Public Health 193 (2021) 83–93

Contents lists available at ScienceDirect

Public Health

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

Original Research

Decomposition analysis of the compositional and contextual factors associated with poor-non-poor inequality in diarrhoea among under-five children in low- and middle-income countries

A.F. Fagbamigbe [a, b, *], O.P. Ologunwa [c], E.K. Afolabi [d], O.S. Fagbamigbe [e], A.O. Uthman [b]

[a] Department of Epidemiology and Medical Statistics, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan, Nigeria
[b] Division of Health Sciences, Populations, Evidence and Technologies Group, Warwick Medical School, University of Warwick, Coventry, United Kingdom
[c] Department of Economics, School of Management Technology, Federal University of Technology, Akure, Nigeria
[d] Department of Nursing Science, Faculty of Basic Medical Sciences, College of Health Sciences, Obafemi Awolowo University, Ile Ife, Nigeria
[e] Portsmouth Business School, Faculty of Business and Law, University of Portsmouth, Portsmouth, United Kingdom

ARTICLE INFO

Article history:
Received 15 June 2020
Received in revised form
8 December 2020
Accepted 17 December 2020
Available online 18 March 2021

Keywords:
Diarrhoea
Wealth inequalities
Fairlie decomposition
Risk difference
Low- and middle-income countries
Pro-poor inequality

ABSTRACT

Objectives: The aim of the study was to assess the magnitude of wealth inequalities in the development of diarrhoea among under-five children in low- and middle-income countries (LMICs) and to identify and quantify contextual and compositional factors' contribution to the inequalities.
Design: This is a cross-sectional study.
Methods: We used cross-sectional data from 57 Demographic and Health Surveys conducted between 2010 and 2018 in LMICs. Descriptive statistics were used to understand the gap in having diarrhoea between the children from poor and non-poor households and across the selected covariates using Fairlie decomposition techniques with multivariable binary logistic regressions at $P = 0.05$.
Results: Of the 57 countries, we found a statistically significant pro-poor odds ratio in only 29 countries, 7 countries showed pro-non-poor inequality and others showed no statistically significant inequality. Among the countries with statistically significant pro-poor inequality, the risk difference was largest in Cameroon (94.61/1000), whereas the largest pro-non-poor risk difference in diarrhoea was widest in Timor-Leste (−41.80/1000). Important factors responsible for pro-poor inequality varied across countries. The largest contributors to the pro-poor inequalities in having diarrhoea are maternal education, access to media, neighbourhood socio-economic status, place of residence, birth order and maternal age.
Conclusion: Diarrhoea remains a major challenge in most LMICs, with a wide range of pro-poor inequalities. These disparities were explained by both compositional and contextual factors, which varied widely across the countries. Thus, multifaceted geographically specific economic alleviation intervention may prove to be a potent approach for addressing the poor and non-poor differentials in the risk of diarrhoea with policies tailored to country-specific risk factors. There is a need for further investigation of factors that drive pro-non-poor inequalities found in 9 of the LMICs.

Introduction

Diarrhoea is one of the major causes of morbidity and mortality among children, particularly in low- and middle-income countries (LMICs).[1] It is the second leading cause of deaths among under-five children (U5C), after acute respiratory infections, particularly pneumonia.[2–6] Globally, it is estimated that about 1.7 billion episodes of childhood diarrhoeal disease occur annually and more than 700,000 of these cases result in preventable deaths.[2,5–7] Thus, diarrhoea, especially among U5C, constitutes a public health concern and is a major obstacle to the achievement of the

Abbreviations: BODA, Blinder-Oaxaca decomposition analysis; CI, confidence interval; DHS, Demographic and Health Survey; FDA, Fairlie decomposition analysis; IRB, Institutional Review Board; LMIC, low- and middle-income countries; OR, odds ratio; PSU, primary sample unit; RD, risk difference; SES, socio-economic status; U5C, under-five children; UNICEF, United Nations International Children's Emergency Fund; WHO, World Health Organization.

* Corresponding author. Department of Epidemiology and Medical Statistics, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan, Nigeria Tel.: +234806134865.
E-mail address: franstel74@yahoo.com (A.F. Fagbamigbe).

https://doi.org/10.1016/j.puhe.2020.12.009

Sustainable Development Goal (SDG) on the reduction of child mortality in LMICs.

Although the contest against diarrhoea among U5C was the subject of several international, national and regional interventions in LMICs, diarrhoea occurrence has persisted in these countries and the poor-rich divide may have widened.[8] It has been estimated that every child has at least 4 episodes of diarrhoea per year in South-east Asia and Africa.[4,9] High prevalence of diarrhoea, as high as 35%, has been reported across these regions, reaching with both seasonal fluctuations and spatial variations.[10] These regions constitute more than 90% of the LMICs.

Diarrhoea is considered a symptom of wider socio-economic inequality within and across populations.[11] Diarrhoea has long-term negative effects on individuals' countries' socio-economic development.[1] Income inequality had been existent for a long time and is regarded as a strong indicator of health uptake.[12] The wider the gap between the rich and the poor in a given area, the worse the health outcomes of that area, a phenomenon that may result in less social cohesion and greater psychosocial stress on the child's growth and well-being that has detrimental health implications among the vulnerable population.[13] Increase in socio-economic inequality has potential impact on the distribution of household- and regional-level determinants of child health outcomes, including diarrhoea.[14] Socio-economic inequalities in health persist among children from poorer regions and neighbourhoods because they have a higher likelihood of exposure to conditions that exacerbate health outcomes.[15]

Earlier studies have documented factors that significantly contributed to having diarrhoea among U5C.[11,13,16–19] These factors include childhood and maternal deprivation, environmental sanitation, maternal health-seeking behaviour and ethnicity diversity.[20] Dairo et al.[4] reported improper disposal of faeces and contaminated water and food as major risk factors of diarrhoea. These factors gave credence to the fact that most populations of the world, especially in LMICs, are still afflicted by poverty, poor sanitation and lack of hygiene.[21–23]

However, these studies have been limited in scope to regions, within-country and inter-district analysis. Besides, we are not aware of any study that focused on identifying compositional and contextual factors that contribute to wealth inequalities in having diarrhoea among U5C in LMICs as a whole, whereas a good understanding of the magnitude and determinants of wealth inequalities in the development of diarrhoea may help reduce these inequalities and prevent diarrhoea occurrences and in reaching the SDGs on reduction in child morbidity and mortality.[24] It is therefore imperative to understand the effect of poor-non-poor inequalities on diarrhoea and identify the drivers of the inequality in LMICs. Besides, the identification of these factors could help inform the focus, levels, direction and magnitude of interventions targeted at closing wealth-related gaps in the prevention of diarrhoea among U5C in LMICs.

