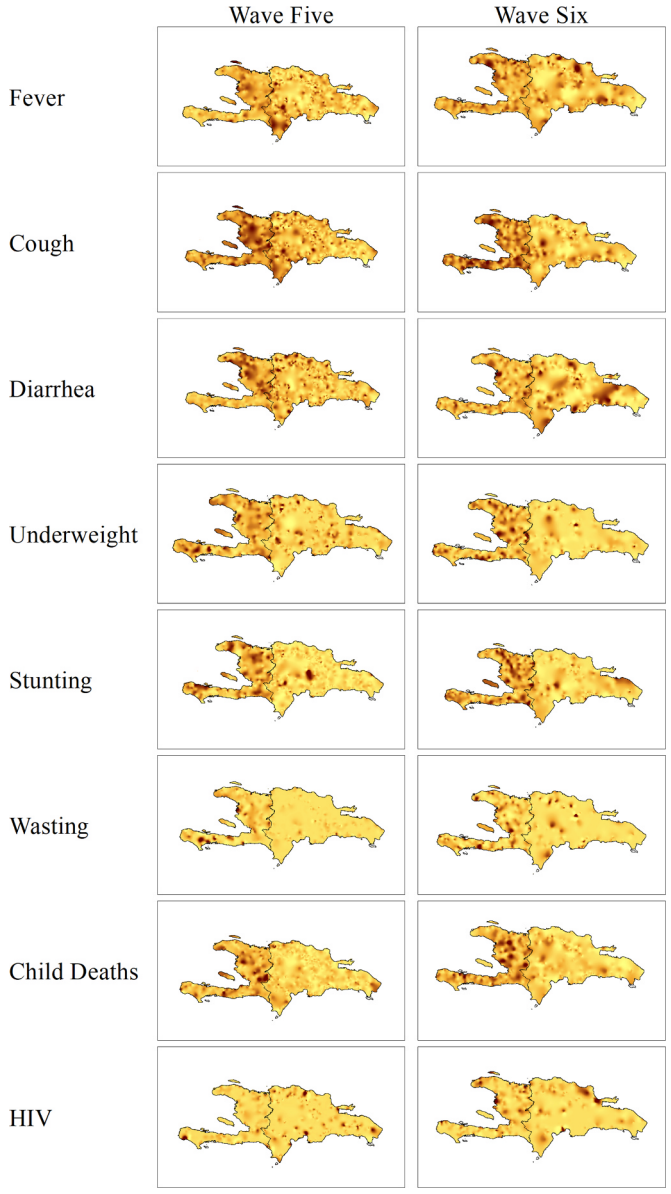


Fig. 3. Health outcome maps for DHS waves five (left) and six (right) for fever, cough, diarrhea, underweight, stunting, wasting, child deaths, and HIV status (top to bottom).

subsequently decreased in wave six. Among all these outcomes, there is one clear outlier – HIV status. In Haiti, HIV is more prevalent among the relatively more affluent, while in the Dominican Republic, it is more prevalent among the less affluent. As a result, the transnational concentration curve displays a pronounced rise in inequality at the middle of the SES spectrum, the effect of combining two of the hidden effects demonstrated in our simulated data.

Finally, the magnitude of the contributions of country, subregion, and urban-rural status to wealth-related inequalities in health are presented graphically in Fig. 5.[21,22] Most of the systematic variation in wealth-related inequalities can be explained by the three location-based variables in every wave and for every outcome, leaving little variation in the residual. Stunting and wasting inequality were mainly driven by urban-rural status in wave three, after which country status became the primary driver of inequality. Wasting displays a different trend in which country of residence was the primary driver of inequality in waves three and five, while subregions have become the primary cause of inequality in wave six. This may be due to the low prevalence of the outcome, or due to the slow, but steady rise in prevalence in the Dominican Republic over each wave. Fever, cough, and diarrhea display no such systematic variation from wave to wave. Interestingly, wealth-related inequalities in HIV status are consistently made more concentrated among the poor by country of residence, but urban-rural status significantly reduces these inequalities. This is driven by increased prevalence in cities, and further elucidates the results seen in Panel 2. Finally, inequalities in child deaths are primarily driven by country of residence in every wave, with lesser contributions of subregions and urban-rural status. These previously hidden trends in the geographic distribution of adverse health outcomes in Hispaniola have significant implications for health inequality research.

5. Discussion

The empirical results of this first transnational wealth-related health inequality analysis demonstrate that the distribution of wealth and of health outcomes across countries affects the estimation of health inequalities in country-by-country comparisons and that these limitations can be overcome using the same sources of data currently used in the literature. The transnational wealth index analysis confirms a large and increasing divergence in household wealth between Haiti and the Dominican Republic over time. However, poorer Dominican respondents living primarily in rural areas are still not as wealthy as the far fewer relatively wealthy Haitian respondents living primarily in urban areas. Acute child health outcomes of fever, cough, and diarrhea are common throughout the island, and decomposition results do not identify a consistent geographic driver of inequality among these outcomes. In contrast, the long-term child health outcomes of underweight, stunting, and wasting were all much more prevalent in Haiti.[23] It appears that this is not attributable to differential incidence of short-term disease, rather, the extremely high concentration index values point to long-term wealth-associated determinants such as nutrition, living conditions, and healthcare access. The ratio of child deaths follows the same mould as these long-term health outcomes, albeit at slightly lower levels of wealth-related inequality.[24] In contrast to these long-term health outcomes, HIV status exhibits a very different distribution. The magnitude of wealth-related inequality is just as large as child deaths, but the decomposition identifies country of residence to be a major driver of inequality, with urban/rural status reducing this inequality significantly. This is because HIV status is the only health outcome which is more prevalent in urban areas, which are relatively wealthier than rural areas in both countries. Looking at the wealth-related inequalities in health over time, it is encouraging that following increases from waves three to five, a decrease in wealth-related inequality for every health outcome has started to take hold.

Researchers investigating global health inequalities should take note of several aspects of these empirical results. First, limiting analysis of health inequalities to country-by-country comparisons effectively ignores the influence of shifting levels of national disease prevalence,

[21] Distributional decompositions of each concentration index are presented in Appendix Tables 10–12.

[22] Wealth itself is not included in the decomposition because household asset index values have no meaningful scale.

[23] This may be partially attributed to recall bias since these outcomes are not directly measured, but the relative rate at which parents recalled their children falling ill within the last two weeks of being surveyed was fairly consistent from wave to wave.

[24] The impact of the devastating 2010 earthquake can certainly not be overlooked, and the health outcome one might have most expected to be affected would be child deaths. Nonetheless, the ratio of child deaths observed in the sample falls continuously from waves three to five to six for both countries, and the Port-au-Prince area does not appear to have a markedly higher child death ratio than surrounding areas in Haiti.

Table 2
Concentration indices for Haiti, the Dominican Republic, and transnational sample with a country-by-country average and differences between both countries and survey waves.

