An Analysis of Infant Mortality in the 2013 and 2019–20 Liberia Demographic and Health Surveys

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Thomas Pullum[1,2]

ICF
Rockville, Maryland, USA

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[1] ICF
[2] The DHS Program

Corresponding author: Thomas Pullum, International Health and Development, ICF, 530 Gaither Road, Suite 500, Rockville, MD 20850, USA; telephone: +1 301–572–0950; fax: +1 301–572–0999; email: Tom.Pullum@icf.com

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Additional information about the 2019–20 LDHS may be obtained from the Liberia Institute of Statistics and Geo-Information Services (LISGIS), Statistics House, Capitol Hill, P.O. Box 629, Monrovia, Liberia; telephone: +231 886 560 435/+231 770 129 883; internet: www.lisgis.net.

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The DHS Program assists countries worldwide in the collection and use of data to monitor and evaluate population, health, and nutrition programs. Additional information about The DHS Program can be obtained from ICF, 530 Gaither Road, Suite 500, Rockville, MD 20850 USA; telephone: +1 301-407-6500, fax: +1 301-407-6501, email: info@DHSprogram.com, internet: www.DHSprogram.com.

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ABSTRACT

The final report on the 2019–20 Liberia Demographic and Health Survey (LDHS) included unexpected findings related to recent under-5 mortality. The under-5 mortality rate almost exactly matched the 2013 LDHS rate, but the rates for perinatal mortality, neonatal mortality, and infant mortality appeared to have increased, despite improvements in antenatal care (ANC), place of birth, and other characteristics that generally affect child survival. This report focuses on the components and determinants of early mortality to better understand the Liberia data. When sampling error is taken into account, there is little evidence of either increases or declines in the sub-intervals of the first year of age. Many possible changes related to covariates are investigated, including for the regions and counties of Libera, but few differences or changes are significant. We find evidence of over-reporting of deaths on day 0, the day of birth; all the rates that include day 0, including the perinatal rate, were spuriously inflated. We are unable to determine conclusively whether the inflation on day 0 was due to errors in reporting births, reporting deaths, or reporting age at death.

ACRONYMS AND ABBREVIATIONS

ANC	antenatal care
CMR	child mortality rate
DHS	Demographic and Health Survey
IMR	infant mortality rate
LDHS	Liberia Demographic and Health Survey
MIS	Malaria Indicator Survey
U5MR	under-5 mortality rate

1 INTRODUCTION

This report concerns one of the most important indicators of health in any country—infant mortality, measured by deaths in the first year after birth. There is a large literature on the analysis of early mortality. It is not reviewed here, but the reader is referred to Balk et al. (2003) and Winter et al. (2013) for analyses of specifically DHS data and to Hill and Choi (2006) for more general background.

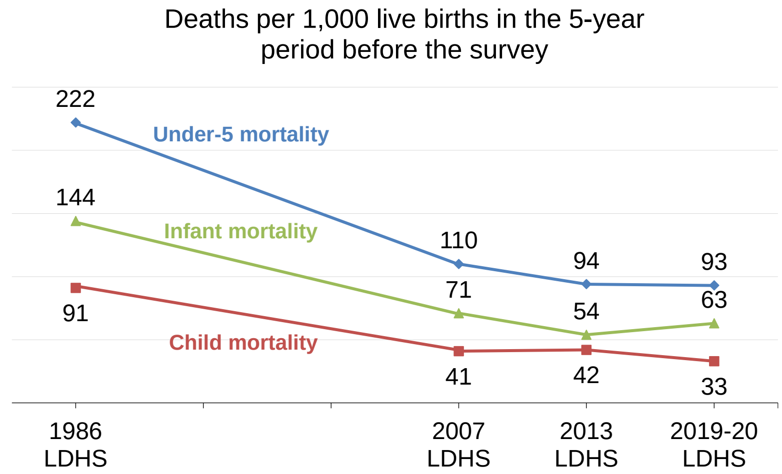
The analysis is limited to Liberia, a West African country with a population of approximately five million people. The final report on the 2019–20 Liberia Demographic and Health Survey (LDHS) found that under-5 mortality had not improved in the recent past, and infant mortality may have increased.[1] This further analysis report reviews and clarifies the 2019–20 LDHS findings.

Liberia has conducted seven national household surveys as part of The Demographic and Health Surveys Program (DHS). Four of these—conducted in 1986, 2007, 2013, and 2019–20—were standard DHS surveys. Three—conducted in 2009, 2011, and 2016—were Malaria Indicator Surveys (MIS).[2] The standard surveys include complete birth reports and information about the survival status of all births, including age at death for children who died. Together, the surveys have documented remarkable long-term improvements in child survival. For the 5-year interval before the 1986 survey, the infant mortality rate (IMR) and under-5 mortality rate (U5MR) were estimated to be 144 and 222 deaths, respectively, per 1,000 births. That is, in the early 1980s, more than one child in eight died before the first birthday, and almost one child in four died before the fifth birthday. Although typical for much of sub-Saharan Africa at that time, those levels were far too high. Because of a wide range of health and development activities, including immunization programs, improvements in water and sanitation, and anti-malarial programs, the rates had fallen dramatically by the reference period before the 2019–20 survey. (For convenience we refer to the year of each survey, but the reference period for the mortality rates is the 5 years, or 60 months, before the month of interview for each woman.) The most recent estimates of the IMR and U5MR are 63 and 93 deaths, respectively, per 1,000 births. Both rates had declined by nearly 60%.

The pace of improvements in survival since the early 1980s has not been steady. Most of the improvements between the reference periods for the 1986 and 2019–20 surveys occurred in the first 20 years. Since the 2007 survey, the rates have been relatively flat. Even more troubling, when the 2013 and 2019–20 surveys are compared there is evidence that the decline has not just stabilized—it has reversed. Figure 1.1, which appeared as Figure 8.1 in the final report on the 2019–20 survey, suggests that the IMR increased from 54 to 63 deaths per 1,000 births between the reference periods for the two latest surveys. Because that increase was offset by a decline in the CMR (child mortality rate, for ages 1–4) from 42 to 33 deaths, the U5MR was unchanged, with estimates of 94 deaths from the 2013 LDHS and 93 deaths from the 2019–20 LDHS.

[1] https://www.dhsprogram.com/pubs/pdf/FR362/FR362.pdf
[2] Malaria Indicator Surveys collect limited information about births and deaths. That is why the 2016 MIS is not included in the analysis.

Figure 1.1 Trajectories of the IMR, CMR, and U5MR in Liberia across the LDHS surveys conducted in 1986, 2007, 2013, and 2019–20



A flattening of the trend in the U5MR, especially at a level where nearly a tenth of all children die before age 5, is not acceptable. Evidence of an increase in the IMR is of even greater concern. This report focuses on the unexpected increase in the infant mortality rate between the 2013 and 2019–20 surveys. We review several potential explanations, including the following interpretations and hypotheses:

- The increase from 54 to 63 deaths is not statistically significant; it can be attributed to sampling error.
- The increase is due to a data quality issue, such that the 2013 estimate is spuriously low or the 2019–20 estimate is spuriously high, or both.
- The rates were affected by classification error, for example the misclassification of stillbirths as early neonatal deaths.
- The calculated increase is accurate and can be traced to a change in the distribution of age at death within the first year of age.
- The calculated increase is accurate and can be traced to a change in the distribution of births across the high-risk categories—“too young, too old, too close, or too many.”
- The calculated increase is accurate and can be traced to subpopulations that experienced a spike in infant mortality.

As part of the review of the infant mortality rates, we look at levels and changes in stillbirths and perinatal mortality, levels and changes in the distribution of established risk factors and antenatal care (ANC) and place of delivery, and levels and changes in covariates such as the mother’s level of education, household wealth quintile, urban/rural residence, region, and county.

2 DATA AND METHODS

The data are limited to the LDHS surveys conducted in 2013[3] and 2019–20. These surveys included complete birth histories, but we focus on the children born during the 5 years, or 60 months, before the month of interview in the respective surveys—the interval that identifies children eligible for the child health questions. The contraceptive calendar in each survey is used to identify stillbirths, which are defined to be pregnancies of 28+ weeks' duration that end in a termination other than a live birth.

Birthdates are given in calendar days, months, and years. If the child died, we do not have the date of death, but instead the age at death. Age at death is specified in terms of days for the first 30 days and months up to the second birthday. Beyond the second birthday, age at death is specified in years. All units of age are interpreted as "completed" units. Thus, age "0 days" refers to a death in the first 24 hours after birth, before the end of the first day.[4] "Early neonatal" is equivalent to "0–6 days," interpreted as seven completed days. "Perinatal" deaths are either stillbirths or early neonatal deaths. The first 28 days, or four weeks, or "0–27 days," is the "neonatal" interval. Deaths that are neonatal but not early neonatal are "late neonatal." The first year, or "0–11 months," is the period of infancy. Deaths that are infant but not neonatal are "post neonatal." These age intervals are standard for medical and public health purposes.

Deaths in the first year after birth are usually concentrated early in that year, and it is well known that early deaths are the most difficult to prevent. In general, in sub-Saharan Africa infant mortality has declined substantially, but neonatal mortality has remained relatively high. As a result, the proportion of infant deaths that are neonatal has tended to increase over time.

The actual numbers of births in the past 5 years, and the number of deaths to those children, convey a sense of sample size limitations. The following are the unweighted frequencies. The 2013 LDHS includes 7,606 births in the past 5 years; 548 of these children died before the mother's date of interview. Of the 548 deaths, 214 were neonatal, 187 were post neonatal, and 147 were after the first birthday. In the 2019–20 LDHS, a somewhat smaller survey, there were 5,704 births in the past 5 years, with 224 neonatal deaths, 146 post neonatal deaths, and 89 deaths after the first birthday, for a total of 459 deaths. While we look at both neonatal and post neonatal deaths, our focus is mainly on the neonatal deaths—the 214 and 224 deaths in the two surveys. When these deaths are categorized by geography or other likely covariates it is difficult to achieve statistical significance. Sampling error in a proportion or rate is affected just as much by the size of the numerator (the number of deaths) as it is by the size of the denominator (the number of births).

This report deviates from standard DHS procedures in two ways:

- DHS final reports and STATcompiler do not explicitly subdivide neonatal deaths into early neonatal and late neonatal. It is also not standard to separate out day 0. However, this report makes these subdivisions and refers to deaths at age "0 days," "1–6 days," "0–6 days," or "7–27 days." Early neonatal deaths, equivalent to age "0–6 days," normally only appear as part of

[3] https://www.dhsprogram.com/pubs/pdf/FR291/FR291.pdf
[4] The first day is intended to refer to the first 24 hours, but in practice it is probably interpreted as the same calendar day as the day of birth. More generally, age at death in days is probably interpreted as elapsed calendar days rather than elapsed multiples of 24 hours.

perinatal mortality in reports and STATcompiler and are not explicitly given as a separate rate. In this report we require more detail on risk of death within the first 28 days.[5]

- All rates are calculated with the number of births in the past 5 years as the denominator and the number of deaths to those children, at the specified age, as the numerator. This approach allows multivariate analysis with individual children as the units of analysis.

The second of these deviations from normal DHS practice requires a more detailed justification. The usual DHS procedure to calculate an infant mortality rate partitions the first year into four segments: completed age 0 months, 1–2 months, 3–5 months, and 6–11 months. DHS normally calculates the conditional probability of dying in one of these subintervals, given that the child survived to the beginning of the subinterval. The probability of dying before the first birthday is calculated from those four component probabilities.[6] In this report, deaths and exposure to risk are within the reference period, consistent with the usual calculations, but we ignore the portion of that exposure which comes from children who were born before the reference period.

In this report, the four age intervals just listed (0, 1–2, 3–5, and 6–11 months) are not detailed enough, because deaths are even more concentrated at the beginning of the first year than is captured by breaking out month 0. It is more useful to look at the first day, the remainder of the first week, the remainder of the first month, and then the remainder of the first year.[7]

Another reason for not using the usual DHS calculations is that rates are a characteristic of an aggregate and cannot be used for individual children. Here we treat age at death as a categorical variable corresponding with age 0 completed days, 1–6 completed days, 7–27 completed days, and any later age within the first year. Binary (0/1) variables are defined for each interval of death and the analysis is done with logit regressions adjusted for the weighting, clustering, and stratification in the survey design. Rates calculated in this way may differ, although only slightly, from more standard rates.

Much of the analysis includes 95% confidence intervals. Such an interval should be interpreted as follows: there is a 95% probability that we have a sample, out of all possible samples that could be drawn under the same sampling design, that has produced an interval estimate that captures the population parameter. A confidence interval, or interval estimate, is not equivalent to a statistical test, but it is a useful guide to whether a difference within the sample exists in the population or is just due to sampling variation.

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[5] Some DHS reports refer to the neonatal interval as the first month. The practical impact of the difference between 28 completed days and one completed month is negligible, especially if misreporting and digit preference are considered. Moreover, the 2013 and 2019–20 LDHSs recorded no deaths at days 28, 29, or 30.

[6] If the conditional probabilities are q1, q2, q3, and q4, then the infant mortality rate (ignoring a factor of 1,000) is calculated as IMR = 1 - [(1 - q1)*(1 - q2)*(1 - q3)*(1 - q4)].

[7] There is some censoring with our approach. Children born less than 24 hours before the interview will have only partial exposure to the first day; those born in the past 7 days will have only partial exposure to the early neonatal interval; those born in the past 4 weeks will have only partial exposure to the neonatal interval; and, more seriously, those born in the past year will have only partial exposure to the risk of an infant death. This downward bias is small and can be assumed to be independent of factors that affect the probability of a death. The CMR would be seriously affected by censoring if limited to births in the past 5 years.

3 ANALYSIS

3.1 The Timing of Deaths within Infancy

The early neonatal, neonatal, and infant death rates are cumulative. They all start with the day of birth, and then cover the interval to the end of the first week, the first four weeks, and the first year.

Figure 3.1.1 is a horizontal bar graph that shows the rate for the day of birth, and then the other three rates just described, for both surveys. Within each pair of bars, the upper bar refers to the 2013 survey and the lower to the 2019–20 survey. In the bottom pair of bars, the bar for the 2019–20 survey is longer than the bar for the 2013 survey, showing (as in Figure 1.1) that infant mortality was higher in the reference period for the second survey than in the reference period for the first survey, the opposite of what was expected. The rate increased by 9 points, from 50.0 to 59.4 deaths per 1,000 births. The increase in Figure 1.1 was from 54 to 63, also a 9-point increase. The difference in the levels (4 points) is entirely due to the simplification (and censoring) in the calculation described above.