The study objectives are to assess the magnitude of wealth inequalities in the development of diarrhoea among U5C in LMICs, identify the compositional and contextual factors that contribute to pro-poor inequalities and quantify the contributions of the significant factors to the inequalities. As postulated by Kumi-Kyereme and Amo-Adjei,[25] we hypothesised that children from poorer households will have a higher likelihood of developing childhood diarrhoea. The study outcomes will provide comparative and evidence-based information that will assist policymakers, program implementers and stakeholders in intervention strategies to address the effect of poor-non-poor inequalities in the development of diarrhoea in LMICs.

Methods

Study design and data

We used data from the Demographic and Health Surveys (DHSs) collected periodically across the LMICs.[26–30] The DHS is cross-sectional nationally representative population-based household surveys. We pooled data from the most recent successive DHS conducted within the last ten years (2010–2019) and available as of April 2020 when our data curation took place. In addition, the survey must have captured information on diarrhoea experience among U5C. Only 57 LMICs met this inclusion criterion and were thus analysed in this study. In each of the countries, the DHS used a multistage stratified sampling design (usually from states/divisions/regions to district to clusters). The households were then selected from the clusters that are the primary sampling units (PSUs).[31,32]

Dependent variable

The outcome variable in this study is the recent experience of diarrhoea. Diarrhoea is defined as 'passage of liquid stools three or more times a day'[33,34] and 'recent experience of diarrhoea' as having an episode of diarrhoea within two weeks before the interview date.[28] The mothers were asked to list their U5C. For each child, the mother was asked if the child had diarrhoea within two weeks preceding the survey. The responses were binary: yes or no.

Main determinant variable

The main determinate variable in this decomposition study is poverty: poor or non-poor. Owing to non-availability of data on participants' expenditures and incomes, the DHS recommended and used household asset ownership as a proxy for calculating household wealth status, which can then be interpreted as an indicator of children households' poverty status. The household wealth quintiles are computed as a composite score of assets owned by households.[35] Additional details of the methodologies and country-specific assets used for the computation of the wealth quintiles are http://dhsprogram.com.[36] The DHS data have already generated and categorised the household wealth quintile variable into 5 categories of 20% each. In this study, we recategorised the household wealth quintile into two categories, poor (lower 40%) and non-poor (upper 60%), so that we can compare recent experiences of diarrhoea among U5C from poor and non-poor groups. A similar categorisation has been used elsewhere.[37–40] Hence, we defined 'wealth inequality' as 'the unequal distribution of assets' among households.

Independent variables

These are made up of the individual-level and neighbourhood-level factors as identified in the literature.[4,11,13,16–21,38–40]

Individual-level factors

The individual-level factors (compositional factors) consist of childs', mothers' and households' characteristics. Childs' characteristics were as follows: sex (male versus female), age in years (less than 1 year and 12–59 months), weight at birth (average+, small and very small), birth interval (firstborn, <36 months and >36 months) and birth order (1, 2, 3 and 4+). Mothers' characteristics were as follows: maternal education (none, primary or secondary plus), maternal age (15–24, 25–34, 35–49), marital status (never, currently and formerly married) and employment status (working

Table 1
Description of demographics and health surveyed data by countries, poverty and diarrhoea prevalence among under-five children in LMICs, 2010–2018.

Country	Year of survey	Number of clusters	Number of under-five children	Weighted (%) poor	Weighted diarrhoea prevalence (%)		
					Overall	Poor	Non-poor
All		63,378	796,150	44.6	14.2[b]	15.0[a]	13.6
Eastern Africa		6298	102,886	45.2	16.7	17.6[a]	15.9
Burundi	2016	554	12,431	43.4	22.5	24.7[a]	20.8
Comoros	2012	252	2949	45.7	17.0	17.8	16.3
Ethiopia	2016	643	9916	46.9	11.9	11.1[a]	12.6
Kenya	2014	1593	19,889	44.3	15.4	17.3[a]	13.8
Malawi	2016	850	16,246	47.1	21.9	22.8[a]	21.2
Mozambique	2011	610	10,157	45.0	11.2	11.1	11.4
Rwanda	2014	492	7474	45.6	12.2	14.7[a]	10.2
Tanzania	2015	608	9445	45.9	12.1	10.4[a]	13.6
Uganda	2016	696	14,379	43.6	20.0	22.0[a]	18.4
Middle Africa		3081	71,630	44.0	19.0	19.6[a]	18.5
Angola	2016	625	13,463	45.1	15.7	14.9[a]	16.4
Cameroon	2011	578	10,326	44.2	21.7	27.0[a]	17.5
Chad	2015	624	16,710	42.0	22.3	23.6[a]	21.3
Congo	2012	384	8723	46.3	19.3	17.5[a]	20.9
Congo DR	2014	536	16,994	43.9	17.0	16.5	17.4
Gabon	2012	334	5414	43.9	16.8	17.6	16.2
Northern Africa		874	15,458	37.5	14.0	16.4[a]	12.7
Egypt	2014	874	15,458	37.5	14.0	16.4[a]	12.7
Southern Africa		2544	25,529	44.9	15.5	17.1[a]	14.3
Lesotho	2014	396	2824	42.4	12.2	13.4	11.4
Namibia	2013	536	4449	43.9	19.1	22.7[a]	16.2
South Africa	2016	668	3241	45.0	11.0	13.8[a]	8.7
Zambia	2018	545	9311	47.5	15.5	16.4[a]	14.7
Zimbabwe	2015	399	5704	42.6	17.1	17.7	16.6
West Africa		6285	139,382	43.3	14.7	16.4[a]	13.4
Benin	2018	555	12,512	41.4	10.5	12.0[a]	9.5
Burkina Faso	2010	573	13,621	41.7	14.9	13.9[a]	15.5
Cote d'Ivoire	2012	351	6876	47.3	18.5	18.9	18.0
Gambia	2013	281	7633	42.4	17.8	17.0	18.3
Ghana	2014	427	5539	43.2	11.9	14.3[a]	10.0
Guinea	2015	401	7213	44.8	14.6	14.1	15.0
Liberia	2013	322	6806	46.5	22.7	24.9[a]	20.9
Mali	2018	345	9171	41.7	17.2	20.0[a]	15.3
Niger	2012	476	11,437	40.0	14.4	13.6	14.9
Nigeria	2018	1389	30,603	43.5	12.8	17.1[a]	9.6
Senegal	2017	400	11,253	46.2	18.0	20.6[a]	15.8
Sierra Leone	2013	435	10,254	45.5	11.5	11.3	11.7
Togo	2013	330	6464	41.3	15.2	19.4[a]	12.2
Central Asia		682	10,216	38.8	10.2	11.8[a]	9.1
Kyrgyz Republic	2012	316	4222	38.9	5.2	5.4	5.0
Tajikistan	2017	366	5994	38.8	13.3	15.9[a]	11.6
South-Eastern Asia		1850	17,168	47.5	9.0	10.0[a]	8.0
Cambodia	2014	609	6934	44.0	12.9	14.1[a]	11.8
Philippines	2017	1241	10,234	50.1	6.1	7.3[a]	4.9
Southern Asia		33,053	322,219	45.3	11.5	11.7[a]	11.4
Afghanistan	2015	956	30,520	39.7	29.1	27.6[a]	30.1
Bangladesh	2014	600	7541	41.4	5.7	6.3	5.3
India	2016	28,321	247,181	46.7	9.2	9.9[a]	8.6
Indonesia	2017	1967	17,155	40.5	14.2	16.1[a]	12.9
Maldives	2016	265	3048	41.9	4.2	4.3	4.2
Nepal	2016	383	4827	42.3	7.7	7.0	8.2
Pakistan	2018	561	11,947	42.0	19.2	18.3[a]	19.9
Western Asia		2048	27,441	46.1	21.8	22.5[a]	21.2
Armenia	2016	306	1709	39.4	3.8	4.9	3.1
Jordan	2017	962	10,454	50.8	9.7	10.1	9.2
Yemen	2013	780	15,278	43.9	31.4	33.3[a]	29.9
Central America		1996	22,524	47.0	18.7	19.5[a]	18.0
Guatemala	2014	856	12,038	48.7	19.2	18.9	19.6
Honduras	2011	1140	10,486	44.8	18.0	20.2[a]	16.2
South America		1401	9408	47.1	12.3	13.7[a]	11.1
Peru	2012	1401	9408	47.1	12.3	13.7[a]	11.1
Southern Europe		651	2745	44.0	6.1	7.7[a]	4.9
Albania	2018	651	2745	44.0	6.1	7.7[a]	4.9
Caribbean		1860	21,129	45.2	15.0	15.2	14.8
Dominican Republic	2013	516	3560	46.6	18.2	22.1[a]	14.7
Haiti	2016	449	6082	45.6	21.4	20.7	21.9
Myanmar	2014	440	4575	51.6	10.5	12.4[a]	8.4