Wave Three	Haiti	DR	Haiti-DR Difference	p-value	Country-by-country	Transnational		
Stunting	-0.275	-0.452	-0.177	0.00*	-0.364	-0.495		
Underweight	-0.254	-0.492	-0.238	0.00*	-0.373	-0.537		
Wasting	-0.125	-0.176	-0.051	0.69	-0.151	-0.400		
Diarrhea	-0.061	-0.135	-0.073	0.06	-0.098	-0.208		
Fever	-0.085	-0.068	0.016	0.68	-0.077	-0.158		
Cough	-0.065	-0.094	-0.03	0.42	-0.080	-0.159		
Child Deaths	-0.069	-0.189	-0.12	0.00*	-0.129	-0.259		
Wave Five	Haiti	DR	Haiti-DR Difference	p-value	Country-by-country	Transnational	Country-by-country change	Transnational change
Stunting	-0.316	-0.265	0.051	0.31	-0.291	-0.579	0.073	-0.084
Underweight	-0.23	-0.314	-0.084	0.13	-0.272	-0.694	0.101	-0.157
Wasting	0.007	0.01	0.003	0.97	0.009	-0.503	0.159	-0.103
Diarrhea	-0.06	-0.061	-0.001	0.98	-0.061	-0.186	0.038	0.022
Fever	-0.041	-0.02	0.021	0.6	-0.031	-0.120	0.046	0.038
Cough	-0.045	-0.056	-0.011	0.79	-0.051	-0.233	0.029	-0.074
HIV	0.044	-0.266	-0.31	0.00*	-0.111	-0.339		
Child Deaths	-0.116	-0.135	-0.019	0.36	-0.126	-0.278	0.004	-0.019
Wave Six	Haiti	DR	Haiti-DR Difference	p-value	Country-by-country	Transnational	Country-by-country change	Transnational change
Stunting	-0.246	-0.265	-0.019	0.78	-0.256	-0.413	0.035	0.166
Underweight	-0.215	-0.273	-0.058	0.42	-0.244	-0.388	0.028	0.306
Wasting	-0.111	-0.034	0.077	0.42	-0.073	-0.290	-0.081	0.213
Diarrhea	-0.015	-0.106	-0.091	0.04*	-0.061	-0.068	0.000	0.118
Fever	-0.017	-0.053	-0.036	0.34	-0.035	-0.073	-0.005	0.047
Cough	0.036	-0.066	-0.102	0.01*	-0.015	-0.219	0.036	0.014
HIV	0.082	-0.322	-0.404	0.00*	-0.120	-0.245	-0.009	0.094
Child Deaths	-0.071	-0.133	-0.061	0.03*	-0.102	-0.234	0.024	0.044

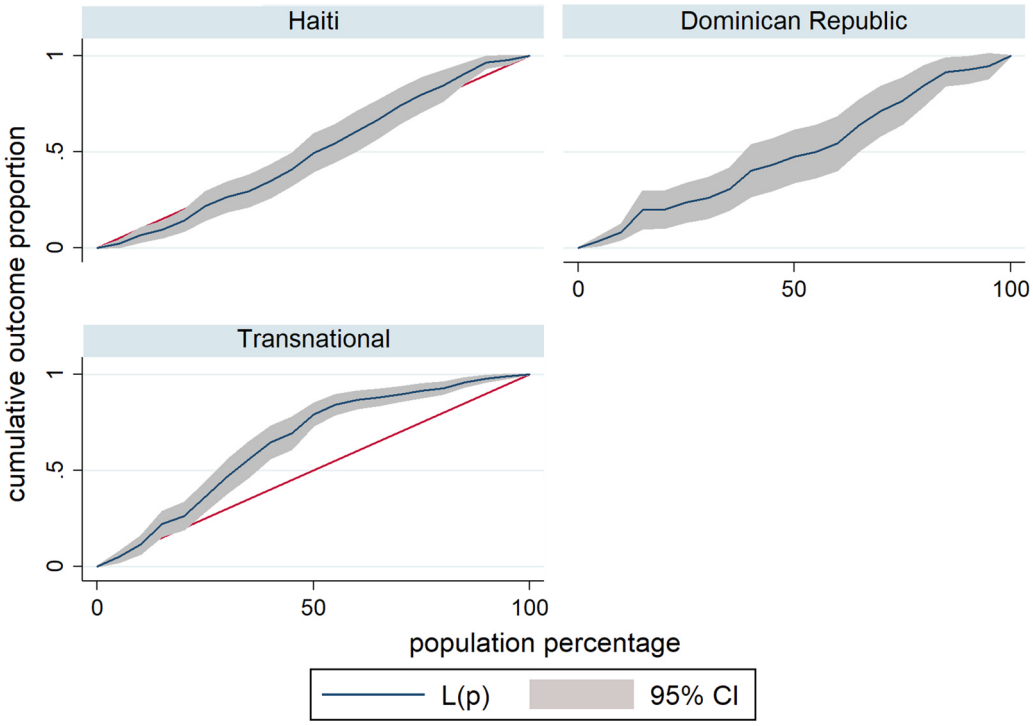


Fig. 4. Wave five wasting concentration curves for Haiti, Dominican Republic, and transnational samples.

absolute wealth, and inequalities in both wealth and health. A researcher could conclude, for example, that wealth-related inequalities in wasting had gone from very low levels in wave three to non-existent in waves five and six using country-by-country comparisons. However, using a transnational sample, the large inequalities primarily driven by country of residence and subregion become clear. Complex distributions of disease can also be made clear, as demonstrated by HIV prevalence in waves five and six. Rather than simply finding that richer Haitians and poorer Dominicans are more likely to be HIV prevalent, a picture emerges of relatively "middle class" urban residents of Hispaniola having an elevated risk of infection. Even attempting to consider the relative distribution of wealth seen in Fig. 1 would be impossible if country-by-country methods were used.

Examining the change in health inequalities from wave to wave clearly reveals the hidden effects we hypothesized in our simulated data. Changes in wasting inequalities from wave five to wave six, for example, would lead a researcher believe that since wealth-related inequalities had increased in both countries, the overall inequality must

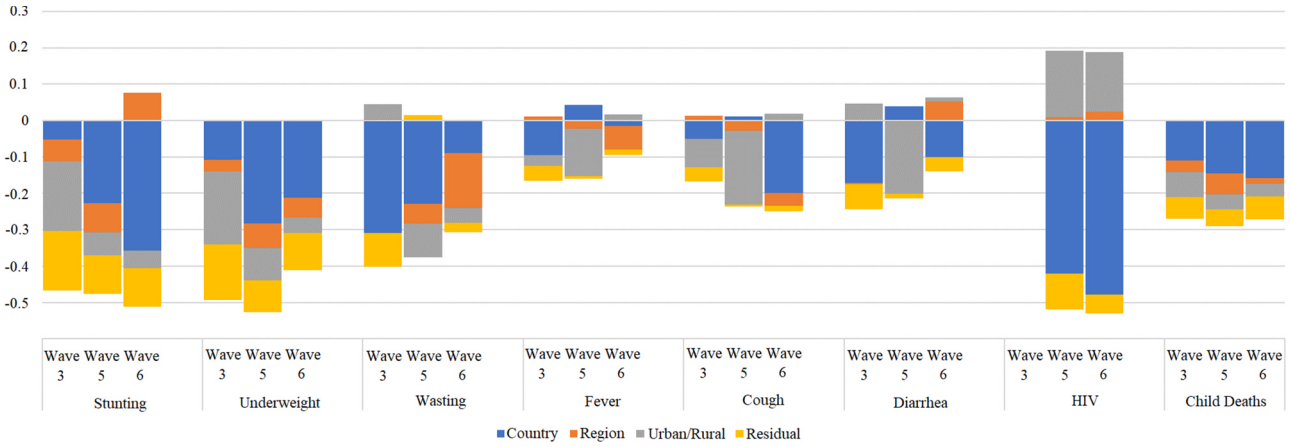


Fig. 5. Concentration index decompositions for every wave and outcome.

have increased using country-by-country methods. In spite of this, there was actually a substantial decrease in transnational inequality primarily due to error #1 identified in the simulated survey data. Just as significantly, changes in stunting, underweight, and wasting from wave three to five would have led a country-by-country researcher to a somewhat mixed conclusion. Wealth-related inequalities had decreased significantly in the Dominican Republic for each outcome, while there was either a decrease, an increase, or no change in inequalities in Haiti. This would have led a researcher to the uncertain but tempting country-by-country conclusion that inequality had probably been reduced overall. Despite this appearance, the transnational approach reveals that overall inequality had actually increased due to a combination of factors, including larger between-country income inequality and larger reductions in absolute prevalence in the richer country. When considering the overall picture of changes in the distribution of health and wealth over time in Hispaniola, these findings are unsurprising, however had a country-by-country approach been undertaken, they would have been completely overlooked.