Figure 3.1.1 Death rates for the first day after birth, and the early neonatal, neonatal, and infant ages based on children born during the 5 years before the 2013 LDHS and 2019–20 LDHS

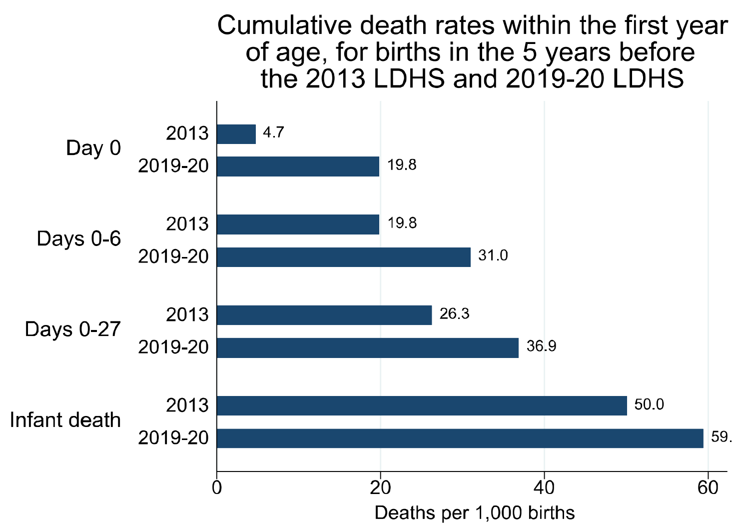
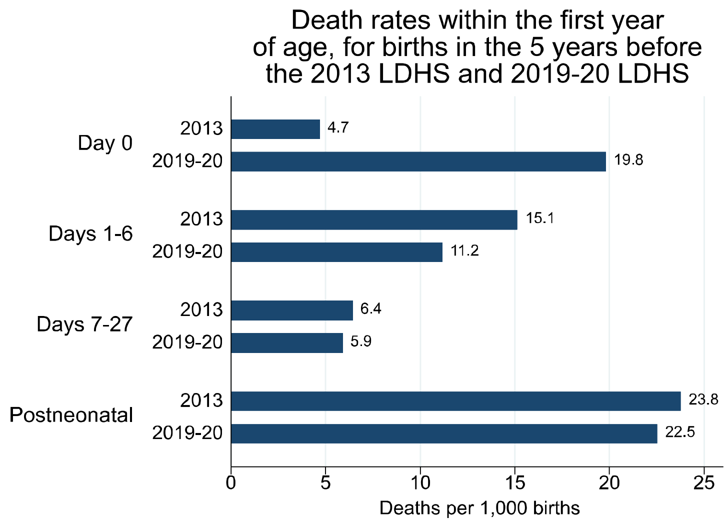


Figure 3.1.1 allows us to see more clearly the pattern within the first year. The second survey produced higher rates for the first year, and higher rates for the neonatal and early neonatal intervals and the first day. For all four pairs of bars, the bar for the second survey is longer than the bar for the first survey. The difference is about the same for each rate but is largest for day 0, which is not normally broken out.

Because the rates in Figure 3.1.1 are cumulative, all of them starting with the first day, we are motivated to see what each successive interval contributed to the infant mortality rate. Figure 3.1.2 partitions the first year into four non-overlapping age intervals: Day 0, days 1–6, days 7–27 (late neonatal), and the remainder of the first year (post neonatal). The sum of these components is the infant mortality rate. (The horizontal scale is different for Figure 3.1.2 than for Figure 3.1.1.)

Figure 3.1.2 shows that for all components other than day 0, the rate in the second survey was *lower* than the rate in the first survey. The differences are small, and it remains to be seen whether they are statistically significant, but there is no evidence of an increase. The only interval with an increase, and it is a large increase, is for day 0. The 2019–20 survey has many more deaths at day 0 than would have been expected. We will return to this observation later in the report.

Figure 3.1.2 Death rates for four non-overlapping age intervals during infancy, based on children born during the 5 years before the 2013 LDHS and 2019–20 LDHS



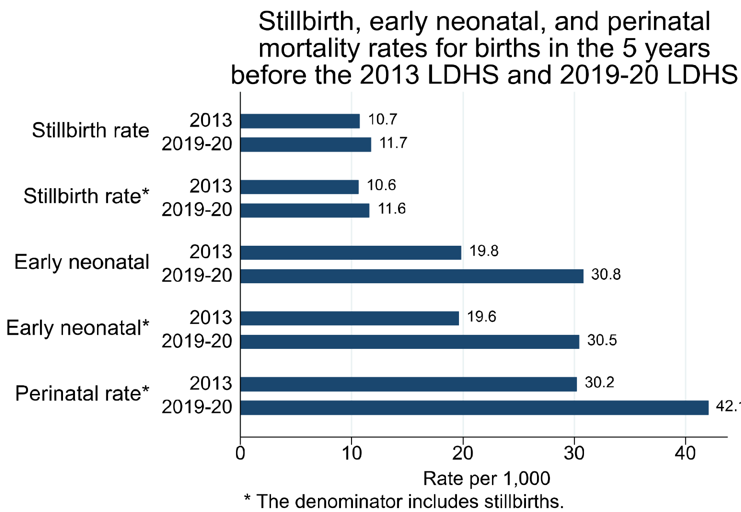
3.2 Perinatal Mortality

It is possible that respondents occasionally deviate from standard definitions by misclassifying a stillbirth as an early neonatal death or misclassifying an early neonatal death as a stillbirth. The distinction rests on whether there are signs of life at the time of delivery. There may indeed be some ambiguous deliveries, but there could also be other reasons why misclassification occurs. (See, for example, Liu et al., 2016.)

The perinatal death rate is defined as the sum of stillbirths and early neonatal deaths, divided by the sum of the number of births and stillbirths (and multiplied by 1,000). In Figure 3.2.1, the bottom two bars give the neonatal mortality rates in the 2013 survey (30.2) and the 2019–20 survey (42.1). These rates were re-calculated for this report and match the rates in the published reports—30 and 42. There was a substantial increase in perinatal deaths in the 2019–20 survey. If the increase was due to a change in the classification of stillbirths and early deaths, we would expect to see at least a partial decline in reported stillbirths accompanying the increase in early neonatal deaths, yet that pattern is not evident.

In order to see the roles of those two components in the overall increase, Figure 3.2.1 includes bars that separate the two components of the perinatal rates—stillbirths and early neonatal deaths. Two rates are calculated for each component. In one version (identified with an asterisk) the denominator is the same as for the perinatal rates—that is, births plus stillbirths. With this denominator, the sum of the stillbirth rate and the early neonatal rate is the perinatal rate. For easier comparison with the early death rates, we also give (without an asterisk) stillbirth and early neonatal rates where the denominator consists only of births.

Figure 3.2.1 Perinatal mortality rates, based on pregnancies of 7+ months duration during the 5 years before the 2013 LDHS and 2019–20 LDHS, and two versions of the stillbirth rate and the early neonatal rate



Whichever denominator is used, there is no evidence that the stillbirth rate declined between the two surveys. Both denominators, in both surveys, imply 11 or 12 stillbirths per 1,000 births—or per 1,000 births plus stillbirths. The increase in the perinatal rate, from 30 to 42, was due almost entirely to the increase in the early neonatal rate, from 20 to 31 deaths per 1,000 births.

If the increase in early neonatal deaths had been due to the misclassification of stillbirths and early neonatal deaths suggested at the beginning of this section—or, more accurately, to a *change* in the *potential* level of misclassification—the evidence would be an apparent decline in the stillbirth rate between the two surveys, accompanying the increase in the early neonatal rate. As there was no decline in the stillbirth rate, we infer that the increase in perinatal mortality is due to the increase in early neonatal mortality as described in Figures 3.1.1 and 3.1.2, rather than to classification error.

3.3 Statistical Significance of the Changes in Rates

Thus far there has been little reference to the potential role of sampling error. The number of children who are reported with an early neonatal death, for example, is relatively small. As shown in Table 8.4 in the final reports on the two surveys, during the 5 years before each survey there were only 129 early neonatal deaths for the 2013 survey (out of 6,572 - 70 = 6,502 births) and 161 in the 2019–20 survey (out of 5,285 - 61 = 5,224 births). (There were 70 and 61 stillbirths in the two surveys in the past 5 years; all of these frequencies are weighted.) We now examine the statistical significance of changes in all the death rates for the first year after birth.

The statistical significance of changes is approached with logit regression. The children in the two surveys are combined in a single file. If a child in the first survey died in a specific interval of age, it is assigned d = 1 (a subscript to identify the age interval is omitted here). If the child died in a different interval or (as with most children) did not die at all, then d = 0. Children in the 2013 survey, which serves as a baseline, are coded with S = 0 ("S" for "survey"). Children in the 2019–20 survey have S = 1. We use logit regression to predict d with S, with appropriate adjustments for sample weights and the sample design.

In Figures 3.3.1 and 3.3.2, red dots show the point estimates of the odds ratios for S in the various age intervals. The vertical lines above and below the red dots show 95% confidence intervals for the odds ratios. The green horizontal line shows the expected values of the odds ratios (1) under a null hypothesis of no change between the two surveys. If a 95% confidence interval crosses the green line, then we infer no change or difference between the surveys (at the .05 level).

Figure 3.3.1 Estimates and 95% confidence intervals for all changes in the odds of a child death within the first year after birth, for all births and infant deaths during the 5 years before the 2013 LDHS and 2019–20 LDHS

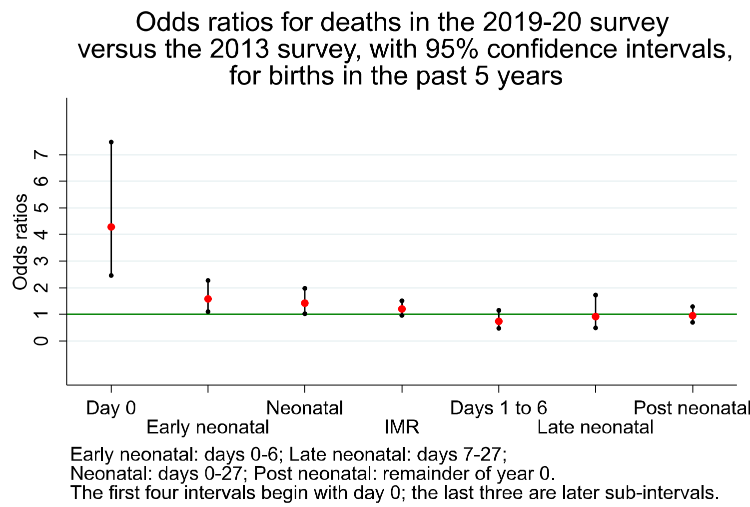
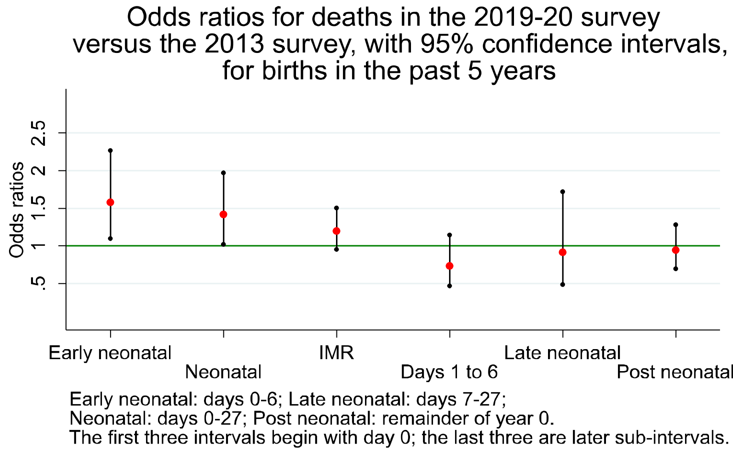


Figure 3.3.2 **95% confidence intervals for all changes in the odds of a child dying within the first year after birth, for all births and infant deaths during the 5 years before the 2013 LDHS and 2019–20 LDHS. The odds ratio for day 0 is omitted.**



The first four rates in Figure 3.3.1 are cumulative and appeared in Figure 3.1.1. The last three are non-overlapping and appeared in Figure 3.1.2. The rate for day 0 appeared in both Figures 3.1.1 and 3.1.2. The highly significant values for day 0 dominate the vertical scale in Figure 3.3.1. For that reason, we follow it with Figure 3.3.2, in which day 0 is removed and we can more easily see the estimates for the other six intervals. The intervals for the early neonatal and neonatal intervals are significantly greater than 1 at the .05 level, but only marginally. Again, it is clear that the early neonatal, neonatal, and infant rates in Figure 3.3.2 are higher in the 2019–20 survey than in the 2013 survey, and that inflation on day 0 is the reason.

3.4 Changes in Household and Child Health Characteristics Related to Child Survival

At this point in the analysis, it appears that infant mortality was flat between the reference periods for the 2013 and 2019–20 surveys, except for the increase for day 0. Apart from day 0, it is remarkable that the two surveys produce such similar estimates of mortality in the early neonatal, neonatal, and post neonatal intervals.

Ideally infant mortality would not have increased, and would not have been flat, but would have declined. We now examine a series of comparisons between the two surveys, in terms of characteristics that are typically related to child survival. Were the distributions of these potential covariates also the same in both surveys?

Potential covariates of child survival are examined in two categories. The first is household characteristics. The second is characteristics limited to children who survived that help describe the general context of child health. Horizontal bar graphs are used to describe levels and changes in the urban, rural, and total populations. For these covariates, the reference date is the date of interview and not the intervals before the surveys. In that sense they are not temporally synchronized with the outcome. This section of the report is descriptive, drawn from STATcompiler, and does not include confidence intervals.

Figures 3.4.1–3.4.4 describe four household-level characteristics: improved water (Figure 3.4.1), improved water on the premises (Figure 3.4.2), improved sanitation (Figure 3.4.3), and access to electricity (Figure 3.4.4). All four showed improvements nationally, and in both urban and rural areas. Perhaps the most conspicuous improvements were in urban areas, where the percentage of households with improved water on the premises increased from 9% to 27%, and the percentage of households with electricity increased from 16% to 39%.

Earlier research suggests that improved water and sanitation, and electricity, tend to have their direct impact on child survival during the post neonatal and child (age 1–4) intervals, and not during the neonatal period, when children are most likely being breastfed. But improvements in these characteristics could directly improve the health of the mother and older siblings.

Figure 3.4.1 Changes in household-level characteristics related to child survival in the 2013 LDHS and 2019–20 LDHS: improved water source

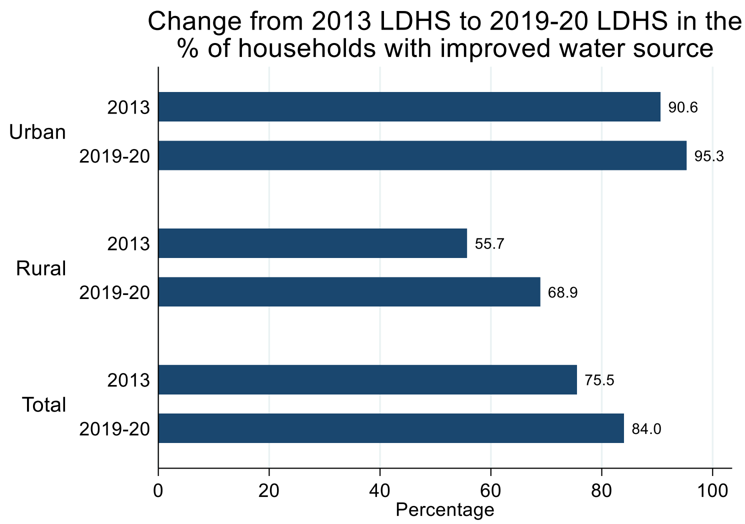


Figure 3.4.2 Changes in household-level characteristics related to child survival in the 2013 LDHS and 2019–20 LDHS: improved water source on the premises

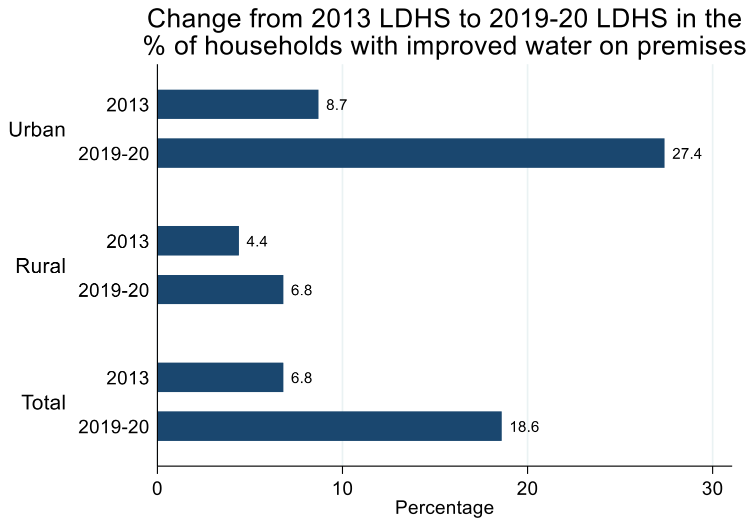


Figure 3.4.3 Changes in household-level characteristics related to child survival in the 2013 LDHS and 2019–20 LDHS: improved sanitation