(*continued on next page*)

Table 1 (*continued*)

Country	Year of survey	Number of clusters	Number of under-five children	Weighted (%) poor	Weighted diarrhoea prevalence (%)		
					Overall	Poor	Non-poor
Timor-Leste	2016	455	6912	40.4	10.8	8.3[a]	12.5
Oceania		755	8415	41.4	15.4	14.8[a]	15.9
Papua New Guinea	2016	755	8415	41.4	15.4	14.8[a]	15.9

LMIC = low- and middle-income country.
[a] Significant at 5% test of equality of proportions between poor and non-poor.
[b] Significant at 5% chi-squared test.

or not working). Households' characteristics were as follows: access to media (at least one of radio, television or newspaper), sources of drinking water (improved or unimproved), toilet type (improved or unimproved), cooking fuel (clean fuel or biomass) and housing materials (improved or unimproved). However, housing materials, access to toilet and clean water were excluded from the decomposition analysis because the DHS has already used them to compute the household wealth quintile, which is the main determinate variable in this study.

Neighbourhood-level factors

The DHS used 'clusters' as the PSU to group people of the same cluster that shares similar contextual factors.[31,32] We used the word 'neighbourhood' to describe the clustering of children within the same geographical environment and 'neighbours' as members of the same cluster. The PSUs were identified using the most recent census in each country where the DHS was held. In this study, we considered rural-urban residence and neighbourhood socio-economic status (SES) as community-level variables. The neighbourhood SES was computed using principal component factor composed of the proportion of respondents within the same neighbourhood without education and employment.

Statistical analyses

Descriptive and inferential statistics comprising bivariable analysis and multivariable Fairlie decomposition techniques using binary logistic regressions were used. The z-test for equality of proportions of children who had diarrhoea from poor and non-poor households within each country and region was conducted and is reported in Table 1, whereas the existence of an association between the explanatory variables and the outcome variable among the two groups of children is reported in Table 2. The risk difference (RD) is the difference in the experience of diarrhoea among U5C from poor and non-poor households (Fig. 1). Charts were used to show the distributions of the RDs versus the prevalence of diarrhoea (Figs. 2 and 3). Finally, the adjusted logistic regression method was applied to the 29 pro-poor countries to carry out a Fairlie decomposition analysis, and the results are presented in Fig. 4.

Decomposition analysis

Multivariable decomposition is often used to quantify the contributions to differences in the prediction of an outcome of interest between two groups in multivariate models.[41] The Fairlie technique works by decomposing the difference in proportions based on either the probit or logit model.[41] The decomposition analysis is carried out by calculating the difference between the predicted probability for one group (say group A) using the other group's (say group B) regression coefficients and the predicted probability for that group (group A) using its regression coefficients.[42] The Fairlie decomposition technique works by constraining the predicted probability between 0 and 1.

Fairlie et al.[41] showed that the decomposition for a non-linear equation can be expressed as follows:

$$\overline{Y}^A - \overline{Y}^B = \overbrace{\left[\sum_{i=1}^{N^A} \frac{F\left(X_i^A \widehat{\beta}^A\right)}{N^A} - \sum_{i=1}^{N^B} \frac{F\left(X_i^B \widehat{\beta}^A\right)}{N^B}\right]}^{1^{st}} + \overbrace{\left[\sum_{i=1}^{N^B} \frac{F\left(X_i^B \widehat{\beta}^A\right)}{N^B} - \sum_{i=1}^{N^B} \frac{F\left(X_i^B \widehat{\beta}^A\right)}{N^B}\right]}^{2^{nd}} \quad (1)$$

where YJ is the average probability of the binary outcome variable with group J and F as the logistic cumulative distribution function, XJ is a row vector of the average values of the explanatory variables and βJ is a vector of coefficient estimates for group J. The numerical details have been reported.[43,44] NA is the sample size for group J.[45]

We used the 'Fairlie' Ado file in STATA to carry out the decomposition analysis using the generalised structure for the model. The R statistical software was used to draw all the figures. All the estimates were weighted, and all statistical tests were set to the 5% significance level. The results of this study are presented in Tables 1 and 2 and Figs. 1–4.