The limitations of these findings mostly relate to survey data methods and difficulties in comparing data across national boundaries. Some health outcomes may be affected by recall or other biases inherent in survey methodology, but half of the outcomes presented are physically measured or lab tested, allowing for apples-to-apples comparisons between countries. It is possible that household assets are valued differently or are of different quality between Haiti and the Dominican Republic, meaning that direct comparisons of these assets would not be appropriate. Wealth indices, whether they are calculated using PCA or not, are not equivalent to household expenditure or income (Howe et al., 2009). This does not mean that the indices are any less valid, but rather that a separate dimension of SES is being measured. In fact, the greater stability over time, potential causal pathways from assets to health outcomes, and direct comparability between countries give wealth indices several advantages over measures based on national currencies or purchasing power parity equivalents. These advantages have even led to promising research assigning an estimated national income distribution according to each household's relative asset index ranking, developed at least in part to address transnational SES measurement issues (Harttgen & Vollmer, 2013; Joseph, da Silva, Fink, Barros, & Victora, 2018). The effect of divergent country-level wealth and disease prevalence is large due to the extreme case selection method used in this study, however, there are many other countries which would likely produce similar results. The results should not be taken to be generalizable to any other contexts due to the case selection method, therefore, and further study should be conducted to reveal whether these trends are echoed in other regions of the world. Although the methods described are theoretically applicable in any country, household asset data are not routinely collected in more wealthy regions such as Europe, meaning that our findings are most applicable to low- and middle-income countries.

The transnational approach is informed by the rapidly growing field of global income and wealth inequality measurement, which primarily utilizes internationally standardized household surveys as data sources and inequality measures such as the Gini index and generalized entropy measures – tools and data sources which have direct analogues in the field of health. Although it has been a topic of theoretical discussion for well over a century, the first published empirical estimation of global income distribution (Milanovic, 2002) was only possible after the widespread implementation of household surveys in the developing world. Global income distribution estimates have since become more comprehensive, both in terms of population and years covered, and have been reinforced through the use of different methodologies and data sources (Darvas, 2016; Lakner & Milanovic, 2013). This research has begun to provide evidence that the within- and between- country composition of inequality changes over time and is sensitive to policy change and technological change. Additionally, research into the political geography of wealth inequality has begun to produce insights into the complex political and economic determinants of inequalities at different scales of analysis (Beramendi, 2012).

Building upon these theoretical foundations, the results of this empirical demonstration of transnational wealth-related health inequality analysis demonstrate the utility and validity of the approach in hopes of inspiring further research at this new scale. Transnational health inequality composition effects such as the divergent child death ratio and HIV status decompositions may point to new hypotheses regarding the determinants of these outcomes at a level not restricted by national boundaries, and clearly have implications for policies meant to address these disparities. Policymakers deciding how to allocate scarce resources at both national and international levels should be informed by empirical research to know which administrative levels to target with health interventions in order to have the greatest impact. In addition, decomposition of the geographic distribution of health outcomes is only one possible use of this approach. Analysis of specific infectious diseases which are endemic to a transnational region could benefit from pooling of data, and groupings of subregions according to primary economic activity or ecologic characteristics offer yet another avenue of research. The many possible applications of transnational health inequality analysis should be of interest to global health researchers, multilateral agencies, and all parties involved in measuring progress in achieving the SDG.

Measuring inequality is not a mere quantitative exercise – it is an actualization of normative judgements. Decisions on whether to use relative versus absolute differences in wealth and which population to

use as a reference point all imply normative judgements – whether they are acknowledged or not (Harper et al., 2010). By ignoring the transnational dimensions of wealth-related health inequalities using a country-by-country approach, the normative position has been to essentially to ignore these differences, or at least outside of the scope of policy. This effect is the result of a well-known process within political science by which the act of measuring itself creates political communities and heavily influences which issues reach the governmental agenda of policymakers (Kingdon, 2003; Stone, 2012). If transnational inequalities in health outcomes targeted by the SDG are politically determined – a hypothesis for which there is much supporting evidence (Ottersen et al., 2014) – then a first step towards a recognition of this pathway is rigorous analysis of the best available data to ensure that we are overlooking hidden dimensions of global health inequalities through inadequate methodology.

Appendix

See Appendix Tables 1–12 and Figs. 1,2.

Ethics approval

Ethics approval is not required for this paper. We used only secondary, publicly available and deidentified DHS data in analysis and no primary human subject data was collected.

Declarations of interest

None.

Role of the funding source

There is no funding source associated with this research.

Appendix Table 1
Concentration indices for simulated survey data.

Variable modified	Direction of modification	Poorer country concentration index	Richer country concentration index	Country-by-country conclusion	Transnational concentration index
None (reference concentration index)		-0.087	-0.132	-0.109	-0.160
Health inequality between countries	Convergence (poor reduces disease prevalence more than rich country)	-0.095	-0.132	-0.113	-0.147
	Divergence (rich reduces disease prevalence more than poor country)	-0.087	-0.151	-0.119	-0.191
Income inequality between countries	Convergence (poor catches up to rich)	-0.087	-0.132	-0.109	-0.150
	Divergence (rich becomes even wealthier than poor)	-0.087	-0.132	-0.109	-0.157
Health inequality within countries	Decrease in richer country	-0.087	-0.045	-0.066	-0.106
	Increase in richer country	-0.087	-0.356	-0.222	-0.268
	Decrease in poorer country	-0.039	-0.132	-0.085	-0.119
	Increase in poorer country	-0.149	-0.132	-0.140	-0.218
Income inequality within countries	Decrease in richer country	-0.087	-0.121	-0.104	-0.156
	Increase in richer country	-0.087	-0.132	-0.109	-0.157
	Decrease in poorer country	-0.080	-0.132	-0.106	-0.156
	Increase in poorer country	-0.087	-0.132	-0.109	-0.157

Appendix Table 2
Description of DHS variables used for child health outcomes[a].

Dataset Used	Variables	Variable Descriptions	Notes
Children's Recode	h22	Has child had a fever in the last two weeks?	
Children's Recode	h31	Has child had a cough in the last two weeks?	
Children's Recode	h11	Has child had diarrhea in the last two weeks?	
Children's Recode	hw8	Weight-for-age Z-score (WAZ)	WAZ < -2 SD* = Underweight
Children's Recode	hw5	Height-for-age Z-score (HAZ)	HAZ < -2 SD* = Stunting
Children's Recode	hw11	Weight-for-height Z-score (WHZ)	WHZ < -2 SD* = Wasting
HIV Dataset	hiv03	Blood test result	Available for waves 5 and 6 only
Individual's Recode	v201, v206, v207	Total children ever born, sons who have died, daughters who have died	(v206 + v207)/v201 = Ratio of child deaths to live births

[a] SD = Standard Deviations.

Appendix Table 3
Spearman's rho for all wealth indices.

Wave 6					
		Polychoric PCA	PCA	DHS Haiti Score	DHS DR Score
Polychoric PCA	rho	1			
	obs	24252			
PCA	rho	0.9728	1		
	obs	23587	23621		
DHS Haiti Score	rho	0.8771	0.9001	1	
	obs	13157	13178	13181	
DHS DR Score	rho	0.9022	0.9203		1
	obs	11095	10443		11464
Wave 5					
		Polychoric PCA	PCA	DHS Haiti Score	DHS DR Score
Polychoric PCA	rho	1			
	obs	39849			
PCA	rho	0.9745	1		
	obs	39849	39988		
DHS Haiti Score	rho	0.8965	0.8069	1	
	obs	9915	9953	9997	
DHS DR Score	rho	0.9462	0.9003		1
	obs	29934	30035		32431
Wave 3					
rho	0.9701				
obs	12882				

Appendix Table 4
Wave Three Children's Summary Statistics.