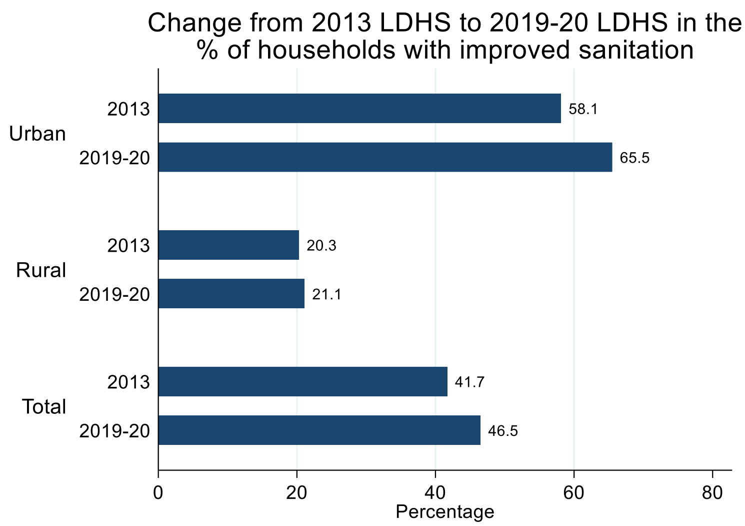
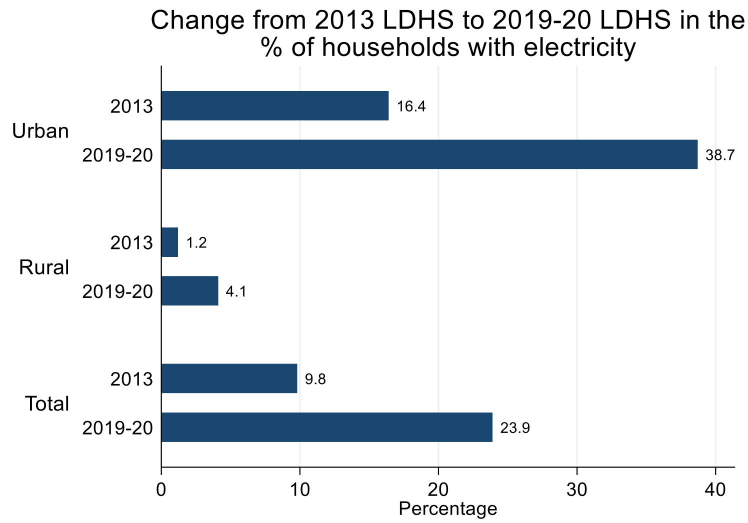


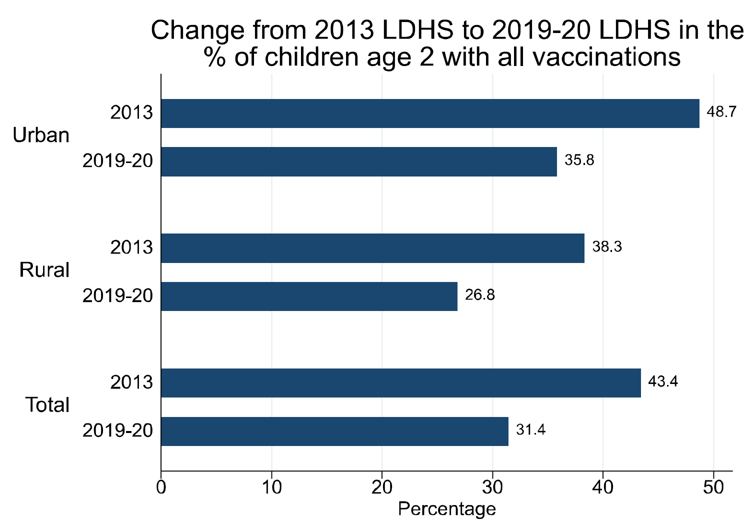
Figure 3.4.4 Changes in household-level characteristics related to child survival in the 2013 LDHS and 2019–20 LDHS: electricity



Figures 3.4.5–3.4.10 shift to information collected about children who were born in the past 5 years and were alive at the time of the survey. Children are the units of analysis, but children who died before the survey are omitted. The indicators in these six figures describe the more general context of child health and the health infrastructure.

Figure 3.4.5 shows the percentages of children age 2 years at last birthday (24–35 completed months) who had received all recommended vaccines. The level of coverage declined from 42% to 31% nationally, with similar declines in both urban and rural areas. This decline may be negatively related to child survival, but mainly after the first year.

Figure 3.4.5 Changes in child-level characteristics related to child survival in the 2013 LDHS and 2019-20 LDHS: vaccination coverage



Figures 3.4.6–3.4.8 describe changes in the level of treatment for child illness—fever or diarrhea—in the two weeks before the interview. Malaria is an important cause of child deaths in West Africa, including neonatal deaths. Fever is a potential symptom of malaria and immediate treatment is advised. Figures 3.4.6, 3.4.7, and 3.4.8 give the percentages of children taken to a facility or provider, the percentages treated with anti-malarial drugs, and the percentages treated with antibiotics. Changes from the 2013 survey to the 2019–20 survey shown in Figure 3.4.6 are mixed. In urban areas, the percentage of children with fever who were taken to a facility for a diagnosis increased from 81% to 87%, a very high level. In rural areas, the percentages are lower and almost exactly the same in both surveys. The percentage receiving antimalarial drugs decreased by 10 points in urban areas and increased slightly, by 3 points, in rural areas (Figure 3.4.7). The percentage receiving antibiotics declined in both urban and rural areas (Figure 3.4.8). The proper course of treatment depends on the diagnosis at the health facility, so it is possible that a decline in antimalarial drugs or antibiotics is the result of more accurate diagnoses, but that interpretation would require other evidence.

Figure 3.4.6 Changes in child-level characteristics related to child survival in the 2013 LDHS and 2019–20 LDHS: treatment for fever

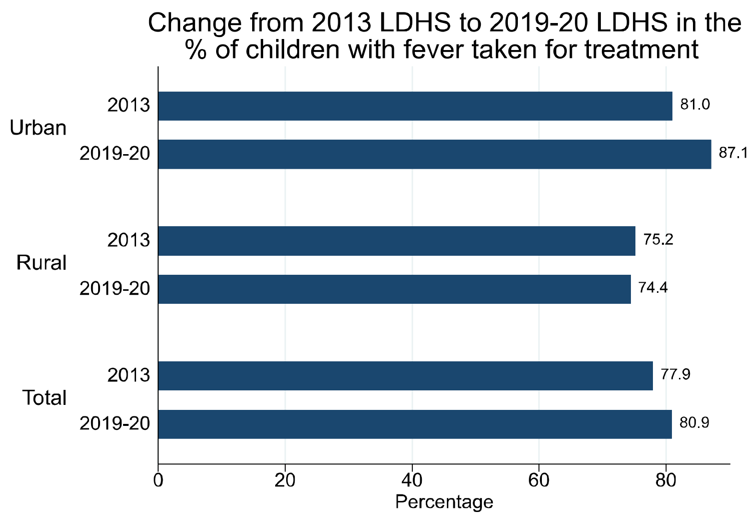


Figure 3.4.7 Changes in child-level characteristics related to child survival in the 2013 LDHS and 2019–20 LDHS: treated with anti-malarial drugs for fever

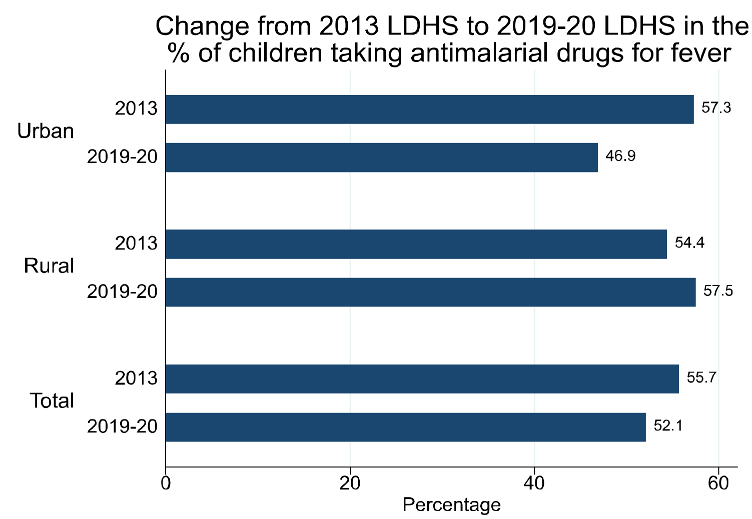


Figure 3.4.8 Changes in child-level characteristics related to child survival in the 2013 LDHS and 2019–20 LDHS: treated with antibiotics for fever

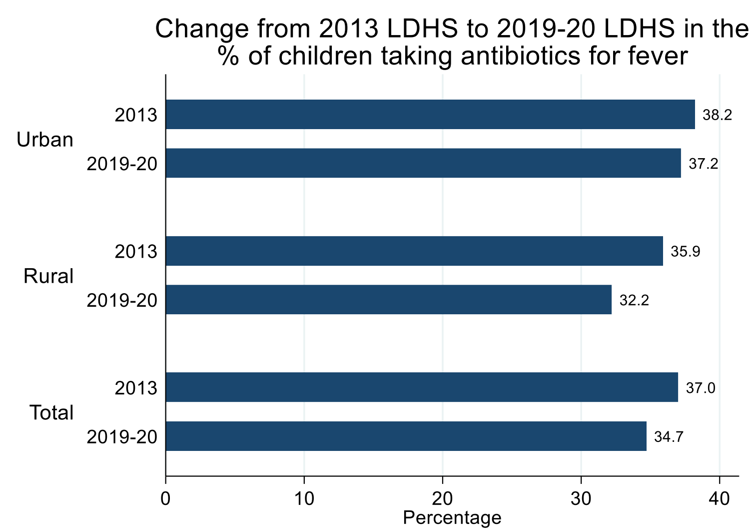


Figure 3.4.9 gives the levels and changes in the percentages of children who received treatment for diarrhea in the past two weeks. Nationally, the percentage declined somewhat, from 70% to 66%. The level was slightly lower in rural areas, and the amount of decline was slightly greater in rural areas than in urban areas.

Figure 3.4.9 Changes in child-level characteristics related to child survival in the 2013 LDHS and 2019–20 LDHS: taken to health facility for diarrhea

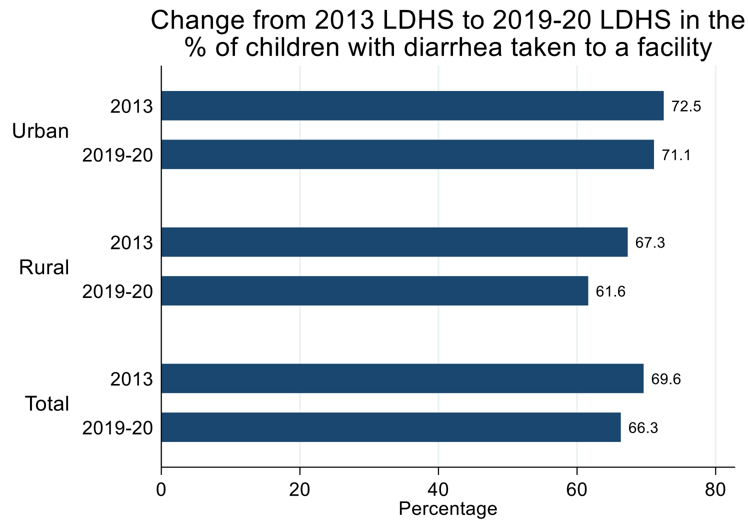
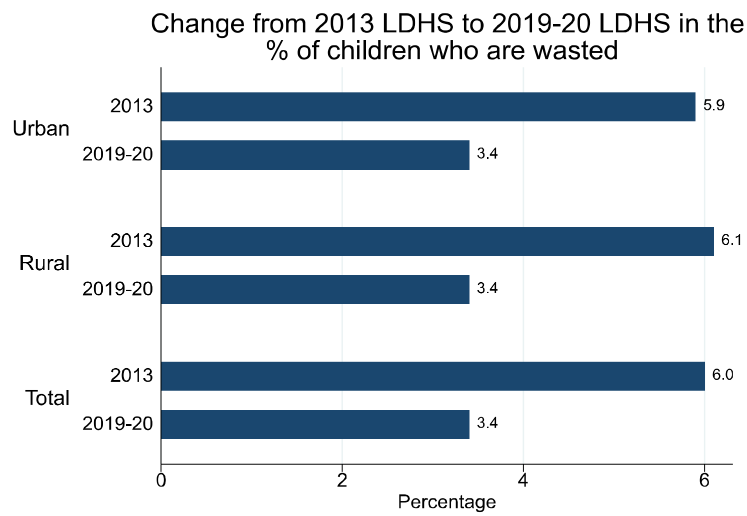


Figure 3.4.10 gives an indicator of nutritional status—the prevalence of wasting for children under 5. Wasting is indicated by a weight that is more than two standard deviations below the normative weight, given the child's height (or length if less than 2 years of age). In a healthy population, only about 2.4% of children would be below the threshold for wasting. In Liberia, in the 2013 LDHS, the estimate was 6.0% of children. By the time of the 2019–20 survey, only about 3.4% of children were wasted, and the level was the same in urban and rural areas. This change suggests some improvement in children's nutritional status.

Figure 3.4.10 Changes in child-level characteristics related to child survival in the 2013 LDHS and 2019–20 LDHS: wasting



Most of the 10 indicators discussed in this section showed improvements between the two surveys, in both urban and rural Liberia and nationally. The only exceptions were related to the type of treatment for fever, and it is impossible to infer whether the shift was from less appropriate to more appropriate treatment. On balance, the changes in these indicators would have been more consistent with improvements in child survival than with stagnation of rates.

3.5 Changes in Antenatal Care and Place of Delivery

Only a few characteristics are available for all children, regardless of whether they survived—and, if they survived, regardless of how long they survived.[8] Two of the most important are the mother's number of antenatal visits and the place of delivery. In virtually all countries, antenatal care and facility deliveries are among the most important components of programs to improve child survival. There is likely some selectivity. Women who receive antenatal care or have their birth in a facility tend to share other characteristics that could affect child survival. For example, women who have better access to health care could also to have better educational opportunities.

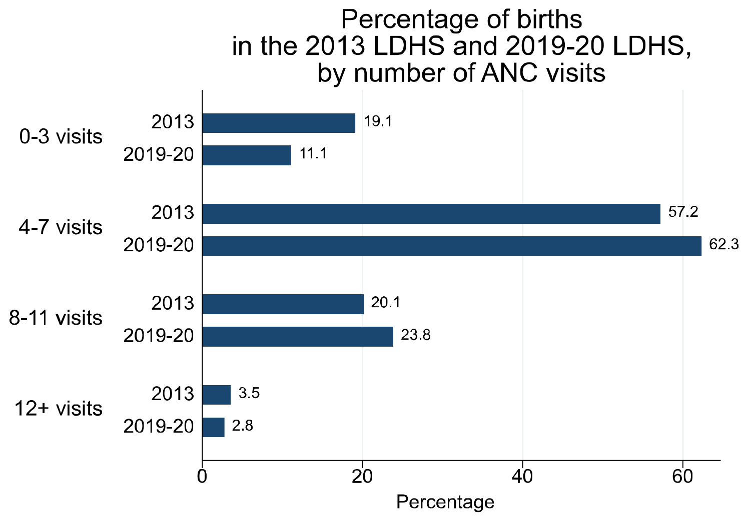
The recommended number of ANC visits was 4+ at the time of the 2013 LDHS and 8+ at the time of the 2019–20 LDHS. The distribution of the number of visits in most DHS surveys, including those in Liberia, is skewed to the right, with some women having 20 or more visits. Some of the very high numbers could be due to misunderstanding the question. However, women whose pregnancy is difficult may have many visits for relatively continuous monitoring as the pregnancy progresses. For this reason, the relationship between the number of ANC visits and child survival is complex. If the pregnancy is difficult, the woman may have many visits *and* the child may have reduced chances of survival. The relationship is probably curvilinear—mothers of surviving children tend to have an intermediate number of visits, and the mothers of children who die tend to have few or many visits.

