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REGULAR ARTICLE

Demographic and health surveys showed widening trends in polio immunisation inequalities in Guinea

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Abstract

Aim: This study examined trends in absolute and relative socio-economic, gender and geographical inequalities in the coverage of polio immunisation in Guinea, West Africa, from 1999 to 2016.

Methods: Data from the 1999, 2005 and 2012 Guinea Demographic and Health Survey and the 2016 Guinea Multiple Indicator Cluster Survey were analysed using the World Health Organization's health equity assessment toolkit. We disaggregated polio immunisation coverage using five equity stratifiers: household economic status, maternal educational level, place of residence, child's gender and region. The four summary measures used were the difference, ratio, population attributable risk and population attributable fraction. A 95% confidence interval (CI) was constructed around point estimates to measure statistical significance.

Results: A total of 4778 1-year-old children were included. Polio immunisation coverage in 1999, 2005, 2012 and 2016 were 43.4%, 50.7%, 51.2% and 38.6%, respectively. Socio-economic and geographical inequalities in polio immunisation favoured children with educated mothers who came from richer families living in urban areas. There were also differences in the eight regions over the 1999–2016 study period.

Conclusion: Targeting children from disadvantaged subgroups must be prioritised to ensure equitable immunisation services that help to eradicate polio in Guinea.

KEYWORDS

global health, Guinea, inequality, polio immunisation, trends

Abbreviations: CI, confidence interval; DHS, Demographic and Health Survey; MICS, Multiple Indicator Cluster Survey; WHO, World Health Organization.

Ziad El-Khatib contributed equally to this work.

1 | INTRODUCTION

Polio is a highly infectious and vaccine preventable disease,[1] and eradicating it is a matter of global importance, especially in sub-Saharan Africa.[2] Although global polio cases decreased by more than 99% from 1988 to 2017, from over 350,000 cases to 22, the disease still exists.[1] The World Health Organization's (WHO) Immunisation Agenda 2030 envisions a world where people of all ages and in all countries fully benefit from good health and well-being as a result of vaccination. The global vaccine action plan specifically aims to eradicate polio by 2023.[3] Increasing and ensuring vaccination coverage and accessibility for all children is also a Sustainable Development Goal agenda.[4] There has been global progress in child immunisation coverage during the last decade,[5] but just under 22 million children in hard-to-reach subpopulations are not receiving their routine vaccinations.[6] The highest burden of polio is in sub-Saharan Africa, mainly West Africa.[7] Internationally, immunisation coverage varies based on socio-economic or demographic and geographic factors, particularly in low-income and middle-income countries.[6,8-10] Reducing inequalities in childhood immunisation is an important part of the initiatives developed by organisations such as the WHO.[8] Monitoring health inequalities is a crucial step towards achieving health equity.[11] Measuring disparities in immunisation is a vital step in identifying where gaps occur, and in planning, as it informs strategies to increase coverage in unvaccinated or under-vaccinated population subgroups.[8] Monitoring inequality involves tracking changes over time and unravelling how national averages are increased in population subgroups.[11]

Guinea, West Africa, was declared free of polio in February 2017, and four national immunisation campaigns achieved more than 95% coverage in most districts.[12] Child health services have significantly improved globally, including childhood immunisation services.[11] Despite this, there has been limited evidence on the trends in inequalities in polio immunisation coverage in Guinea. The aim of this study was to examine the trends in absolute and relative socio-economic gender-based and geographical inequalities in polio immunisation in Guinea from 1999 to 2016.

Keynotes

- This study examined trends in polio immunisation in Guinea, West Africa, from 1999 to 2016, by analysing data from four national surveys with a World Health Organization toolkit.
- A total of 4778 one-year-old children were included and the polio immunisation coverage rates in 1999, 2005, 2012 and 2016 were 43.4%, 50.7%, 51.2% and 38.6%, respectively.
- Immunisation was higher in children with educated mothers who came from richer families living in urban areas.

2 | METHODS

2.1 | Data sources

We used the offline version of the WHO health equity assessment toolkit software, version 3.1. This enables users to examine and analyse more than 30 health inequalities within, and between countries, including reproductive, maternal, newborn infant and child health indicators, such as immunisation.[13] The database stores data from the Demographic and Health Survey (DHS) and Multiple Indicator Cluster Survey (MICS), which are conducted in many low-income and middle-income countries, including Guinea. For this study, we used data on Guinea from the 1999, 2005 and 2012 DHS and the 2016 MICS, which are stored in the WHO health equity assessment toolkit software. The Guinea DHS was conducted by the country's National Institute of Statistics of the Ministry of Planning, with financial support from the United States Agency for International Development and technical assistance from the USA-based Inner-City Fund International. The MICS was conducted with the technical assistance of the United Nations Children's Fund. Both collected nationally representative data relating to health, maternal education and mortality, which can be used to track progress towards sustainable development goals.[14]