Dominican Republic	**Age (months)**	**Stunting**	**Wasting**	**Underweight**	**Diarrhea**	**Cough**	**Fever**	**PCA**	**Polychoric PCA**
mean	29.4	0.131	0.016	0.078	0.170	0.417	0.298	0.385	0.105
se(mean)	0.26	0.006	0.002	0.004	0.006	0.008	0.007	0.029	0.020
N	4413	3739	3740	3739	4288	4288	4285	4219	4219
min	0	0	0	0	0	0	0	-3.976	-3.452
max	59	1	1	1	1	1	1	4.764	3.230
Haiti	**Age (months)**	**Stunting**	**Wasting**	**Underweight**	**Diarrhea**	**Cough**	**Fever**	**PCA**	**Polychoric PCA**
mean	29.3	0.316	0.078	0.274	0.282	0.526	0.411	-1.693	-1.286
se(mean)	0.31	0.009	0.005	0.009	0.008	0.009	0.009	0.026	0.016
N	3208	2740	2753	2740	3113	3099	3099	3542	3542
min	0	0	0	0	0	0	0	-4.259	-3.150
max	59	1	1	1	1	1	1	4.336	2.777
Total	**Age (months)**	**Stunting**	**Wasting**	**Underweight**	**Diarrhea**	**Cough**	**Fever**	**PCA**	**Polychoric PCA**
mean	29.4	0.209	0.042	0.161	0.217	0.463	0.346	-0.563	-0.530
se(mean)	0.20	0.005	0.002	0.005	0.005	0.006	0.006	0.023	0.015
N	7621	6479	6493	6479	7401	7387	7384	7761	7761
min	0	0	0	0	0	0	0	-4.259	-3.452
max	59	1	1	1	1	1	1	4.764	3.230

Appendix Table 5
Wave Three Individual's Summary Statistics.

Dominican Republic	**Age**	**Death Ratio**	**PCA**	**Polychoric PCA**
mean	28.8	0.064	1.039	0.584
se(mean)	0.10	0.002	0.021	0.014
N	8422	5942	7925	7925
min	15	0	-3.976	-3.452
max	49	1	4.884	3.230
Haiti	**Age**	**Death Ratio**	**PCA**	**Polychoric PCA**
mean	28.0	0.147	-1.061	-0.854
se(mean)	0.13	0.004	0.025	0.016
N	5356	3288	5335	5335
min	15	0	-4.259	-3.150
max	49	1	4.681	2.854
Total	**Age**	**Death Ratio**	**PCA**	**Polychoric PCA**
mean	28.5	0.094	0.194	0.005
se(mean)	0.08	0.002	0.018	0.012
N	13778	9230	13260	13260
min	15	0	-4.259	-3.452
max	49	1	4.884	3.230

Appendix Table 6
Wave Five Children's Summary Statistics.

Dominican Republic	**Age (months)**	**Stunting**	**Wasting**	**Underweight**	**Diarrhea**	**Cough**	**Fever**	**PCA**	**Polychoric PCA**
mean	29.8	0.083	0.017	0.047	0.167	0.287	0.224	0.795	0.256
se(mean)	0.17	0.003	0.001	0.002	0.004	0.004	0.004	0.018	0.013
N	10038	9255	9264	9255	10587	10606	10570	10276	10236
min	0	0	0	0	0	0	0	-7.158	-4.782
max	59	1	1	1	1	1	1	3.907	3.256
Haiti	**Age (months)**	**Stunting**	**Wasting**	**Underweight**	**Diarrhea**	**Cough**	**Fever**	**PCA**	**Polychoric PCA**
mean	27.7	0.245	0.083	0.216	0.222	0.462	0.262	-3.405	-2.629
se(mean)	0.34	0.009	0.005	0.008	0.006	0.007	0.006	0.029	0.019
N	2620	2536	2538	2536	5470	5477	5468	5985	5964
min	0	0	0	0	0	0	0	-7.899	-5.285
max	59	1	1	1	1	1	1	3.773	2.864
Total	**Age (months)**	**Stunting**	**Wasting**	**Underweight**	**Diarrhea**	**Cough**	**Fever**	**PCA**	**Polychoric PCA**
mean	29.3	0.118	0.031	0.083	0.186	0.347	0.237	-0.751	-0.806
se(mean)	0.16	0.003	0.002	0.003	0.003	0.004	0.003	0.022	0.015
N	12658	11791	11802	11791	16057	16083	16038	16261	16200
min	0	0	0	0	0	0	0	-7.899	-5.285
max	59	1	1	1	1	1	1	3.907	3.256

Appendix Table 7
Wave Five Individual's Summary Statistics.

Dominican Republic	**Age**	**Death Ratio**	**HIV Positive**	**PCA**	**Polychoric PCA**
mean	29.7	0.041	0.008	1.237	0.666
se(mean)	0.06	0.001	0.001	0.011	0.008
N	27195	19541	25452	25771	25676
min	15	0	0	-7.158	-4.782
max	49	1	1	3.987	3.413
Haiti	**Age**	**Death Ratio**	**HIV Positive**	**PCA**	**Polychoric PCA**
mean	28.2	0.101	0.025	-2.708	-2.075
se(mean)	0.10	0.002	0.002	0.024	0.016
N	10757	6547	5224	10709	10651
min	15	0	0	-7.899	-5.285
max	49	1	1	3.828	2.969
Total	**Age**	**Death Ratio**	**HIV Positive**	**PCA**	**Polychoric PCA**
mean	29.2	0.056	0.011	0.079	-0.138
se(mean)	0.05	0.001	0.001	0.014	0.010
N	37952	26088	30676	36480	36327
min	15	0	0	-7.899	-5.285
max	49	1	1	3.987	3.413

Appendix Table 8
Wave Six Children's Summary Statistics.

Dominican Republic	**Age (months)**	**Stunting**	**Wasting**	**Underweight**	**Diarrhea**	**Cough**	**Fever**	**PCA**	**Polychoric PCA**
mean	29.2	0.053	0.019	0.051	0.179	0.280	0.233	2.131	1.196
se(mean)	0.3	0.004	0.002	0.004	0.006	0.008	0.007	0.027	0.018
N	3387	3090	3188	3188	3560	3568	3570	3337	3580
min	0	0	0	0	0	0	0	-3.634	-3.348
max	59	1	1	1	1	1	1	4.966	3.961
Haiti	**Age (months)**	**Stunting**	**Wasting**	**Underweight**	**Diarrhea**	**Cough**	**Fever**	**PCA**	**Polychoric PCA**
mean	27.4	0.179	0.045	0.150	0.214	0.526	0.284	-2.181	-1.639
se(mean)	0.3	0.006	0.003	0.006	0.005	0.006	0.006	0.022	0.014
N	4074	3967	3968	3968	6598	6596	6617	7247	7240
min	0	0	0	0	0	0	0	-5.822	-4.221
max	59	1	1	1	1	1	1	4.824	3.465
Transnational	**Age (months)**	**Stunting**	**Wasting**	**Underweight**	**Diarrhea**	**Cough**	**Fever**	**PCA**	**Polychoric PCA**
mean	28.2	0.124	0.034	0.106	0.202	0.440	0.266	-0.822	-0.701
se(mean)	0.2	0.004	0.002	0.004	0.004	0.005	0.004	0.026	0.017
N	7461	7057	7156	7156	10158	10164	10187	10584	10820
min	0	0	0	0	0	0	0	-5.822	-4.221
max	59	1	1	1	1	1	1	4.966	3.961

Appendix Table 9
Wave Six Individual's Summary Statistics.