Four figures—3.5.1, 3.5.2, 3.5.3, and 3.5.4—relate to this covariate. The first figure shows the distribution of the number of ANC visits (grouped as 0–3, 4–7, 8–11, and 12+) in the two surveys. In Figure 3.5.1, the bars for each survey add to 100%. The next three figures give the death rates for non-overlapping age intervals. The figures do not include confidence intervals.

Figure 3.5.1 gives the distributions of ANC visits in the two surveys. It shows a reduction of 8 points in the percentage of births that were preceded by fewer than four ANC visits. By the time of the second survey, only 11% of births were in this category. The shift led to increases in both the percentage with 4–7 visits and the percentage with 8–11 visits: 86% of the births in the 2019–20 survey were preceded by 4–11 visits.

[8] Information on breastfeeding, for example, is not reliable for children who died very early.

Figure 3.5.1 Percentages of births in the past 5 years, in the 2013 LDHS and 2019–20 LDHS, with 0–3, 4–7, 8–11, and 12+ ANC visits



Figures 3.5.2, 3.5.3, and 3.5.4 give the death rates for three non-overlapping age intervals in the first year: 1–6 days, 7–27 days, and the post neonatal interval. The early neonatal interval does not include day 0, to bypass concerns about over-reporting on day 0. Characteristics of the pregnancy and delivery, including the number of ANC visits, would be expected to have their greatest impact on survival soon after the birth.

In Figure 3.5.2, for early neonatal mortality, the sharpest contrast between the two surveys appears for mothers with 0–3 ANC visits, compared to those with 8–11 visits. In the 2013 survey, both categories had the same early neonatal rate–14 deaths per 1,000 births. In the second survey, following the substantial shift toward more ANC visits, the neonatal rate was 19 per 1,000 births for women with the fewest visits and only 4 per 1,000 for women with 8–11 visits. The rate for women with 4–7 visits was steady, at 8 deaths per 1,000 in both surveys. There was an increase in neonatal mortality for women with 12+ visits, to 5 per 1,000, a pattern that could be due to programmatic emphasis on increased numbers of ANC visits for women with difficult pregnancies.

Figure 3.5.2 Early neonatal death rates omitting day 0 (at age 1–6 days) in the 2013 LDHS and 2019–20 LDHS, for children whose mothers had 0–3, 4–7, 8–11, and 12+ ANC visits. Rates are per 1,000 children born during the 5 years before the survey

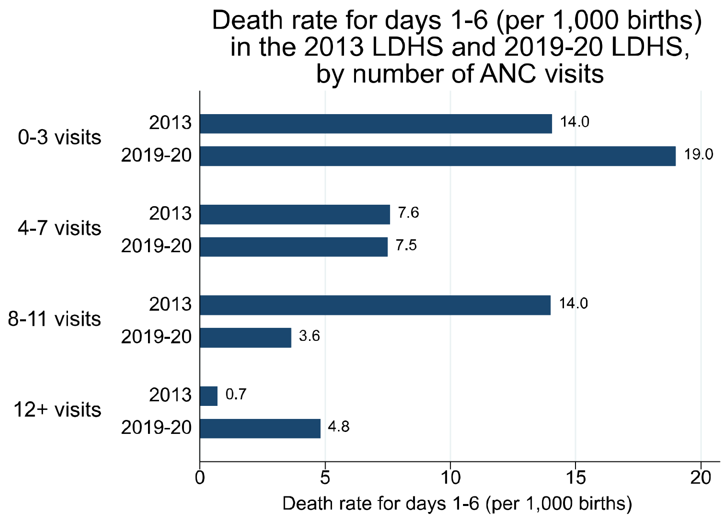


Figure 3.5.3 is analogous to Figure 3.5.2 but describes the late neonatal interval. The death rates are small, lower than the early neonatal rates, and the changes are not statistically significant, with one conspicuous exception: an increase in the rate for women with 12+ visits. In both surveys, as was seen in Figure 3.5.1, only about 4% of women have 12+ visits, and the number of deaths reported in this category is small. Our interpretation of the increased risk of death in this category is the same as for Figure 3.5.2. The pattern is what would be expected if women who have difficult or problematic pregnancies are being identified and targeted for extra ANC visits. A high number of ANC visits is an appropriate response to high risk, even if the greater number of visits cannot fully compensate for a higher risk that the child may die.

Figure 3.5.3 Late neonatal death rates (at age 7–27 days) in the 2013 LDHS and 2019–20 LDHS, for children whose mothers had 0–3, 4–7, 8–11, and 12+ ANC visits. Rates are per 1,000 children born during the 5 years before the survey

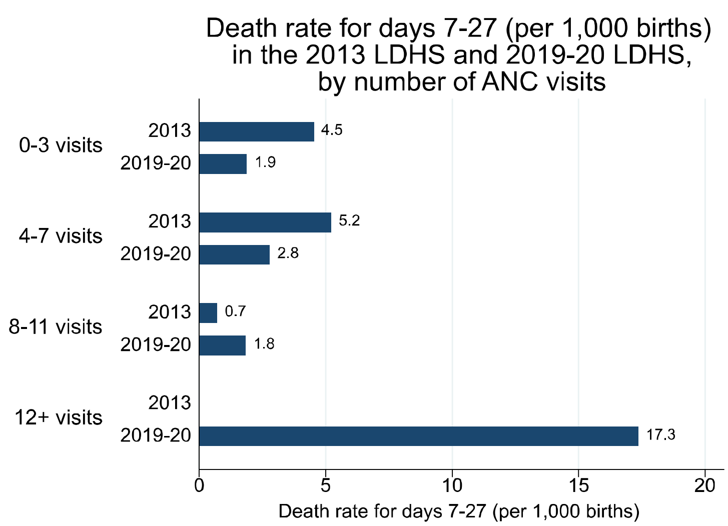
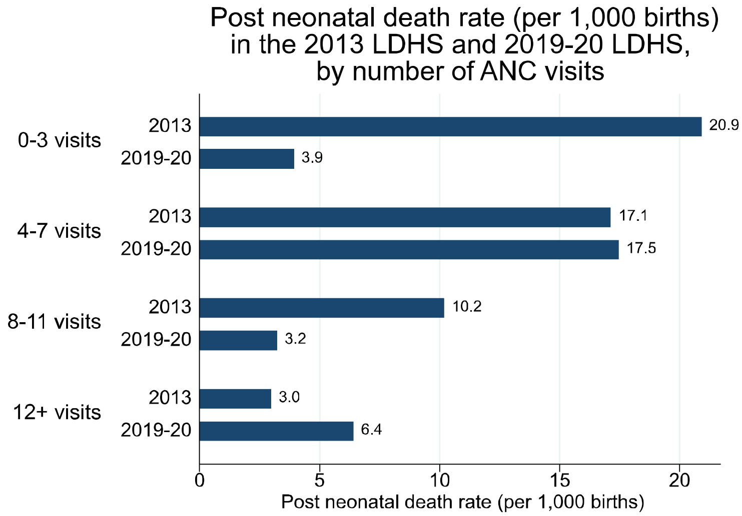


Figure 3.5.4 gives mixed evidence of survival benefits from antenatal care in the post neonatal interval. Except for the category of 0–3 visits, the pattern matches exactly with what was seen for the early neonatal interval: no change in the rates for 4–7 visits, a reduction in the rate for 8–11 visits, and an increase in the rate for 12+ visits, which we suggest is due to better identification of difficult pregnancies. However, for women with 0–3 visits, the second survey has a much lower post neonatal death rate than the 2013 survey. This finding is not consistent with expectations.

Figure 3.5.4 Death rates at post neonatal ages in the 2013 LDHS and 2019–20 LDHS, for children whose mothers had 0–3, 4–7, 8–11, and 12+ ANC visits. Rates are per 1,000 children born during the 5 years before the survey



Because of the importance of interventions related to ANC visits, we now synthesize the age intervals and add confidence intervals. Figure 3.5.5 covers the entire first year of age, including day 0, with point and interval estimates for each of the four categories of ANC visits in both surveys. In both surveys, infant mortality is highest for the category of only 0–3 ANC visits. In the first survey it is lowest for 12+ visits, but by the time of the second survey, there is a curvilinear pattern, such that the rate is lowest for children whose mothers had 8–11 ANC visits. The confidence intervals are wide, but in the second survey the 8–11 category definitively has lower infant mortality than the mean.

Figure 3.5.5 Infant deaths per 1,000 births in the past 5 years in the 2013 LDHS and 2019–20 LDHS, for children whose mothers had 0–3, 4–7, 8–11, and 12+ ANC visits

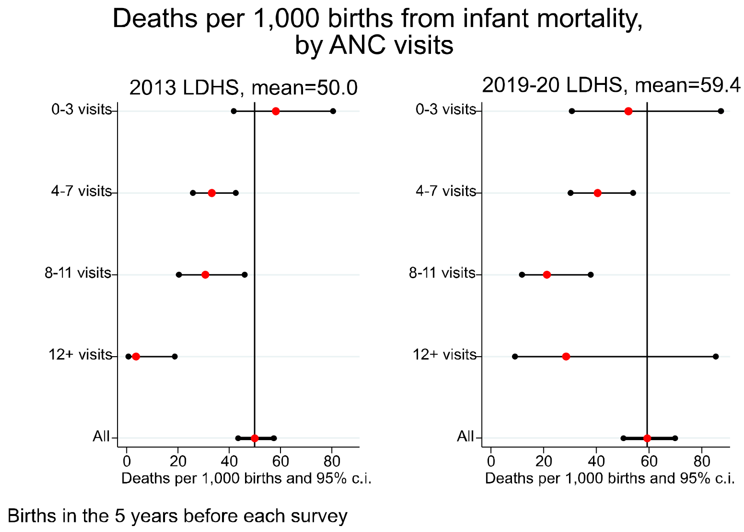
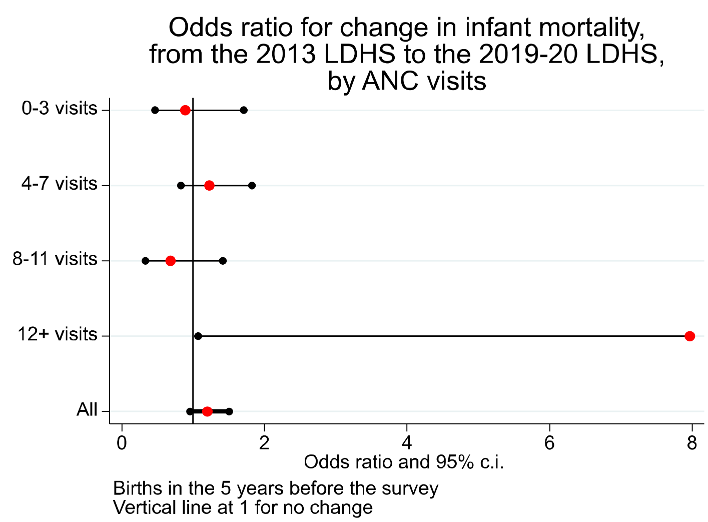


Figure 3.5.6 essentially compares the patterns on the right side of Figure 3.5.5 with the pattern on the left side, to identify change between the two surveys. Change is described with an odds ratio for each category. There was some change in the odds ratios, but the confidence intervals are wide and do not provide convincing evidence of change in the population. For 12+ visits, the confidence interval is so wide that only the lower arm of the interval is shown. The upper arm is suppressed because, if it were retained, the horizontal scale would change dramatically. As discussed earlier, there is a hint of an increase in the rate for 12+ visits that would be consistent with identification and targeting of difficult pregnancies for more ANC visits, but the numbers are small and there is high uncertainty.

Figure 3.5.6 Odds ratios for change in infant deaths per 1,000 births in the past 5 years, from the 2013 LDHS to the 2019–20 LDHS, for children whose mothers had 0–3, 4–7, 8–11, and 12+ ANC visits

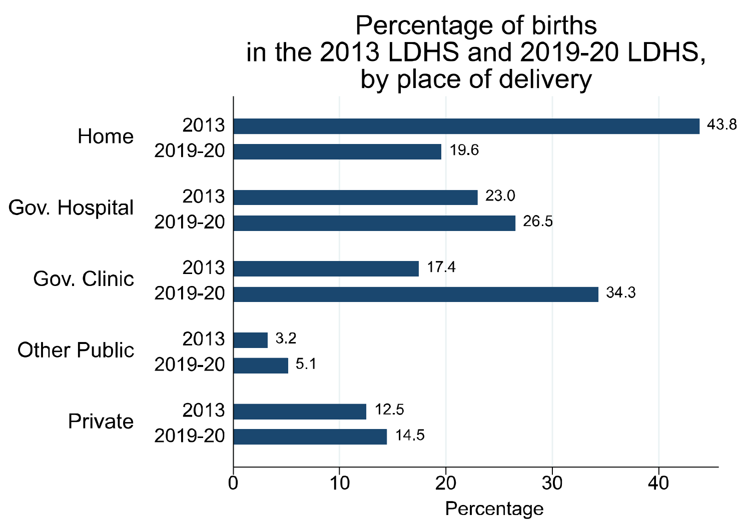


3.6 Changes in Place of Delivery

A second group of four figures—labeled 3.6.1, 3.6.2, 3.6.3, 3.6.4—relates to place of delivery. The categories of this variable are adapted to the Liberian context. “Home” refers to the respondent’s home or another home, presumably that of a relative or friend. Three categories of public facilities are broken out: “Government Hospital,” “Government Clinic,” and “Other Public.” A fifth category, “Private,” includes a range of sizes and types of facilities but relatively few births. Figure 3.6.1 gives the distributions of births in the two surveys, across the five types of places. Figures 3.6.2, 3.6.3, and 3.6.4 give the death rates within the five categories.

Figure 3.6.1 shows a dramatic decline in the percentage of births taking place in a home, from 44% to 20%. The shift out of this category is reflected by increases in all four types of facilities. The largest increase was an approximate doubling of the percentage in government clinics. In the 2013 LDHS, government hospitals were the dominant location for facility births, but in the 2019–20 LDHS government clinics had become the dominant location. In the 2013 survey, public facilities accounted for 44% of all births and private facilities for 13%. In the 2019 survey, the percentages were 66% and 15%, respectively.

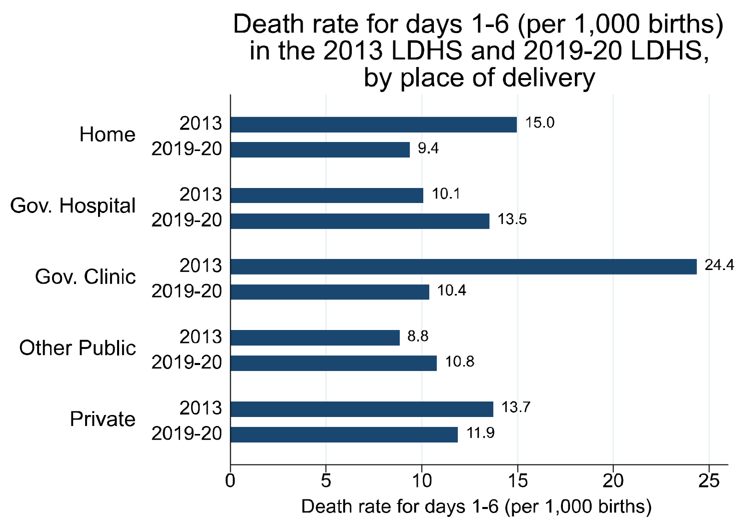
Figure 3.6.1 Percentages of births in the past 5 years, in the 2013 LDHS and 2019–20 LDHS, in five types of place of birth



The next figure, Figure 3.6.2, gives the early neonatal death rates, excluding day 0, for each of these places of delivery in each survey. The most conspicuous change is that the rate for births in government clinics declined from 24 per 1,000 births to 10 per 1,000. It is remarkable that as the percentage of births occurring in government clinics doubled, from 17% to 34%, the early neonatal rate for those clinics fell by more than half. This improvement was only partially offset by small increases in the other two categories of public facilities (government hospitals and “other” public). There were also reductions in the rate of deliveries at home and in private facilities.