Results

The analysed data consist of 796,150 U5C living within 63,378 neighbourhoods nested in 57 LMICs. The overall proportion of children from poor households was 45%, the lowest in Egypt (38%) and highest in Myanmar (52%). The overall diarrhoea prevalence was 14.2% (significantly different across countries at $P < 0.001$), with 15.0% and 13.6% ($P < 0.001$) among children from poor and non-poor households, respectively (Table 1 and Fig. 1). The prevalence of diarrhoea among children from poor households ranged from 4.3% in Maldives to 33.3% in Yemen, whereas it ranged from 3.1% in Armenia to 30.1% in Afghanistan among children from non-poor households. The z-test of equality of prevalence among children from poor and non-poor households was statistically significant ($P < 0.05$) in 35 countries.

We found statistical significance in the association among all the explanatory variables considered in this study ($P < 0.05$) with the occurrence of diarrhoea and also by poverty divides of the children households, except media access and the sex of the household head that were insignificantly associated with the occurrence of diarrhoea among children from poor and non-poor households (Table 2). The prevalence of diarrhoea was consistently higher among the infants than among those aged 12–59 months, irrespective of their households' poverty status: 18% vs 14% for poor households and 17% vs 13% for non-poor households, respectively.

Table 2
Summary of pooled sample characteristics of the studied children in 57 LMICs.

Characteristics	N	Weighted %	Weighted (%) poor	Weighted diarrhoea prevalence (%)		
				Overall	Poor	Non-poor
Age						
Infant	164,438	20.7	44.4	17.4[a]	18.1[a]	16.9[a]
12–59 months	631,712	79.4	44.7	13.4	14.1	12.8
Sex						
Female	389,173	48.9	45	13.8[a]	14.6[a]	13.1[a]
Male	406,977	51.1	44.3	14.6	15.3	14.1
Household head						
Male	669,287	84.1	44.4	14.2[a]	14.9[a]	13.6
Female	126,863	15.9	45.8	14.5	15.5	13.7
Maternal age						
15–24 years	234,550	29.5	46.3	16.4[a]	16.6[a]	16.1[a]
25–34 years	414,014	52.0	42.5	13.2	14.1	12.6
35–49 years	147,586	18.5	47.9	13.4	14.4	12.5
Maternal education						
No education	273,056	34.3	62.7	15.8[a]	15.2[a]	16.6[a]
Primary	202,835	25.5	51.7	16.3	16.3	16.2
Secondary or higher	320,257	40.2	25.6	11.7	12.7	11.4
Employment						
Employed	526,983	66.2	45.6	13.3[a]	14.3[a]	12.4[a]
Unemployed	269,167	33.8	42.7	16.0	16.3	15.8
Media access						
No	316,993	39.9	67.1	15.2[a]	15.1	15.5[a]
Yes	478,517	60.2	30.8	14.2	14.8	13.1
Drinking water sources						
Unimproved sources	175,663	22.8	65.8	16.9[a]	17.2[a]	16.3[a]
Improved sources	595,332	77.2	39.2	13.6	14.0	13.3
Toilet type						
Unimproved sources	388,386	50.4	66.4	15.4[a]	15.2[a]	15.9[a]
Improved sources	382,305	49.6	23.6	13.1	14.5	12.7
Marital status						
Never married	23,560	3.0	37.7	16.9[a]	18.3[a]	16.0[a]
Currently married	739,740	92.9	44.7	14.0	14.7	13.4
Formerly married	32,850	4.1	47.3	17.1	17.9	16.4
Cooking fuel						
Unclean/biomass	581,710	77.0	56.2	14.9[a]	15.0	14.8[a]
Clean fuel	173,921	23.0	12.4	12.4	14.8	12.1
Housing materials						
Unimproved sources	676,227	89.5	49.5	14.8[a]	15.1[a]	14.6[a]
Improved source	79,157	10.5	12.2	10.0	10.7	9.9
Weight at birth						
Average+	643,472	84.0	43.5	13.6[a]	14.3[a]	13.1[a]
Small	90,809	11.9	47.9	17.2	18.3	16.2
Very small	31,924	4.2	50.6	20.1	20.7	19.4
Birth interval						
1st birth	223,779	28.2	37.3	13.1[a]	14.3[a]	12.4[a]
<36 months	308,310	38.8	51.0	15.0	15.3	14.7
36+ months	262,278	33.0	43.8	14.3	14.9	13.7
Birth order						
1st	223,777	28.1	37.3	13.1[a]	14.3[a]	12.4[a]
2nd	192,088	24.1	40.1	13.1	13.9	12.6
3rd	129,829	16.3	46.3	14.2	14.6	13.9
4+	250,456	31.5	54.4	16.2	16.2	16.1
Location						
Urban	239,222	30.1	14.5	13.4[a]	13.8[a]	13.3[a]
Rural	556,928	70.0	58.8	14.6	15.1	13.9
Neighbourhood SES						
Highest	159,709	20.1	18.7	9.8[a]	10.9[a]	9.6[a]
2	158,969	20.0	23.0	14.9	13.9	15.2
3	160,077	20.1	50.5	15.8	16.1	15.5
4	159,153	20.0	59.0	16.7	17.3	15.8
Lowest	158,242	19.9	74.9	14.0	13.6	15.1
Total	796,150	100.0	44.6	**14.2	**15.0	**13.6

LMIC = low- and middle-income country; SES = socio-economic status.
[a] (a) *significant at 5% test of equality of proportions between poor and non-poor (b) **a Significant at 5% chi-squared test.