The sample design adequately represented all eight administrative regions in Guinea: Boké, Conakry, Faranah, Kankan, Kindia, Labé, Mamou and N'Zérékoré. This included urban and rural areas, where estimates were available for all key indicators.[14] The two-stage stratified sampling technique was applied to the four DHS and MICS surveys. The first stage was to divide the country into enumeration areas based on the most recent census before each survey. Clusters were selected at random and distributed uniformly throughout Guinea. Then, 20–30 households were selected in each cluster and were eligible for measurements and interviews. The subjects were all household residents, including those who had stayed the night before they participated. We were particularly interested in data relating to children aged 6–59 months and women of reproductive age, namely 15–49 years.[14]

2.2 | Variables and measurements

Our variable of interest was whether one-year-old children had been vaccinated for polio and what percentage had received three doses.[8,11] Inequality in polio immunisation was measured using five equity stratifiers: economic status, educational status, residence, gender and region. Economic status was measured using a wealth index, which it is generally calculated using ownership of durable goods, household characteristics and essential services, as previously described.[15] The built wealth index was then categorised into quintiles one to five. Maternal education was divided into three categories: no education, primary education and secondary education or more. We also looked at place of residence, namely urban or rural, and gender. There were five regions included in the 1999 survey and eight in the 2005, 2012 and 2016 surveys.

2.3 | Statistical analysis

We assessed inequalities in polio immunisation in two steps. First, the coverage of polio immunisation was disaggregated by five equity stratifiers: economic status, educational status, place of residence, gender and region. Second, the socio-economic, gender and geographical inequalities were assessed using the four measures of inequality: difference, ratio, population attributable risk and population attributable fraction. Detailed explanations on how each summary measure was calculated have previously been described.[16,17] Briefly, summary measures are chosen for inequality studies based on the dimensions being assessed and they can be simple or complex.[17] At the same time, summary measures need to be relative and absolute measures that can examine inequality from different angles.[17] We chose measures of inequality in accordance with these recommendations. The difference was a simple, unweighted measure of inequality that showed the absolute inequality between the two subgroups. The difference was calculated as the difference between the two subgroups: Yhigh minus Ylow.

When it came to the binary dimensions, such as place of residence and gender, and non-ordered dimensions, including region, Yhigh referred to the subgroup with the highest estimate of polio immunisation and Ylow to the subgroup with the lowest estimate. For ordered dimensions, such as educational level and economic status, Yhigh referred to the most advantaged subgroup, such as secondary school and above and wealth quintile five, and low to the most disadvantaged subgroup, such as no education and wealth quintile one. If there was no inequality, the difference had a value of zero. Greater absolute values indicated higher levels of inequality. Positive values for the difference indicated higher coverage of polio immunisation in the advantaged subgroups. These were secondary school and above for the equity stratifier of maternal education, wealth quintile five for household economic status, urban resident for place of residence and female for gender equity. Negative difference values indicated higher coverage in the disadvantaged subgroups.

The ratio was a simple, unweighted measure of inequality that showed the relative inequality between the two subgroups. R was calculated as the ratio of two subgroups: Yhigh/Ylow. If there was no inequality, R had a value of one. Positive values were larger or smaller than one and the further away they were from one, the higher level of inequality. The reference groups and interpretation of the ratio were similar to the difference. The population attributable risk was a complex, weighted measure of inequality that showed the potential for improvement in the national level of polio immunisation coverage that could be achieved if all subgroups had the same level of polio immunisation coverage as the reference subgroup. The population attributable risk was calculated as the difference between the estimate for the reference subgroup (Yref) and the national average (μ): Yref minus μ.

For binary dimensions, such as the place of residence, and gender for non-ordered dimensions including region, Yref referred to the subgroup with the highest estimate of polio immunisation coverage. For ordered dimensions, such as educational level and economic status, Yref referred to the most advantaged subgroup, such as secondary school and above and wealth quintile five, respectively. The population attributable risk had positive values for favourable health intervention indicators, such as polio immunisation coverage. The larger the absolute value of population attributable risk, the higher the level of inequality. The population attributable risk was zero if no further improvement could be achieved because all subgroups had reached the same level of polio immunisation coverage as the reference subgroup. The population attributable fraction was a complex, weighted measure of inequality that showed the potential for national improvements in the level of polio immunisation coverage, in relative terms. This was the level that could be achieved if all subgroups had the same level of polio immunisation coverage as the reference subgroup. The population attributable fraction was calculated by dividing the population attributable risk by the national average of μ and multiplying the fraction by 100. This fraction produced positive values for favourable health intervention indicators such as polio immunisation coverage. The larger the absolute value of the population attributable fraction, the larger the degree of inequality. The population attributable fraction was zero if no further improvements could be achieved because all subgroups had reached the same level of coverage of polio immunisation as the reference subgroup. Inequality trends were assessed with caution and by referring to the 95% confidence intervals (CI) of each summary measure in the different surveys. That means that if the CIs did not overlap there were increasing or decreasing changes, but if they did overlap that was considered a constant pattern. However, small and large overlapping were not treated equally and the authors considered this important concept when interpreting the trends. The pattern of inequality trends was expressed as increasing or widening, decreasing or narrowed, constant or mixed. A mixed pattern indicated that the inequality included at least two of the three above mentioned patterns in the specifically mentioned summary measures. Different summary measures were capable of having different patterns.