A full accounting of the changes from the reference period of the 2013 survey to the reference period of the 2019–20 survey would require more information than is available in the surveys. The change in the distribution of place of birth seen in Figure 3.6.1 was produced largely by a shift from births at home to births in facilities, and there was also some shifting from one type of facility to another. The decline in early neonatal mortality for home births, seen in Figure 3.6.2, may be explained by the kind of identification and targeting described in the discussion of Figures 3.5.2–3.5.4. If the pregnancies that had higher risk were the ones that were shifted from homes to facilities, the result would be a decline in the rate for births at home and potentially an increase in the rates for government hospitals or "other" public facilities. Whatever accounts for the other changes in Figure 3.6.2, the most significant finding is the substantial decline in the early neonatal death rate for government clinics at the same time their coverage was doubling.

Figure 3.6.2 Early neonatal death rates omitting day 0 (at age 1–6 days) in the 2013 LDHS and 2019–20 LDHS, for children in five types of place of birth. Rates are per 1,000 children born during the 5 years before the survey.



The horizontal scales for Figures 3.6.2, 3.6.3, and 3.6.4 are different. Figure 3.6.3 is analogous to Figure 3.6.2 but refers to the late neonatal period, days 7–27. The two bars for government clinics show—as before—a mortality decline of more than half from the first survey to the second. The rate declined from 11 deaths per 1,000 births to only 5. The only other evidence of change is in the rate for government hospitals, which increased from 3 deaths per 1,000 to 9. We saw an increase for government hospitals in Figure 3.6.2, but the difference is larger in Figure 3.6.3 and would be difficult to explain by compositional change in the balance of higher risk births between the surveys.

For most babies born in a facility, the mother and baby will leave the facility early in the first week, but there should be follow-up postnatal care for both. There may be differences in postnatal care for different types of facilities that would help us understand why both early neonatal and late neonatal mortality improved dramatically for government clinics. Late neonatal mortality increased in government hospitals to become greater in hospitals than in clinics, reversing the pattern in the first survey. Risks associated with a premature birth, and capacity to care for a premature birth, may also be relevant.

Figure 3.6.3 **Late neonatal death rates (at age 7–27 days) in the 2013 LDHS and 2019–20 LDHS, for children in five types of place of birth. Rates are per 1,000 children born during the 5 years before the survey.**

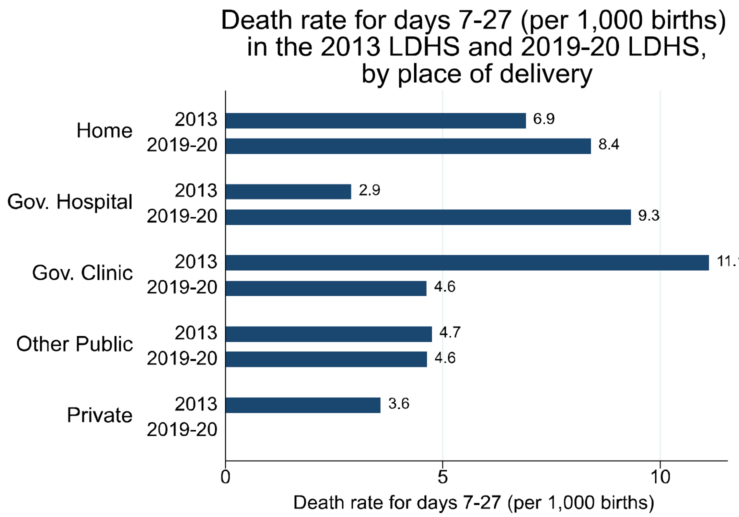
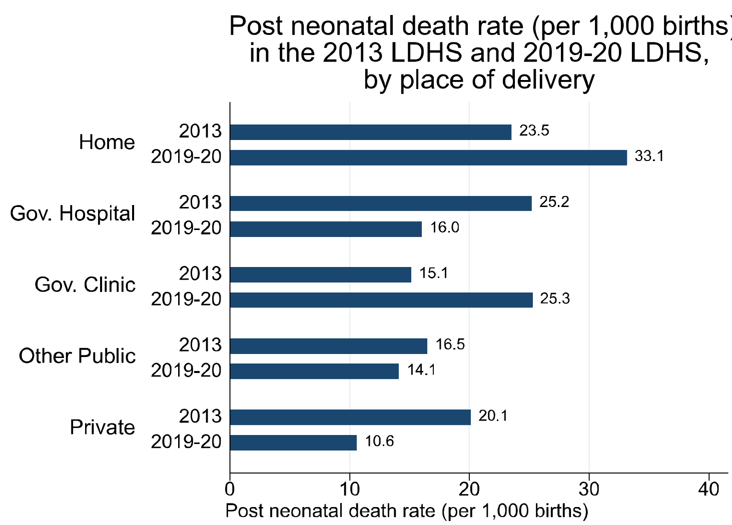


Figure 3.6.4, the final figure in this group, describes post neonatal mortality. We would expect the effects of place of delivery to be attenuated after the child has already survived the first 28 days, and there is less heterogeneity across the five possible places of delivery. Mortality is higher in the second survey for births at home or in government clinics, by 9 to 10 points. It is lower in the second survey for government clinics and other public facilities, by 9 to 10 points. Some of these differences are consistent with Figures 3.5.2 and 3.5.3, but others are not.

Figure 3.6.4 **Death rates at post neonatal ages in the 2013 LDHS and 2019–20 LDHS, for children in five types of place of birth. Rates are per 1,000 children born during the 5 years before the survey.**



As with ANC visits, we add two figures that encompass the full first year of age, including day 0, and include confidence intervals. Figure 3.6.5 shows that the rates for the different types of places are similar, especially when statistical uncertainty is considered. In the 2019–20 survey, the rate for private facilities is lowest, by a marginally significant amount. Figure 3.6.5 shows that mortality increased for home and government hospital births, by marginally significant amounts.

Figure 3.6.5 Infant deaths per 1,000 births in the past 5 years in the 2013 LDHS and 2019–20 LDHS, for children in five types of place of birth

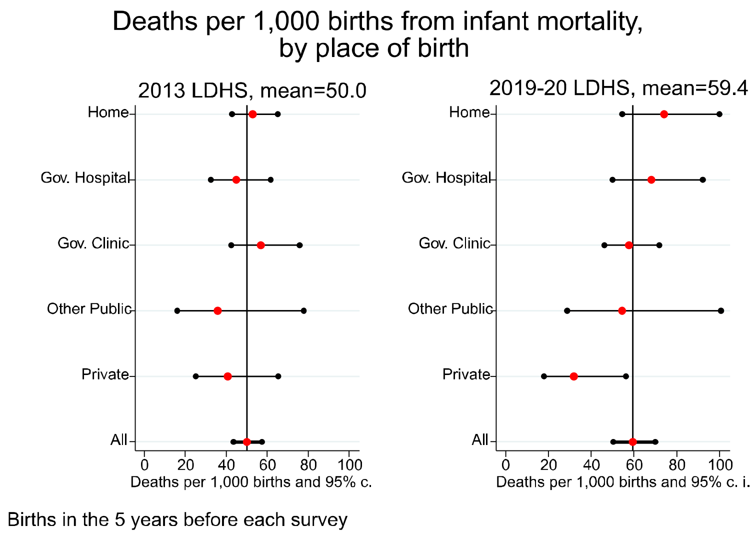
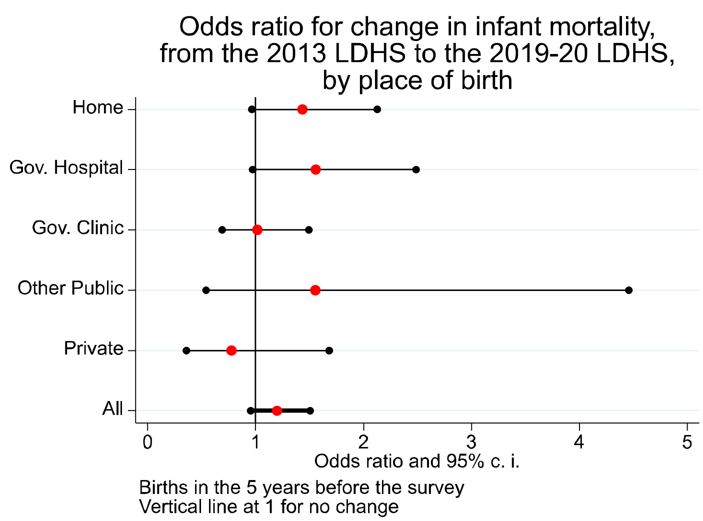


Figure 3.6.6 Odds ratios for change in infant deaths per 1,000 births in the past 5 years, from the 2013 LDHS to the 2019–20 LDHS, for children in five types of place of birth



3.7 Differences in Infant Mortality by Socioeconomic Characteristics

This section describes infant mortality during the full first year, within each value of five covariates. We examined the three age intervals (days 1–6, days 7–27, and the remainder of the first year) in the preceding section, but the confidence intervals are wide and the findings are repetitive. Here we include day 0, which was omitted from the early neonatal period in the previous discussion. The likely over-reporting of day 0 has the least effect on estimates for the full first year. There is some censoring (incomplete exposure to risk) in the post neonatal period, so the rate given here is consistently slightly lower than the estimate that would be obtained with the usual DHS rate construction methods, but the analytical advantages described in Section 2 outweigh that bias. Infant mortality is reviewed according to region, mother's education, household wealth, combinations of region and urban/rural residence, and county.

For each of the five covariates, we present a pair of figures that include confidence intervals. Within each pair, the first figure includes two subfigures, one on the left for the 2013 LDHS and one on the right for the 2019–20 LDHS. The horizontal axis gives the number of infant deaths per 1,000 births in the past 5 years. The scale is the same for both subfigures. A vertical line is placed at the overall mean. For each category of the covariate, a red dot is placed at the observed rate. Horizontal black lines represent 95% confidence intervals. Categories with more births and deaths tend to have narrower confidence intervals and to have more impact on the mean. A second figure describes the odds ratio for the second survey compared with the first. An odds ratio greater than 1 indicates an increase in mortality. In general, of course, we would hope to see a decline in mortality.

We saw earlier, in Figure 3.1.2, that the increase in the IMR between the surveys could be attributed entirely to the excess deaths reported on day 0. When day 0 is included, the increase between the two surveys is marginally significant. When day 0 is excluded, there is virtually no change in the national-level IMR; there is a slight decline, but it is not significant. The excess at day 0 appears to be close to random with respect to the covariates, so inferences about differences between categories of covariates does not depend on whether day 0 is included or not.

Figures 3.7.1–3.7.2 describe infant mortality in the five major regions. At the time of the 2013 survey, mortality in the North Western and South Eastern B regions was significantly above the mean, and North Central was significantly (marginally) below the mean. However, in the 2019–20 survey, there were no significant differences between the regions. There was a reduction in the differences.

Figure 3.7.2 describes the change between surveys. The greatest contrast is between South Eastern A, where mortality increased significantly, and South Eastern B, the only region where reported mortality declined, although not significantly.

Figure 3.7.1 Infant deaths per 1,000 births in the past 5 years in the 2013 LDHS and 2019–20 LDHS, for the major regions of Liberia

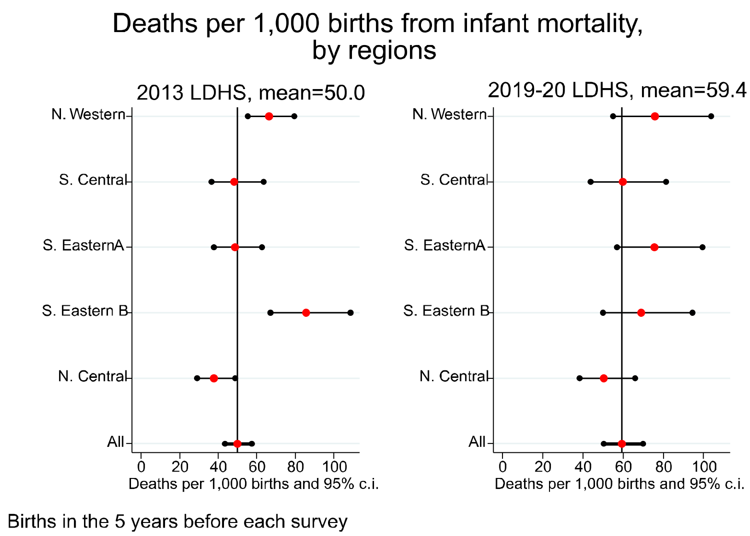
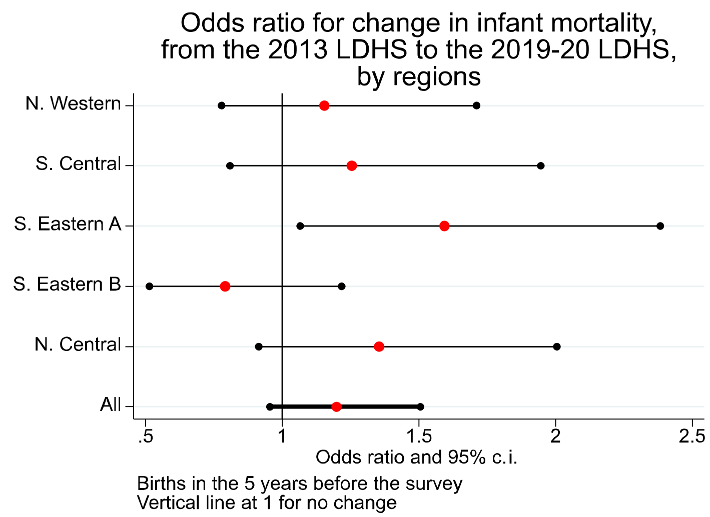


Figure 3.7.2 Odds ratios for change in infant deaths per 1,000 births in the past 5 years, from the 2013 LDHS to the 2019–20 LDHS, for the major regions of Liberia



Figures 3.7.3–3.7.4 describe mortality by the mother's level of education. The pattern is easily summarized. Children of mothers with secondary and higher education had the lowest infant mortality in both surveys, but the differences across education categories were small and not significant. The increases (due to the inclusion of day 0) were almost the same in all three categories.