Magnitude and variations in poor-non-poor inequality in diarrhoea

A meta-analysis of the RDs, a measure of inequality in the risk of having diarrhoea among children from poor and non-poor households, across the 57 countries is presented in Fig. 1. The prevalence of diarrhoea was generally higher among children from poor households than those from non-poor households in all the countries, except in Angola, Congo, Ethiopia, Burkina Faso, Pakistan, Afghanistan, Niger, Tanzania and Timor-Leste, where the RD was significantly higher among children from non-poor households. The differences were however insignificant in 19 countries. The overall, that is, random effect of the RD was 17.31 of 1000 children,

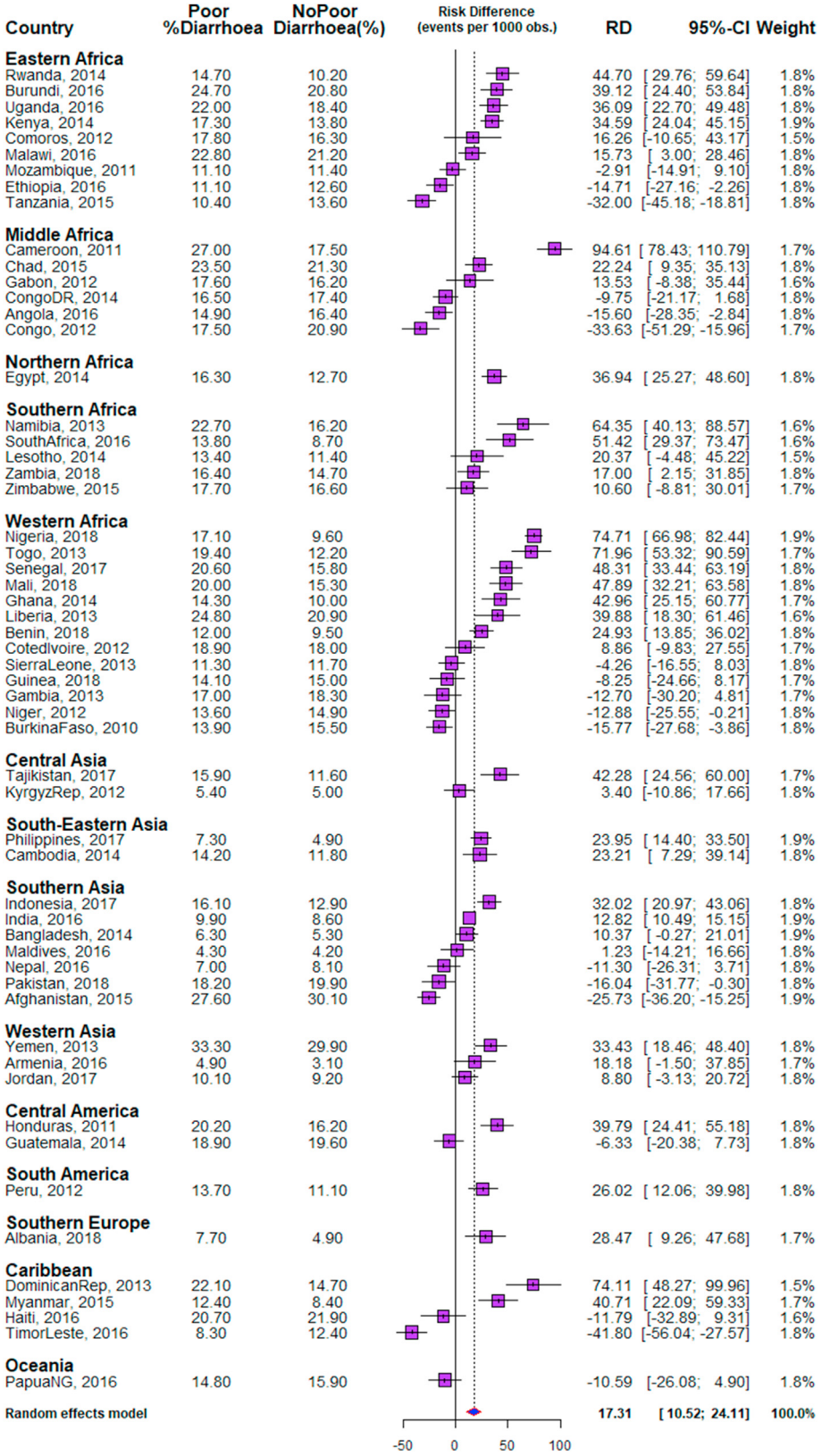

Fig. 1. Risk difference between children from poor and non-poor households in the prevalence of diarrhoea by countries. CI = confidence interval; RD = risk difference.