We followed similar procedures as previous inequality studies.[18] To account for the complex nature of the DHS and MICS data, all three design elements, such as weight, cluster and strata, were taken into consideration during the initial analysis by the WHO inequality experts. We then reanalysed the data stored in the health equity assessment toolkit software. The authors mixed unweighted and simple summary measures, such as differences and ratios, as well as weighted summary measures, such as population attributable risk and the population attributable fraction. This was a reflection of the complex nature of the DHS and MICS data.

2.4 | Ethical considerations

We used publicly available demographic and health survey data for the analysis. Therefore, there was no need for ethical permission. All the DHS and MICS surveys were approved by ICF International and the Institutional Review Board of Guinea to ensure that the protocols complied with the United States Department of Health and Human Services regulations for the protection of human subjects.[14]

3 | RESULTS

3.1 | Background characteristics of the children and mothers

The study comprised 4,778 one-year-old children (51.4% male) from all four surveys, and 72.0% lived in rural areas. Approximately 78.6% of the mothers had no formal education, 11.4% had attended primary school and 10.0% had secondary education or above.

3.2 | Coverage of polio immunisation

Table 1 shows trends in polio immunisation coverage among one-year-old children across socio-economic, gender-based and regional subgroups in Guinea from 1999 to 2016. Polio immunisation coverage was 43.4% in 1999, 50.7% in 2005, 51.2% in 2012 and 38.6% in 2016. There were no significant changes in immunisation coverage across the wealth quintiles from 1999 to 2016. However, the coverage decreased by 9.5 percentage points among the poorest subgroup (quintile one) and 3.3 percentage points among the richest subgroup (quintile five) between 1999 and 2016. When we compared the 1999 and 2016 surveys, polio immunisation coverage significantly decreased among non-educated subgroups but was constant among all educated subgroups. For instance, the coverage decreased by 8.2 percentage points (95% CI 7.91–8.47) among non-educated subgroups from 1999 to 2016 years, but only decreased by 1.9 percentage point (95% CI −1.63–4.75) among secondary school and above subgroups over the same period. The results also showed higher immunisation coverage among urban than rural residents, but the coverage was consistent across both subgroups. The polio immunisation coverage was similar between boys and girls under the age of one year from 1999 to 2016. Meanwhile, polio immunisation coverage varied across regions. The patterns decreased in some regions from 1999 to 2016 and increased in other regions. For instance, the patterns were constant in the Boke region, but decreased from 2012 to 2016, especially in regions such as Labe and Kankan.

3.3 | Magnitude and trends in inequality

Table 2 shows no inequality based on the child's gender, but there were significant socio-economic and geographic-based inequalities in the coverage of polio immunisation in Guinea from 1999 to 2016. Different summary measures showed that there were constant or increased or decreased.

3.4 | Economic inequality

There was a significant absolute and relative wealth-driven inequality in polio immunisation coverage from 1999 to 2016 using all four summary measures. The exception was the ratio summary in 2005. The ratio measure in 2016 indicated that the coverage of polio immunisation among children in the richest families were 3.24 times higher (95% CI 2.22–4.25) than the children in the poorest families. Moreover, in 2016 the population attributable risk and population attributable fraction measures showed that the national average of polio immunisation coverage in that year could have been improved by approximately 24 and 61 percentage points if absolute and relative wealth-driven inequality could have been avoided, respectively. With regard to trends, generally mixed patterns of wealth-driven inequality were observed between 1999 and 2016, when both simple and complex measures were used. More specifically, both the absolute and relative wealth-driven inequalities decreased from 1999 to 2005. The pattern of relative wealth-driven inequality by the complex measure of population attributable fraction dramatically narrowed, in other words decreased, from 50.5 in 1999 to 13.7 in 2005. Moreover, based on the simple measure, namely the difference, the pattern of absolute wealth-driven inequality decreased from 36.7 in 1999 to 17.8 in 2005.

3.5 | Education-related inequality

Education was significantly absolutely and relatively related to inequality in the coverage of polio immunisation from 1999 to 2016 using all four summary measures. The population attributable fraction and population attributable risk measures in the 2016 survey confirmed the presence of relative and absolute education-related inequality favouring children from educated mothers. They further indicated that the country could have improved the 2016 national polio immunisation coverage by 52 and 20 percentage points if education-related relative and absolute inequality could have been avoided, respectively. Mixed patterns of all forms of education-based inequality were observed. More specifically, inequality increased from 1999 to 2005, then decreased from 2005 to 2012, and increased again from 2012 to 2016. When the complex measure of population attributable risk was used, the pattern of education-related absolute inequality increased from 17.1 in 1999 to 24.6 in 2005. It then decreased to 15.8 in 2012 and again increased to 20.0 in 2016. Similar patterns of inequality were seen when the simple measures of differences and ratios were used, but the changes were not as substantial as the complex measures. Education-related absolute inequality was increased by using the difference measure, from 19.2 in 1999 to 26.4 in 2005, then decreased to 17.7 in 2012 and again increased to 25.6 in 2016.