Figure 3.7.3 Infant deaths per 1,000 births in the past 5 years in the 2013 LDHS and 2019–20 LDHS, by the mother's level of education

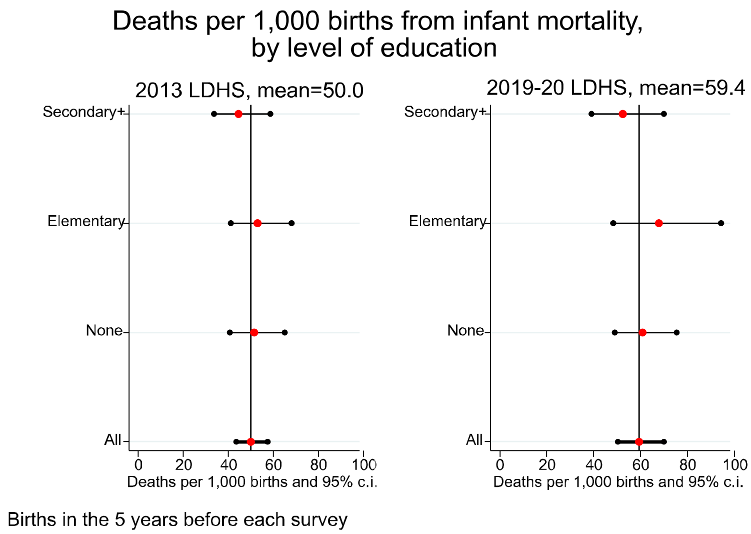
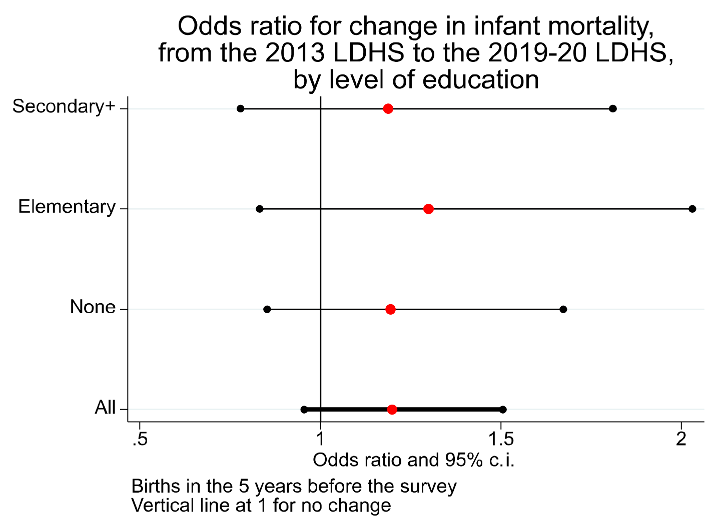


Figure 3.7.4 Odds ratios for change in infant deaths per 1,000 births in the past 5 years, from the 2013 LDHS to the 2019–20 LDHS, by the mother's level of education



The relationship of infant mortality to household wealth quintile is shown in Figures 3.7.5–3.7.6. Children born into households in the highest wealth quintile have the lowest risk of an infant death. That advantage was smaller in the second survey than in the first, though none of the differences were statistically significant. Otherwise, there is no systematic relationship between wealth quintile and infant mortality.

Figure 3.7.5 Infant deaths per 1,000 births in the past 5 years in the 2013 LDHS and 2019–20 LDHS, by household wealth quintile

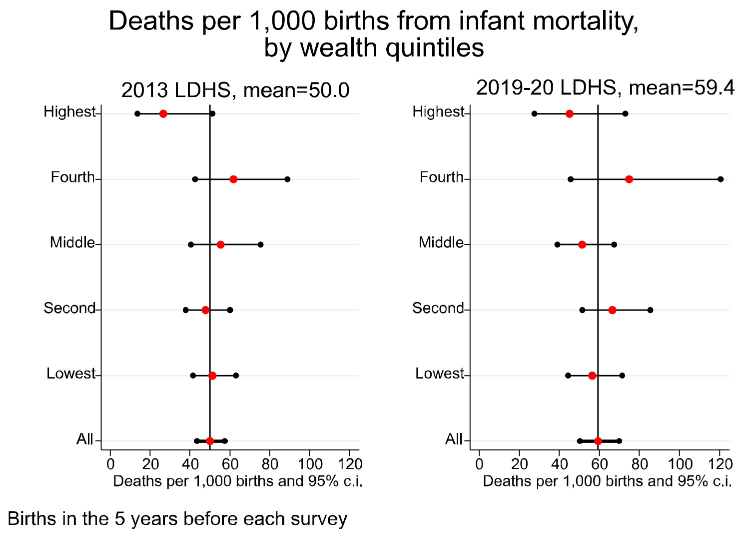
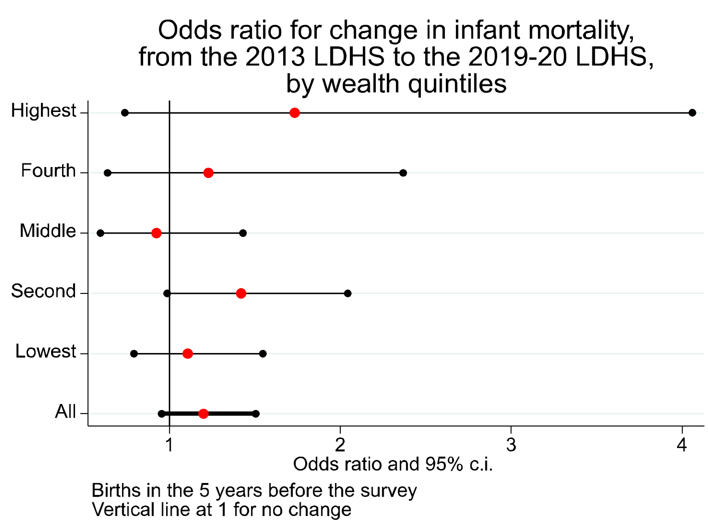


Figure 3.7.6 Odds ratios for change in infant deaths per 1,000 births in the past 5 years, from the 2013 LDHS to the 2019–20 LDHS, by household wealth quintile



Figures 3.7.7–3.7.8 describe mortality in 10 combinations of region and urban/rural residence. In Figure 3.7.8, a comparison of the changes in rural areas with those in urban areas, within the same region, indicates that increases were primarily in rural areas (the red dots for rural areas are consistently displaced to the right of the red dots for urban areas) but those pairwise differences are not significant, partly because the numbers of cases are small. The increases were significant in the rural areas of South Central and South Eastern A.

Figure 3.7.7 Infant deaths per 1,000 births in the past 5 years in the 2013 LDHS and 2019–20 LDHS, by combinations of region and urban/rural residence

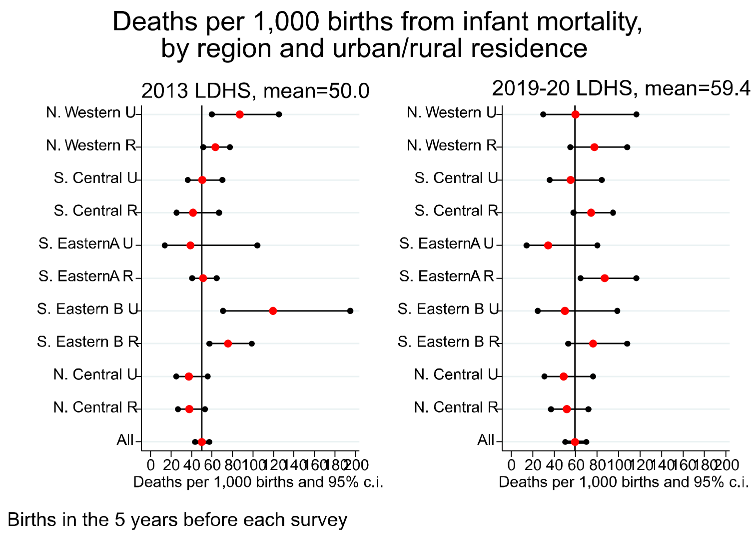
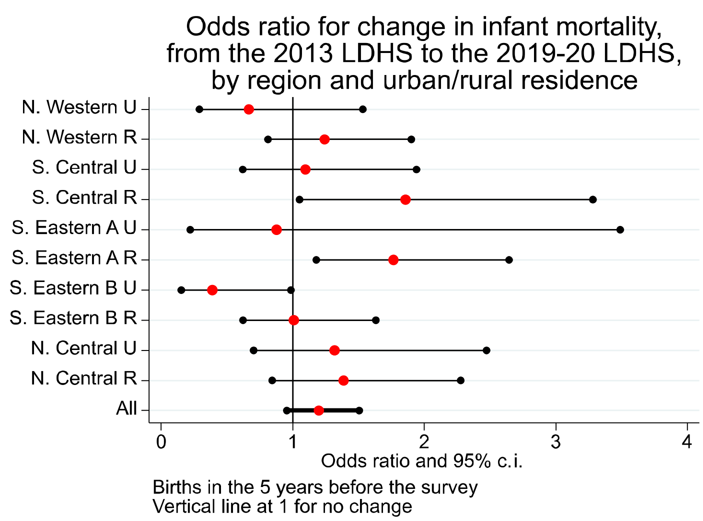


Figure 3.7.8 Odds ratios for change in infant deaths per 1,000 births in the past 5 years, from the 2013 LDHS to the 2019–20 LDHS, by combinations of region and urban/rural residence



Finally, in Figures 3.7.9–3.7.10, the population is divided even more finely into counties. Grand Bassa and Sinoe had the largest increases and the only statistically significant ones. By the 2019–20 survey, they were the only counties that were significantly above the national mean. Bomi and Bong had the lowest rates in the second survey, and Bomi had the largest decline in its relative position among the counties, but the differences and change were not significant.

Figure 3.7.9 Infant deaths per 1,000 births in the past 5 years in the 2013 LDHS and 2019–20 LDHS, for the counties of Liberia

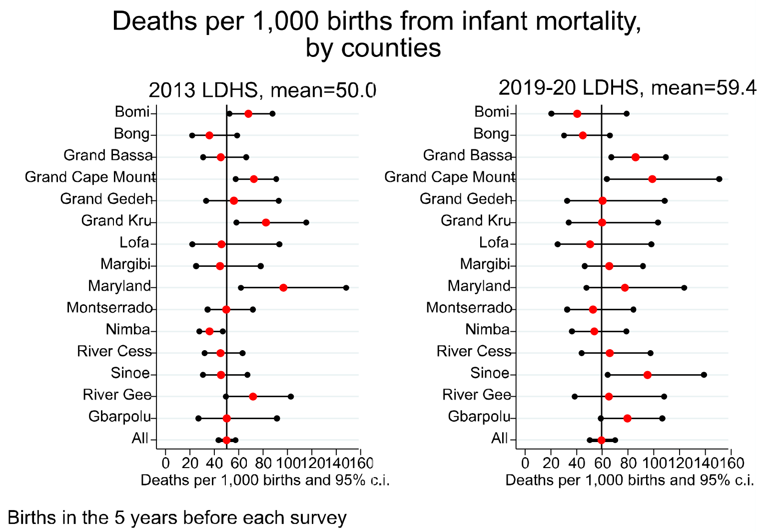
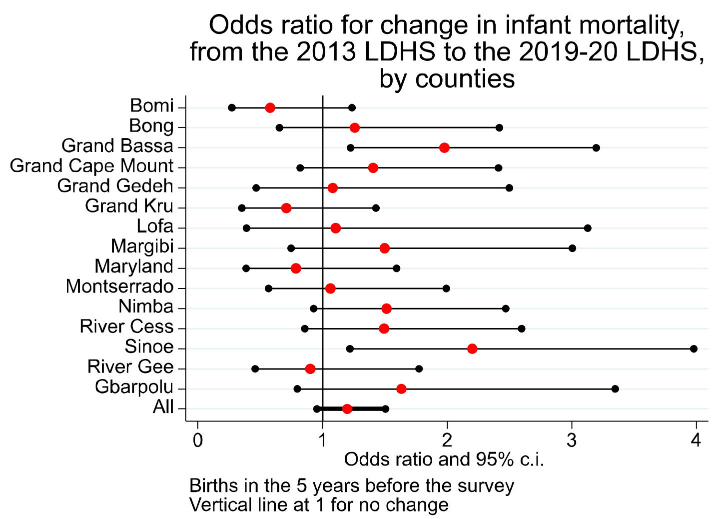


Figure 3.7.10 Odds ratios for change in infant deaths per 1,000 births in the past 5 years, from the 2013 LDHS to the 2019–20 LDHS, for the counties of Liberia



The findings in this section are severely limited by the sample size. Both the rates and the odds ratios for change have been estimated with logit regression, using adjustments for weights, clusters, and strata. The methods are relatively sophisticated, but the confidence intervals are wide. We have described the variation in point estimates, indicated with red dots in the figures, but a single value masks a wide range of uncertainty. Even for education of the mother, which has only three categories, and major region and wealth quintiles, which only have five categories, few differences can be identified. When the major regions are divided into urban and rural areas, or counties are used as the covariate, it becomes even more difficult to identify differences. The main conclusion of this section, unfortunately, is that—within the limitations of statistical analysis—few differences between subpopulations or differences between surveys, within subpopulations, can be identified with confidence. Differences that are observed may result in part from differences in the over-reporting of day 0.

3.8 High-risk Fertility

The final report on the 2019–2020 LDHS included a table (Table 8.6) on high-risk fertility, a term that refers specifically to births that exceed thresholds for "too young," "too old," "too close," and/or "too many." The thresholds are defined as follows:

- Too young: the mother's age is <18 at the time of the birth
- Too old: the mother's age is >34 at the time of the birth
- Too close: the interval between the birth and the immediately preceding birth is <24 months
- Too many: the order of the birth is >3.

These categories and thresholds are based on previous research in various settings, and evidence of higher mortality in the categories, but the context is important.

The categories can occur individually or in combinations. For example, "too old" and "too many" may occur together if a woman has many children throughout her reproductive life. "Single high-risk category" refers to a birth in one of the four categories listed above but not in more than one; "multiple high-risk category" refers to a birth in two or even three categories. There are five possible multiple risk categories:

- Too young and too close
- Too old and too close
- Too old and too many
- Too old and too many and too close
- Too many and too close.

As described in the final report, the percentages in the four single risk categories are 9.8%, 1.8%, 3.8%, and 19.3%, respectively, for a total of 34.7%. Another 18.8% of births have multiple high risk. The largest component is the combination of "too old" and "too many"—11.9% of births are in that combination. The sum of single risk and multiple risk, 34.7% + 18.8% = 53.5% of all births, are said to have avoidable high risk.

As an example of the importance of context, the final report found that births in the "too old" and "too many" categories *do not* have higher risk of death in Liberia *unless* they appear in combination with each other or with "too close." The combination of "too old," "too many," and "too close" poses the highest risk of all combinations but includes only about 2% of all births in the Liberia 2019–20 LDHS.

As a generalization, in Liberia only about 10% of births are to women who are too young and another 11% are too soon after the preceding birth. About 16% of births are to women age 35+. The largest high-risk factor is too many, which characterizes about 38% of all births and more than two-thirds of all high-risk births. Subpopulations with high risk tend to be those with high fertility.

This section of the report looks primarily at any avoidable risk. We also describe mortality for children who are not in any risk category at all and for the following eight categories or combinations of categories:

- Too young, regardless of other risk
- Too old, regardless of other risk
- Too close, regardless of other risk
- Too many, regardless of other risk
- Too young, with no other risk
- Too old, with no other risk
- Too close, with no other risk
- Too many, with no other risk

We now describe variation and change in risk with figures that include 95% confidence intervals, focusing on the percentage of births that had any avoidable risk. This is the aggregation of births that are in any of the risk categories, individually or in combinations.

The following figures are in pairs. The first figure includes two subfigures, one on the left for the 2013 LDHS and one on the right for the 2019–20 LDHS. The horizontal axis gives the percentage of births that are in any avoidable risk category; the scale is the same for both subfigures. A vertical line is placed at the overall mean percentage—55.4% in the first survey and 53.5% in the second. For each category of the covariate, a red dot is placed at the observed percentage and a horizontal black line represents a 95% confidence interval. Again, categories with more births tend to have narrower confidence intervals and to have more impact on the mean. The second figure in the pair describes the odds ratio for the second survey compared with the first. An odds ratio greater than 1 indicates an increase in the percentage of births with high risk. In general, we would hope to see a decline in risk.

Figures 3.8.1–3.8.2 describe variation across the five major geographic regions in Liberia. In both surveys, risk is lowest in South Central, the largest region. In the first survey it was highest in South Eastern A, but by the second survey it was highest in North Western. North Central was the only other region to show an increase between the two surveys, but Figure 3.8.2 shows that North Western was the only region in which the change was statistically significant (at the .05 level).