Dominican Republic	**Age**	**Death Ratio**	**HIV**	**PCA**	**Polychoric PCA**
mean	29.8	0.039	0.009	2.458	1.435
se(mean)	0.10	0.002	0.001	0.015	0.011
N	9372	6687	8897	8804	9180
min	15	0	0	-4.258	-3.348
max	49	1	1	5.039	3.961
Haiti	**Age**	**Death Ratio**	**HIV**	**PCA**	**Polychoric PCA**
mean	28.1	0.089	0.027	-1.602	-1.276
se(mean)	0.08	0.002	0.002	0.017	0.011
N	14287	8671	9326	14286	14249
min	15	0	0	-5.860	-4.221
max	49	1	1	5.495	3.465
Total	**Age**	**Death Ratio**	**HIV**	**PCA**	**Polychoric PCA**
mean	28.8	0.067	0.018	-0.054	-0.214
se(mean)	0.06	0.001	0.001	0.018	0.012
N	23659	15358	18223	23090	23429
min	15	0	0	-5.860	-4.221
max	49	1	1	5.495	3.961

Appendix Table 10
Decomposition of concentration indices for wave six[a].

	Stunting	Underweight	Wasting	Fever	Cough	Diarrhea	Death Ratio	HIV
Country elasticity	-0.805	-0.483	-0.215	-0.021	-0.241	-0.166	-0.358	-1.301
Country concentration index	0.444	0.438	0.411	0.652	0.824	0.608	0.442	0.367
Country contribution	**-0.357**	**-0.212**	**-0.088**	**-0.014**	**-0.199**	**-0.101**	**-0.158**	**-0.478**
Country percentage contribution	0.911	0.514	0.289	0.179	0.857	1.332	0.581	1.394
Urban/Rural elasticity	0.388	0.352	0.352	-0.115	-0.096	-0.077	0.134	-0.247
Urban/Rural concentration index	-0.123	-0.122	-0.114	-0.150	-0.190	-0.141	-0.110	-0.099
Urban/Rural contribution	**-0.048**	**-0.043**	**-0.040**	**0.017**	**0.018**	**0.011**	**-0.015**	**0.024**
Urban/Rural percentage contribution	0.122	0.104	0.131	-0.222	-0.079	-0.143	0.054	-0.071
Contribution of regional fixed effects	**0.077**	**-0.055**	**-0.152**	**-0.066**	**-0.036**	**0.052**	**-0.035**	**0.165**
percentage contribution of regional fixed effects	-0.178	0.133	0.495	0.844	0.153	-0.693	0.128	-0.481
residual	**-0.107**	**-0.103**	**-0.026**	**-0.016**	**-0.016**	**-0.038**	**-0.065**	**-0.054**

[a] Bolded numbers are the primary outcomes, representing each variable's contribution to the concentration index. Elasticity, variable-specific concentration index, and percentage contribution are presented for as supporting information.

Appendix Table 11
Decomposition of concentration indices for wave five[a].

	Stunting	Underweight	Wasting	Fever	Cough	Diarrhea	Death Ratio	HIV
Country elasticity	-0.600	-0.766	-0.663	0.070	0.015	0.069	-0.343	-1.508
Country concentration index	0.379	0.370	0.345	0.622	0.761	0.581	0.423	0.279
Country contribution	**-0.227**	**-0.283**	**-0.229**	**0.043**	**0.012**	**0.040**	**-0.145**	**-0.421**

(*continued on next page*)

Appendix Table 11 (*continued*)

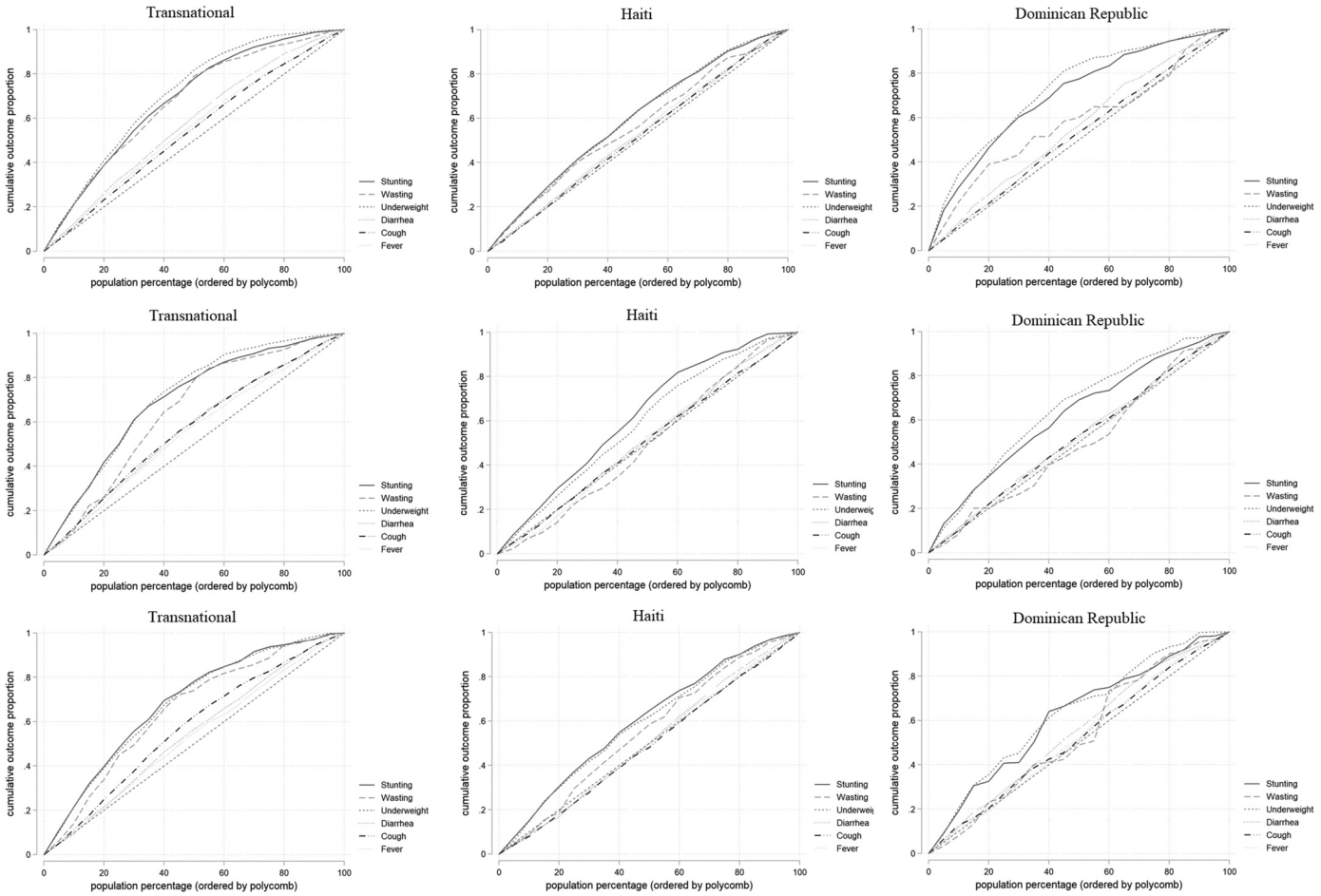
	Stunting	Underweight	Wasting	Fever	Cough	Diarrhea	Death Ratio	HIV
Country percentage contribution	0.477	0.538	0.635	-0.374	-0.052	-0.230	0.499	1.283
Urban/Rural elasticity	0.627	0.536	0.463	0.140	0.154	0.030	0.476	-0.087
Urban/Rural concentration index	-0.128	-0.124	-0.116	-0.152	-0.186	-0.142	-0.119	-0.106
Urban/Rural contribution	**-0.080**	**-0.067**	**-0.054**	**-0.021**	**-0.029**	**-0.004**	**-0.057**	**0.009**
Urban/Rural percentage contribution	0.168	0.127	0.149	0.184	0.128	0.025	0.196	-0.028
Contribution of regional fixed effects	**-0.063**	**-0.090**	**-0.093**	**-0.132**	**-0.203**	**-0.197**	**-0.042**	**0.182**
percentage contribution of regional fixed effects	0.132	0.171	0.257	1.137	0.902	1.137	0.144	-0.556
residual	**-0.107**	**-0.087**	**0.015**	**-0.006**	**-0.005**	**-0.012**	**-0.047**	**-0.099**