TABLE 1 Trends in *Polio immunisation coverage among under-one-year children* across socio-economic, *sex*- and area-based subgroups in Guinea from 1999 to 2016: Evidence from Guinea DHSs (1999–2012) and MICS (2016)

Dimension of inequality	Subgroup		1999 Estimate (95% CI)	1999 Pop^n	2005 Estimate (95% CI)	2005 Pop^n	2012 Estimate (95% CI)	2012 Pop^n	2016 Estimate (95% CI)	2016 Pop^n
Economic status	Quintile 1 (poorest)		28.65 (21.77–36.69)	198	39.87 (28.20–52.82)	282	37.57 (30.60–45.09)	281	19.16 (14.15–25.40)	280
	Quintile 2		31.74 (24.47–40.02)	176	45.67 (38.84–52.67)	245	52.94 (45.03–60.70)	275	34.23 (27.37–41.82)	328
	Quintile 3		42.61(34.61–51.01)	196	53.76 (46.02–61.33)	215	50.35 (43.05–57.64)	290	36.64 (31.13–42.53)	301
	Quintile 4		51.94 (43.89–59.89)	185	62.78 (56.15–68.96)	202	59.02 (50.68–66.87)	240	44.20 (37.18–51.46)	290
	Quintile 5 (richest)		65.36 (57.10–72.78)	163	57.67 (47.08–67.59)	172	59.75 (52.16–66.90)	207	62.09 (54.76–68.91)	247
Education	No Educ.		41.30 (37.37–45.35)	776	48.88 (43.84–53.94)	960	49.30 (44.84–53.77)	1000	33.07 (29.46–36.88)	1020
	Primary		50.67 (38.52–62.73)	83	53.59 (43.06–63.81)	97	49.95 (41.66–58.24)	160	44.18 (36.60–52.05)	203
	Secondary+		60.53 (48.75–71.21)	61	75.33 (60.74–85.76)	60	67.05 (58.48–74.61)	135	58.65 (50.38–66.46)	222
Place of residence	Rural		37.75 (33.23–42.50)	675	49.08 (43.52–54.67)	870	48.74 (43.72–53.79)	960	31.40 (27.59–35.48)	935
	Urban		59.00 (52.34–65.35)	245	56.46 (48.18–64.39)	247	58.37 (52.51–64.00)	335	51.69 (46.13–57.21)	511
Sex	Female		44.00 (38.87–49.26)	446	49.94 (44.17–55.72)	556	47.89 (42.68–53.16)	621	36.49 (32.41–40.77)	697
	Male		42.88 (37.54–48.39)	474	51.48 (46.05–56.86)	561	54.31 (49.59–58.95)	674	40.51 (36.18–45.00)	750
Subnational region	01 lower guinea	01 boke	44.71 (35.59–54.19)	211	42.93 (31.57–55.08)	130	52.73 (39.96–65.16)	133	46.99 (38.04–56.14)	170
	02 central Guinea	02 conakry	36.86 (28.66–45.88)	194	47.14 (33.34–61.39)	114	55.55 (47.64–63.20)	182	57.27 (49.09–65.08)	281
	03 upper guinea	03 faranah	37.18 (29.75–45.28)	181	50.36 (39.98–60.70)	94	38.63 (28.14–50.28)	124	35.69 (27.18–45.22)	122
	04 forest guinea	04 kankan	41.11 (33.57–49.09)	206	57.52 (48.64–65.93)	164	55.14 (45.55–64.37)	212	23.51 (17.94–30.18)	255
	05 conakry	05 kindia	64.02 (55.83–71.47)	127	59.12 (50.39–67.30)	152	47.89 (35.69–60.33)	219	37.63 (28.93–47.21)	162
	NA	06 labe	NA	NA	49.05 (35.08–63.18)	108	43.27 (31.81–55.50)	114	18.26 (12.50–25.90)	119
	NA	07 mamou	NA	NA	42.67 (33.29–52.60)	73	40.09 (28.89–52.43)	99	26.60 (18.69–36.37)	120
	NA	08 nzer ekore	NA	NA	50.11 (36.84–63.35)	280	63.24 (53.03–72.38)	208	45.66 (35.28–56.42)	214
National average			43.4	920	50.7	1,117	51.2	1,295	38.6	1,446

Notes: Pop^n population, Pop^n population, NA not available for 1999 year of survey, DHS demographic and health survey, MICS multiple indicator cluster survey.