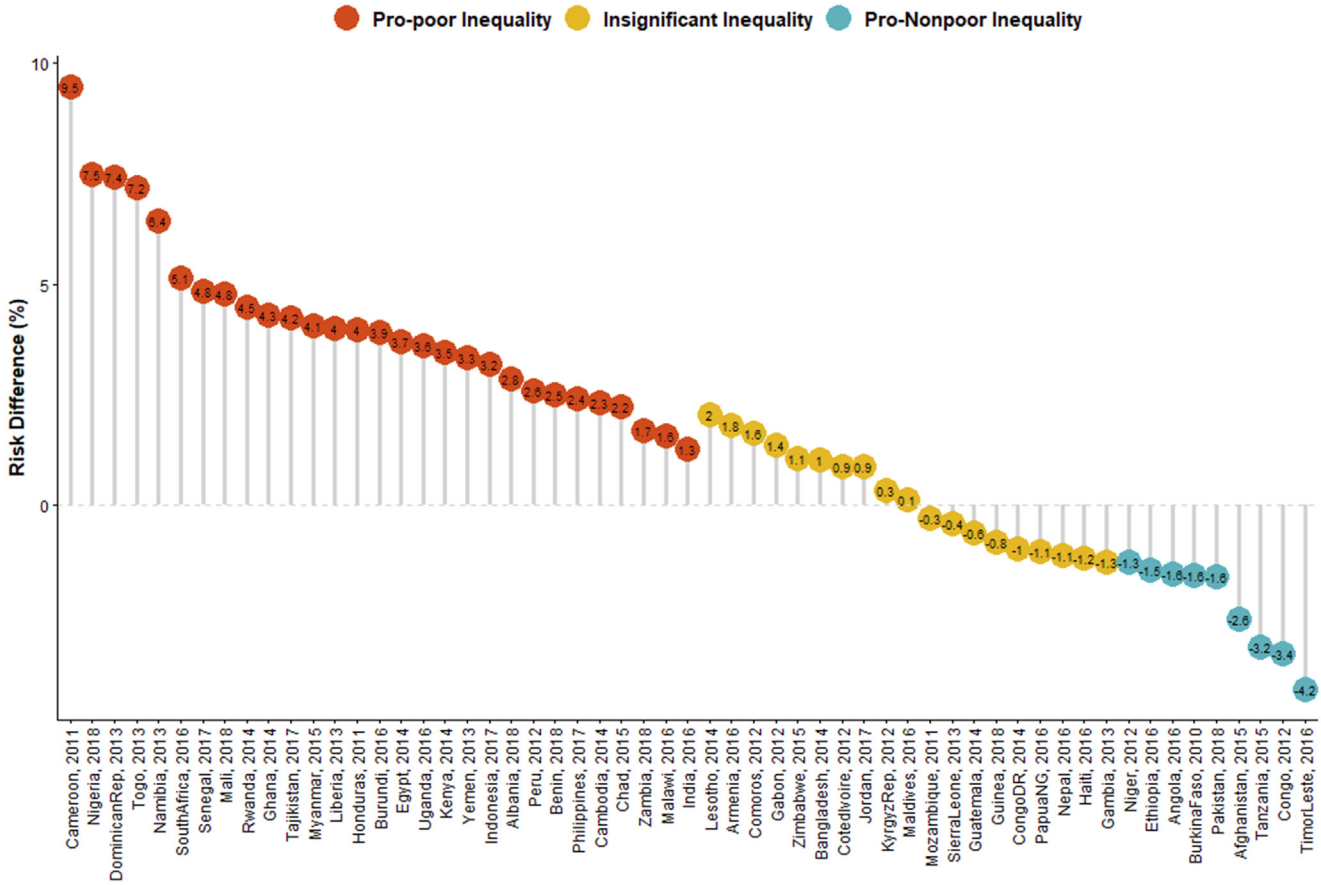

Fig. 2. Risk difference between children from poor and non-poor households in the prevalence of diarrhoea by countries.

with a 95% confidence interval (CI) of 10.52–24.11. This is evident of significant overall pro-poor inequality. The greatest contribution (weight) to the random effect was found in Kenya, Nigeria, Philippines, Bangladesh, Afghanistan and India, at 1.9% each, whereas the least contribution was found in Comoros, Lesotho and the Dominican Republic, at 1.5% each (Fig. 1).

Relationship between prevalence of diarrhoea and magnitude of inequality

The relationships between the prevalence of diarrhoea and the magnitude of poor-non-poor inequality, a function of RD, across the 57 countries are presented in Fig. 3. We categorised the countries into 4 distinct categories based on their prevalence of diarrhoea and whether or not the RD were small or large: (i) high diarrhoea prevalence and high pro-poor inequality countries such as Togo, Yemen, Cameroun, the Dominican Republic and Liberia; (ii) high diarrhoea prevalence and high pro-non-poor inequality countries such as Afghanistan, Congo and Pakistan; (iii) low diarrhoea prevalence and high pro-poor inequality countries such as Nigeria, South Africa, Rwanda and Tajikistan; and (iv) low diarrhoea prevalence and high pro-non-poor inequality countries such as Timor-Leste, Tanzania and Ethiopia.

Decomposition of poverty inequality in the prevalence of diarrhoea

We first computed Mantel-Haenszel pooled estimate of the odds ratio (OR) of having diarrhoea while controlling for the country among all the children as 1.12 (95% CI: 1.11–1.14) and tested the null hypothesis that OR = 1; we estimated z = 17.4 and $P = 0.000$ and Test of heterogeneity, we estimated $X^2 = 819.27$, degree of freedom (d.f.) = 56, and $P = 0.000$, I-squared (variation in OR attributable to heterogeneity) = 93.2%. Of the 57 countries, we found statistically significant pro-poor OR (pro-poor inequality) in only 29 countries, 7 showed pro-non-poor inequality and the remaining 21 countries showed no statistically significant inequality.

Across the 29 countries, the largest contributions to gaps in having diarrhoea among the groups of children from the poor and non-poor households are maternal education, access to media neighbourhood SES, place of residence, birth order and maternal age. Among these contributors, the maternal education and access to media contributed most and were clustered together, whereas the other important contributors formed another cluster (Fig. 4). Bangladesh, India, Malawi, Zambia and Peru had the highest experience of the contributions of these factors, as shown in the clustering in Fig. 4. The contributions were most visible in Bangladesh and India. Specifically, the largest contributions to pro-poor inequality in the prevalence of diarrhoea in Bangladesh were maternal education (306% higher among children whose parents had no education), media access (219% higher among children whose mother had no media access) and neighbourhood SES (170% higher in communities with lowest SES), followed by birth order (130%), maternal education (21%) and place of residence (19% higher among rural residents). Other factors such as childbirth weight, age, sex and mothers' employment status had the lowest contribution to poverty-related inequalities in the prevalence of diarrhoea across these countries.