[a] Bolded numbers are the primary outcomes, representing each variable's contribution to the concentration index. Elasticity, variable-specific concentration index, and percentage contribution are presented for as supporting information.

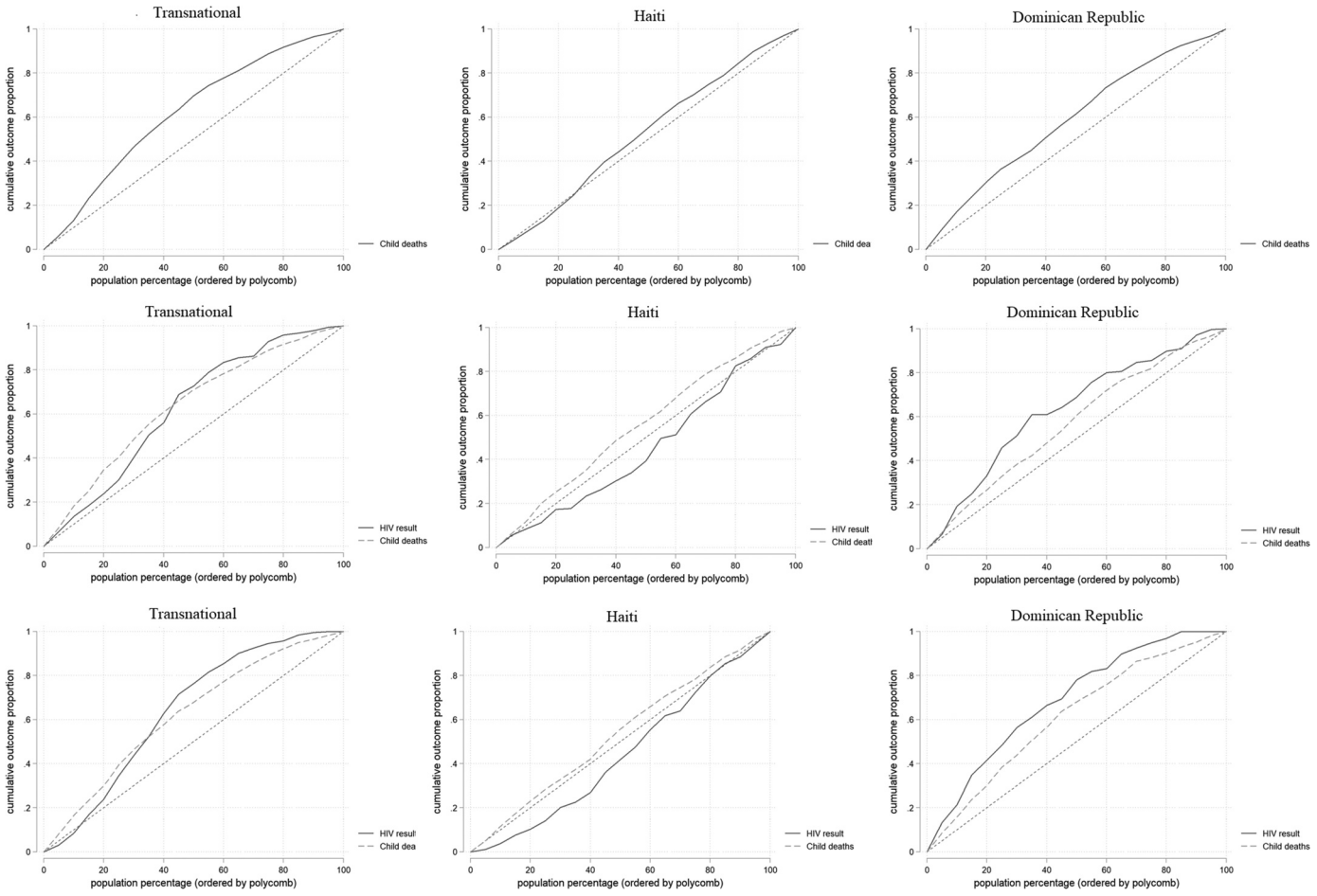
Appendix Table 12
Decomposition of concentration indices for wave three[a].

	Stunting	Underweight	Wasting	Fever	Cough	Diarrhea	Death Ratio
Country elasticity	-0.104	-0.225	-0.744	-0.156	-0.069	-0.337	-0.291
Country concentration index	0.505	0.477	0.414	0.611	0.737	0.506	0.378
Country contribution	**-0.052**	**-0.107**	**-0.308**	**-0.095**	**-0.051**	**-0.171**	**-0.110**
Country percentage contribution	0.112	0.217	0.862	0.619	0.326	0.864	0.409
Urban/Rural elasticity	0.474	0.272	-0.034	-0.069	-0.069	0.027	0.266
Urban/Rural concentration index	-0.125	-0.118	-0.102	-0.156	-0.188	-0.130	-0.118
Urban/Rural contribution	**-0.059**	**-0.032**	**0.003**	**0.011**	**0.013**	**-0.004**	**-0.031**
Urban/Rural percentage contribution	0.127	0.065	-0.010	-0.070	-0.084	0.018	0.116
Contribution of regional fixed effects	**-0.192**	**-0.201**	**0.041**	**-0.030**	**-0.078**	**0.047**	**-0.070**
percentage contribution of regional fixed effects	0.411	0.407	-0.115	0.194	0.505	-0.238	0.260
residual	**-0.164**	**-0.154**	**-0.094**	**-0.040**	**-0.039**	**-0.070**	**-0.058**

[a] Bolded numbers are the primary outcomes, representing each variable's contribution to the concentration index. Elasticity, variable-specific concentration index, and percentage contribution are presented for as supporting information.



Appendix Fig. 1. Original PCA and Polychoric PCA Comparison.



Appendix Fig. 2. Spline Interpolation and Kriging Comparison.

References

Allanson, P. (2017). Monitoring income-related health differences between regions in Great Britain: A new measure for ordinal health data. *Soc Sci Med, 175*, 72–80. https://doi.org/10.1016/j.socscimed.2016.12.033.

Allin, S. (2008). Does equity in healthcare use vary across Canadian provinces? *Healthc Policy, 3*, 83–99.

Arsenault, C., Harper, S., Nandi, A., Rodríguez, J. M. M., Hansen, P. M., & Johri, M. (2017). An equity dashboard to monitor vaccination coverage. *Bull World Health Organ, 95*, 128–134. https://doi.org/10.2471/BLT.16.178079.

Auchincloss, A. H., Diez Roux, A. V., Brown, D. G., Raghunathan, T. E., & Erdmann, C. A. (2007). Filling the gaps: spatial interpolation of residential survey data in the estimation of neighborhood characteristics. *Epidemiology, 18*, 469–478.