TABLE 2 Trends in socio-economic, sex-based and geographical inequalities in polio immunisation coverage among under-one years of age children: Evidence from Guinea DHSs (1999–2012) and MICS (2016)"

		1999	2005	2012	2016
Dimension	Measure	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)	Estimate (95% CI)
Economic status	D	36.70 (25.92–47.48)	17.79 (1.63–33.94)	22.18 (11.81–32.54)	42.93 (33.89–51.97)
	PAF	50.50 (37.25–63.75)	13.70 (3.82–23.58)	16.62 (6.69–26.55)	60.96 (49.65–72.26)
	PAR	21.93 (16.17–27.68)	6.95 (1.94–11.96)	8.51 (3.42–13.60)	23.51 (19.15–27.87)
	R	2.28 (1.63–2.93)	1.44 (0.92–1.96)	1.59 (1.22–1.95)	3.24 (2.22–4.25)
Education	D	19.23 (7.25–31.20)	26.44 (12.96–39.93)	17.74 (8.50–26.98)	25.58 (16.69–34.47)
	PAF	39.40 (36.12–42.67)	48.52 (46.17–50.87)	30.86 (27.96–33.75)	52.04 (47.64–56.45)
	PAR	17.11 (15.68–18.53)	24.61 (23.41–25.80)	15.81 (14.33–17.29)	20.08 (18.38–21.77)
	R	1.46 (1.15–1.77)	1.54 (1.24–1.84)	1.35 (1.15–1.56)	1.77 (1.45–2.08)
Residence	D	21.25 (13.30–29.20)	7.37 (−2.44–17.19)	9.63 (1.99–17.26)	20.28 (13.48–27.09)
	PAF	35.87 (31.22–40.52)	11.32 (8.23–14.40)	13.93 (10.78–17.07)	33.99 (29.00–38.98)
	PAR	15.57 (13.56–17.59)	5.74 (4.17–7.30)	7.13 (5.52–8.75)	13.11 (11.19–15.04)
	R	1.56 (1.30–1.81)	1.15 (0.94–1.36)	1.19 (1.02–1.36)	1.64 (1.37–1.91)
Sex	D	1.11 (−6.35–8.58)	−1.53 (−9.40–6.34)	−6.41 (−13.42–0.60)	−4.02 (−10.09–2.04)
	PAF	1.32 (−5.83–8.47)	0 (−5.75–5.75)	0 (−5.11–5.11)	0 (−6.26–6.26)
	PAR	0.57 (−2.53–3.68)	0 (−2.91–2.91)	0 (−2.61–2.61)	0 (−2.41–2.41)
	R	1.02 (0.84–1.20)	0.97 (0.81–1.12)	0.88 (0.75–1.00)	0.90 (0.75–1.04)
Region	D	27.16 (15.55–38.77)	16.44 (3.58–29.30)	24.61 (9.76–39.45)	39.01 (28.57–49.44)
	PAF	47.43 (33.38–61.48)	16.56 (−5.24–38.38)	23.42 (7.36–39.48)	48.46 (30.52–66.41)
	PAR	20.60 (14.50–26.70)	8.40 (−2.66–19.46)	12.00 (3.77–20.23)	18.69 (11.77–25.62)
	R	1.73 (1.27–2.19)	1.38 (1.01–1.75)	1.63 (1.09–2.17)	3.13 (1.91–4.36)

Notes: CI confidence interval, D difference, PAF population attributable fraction, PAR population attributable risk, R ratio, DHS demographic and health survey, MICS multiple indicator cluster survey.

3.6 | Place of residence inequality

There was an absolute and relative urban-rural inequality in the coverage of polio immunisation between 1999 and 2016 when we used both simple and complex measures. The exception was when used the simple measures of difference and ratio in 2005. The difference measurements of 20.28 (95% CI 13.48–27.09) in the 2016 survey indicated that the coverage of polio immunisation among children residing in urban areas were 20.3 percentage points higher than children living in rural areas. Moreover, the population attributable fraction and population attributable risk measures in the 2016 survey showed that the 2016 national polio immunisation coverage could have been improved approximately by 34.0 and 13.1 percentage points if the relative and absolute urban-rural inequality had been avoided, respectively.

Regarding trends, the simple and complex measures showed different patterns of inequality. When the simple measures of differences and ratios were used, the inequality between urban and rural areas reduced from 1999 to 2005 or disappeared in 2005. Then, the inequality reappeared in 2012 and was much wider in 2016. Despite the similar inequality patterns that were observed with the simple measures, the inequality did not disappear in 2005 when the complex measures of population attributable risk and population attributable fraction were used. When using the simple difference measure to calculate the absolute urban-rural inequality in polio immunisation showed that it decreased from 21.2 to 7.3 from 1999 to 2005 and then increased from 9.6 to 20.3 from 2012–2016 survey. Using the complex population attributable fraction measure showed that relative urban-rural inequality in polio immunisation decreased from 35.9 in 1999 to 11.3 in 2005, showed a rise to 13.9 in 2011 and then increased to 34.0 in 2016. There was no gender-based inequality in polio immunisation coverage in Guinea from 1999 to 2016. For instance, the population attributable fraction measure was 0.5 in 1999 and zero in the other three surveys in 2005, 2012 and 2016. This indicated that there was no relative gender inequality in polio immunisation coverage in Guinea between 1999 and 2016.