Figure 3.8.1 Percentage of births with any avoidable risk in the 2013 LDHS and 2019–20 LDHS, for the major regions of Liberia

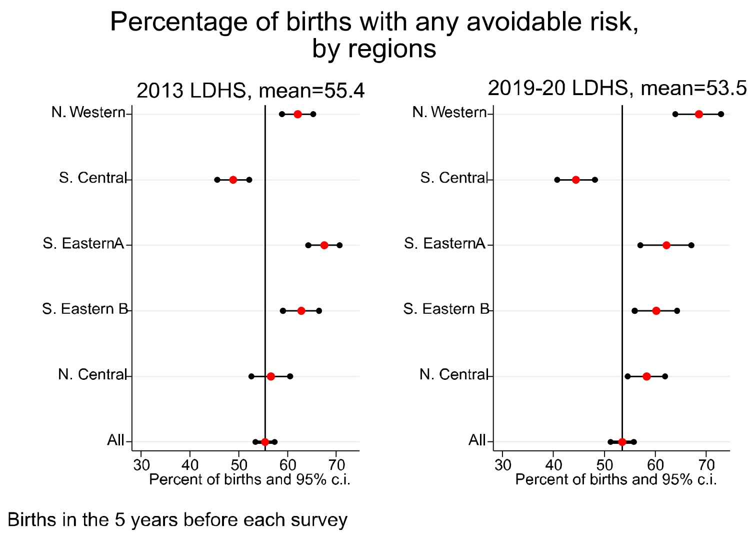
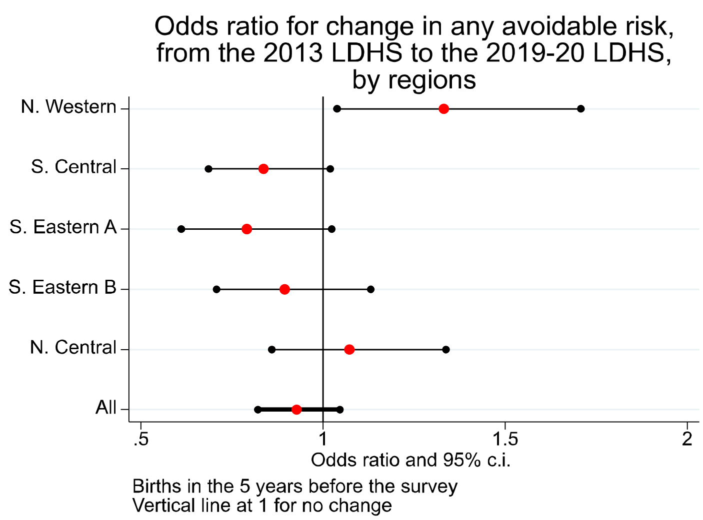


Figure 3.8.2 Odds ratios for change in the percentage of births with any avoidable risk, from the 2013 LDHS to the 2019–20 LDHS, for the major regions of Liberia



Figures 3.8.3–3.8.4 and 3.8.5–3.8.6, which show the patterns by the mother's level of education and household wealth quintile, are very similar. Risk is negatively related to both education and wealth. Risk is lowest for mothers with more education and households with more wealth, which appear at the top of the respective figures, with steadily and monotonically increasing risk for women who have less schooling or lower wealth. Indeed, the three confidence intervals for the three categories of education do not even overlap one another.

The negative relationship between the percentage of high-risk births, on the one hand, and the levels of schooling and wealth, on the other, is not surprising. However, Figures 3.8.4 and 3.8.5 show clearly that the differences were exacerbated between the two surveys. The confidence intervals overlap, and the differences are not significant, but risk tended to decline where it was already lowest and to increase where it was already highest.

Figure 3.8.3 Percentage of births with any avoidable risk in the 2013 LDHS and 2019–20 LDHS, by the mother's level of education

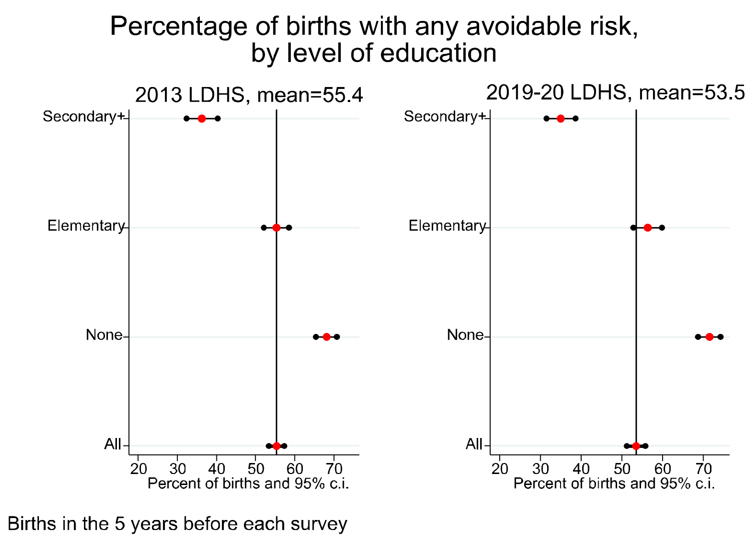


Figure 3.8.4 Odds ratios for change in the percentage of births with any avoidable risk, from the 2013 LDHS to the 2019–20 LDHS, by the mother's level of education

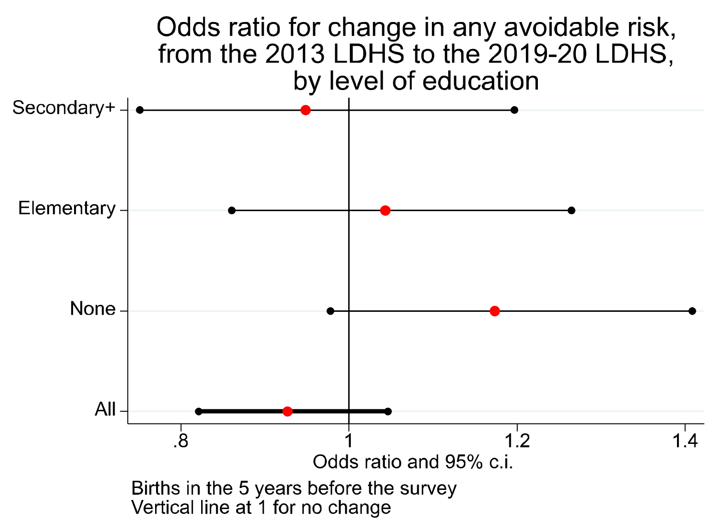


Figure 3.8.5 Percentage of births with any avoidable risk in the 2013 LDHS and 2019–20 LDHS, by household wealth quintiles

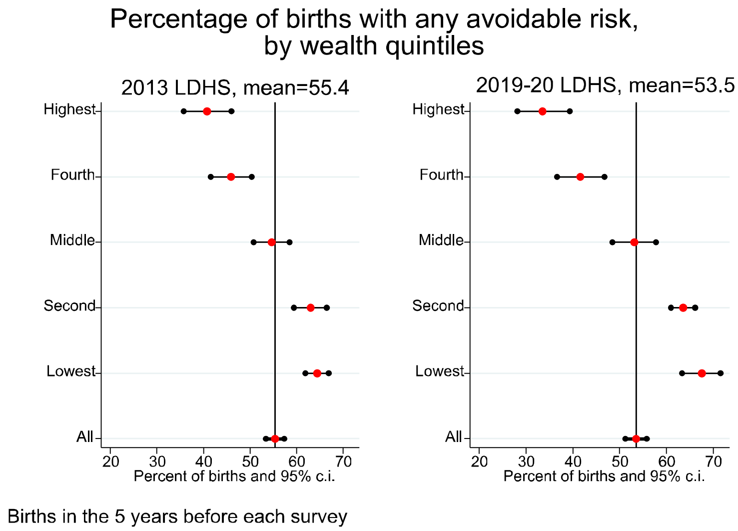
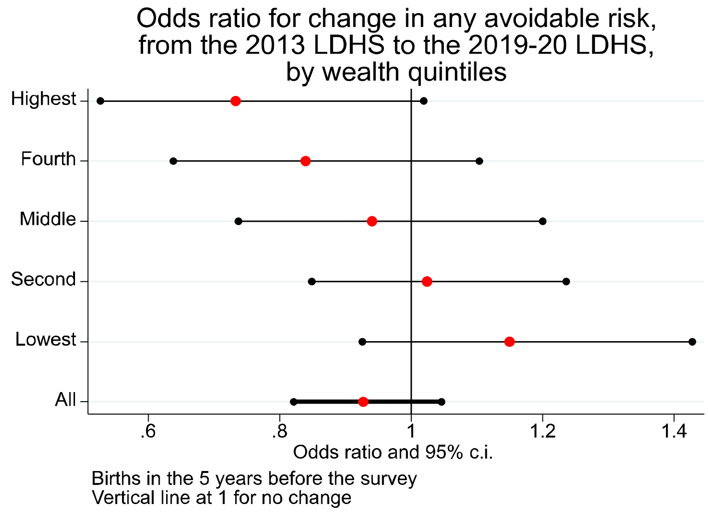


Figure 3.8.6 Odds ratios for change in the percentage of births with any avoidable risk, from the 2013 LDHS to the 2019–20 LDHS, by household wealth quintiles



Figures 3.8.7–3.8.8 describe the levels and changes in avoidable risk in 10 subpopulations, constructed as the urban and rural areas of the five major geographic regions. Within some regions we see large differences between urban and rural areas. South Central is the main example of such a difference. In that region, the urban areas have the lowest risk of all 10 subpopulations and the rural areas are among the highest. In every region the rural areas have more high-risk births. In South Central the difference is substantial and highly significant. Risk increased in both the urban and rural parts of North Western, and decreased in both parts of South Central and South Eastern A, but no changes were statistically significant at the .05 level.

Figure 3.8.7 Percentage of births with any avoidable risk in the 2013 LDHS and 2019–20 LDHS, for combinations of region and type of place of residence

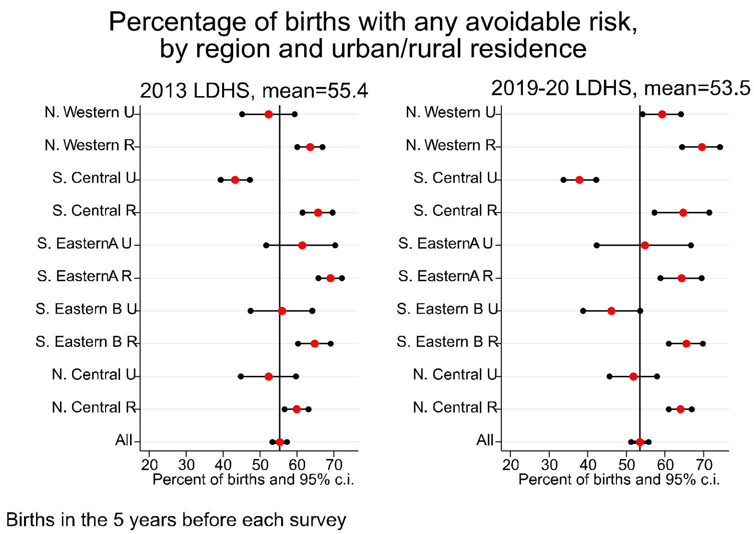
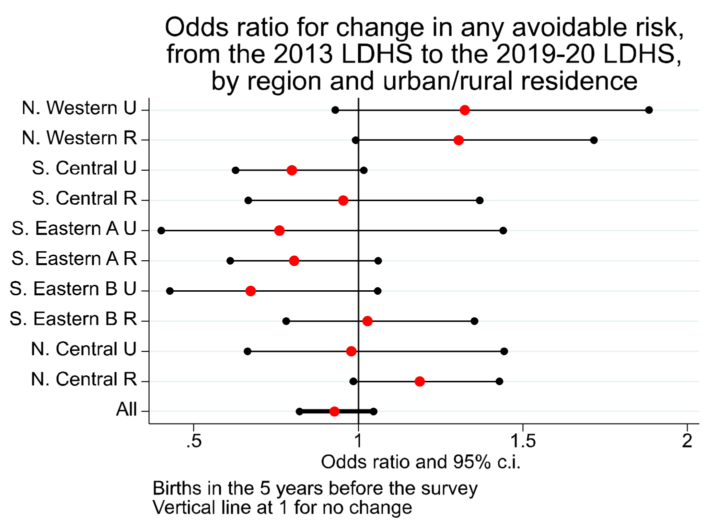


Figure 3.8.8 Odds ratios for change in the percentage of births with any avoidable risk, from the 2013 LDHS to the 2019–20 LDHS, for combinations of region and type of place of residence



Finally, Figure 3.8.9 gives the distribution of avoidable risk in Liberia's counties. Montserrado is the most populous county, by far, and that is why it and only two other counties are below the national mean, and most counties are above the mean. Indeed, Montserrado is both far below the mean and significantly below the mean. Bomi and Gbarpolu increased between the two surveys, and by the time of the 2019–20 LDHS were significantly above the mean. Sinoe and River Gee moved to lower levels of high-risk births, and by the second survey were no longer significantly above the mean.

Figure 3.8.9 Percentage of births with any avoidable risk in the 2013 LDHS and 2019–20 LDHS, for the counties of Liberia

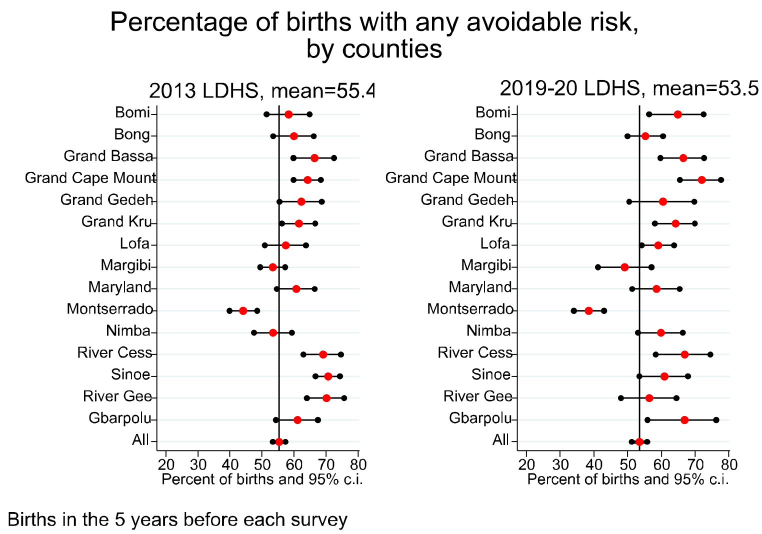
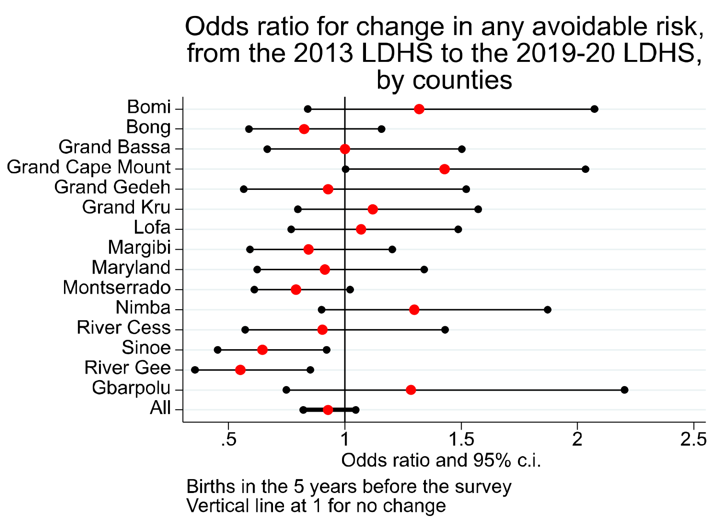


Figure 3.8.10 Odds ratios for change in the percentage of births with any avoidable risk, from the 2013 LDHS to the 2019–20 LDHS, for the counties of Liberia



3.9 Mortality in the High-risk Categories

The definitions of the high-risk categories were originally based on having a higher risk of worse outcomes for both the child and the mother. We now examine evidence as to whether there is indeed a correspondence with child survival in the Liberia surveys. Deaths in different age intervals are examined separately.