Auchincloss, A. H., Gebreab, S. Y., Mair, C., & Diez Roux, A. V. (2012). A review of spatial methods in epidemiology, 2000–2010. *Annu Rev Public Heal, 33*, 107–122.

Bärnighausen, T., Bor, J., Wandira-Kazibwe, S., & Canning, D. (2011). Correcting HIV prevalence estimates for survey nonparticipation using Heckman-type selection models. *Epidemiology, 22*, 27–35. https://doi.org/10.1097/EDE.0b013e3181ffa201.

Beramendi, P. (2012). *The Political Geography of Inequality*. Cambridge University Press (https://doi.org/10.1017/CBO9781107415324.004).

Bollen, K. A., Glanville, J. L., & Stecklov, G. (2002). Economic status proxies in studies of fertility in developing countries: Does the measure matter? *Popul Stud (NY), 56*, 81–96. https://doi.org/10.1080/00324720213796.

Burke, M., Heft-Neal, S., & Bendavid, E. (2016). Sources of variation in under-5 mortality across sub-Saharan Africa: A spatial analysis. *Lancet Glob Heal, 4*, e936–e945. https://doi.org/10.1016/S2214-109X(16)30212-1.

Cardona, D., Acosta, L. D., & Bertone, C. L. (2013). Inequidades en salud entre países de Latinoamérica y el Caribe (2005–2010). *Gac Sanit, 27*, 292–297. https://doi.org/10.1016/j.gaceta.2012.12.007.

Chalasani, S. (2012). Understanding wealth-based inequalities in child health in India: A decomposition approach. *Soc Sci Med, 75*, 2160–2169. https://doi.org/10.1016/j.socscimed.2012.08.012.

Corsi, D. J., Neuman, M., Finlay, J. E., & Subramanian, S. V. (2012). Demographic and health surveys: A profile. *Int J Epidemiol, 41*, 1602–1613. https://doi.org/10.1093/ije/dys184.

Danquah, L., Polack, S., Brus, A., Mactaggart, I., Houdon, C. P., Senia, P., Gallien, P., & Kuper, H. (2015). Disability in post-earthquake Haiti: Prevalence and inequality in access to services. *Disabil Rehabil, 37*, 1082–1089. https://doi.org/10.3109/09638288.2014.956186.

Darvas, Z. (2016). *Some are more equal than others: New estimates of global and regional inequality (No. 8)*. Brussels: Bruegel Working Papers.

Erreygers, G. (2009). Correcting the Concentration Index. *J Health Econ, 28*, 504–515. https://doi.org/10.1016/j.jhealeco.2008.02.003.

Erreygers, G., & Ourti, T. Van (2012). Measuring socioeconomic inequality in health, health care and health financing by means of rank-dependent indices: A recipe for good practice. *J Heal Econ, 29*, 997–1003. https://doi.org/10.1016/j.biotechadv.2011.08.021.Secreted.

Fenn, B., Kirkwood, B. R., Popatia, Z., & Bradley, D. J. (2007). Inequities in neonatal survival interventions: Evidence from national surveys. *Arch Dis Child Fetal Neonatal Ed, 92*, F361–F366. https://doi.org/10.1136/adc.2006.104836.

Filmer, D., & Scott, K. (2012). Assessing asset indices. *Demography, 49*, 359–392. https://doi.org/10.1007/s13524-011-0077-5.

Filmer, D., & Pritchett, L. H. (2001). Estimating wealth effects without expenditure data - or tears: an application to educational enrollment in states of India. *Demography, 38*, 115–132. https://doi.org/10.1353/dem.2001.0003.

Fortson, J. G. (2008). The Gradient in Sub-Saharan Africa: Socioeconomic Status and HIV/AIDS. *Demography, 45*, 303–322.

Gakidou, E., King, G. (2000). An individual-level approach to health inequality: child survival in 50 countries (No. 18), GPE Discussion Paper Series.

GBD 2015 SDG Collaborators (2016). Measuring the health-related Sustainable Development Goals in 188 countries: A baseline analysis from the Global Burden of Disease Study 2015. *Lancet, 6736*, 1–38. https://doi.org/10.1016/S0140-6736(16)31467-2.

Goesling, B., & Firebaugh, G. (2004). The Trend in International Health Inequality. *Popul Dev Rev, 30*, 131–146. https://doi.org/10.1111/j.1728-4457.2004.00006.x.

Gwatkin, D. R., Rutstein, S., Johnson, K., Suliman, E., Wagstaff, A., & Amouzou, A. (2007). *Socio-economic differences in health, nutrition, and population within developing countries* (Country Reports on HNP and Poverty)The World Bank.

Gwatkin, D. R., Rutstein, S., Johnson, K., Suliman, E., Wagstaff, A., & Amouzou, A. (2007a). *Socio-Economic Differences in Health, Nutrition, and Population: Haiti*. The World Bank.

Gwatkin, D. R., Rutstein, S., Johnson, K., Suliman, E., Wagstaff, A., & Amouzou, A. (2007b). *Socio-Economic Differences in Health, Nutrition, and Population: Dominican Republic*. The World Bank.

Harper, S., King, N. B., Meersman, S. C., Keichman, M. E., Breen, N., & Lynch, J. (2010). Implicit value judgements in the measurement of health inequalities. *Milbank*