3.7 | Regional region inequality

At the regional level, there was an absolute and relative regional inequality in polio immunisation coverage from 1999 to 2016 when the difference measure was used. However, using the ratio measure for the 2005 (R = 1.38, 95% CI 1.10–1.75) and 2012 (R = 1.63, 95% CI 1.09–2.17), data did not show the relative regional inequality that existed in the 1999 and 2016 surveys. Similarly, using complex measures in 2005 did not show the relative and absolute region-based inequality in the coverage of polio immunisation in 2005 that existed in other survey periods: the population attributable fraction was 16.56 (95% CI −5.24–38.38) and the population attributable fraction was 8.40 (95% CI −2.66–19.46). For instance, the difference measure of 39.01 (95% CI 28.57–49.44) in the 2016 survey indicated that polio immunisation coverage among children in the Conakry region was 39 percentage points higher than children living in the Labe region. Similarly, the population attributable risk measure of 18.69 (95% CI 11.77–25.62) in the 2016 survey indicated that the national 2016 polio immunisation coverage could have been improved by 18.7% if the country had avoided whole region-based inequality. An example of trends was that the population attributable risk measure showed that the absolute regional inequality was dramatically decreased from 20.6 in 1999 to 8.4 in 2005, then increased to 12.0 in 2012 and finally increased to 18.6 in 2016. This demonstrated a generally mixed pattern. Similarly, the pattern of relative regional inequality identified by the complex measure of the population attributable fraction decreased from 47.4 in 1999 to 16.5 in 2005, then increased a little to 23.4 in 2012 and finally increased to 48.4 in 2016.

4 | DISCUSSION

This study reported trends in socio-economic and geographic-based inequalities in polio immunisation coverage among one-year-old children in Guinea. The coverage of polio immunisation in 1999, 2005, 2012 and 2016 were 43.4%, 50.7%, 51.2% and 38.6% respectively. The national coverage of polio immunisation increased by 7.3% from 1999 to 2005, but decreased by 12.6% from 2012 to 2016. The reason for the decline in polio immunisation coverage in 2016 may partly be explained by the influence of the 2014–2015 Ebola outbreaks in the country.[19] In spite of this, polio vaccine coverage remained stable throughout the outbreak period after an initial drop right after the start of the outbreak. There were two key reasons for this. The first was the three polio vaccine mass campaigns undertaken in 2013, before the outbreak, and the four campaigns undertaken between March 2015 and January 2016, after the outbreak. The second reason was that the polio vaccine is given orally and parents may prefer polio vaccine to intramuscular vaccines, due to the mode of the transmission of the Ebola virus.[19] Thus, parents may have preference for polio vaccine for some personal reasons. But, like numerous essential infant health services, polio vaccine coverage have decreased in the post-Ebola virus disease length, due to both supply and demand factors associated with the Ebola outbreak.[19] Significant socio-economic and geographic-based inequalities in the coverage of polio immunisation among children under the age of one year were observed between 1999 and 2016, with different patterns based on different summary measures. More specifically, relative inequalities in the coverage of polio immunisation were observed in richer families over that period.