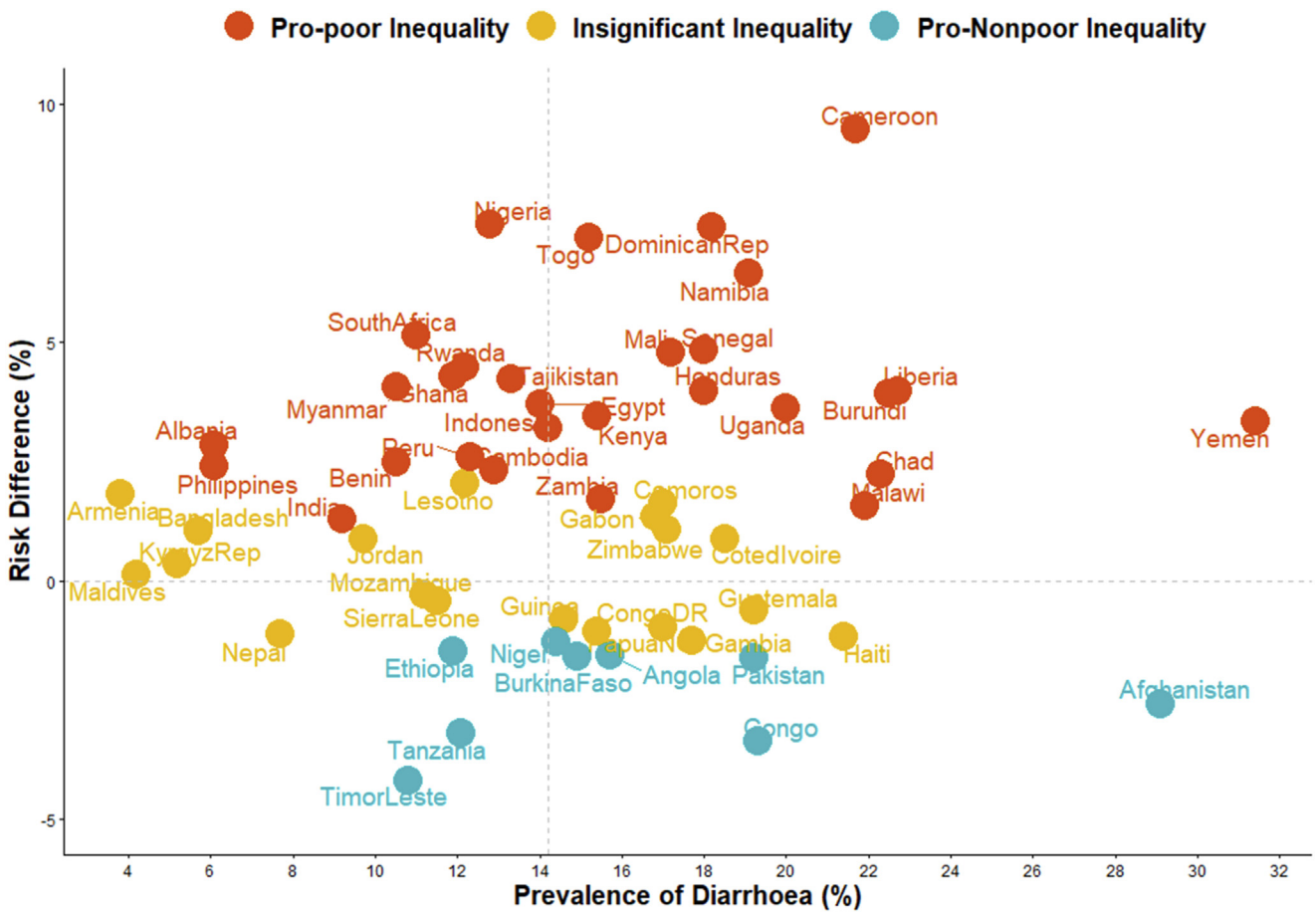

Fig. 3. Scatter plot of the rate of diarrhoea and risk difference between children from poor and non-poor households in LMICs. LMIC = low- and middle-income country.

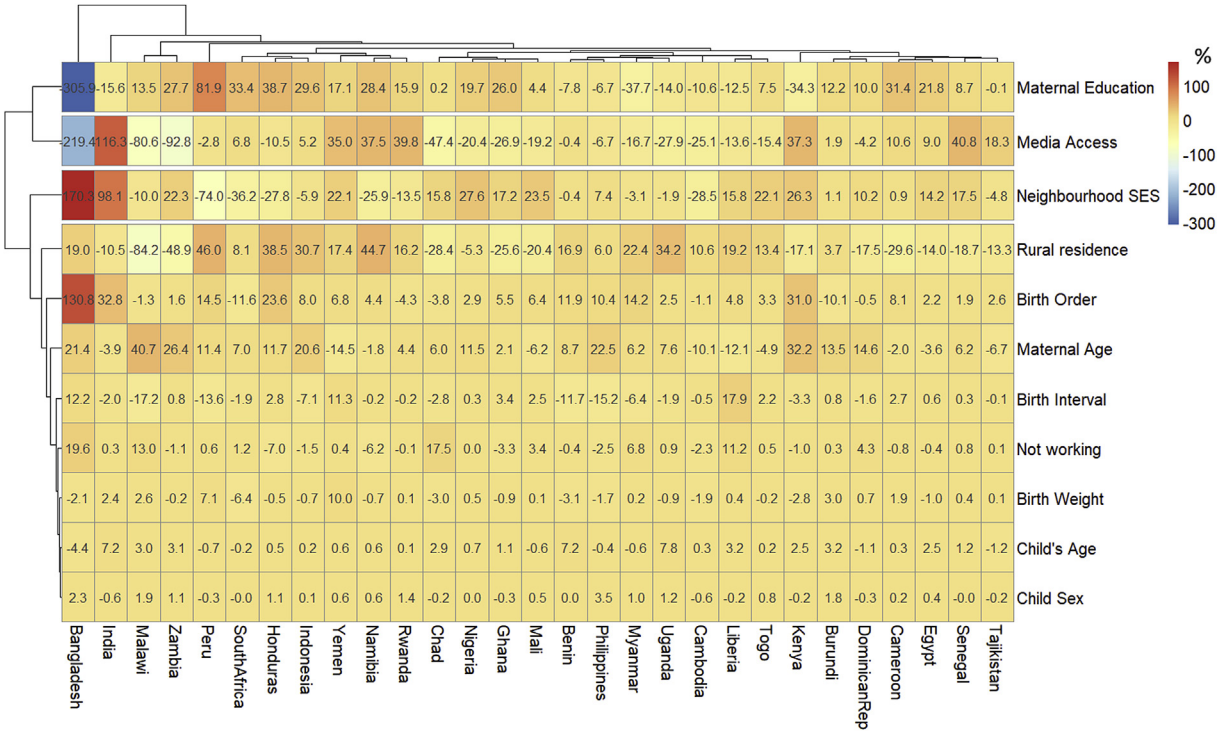

Fig. 4. Contributions of differences in the distribution 'compositional effect' of the determinants of diarrhoea to the total gap between children from poor and non-poor households by countries. SES = socio-economic status.

Discussion

The need to understand the compositional and contextual factors that contributed to the gap in the risk of diarrhoea among children from poor and non-poor households in 57 LMICs motivated this study. The prevalence of diarrhoea among children from poor and non-poor households varied significantly and was nested at both the neighbourhood and country levels. We identified countries with pro-poor inequalities and those with pro-non-poor inequalities. There were unique variabilities in the factors that drive pro-poor inequalities in the development of diarrhoea across these countries. The findings from this article highlight the need for multiple approaches to understand and tackle the different factors that contributed to the inequalities in the risk of diarrhoea between the children from poor and non-poor households in LMICs. We found significant pro-poor inequality in 29 of all the 57 countries and pro-non-poor inequality in 7 of the countries, whereas there were insignificant gaps in the remaining countries.

The RDs in the prevalence of diarrhoea between children from poor and non-poor households showed that the fixed effect of pro-poor inequality was widest in Cameroon, whereas the fixed effect of pro-non-poor inequality was widest in Timor-Leste on the aggregate. These findings might be attributed to the difference in the socio-demographic, environmental and behavioural characteristics among the poor and non-poor households. Results of other studies agreed with this finding.[46–51] Diarrhoea was found to be more prevalent among infants than among those aged 12–59 months, irrespective of their households' poverty status. This finding is consistent with that of earlier studies.[52–55] The variations by the childrens' age may be ascribed to the fact that infants often have complementary feeding and higher exposure to contaminated food and water, which place them at higher risk of diarrhoea. This is an indication that greater efforts should be placed on prevention of diarrhoea among children especially at the earlier days of life.