Quarterly, 88, 4–38. https://doi.org/10.1111/j.1468-0009.2008.00538.x.
Harttgen, K., & Vollmer, S. (2013). Using an asset index to simulate household income. *Econ Lett, 121*, 257–262. https://doi.org/10.1016/j.econlet.2013.08.014.
Hosseinpoor, A. R., & Bergen, N. (2016). Area-based units of analysis for strengthening health inequality monitoring. *Bull World Health Organ, 94*, 856–858. https://doi.org/10.2471/BLT.15.165266.
Hosseinpoor, A. R., Bergen, N., Barros, A. J. D., Wong, K. L. M., Boerma, T., & Victora, C. G. (2016). Monitoring subnational regional inequalities in health: Measurement approaches and challenges. *Int J Equity Health, 15*, 18. https://doi.org/10.1186/s12939-016-0307-y.
Howe, L. D., Hargreaves, J. R., Gabrysch, S., & Huttly, S. Ra (2009). Is the wealth index a proxy for consumption expenditure? A systematic review. *J Epidemiol Community Health, 63*, 871–877. https://doi.org/10.1136/jech.2009.088021.
ICF International (2012). Demographic and Health Surveys Sampling and Household Listing Manual. Calverton, Maryland.
Jimenez-Rubio, D., Smith, P. C., & van Doorslaer, E. (2008). Equity in health and health care in a decentralized context: evidence from Canada. *Health Econ, 17*, 377–392. https://doi.org/10.1002/hec.
Joseph, G., da Silva, I. C. M., Fink, G., Barros, A. J. D., & Victora, C. G. (2018). Absolute income is a better predictor of coverage by skilled birth attendance than relative wealth quintiles in a multicountry analysis: Comparison of 100 low- and middle-income countries. *BMC Pregnancy Childbirth, 18*. https://doi.org/10.1186/s12884-018-1734-0.
Kakwani, N., Wagstaff, A., & van Doorslaer, E. (1997). Socioeconomic inequalities in health: Measurement, computation, and statistical inference. *J Econom, 77*, 87–103.
Kazembe, L. N., & Mpeketula, P. M. G. (2010). Quantifying spatial disparities in neonatal mortality using a structured additive regression model. *PLoS One, 5*, e11180. https://doi.org/10.1371/journal.pone.0011180.
Kingdon, J. W. (2003). *Agendas, Alternatives, and Public Policies* (2nd ed.). New York, NY: HarperCollins College Publishers.
Kjellsson, G., & Gerdtham, U. G. (2013). On correcting the concentration index for binary variables. *J Health Econ, 32*, 659–670. https://doi.org/10.1016/j.jhealeco.2012.10.012.
Kolenikov, S., & Angeles, G. (2009). Socioeconomic status measurement with discrete proxy variables: Is principal component analysis a reliable answer? *Rev Income Wealth, 55*, 128–165. https://doi.org/10.1111/j.1475-4991.2008.00309.x.
Koolman, X., & van Doorslaer, E. (2004). On the interpretation of a concentration index of inequality. *Health Econ, 13*, 649–656. https://doi.org/10.1002/hec.884.
Lakner, C., & Milanovic, B. (2013). Global income distribution: From the fall of the Berlin Wall to the Great Recession. *World Bank Econ Rev,* 1–30. https://doi.org/10.1093/wber/lhv039.
Li, Z., Li, M., Subramanian, S. V., & Lu, C. (2017). Assessing levels and trends of child health inequality in 88 developing countries: From 2000 to 2014. *Glob Health Action, 10*, 1408385. https://doi.org/10.1080/16549716.2017.1408385.
Marmot, M. (2005). Public Health Social determinants of health inequalities. *Lancet, 365*, 1099–1104. https://doi.org/10.1016/S0140-6736(05)71146-6.
Marmot, M. G., Stansfeld, S., Patel, C., North, F., Head, J., White, I., Brunner, E., Feeney, A., Marmot, M. G., & Smith, G. D. (1991). Health inequalities among British civil servants: The Whitehall II study. *Lancet, 337*, 1387–1393. https://doi.org/10.1016/0140-6736(91)93068-K.
McGrail, K. M., van Doorslaer, E., Ross, N. A., & Sanmartin, C. (2009). Income-related health inequalities in Canada and the United States: A decomposition analysis. *American Journal of Public Health, 99*, 1856–1863. https://doi.org/10.2105/AJPH.2007.129361.
McKinnon, B., Harper, S., Kaufman, J. S., & Bergevin, Y. (2014). Socioeconomic inequality in neonatal mortality in countries of low and middle income: A multicountry analysis. *Lancet Glob Heal, 2*, e165–e173. https://doi.org/10.1016/S2214-109X(14)70008-7.
Milanovic, B. (2002). True World Income Distribution, 1988 and 1993: First Calculation Based on Household Surveys Alone. *Econ J, 112*, 51–92.
Mokdad, A. H., Gagnier, M. C., Colson, K. E., Zúñiga-Brenes, P., Ríos-Zertuche, D., Haakenstad, A., Palmisano, E. B., Anderson, B. W., Desai, S. S., Gillespie, C. W., Murphy, T., Naghavi, P., Nelson, J., Ranganathan, D., Schaefer, A., Usmanova, G., Wilson, S., Hernandez, B., Lozano, R., & Iriarte, E. (2015). Health and wealth in Mesoamerica: Findings from Salud Mesomérica 2015. *BMC Med, 13*, 164. https://doi.org/10.1186/s12916-015-0393-5.
Mújica, O. J., Vázquez, E., Duarte, E. C., & Cortez-Escalante, J. J. (2014). Socioeconomic inequalities and mortality trends in BRICS, 1990–2010. *Bull World Health Organ, 92*, 405–412. https://doi.org/10.2471/BLT.13.127977.
O'Donnell, O., van Doorslaer, E., Wagstaff, A., & Lindelow, M. (2008). *Analyzing Health Equity Using Household Survey Data; A Guide to Techniques and Their Implementation.* Washington, D.C: The World Bank.
Ottersen, O. P., Dasgupta, J., Blouin, C., Buss, P., Chongsuvivatwong, V., Frenk, J., Fukuda-parr, S., & Bank, W. (2014). The political origins of health inequity: Prospects for change. *Lancet,* 6736. https://doi.org/10.1016/S0140-6736(13)62407-1.
Paraje, G. (2009). Desnutrición crónica infantil y desigualdad socioeconómica. *Rev CEPAL,* 43–63.
Pradhan, M., Sahn, D. E., & Younger, S. D. (2003). Decomposing world health inequality. *J Health Econ, 22*, 271–293. https://doi.org/10.1016/S0167-6296(02)00123-6.
Pulok, M. H., Uddin, J., Enemark, U., & Hossin, M. Z. (2018). Socioeconomic inequality in maternal healthcare: An analysis of regional variation in Bangladesh. *Heal Place, 52*, 205–214. https://doi.org/10.1016/j.healthplace.2018.06.004.
Rutstein, S. O. (2008). *The DHS Wealth Index: Approaches for rural and urban areas.* Calverton, Maryland: Demographic and Health Survey Working Papers.
Sachs, J., Schmidt-Traub, G., Kroll, C., Durand-Delacre, D., & Teksoz, K. (2016). *SDG Index & Dashboards - Global Report.* New York: Bertelmann Stifung and Sustainable Development Solutions (SDSN).
Sahn, D. E., & Stifel, D. (2003). Exploring alternative measures of welfare in the absence of expenditure data. *Rev Income Wealth, 49*, 463–489. https://doi.org/10.1111/j.0034-6586.2003.00100.x.
Sahn, D. E., & Younger, S. D. (2006). Changes in Inequality and Poverty in Latin America: Looking beyond Income to Health and Education. *J Appl Econ, 9*, 215–233. 〈https://doi.org/http://www.cema.edu.ar/publicaciones/jae.html〉.
Seawright, J., & Gerring, J. (2008). Case selection techniques case study research options. *Polit Res Quarterly, 61*, 294–308.
Stone, D. (2012). *Policy Paradox: The Art of Political Decision Making* (3rd ed.). New York, NY: WW Norton & Company.
Strømme, E. M., & Norheim, O. F. (2017). Global health inequality: comparing inequality-adjusted life expectancy over time. *Public Health Ethics, 10*, 188–211. https://doi.org/10.1093/phe/phw033.
The World Bank (2017). *World Development Indicators [WWW Document]*. World Dev. Indic〈http://data.worldbank.org/data-catalog/world-development-indicators〉.
United Nations (2015). Transforming Our World: The 2030 Agenda For Sustainable Development, A/RES/70/1. 〈https://doi.org/10.1007/s13398-014-0173-7.2〉.
Van De Poel, E., Hosseinpoor, A. R., Speybroeck, N., Van Ourti, T., & Vega, J. (2008). Socioeconomic inequality in malnutrition in developing countries. *Bull World Health Organ, 86*, 282–291. https://doi.org/10.2471/BLT.07.044800.
Wagstaff, A. (2002a). Inequalities in health in developing countries: Swimming against the tide? *Policy Res Work Pap, 40*. https://doi.org/10.1596/1813-9450-2795.
Wagstaff, A. (2002b). Inequality aversion, health inequalities and health achievement. *J Health Econ, 21*, 627–641. https://doi.org/10.1016/S0167-6296(02)00006-1.
Wagstaff, A. (2005). The bounds of the concentration index when the variable of interest is binary, with an application to immunization inequality. *Health Econ, 14*, 429–432. https://doi.org/10.1002/hec.953.
Wagstaff, A., Bredenkamp, C., & Buisman, L. R. (2014). Progress on global health goals: Are the poor being left behind? *World Bank Res Obs,* 1–26. https://doi.org/10.1093/wbro/lku008.
Wagstaff, A., Paci, P., & van Doorslaer, E. (1991). On the measurement of inequalities in health. *Soc Sci Med, 33*, 545–557. https://doi.org/10.1016/0277-9536(91)90212-U.
Wang, L. (2003). Determinants of child mortality in LDCs: Empirical findings from demographic and health surveys. *Health Policy (New York), 65*, 277–299. https://doi.org/10.1016/S0168-8510(03)00039-3.