Previous studies by the WHO also reported absolute economic inequalities in polio immunisation in Guinea and a number of other low-income and middle-income countries, such as Afghanistan, Cambodia, Cameron and Benin.[6] The accessibility of health services in Guinea are highly dependent on whether individuals can pay transport costs to visit healthcare facilities.[20] Most of the poor households in Guinea work in agriculture, are self-employed, work on an informal basis and have a low source of income.[20] In addition, they sometimes live too far away from major infrastructure, such as health centres, roads, public transport and schools.[20] Mixed trends in economic inequality were seen over the 17-year study period. More specifically, inequalities decreased from 1999 to 2005, remained constant from 2005 to 2012 and then increased from 2012 to 2016. Our finding was consistent with a previous study conducted by the WHO in Guinea,[8] which showed a similar pattern of economic inequalities in immunisation from 1999 to 2012. The reason for narrowing or decreasing absolute economic inequality from 1999 to 2005 may have been due to the immunisation coverage decreasing by 7.7 percentage points in the richest quintile five families but increasing by 11.2 percentage points among the poorest quintile one families. The evidence shows that the families' income level influenced their accessibility to healthcare services. These included preventive care, such as childhood immunisation, and were more commonly related to indirect costs like transport, which was easier for higher-income households to afford.[21] Furthermore, we found absolute and relative education-based inequalities in polio immunisation in Guinea from 1999–2016, which were comparable with previous studies.[6] A study by the WHO in Cambodia reported a similar pattern in polio immunisation that was related to absolute education-related inequality. The difference between the least and most-educated subgroups was consistently high, at about 25%.[8] Numerous studies have found that parental education, especially maternal education, was related to a better uptake of childhood immunisation. These findings highlight the importance that maternal education plays in childhood immunisation. Similarly, a study in Pakistan confirmed that parental knowledge about vaccination and maternal education levels were significantly associated with polio immunisation, as well as full immunisation.[22] Another study, conducted in India, showed that maternal education played a significant role in the use of health services, including polio immunisation.[23] We found significant absolute and relative pro-urban inequality in polio immunisation in Guinea over the 17-year study period, in line with previous studies by the WHO.[9,24] The variation in immunisation coverage among urban and rural residents could be explained by parental education, wealth and the presence of a skilled birth attendant.[9] Furthermore, this study demonstrated that there were significant regional disparities in polio immunisation in all five surveys. Previous studies in Nigeria[25] and Bangladesh[26] reported similar findings. National immunisation coverage often hides huge disparities in coverage and access within a country that can be identified by regional monitoring. For instance, providing polio immunisation services to large proportions of children from some of the regions that have higher coverage than the national average may not guarantee whether or not children in another region receive the polio immunisation service.[11] Concentrating interventions at a particular regional area will help the country to achieve high and equitable coverage and meet global vaccine action plan targets.[27] Variations in polio immunisation within a country can be explained by differences in socio-economic status, culture, religion and the accessibility and availability of healthcare services, including vaccine supplies.[10] In Guinea, there are huge socio-economic disparities among regions.[20] For instance, the highest poverty rates are concentrated in regions such as Nzerekore (67%) and Labe (65%) and the lowest poverty rate has been reported in the Kankan region (49%). The poverty variations are mainly explained by differences in socio-economic distinctions across regions.[20] Finally, the disparities can be explained by differences in several factors related to supply and demand, such as the distance between people's homes and the health facilities and vaccination centres and poor communication systems in some remote areas. The other factors include fear of the side effects of vaccines, religious opposition or conservatism and education status and variations in the level of awareness about the importance of vaccinating children.[28,29]

4.1 | Strengths and limitations

The study had some strengths. First, the inequality analysis was based on the WHO's high-quality health equity monitoring database, which we believe increased the quality of our findings. Second, including different inequality summary measures helped us to understand polio immunisation inequality from different standpoints. We also used simple and complex measures to analyse absolute and relative inequalities, which strengthened our statistical technique. For example, simple measures of health inequality are easier to calculate and understand than complex summary measures, but they are more appropriate for binary equity stratifiers.[17] Due to the fact that simple measures no longer account for the subpopulations within the centre when implemented to an equity stratifier with more than two categories, we included wealth index and maternal educational level instead of taking subgroups with the lowest and highest value. This problem was further avoided by adopting complex measures, where the estimates were primarily based on the sizes of all classes of a selected dimension of inequality.[17] The limitations included the cross-sectional data collection method, which made it difficult to infer cause and effect with regard to the inequality of polio immunisation. Finally, since we conducted a descriptive analysis, further decomposition studies are recommended in order to explore the underlying factors for the observed inequalities in polio immunisation coverage. This would help to explain why socio-economic, gender-based and regional inequalities in polio immunisation coverage remained in Guinea.

5 | CONCLUSION

This study identified disproportionate absolute and relative socio-economic and regional inequalities in polio immunisation from 1999 to 2016, which favoured children with educated, wealthier parents living in urban areas and in regions such as Conakry. There was no gender-based disparities in polio immunisation. Generally, mixed socio-economic and regional disparities were seen. The way forward includes empowering women through education and economic opportunities and targeting children from disadvantaged, uneducated, poor, rural regions like Labe. This will help to achieve equitable immunisation services and ensure the sustainable eradication of polio. In addition, areas with low vaccination coverage need to be targeted with innovative approaches, demand and supply enhancement strategies and awareness programmes, mainly in hilly areas. Furthermore, outreach and mobile immunisation programmes also need to be considered.

CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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REFERENCES