Overall, the largest contributions to the pro-poor inequalities in having diarrhoea are maternal education, access to media, neighbourhood SES, place of residence, birth order and maternal age. We found an interesting pattern in the relationship and closeness among these compositional and contextual factors. The mothers' educational attainment and access to media were the greatest contributors to the inequalities and were clustered together, whereas the neighbourhood SES, rural-urban differences in the place of residence, birth order and maternal age formed another cluster. These two clusters later merged and formed a single cluster, which helped to explain the gaps in poor-non-poor diarrhoea prevalence.

The central role of maternal education in individuals' empowerment, well-being, access to quality information and capacity to make the right decisions cannot be overemphasised. Education, especially among women, is a gateway to opportunities, and it has been serially associated with health outcomes in the literature.[56–59] The significance of maternal education to wealth inequality as found in the present study has several implications. First, there is a need for most LMICs to develop and strengthen policies on the education of women as a means of family economic empowerment. Second, there is a dire need for public health policies, interventions and programmes that particularly inform and train mothers on how diarrhoea could be prevented. In addition, increasing the knowledge of mothers and all household members in general to join the diarrhoea prevention wagon is a must if diarrhoea prevalence should be drastically reduced.

Access to radio, television or newspaper can enhance mothers' knowledge about diarrhoea prevention practices. For instance, access to media remains the broader channel through which mothers could know that using Aquaguard could help prevent microbial contamination in water.[60] It suffices to say children whose mothers had media access as a result of having a form of education were less likely to develop diarrhoea than children whose mothers had not attended any formal education. This may be ascribed to the fact that education is likely to enhance household health and sanitation practices and also encourage behavioural changes at the household level.[46–51]

The neighbourhood SES, a composite measure of the community's proportion of women who are unemployed, illiterate and rural dwellers, was significant to pro-poor inequalities in having diarrhoea. A similar assertion has been made in earlier reports that the SES is the major driver of health outcomes in developing countries.[11,13,16–18] Therefore, concerted efforts are needed to ensure the overall community's SES through individuals' empowerment.

Rural-urban divides in the place of residence of children also contributed to the pro-poor inequality in the development of diarrhoea among U5C. The literature is replete that children who lived in rural areas coupled with lower means of livelihood are at higher odds of poorer health outcomes.[61] This could be as a result of limited economic capabilities, poor access to healthcare facilities and poor sanitation in rural areas. For instance, rural dwellers in countries such as Bangladesh, India, Malawi, Zambia and Peru and most sub-Saharan African countries, the source of drinking water is mainly from rivers, ponds and streams, which are prone to contamination.[62] In most rural areas, there are no improved toilet types, so open defecation prevails. Poor disposal of excreta is the main risk factor for diarrhoeal diseases.[4,20,63,64] More so, children with diarrhoeal disease may easily transmit the disease to others who live in the same area, especially in rural neighbourhoods with high poverty rates.

We found interesting results in the categorisation of countries by the distribution of the prevalence of diarrhoea and the RDs in having diarrhoea among children from poor and non-poor households. The categorisation includes countries with a high prevalence of diarrhoea and high pro-poor inequality such as Cameroon, Togo, Yemen, the Dominican Republic and Liberia and those with a low prevalence of diarrhoea and high pro-poor inequality such as South Africa, Rwanda, Nigeria and Tajikistan. Of particular concern is the group of countries with high prevalence and high pro-poor inequality. The variations across these countries were explainable by disparities in educational attainment, access to media, available country-level policies and programmes for child health, as well as political and economic instability. There is a need for countries with a high prevalence of diarrhoea and high pro-poor inequality to take a cue from what is been done right in the countries with low prevalence and low pro-non-poor inequalities.

Strengths and limitations

Secondary data were used for the analysis. The data required that mothers should recall a recent episode of diarrhoea without any means of verification by the interviewers. Besides, correct identification of what diarrhoea is could be a potential recall bias. Data analysis of three-quarters of a million children spread across 57 LMICs is a major strength of our study as it showed a wide coverage and generalisability. We quantified the magnitude of the

factors associated with pro-poor inequalities in the development of diarrhoea using the Fairlie decomposition methods that provided robust evidence of wealth-related inequalities after controlling for the exposure variables.

Conclusions

Diarrhoea remains a major challenge in the majority of the LMICs with a wide range of pro-poor inequalities. These disparities were explained by compositional and contextual factors that cut across individual-, household- and community-level factors. The overall significance of our determinate variable in explaining the difference in diarrhoea prevalence is a pointer to the fact that empowerment of individuals is very important to achieving favourable child health outcomes in most countries. The magnitude of the contributions of factors associated with the pro-poor inequalities varied widely across the countries. Thus, multifaceted geographically specific intervention may prove to be a potent approach to address the poor and non-poor differentials in the risk of diarrhoea among U5C, with policies tailored to country-specific conditions.

Author statements

Acknowledgements

The authors are grateful to ICF Macro, USA, for granting the authors the request to use the Demographic and Health Survey data. The authors appreciate the logistic supports provided by the Consortium for Advanced Research and Training in Africa (CARTA) to A.F.F. in the course of writing this article. The CARTA is jointly led by the African Population and Health Research Center and the University of the Witwatersrand and funded by the Carnegie Corporation of New York (grant no: B 8606.R02), Sida (grant no: 54100029) and the DELTAS Africa Initiative (grant no: 107768/Z/15/Z).

Ethical approval

This study was based on the analysis openly available on secondary data. The Institutional Review Board (IRB) of ICF Macro at Fairfax, Virginia, in the USA reviewed and approved the MEASURE Demographic and Health Surveys Project Phase III. The 2010–2018 Demographic and Health Surveys are categorised under that approval. The IRB of ICF Macro complied with the United States Department of Health and Human Services requirements for the 'Protection of Human Subjects' (45 CFR 46). Written informed consent was obtained from every study participant before participation, and all information was collected without identifiers and kept confidentially. ICF Macro permitted the authors to use the data. The full details of the ethical approvals can be found at http://dhsprogram.com.

Funding

None declared.

Competing interests

None declared.

Consent for publication

Not applicable.

Availability of data and materials

The data supporting this article is available at http://dhsprogram.com.

Author contributions

A.F.F. conceptualised, designed the study, curated and analysed the data. A.F.F., O.O.P., E.K.A., O.S.F. and O.A.U. contributed to the literature search, figures, data interpretation and writing of the manuscript.

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