1. WHO. Does polio still exist: Is it curable? 2020. Available at: https//www.who.int/westernpacific/news/q-a-detail/does-polio-still-exist-is-it-curable. Accessed on 12 Feb 2021.
2. Mutua MK, Mohamed SF, Porth JM, Faye CM. Inequities in on-time childhood vaccination: evidence from Sub-Saharan Africa. Am J Prev Med. 2021;60(1):S11-S23.
3. World Health Organization. Immunization Agenda 2030: A Global Strategy To Leave No One Behind. WHO; 2020.
4. GAVI. The vaccine alliance. Achieving the Sustainable Development Goals: six reasons why immunisation matters. Available at: org/achieving-the-sustainable-development-goals-six-reasons-why-immunisation-matters. Accessed on 4 May 2021.
5. Fulfilling the health agenda for women and children: the 2014 report. Geneva: World Health Organization. 2014. Available from: http://www.countdown2015mnch.org/documents/2014Report/Countdown_to_2015Fulfilling the Health_Agenda_for_Women_and_ChildrenThe_2014_ReportConference_Draft.pdf. Accessed on 28 Oct 2020.
6. Restrepo-Méndez MC, Barros AJ, Wong KL, et al. Inequalities in full immunization coverage: trends in low- and middle-income countries. Bull World Health Organ. 2016;94(11):794-805.
7. UNICEF. UNICEF statistics. Available at: https://data.unicef.org/. Accessed 28 Oct 2020.
8. State of inequality: childhood immunization. World Health Organization; 2016. Licence: CC BY-NC-SA 3.0 IGO.
9. Fernandez RC, Awofeso N, Rammohan A. Determinants of apparent rural-urban differentials in measles vaccination uptake in Indonesia. Rural Remote Health. 2011;11:1702.
10. Geremew TT, Gezie LD, Abejie AN. Geographical variation and associated factors of childhood measles vaccination in Ethiopia: a spatial and multilevel analysis. BMC Public Health. 2019;19:1194.

11. World Health Organization. State Of Inequality Reproductive, Maternal, Newborn and Child Health. Geneva: World Health Organization; 2015.
12. UNICEF Annual Report 2017. Available at: https://www.unicef.org/media/47861/file/UNICEF_Annual_Report_2017-ENG.pdf Accessed on 5 May 2021.
13. WHO. Global Health Observatory (GHO) data. Health Equity Assessment Toolkit. Overview. Available from: int/gho/health_equity/assessment_toolkit/en/. Accessed on 5 May 2021.
14. National Institute of Public Health (NPHI) (Guinea), National Institute of Statistics (Guinea), National Malaria Control Program (Guinea), United Nations Children's Fund (UNICEF). Guinea Multiple Indicator Cluster Survey 2016. United Nations Children's Fund (UNICEF). 2018.
15. Rutstein SO, Johnson K. The DHS Wealth Index. DHS Comparative Reports No. 6. ORC Macro. 2004.
16. World Health Organization. Health Equity Assessment Toolkit (HEAT): Software for Exploring and Comparing Health Inequalities in Countries. Builtin Database edition. Version 3.1. World Health Organization; 2019.
17. World Health Organization. Handbook on Health Inequality Monitoring With A Special Focus On Low And Middle Income Countries. World Health Organization; 2013.
18. Shibre G, Zegeye B, Idriss-Wheeler D, Yaya S. Inequalities in measles immunization coverage in Ethiopia: a cross-sectional analysis of demographic and health surveys 2000–2016. BMC Infect Dis. 2020;20:481.
19. Delamou A, Ayadi AME, Sidibe S, et al. Effect of Ebola virus disease on maternal and child health services in Guinea: a retrospective observational cohort study. Lancet Global Health. 2017;5(4):e448-e457.
20. Republic of Guinea. Overcoming growth stagnation to reduce poverty. Systematic country diagnostic. March 16, 2018. Report No. 123649-GN.
21. Sia D, Kobiané JF, Sondo BK, Fournier P. Individual and environmental characteristics associated with immunization of children in rural areas in Burkina Faso: a multi-level analysis. Sante. 2007;17:201-206.
22. Mitchell S, Andersson N, Ansari NM, Omer K, Soberanis JL, Cockcroft A. Equity and vaccine uptake: a cross-sectional study of measles vaccination in Lasbela District, Pakistan. BMC Int Health Hum Rights. 2009;9(Suppl 1):S7.
23. Kusuma YS, Kumari R, Pandav CS, Gupta SK. Migration and immunization: determinants of childhood immunization uptake among socioeconomically disadvantaged migrants in Delhi, India. Trop Med Int Health. 2010;15:1326-1332.
24. Glatman-Freedman A, Nichols K. The effect of social determinants on immunization programs. Hum Vaccin Immunother. 2012;8(3):293-301.
25. Antai D. Inequitable childhood immunization uptake in Nigeria: a multilevel analysis of individual and contextual determinants. BMC Infect Dis. 2009;9:181.
26. Sarker AR, Akram R, Ali N, Sultana M. Coverage and factors associated with full immunisation among children aged 12–59 months in Bangladesh: insights from the nationwide crosssectional demographic and health survey. BMJ Open. 2019;9:e028020.
27. WHO. Regional immunization coverage data. 2020. Available from int/immunizatio/monitoring_surveillance/data/regional/en/. Accessed on 4 May 2021.
28. Uddin MJ, Shamsuzzaman M, Horng L, et al. Use of mobile phones for improving vaccination coverage among children living in rural hard-to-reach areas and urban streets of Bangladesh. Vaccine. 2016;34(2):276-283.
29. Savoia E, Piltch-Loeb R, Goldberg B, et al. Predictors of COVID-19 vaccine hesitancy: socio-demographics, co-morbidity, and past experience of racial discrimination. Vaccines. 2021;9(7):767.

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