Figure 3.9.1 is the first of three figures showing the odds of dying (versus surviving) for children born in each of 10 possible risk categories, relative to the odds of dying for children who are not in the risk category. The categories were defined above and are not mutually exclusive. Each figure includes two subfigures, on the left for the 2013 LDHS and on the right for the 2019–20 LDHS. Both subfigures have the same horizontal scale to facilitate comparisons. Each line in the figure is based on a logit regression using all children born in the past 5 years in the specific risk category. The binary outcome variable is 1 if the child died in the specified time interval and 0 otherwise.

Each figure includes a vertical black line for an odds ratio of 1. The red dots, which are the estimates of the odds ratios, are on the right of the vertical line if the children born in the risk category have an elevated risk of dying in the age interval, compared with all other children. The horizonal lines represent 95% confidence intervals for the odds ratios. Most of the confidence intervals are wide; the narrowest interval is for "any avoidable risk," because it is an aggregation of the single and multiple risk categories and has more children in both the numerator and the denominator. If a confidence interval extends both left and right of the vertical line, then the odds of dying are not significantly different from 1 at the .05 level of significance. The absence of statistical significance should not be interpreted as the absence of a relationship; there could be a relationship, but the sample is not large enough to detect it.

In Figure 3.9.1, very few children are in the “too old ONLY” category. As a result, in the 2013 LDHS there is no horizonal line for a confidence interval, and in the 2019–20 LDHS the line is wide. This very small category could be ignored but it has been retained in the figure.

In Figure 3.9.1, none of the risk categories in either survey is significantly associated with higher risk of dying during days 1–6 (the early neonatal interval with day 0 omitted because of possible data quality concerns). In the second survey, the odds ratios (the red dots) for “too old” and “too close,” when possibly in combination with other factors, are greater than 1, but not by a statistically significant amount.

Figure 3.9.1 Odds of death for days 1–6 for births in different risk categories, for all births in the 5 years before the 2013 LDHS and 2019–20 LDHS

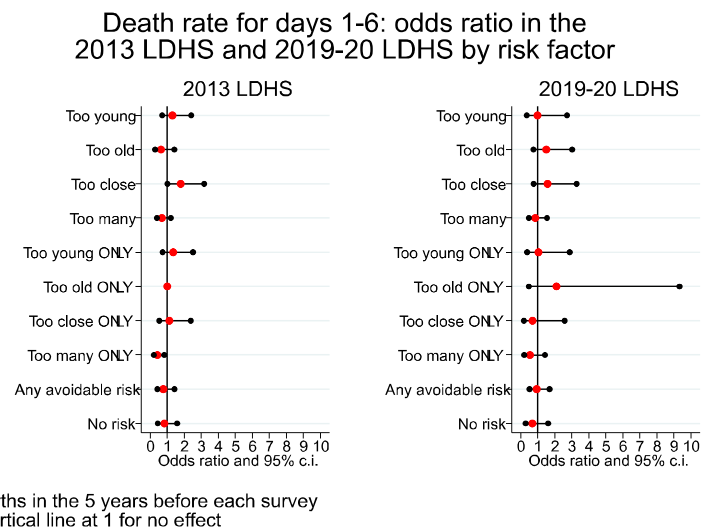


Figure 3.9.2 is similar to Figure 3.9.1 but describes days 7–27, the late neonatal interval. Again, no risk factor, including “any avoidable risk” or “no risk,” is statistically significant.

Figure 3.9.2 Odds of a late neonatal death for births in different risk categories, for all births in the 5 years before the 2013 LDHS and 2019–20 LDHS

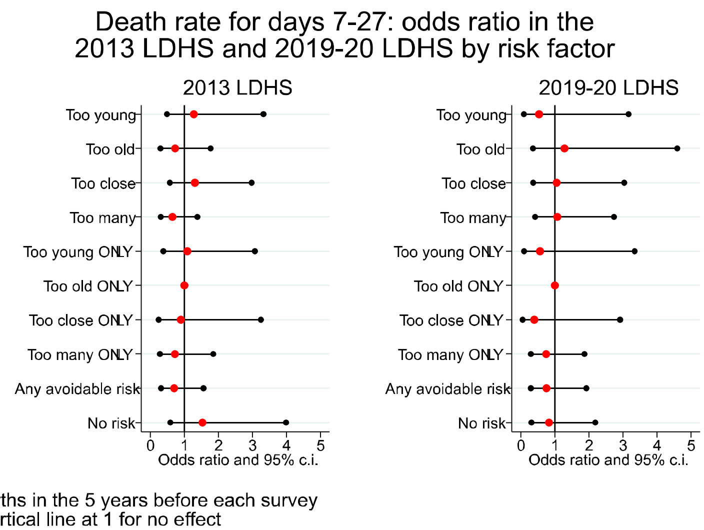
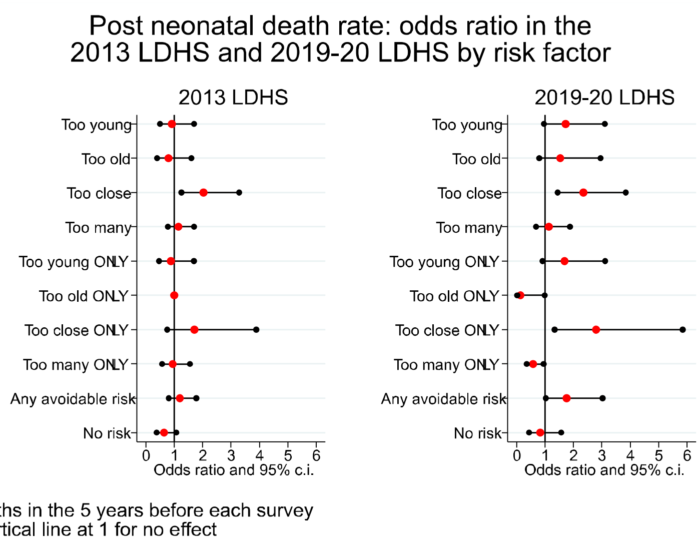


Figure 3.9.3 looks at the post neonatal interval, and includes results that are more useful, particularly for the second survey, shown in the subfigure on the right. Except for “too old ONLY” and “too many ONLY,” all the risk factors have elevated mortality. In both surveys, the odds ratios are highest for “too close” and “too close ONLY,” the odds ratios are significantly greater than 1 (at the .05 level). For “too young” and “any avoidable risk,” the statistical significance is marginal.

This analysis does not extend beyond the first year of age. Within that first year, we have evidence that the impact of the risk factors tends to appear after the neonatal interval. It was mentioned above that the final report on the 2019–20 LDHS includes a table (Table 8.6) on high-risk fertility. That table is based on all births in the past 5 years—exactly the same as Figures 3.9.1, 3.9.2, and 3.9.3. It gives risk ratios (which are only slightly different from odds ratios), without confidence intervals or any measure of statistical significance. The main difference is that the deaths in the risk ratios in that table could have occurred at any time between the birth and the interview. That expanded definition of mortality includes the age intervals in Figures 3.9.1, 3.9.2, and 3.9.3 and also deaths when age 1–4 years. Our findings are consistent with the report but add more detail on the relationship between the risk factors and age at death—in particular, that birth spacing is the dominant risk factor and its importance emerges after, not during, the neonatal period.

Figure 3.9.3 Odds of a post neonatal death for births in different risk categories, for all births in the 5 years before the 2013 LDHS and 2019–20 LDHS



4 CONCLUSIONS

This report has attempted to interpret an unexpected finding for recent infant mortality in the final report on the 2019–20 LDHS. According to that report, under-5 mortality was unchanged from the level in the 2013 LDHS—certainly an unwelcome finding—but even more disappointingly, infant mortality had increased. Our principal conclusion is that infant mortality *did not* increase, nor did it decline. It remained flat. It appears that the perinatal, early neonatal, late neonatal, and post neonatal rates were all remarkably consistent in the two surveys.

Most of the potential correlates of child survival showed improvements between the surveys. Improvements in water and sanitation, ANC visits and place of delivery could have been expected to be associated with improvements in child survival, but there is only minor evidence of impact.

We examined the distribution of high-risk fertility, and its potential relationship to child survival. We also considered socioeconomic and geographic correlates, including variation across the counties of Liberia. Many estimates were in the expected direction but did not reach significance. The number of deaths occurring in the past 5 years in the sample, especially when subdivided into different age intervals and categories of covariates, leads to sample size limitations. We have pushed the limits of how detailed an analysis of infant mortality can be with a DHS survey.

The analysis is complicated by the clear evidence of over-reporting of deaths on day 0, the day of birth. During the 5 years before the 2019–20 LDHS the excess amounted to only about 80 deaths, but as is detailed in the Appendix, the excess amounted to several hundred over the full course of the birth histories and can largely be traced to a relatively small number of interviewers. Within the report, there has been a mix of analysis in which day 0 was included and in which it was omitted. It is not clear that either choice is closer to the truth. Day 0 is the generally the day of highest risk, and a substantial fraction of the deaths reported for that day should be accepted as real. Compared to other surveys, the proportion of deaths reported on day 0 was relatively low in the 2013 LDHS—and then it was impossibly high in the 2019–20 LDHS.

There are two possible explanations for excess deaths on day 0 that we consider highly unlikely. The first is that both the birth and the death are misreported. This possibility would lead to over-estimation of fertility, as well as mortality, although the effect on fertility would be negligible. A second possibility is that the birth was real but the death did not occur at all. Based on experience with DHS data, with the procedures for supervising and checking fieldwork, and with the motivations of the interviewers, these two possibilities are judged to be very unlikely. It seems more likely that these were genuine births and genuine deaths but the age at death is reported or coded incorrectly. Yet, as is also shown in the Appendix, the attribution of those deaths to any of the sub-intervals within the first year raises the estimates for those sub-intervals to levels that seem too high, based on the improvements in correlates of mortality, antenatal care, place of delivery, and other socioeconomic indicators. For the present, we do not have a satisfactory explanation for the excess deaths on day 0.

The analysis has identified important measurement issues, but the principal finding is that the pattern of infant mortality in Liberia, with respect to the component age intervals, high-risk factors, interventions, and covariates, has been remarkably—and disappointingly—stable for more than a decade. Uncovering the reasons behind this frustrating lack of change may require alternative kinds of data and methods.

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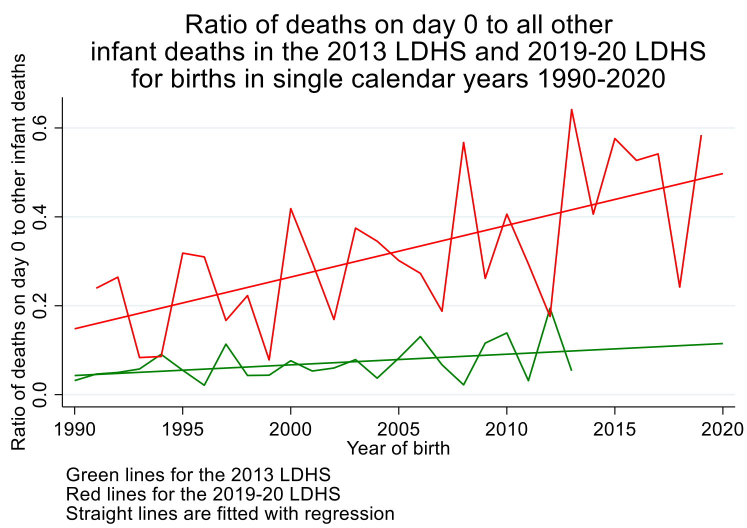
APPENDIX: EXCESS DEATHS REPORTED ON DAY 0

Early in this analysis it became clear that more deaths than expected were recorded for day 0, the day of birth. This pattern was not detected during fieldwork or during the preparation of the final report, because day 0 is not normally broken out and monitored; the pattern seems to be unique to the 2019–20 LDHS. When it was discovered, the initial interpretation was that there was better detection of stillbirths in the second survey but many had been misclassified as live births followed by immediate death. As described earlier in Section 3.2, internal evidence does not support that hypothesis.

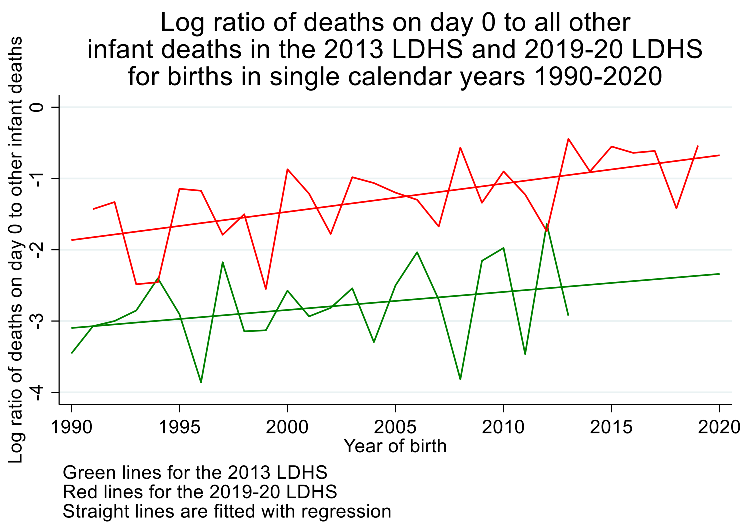
A second interpretation was that there had been a genuine spike in very early deaths within the 5 years preceding the survey. However, an examination of the full birth histories in both surveys shows that the excess characterizes the entire birth histories in the 2019–20 LDHS. Figure A.1 shows the ratio of deaths on day 0 to all other infant deaths (the odds that an infant death was reported on day 0) in both surveys, using green for the first survey and red for the second one. The zigzag lines show annual estimates and the straight lines are fitted estimates. The red lines are consistently above the green lines; the high levels of deaths on day 0 in the 2019–20 LDHS are not restricted to the 5 years before the survey. The ratios from this survey are higher than in the 2013 LDHS for estimates going back to 1990.

Figure A.1 Ratio of deaths on day 0 to all other infant deaths in the 2013 LDHS and 2019–20 LDHS, for births in single calendar years 1990–2020



A second perspective on the pattern in Figure A.1 is given by rescaling the vertical axis, redefining the outcome to be the natural log of the ratio, as shown in Figure A.2. On this scale, the two lines are essentially parallel (in a logit regression model, the two slopes are not significantly different by any criterion for significance). In effect, the ratio (of deaths on day 0 to all other infant deaths) in a given calendar year in the second survey is equal to the same ratio in the first survey, times a constant factor that does not depend on the calendar year. Figures A.1 and A.2 provide strong evidence that the increase in deaths on day 0 in the second survey was an artifact of data collection. There was a systematic tendency to over-report age at death as day 0, for all infant deaths, no matter how long ago they occurred.[9]

Figure A.2 Log of the ratio of deaths on day 0 to all other infant deaths in the 2013 LDHS and 2019–20 LDHS, for births in single calendar years 1990–2020



If we accept that this pattern was specific to the second survey, a possible question is whether it arose during data collection or data processing. An example of a data processing error would be that deaths reported at some other ages were incorrectly recoded into day 0. We find no evidence of such an error, and data processing errors are extremely unlikely for procedures that have been relatively fixed for decades. We thus turn to differences in fieldwork, particularly to possible variation across interviewers or interviewer teams in the 2019–20 survey.

DHS has developed several approaches to possible data quality issues. Pullum, Assaf, and Staveteig (2017) described strategies to compare estimates with other DHS data and other data sources. Pullum and Becker (2014) analyzed potential omission and displacement within the birth histories. Pullum and Staveteig (2017) looked specifically at the quality and consistency of age and date reporting. Pullum et al. (2018) described how to identify statistically significant variation in data quality by teams and individual interviewers. These methods have been used in this analysis of the Liberia data.

The 2013 survey included 3,142 infant deaths in the complete birth histories, of which 213 were reported on day 0 and 3,142 - 213 = 2,929 were reported later in the first year of age. The ratio is 213/2929 = 0.0727. The proportion of deaths reported on day 0 is 213/3142 = 0.0678. In the 2019–20 survey, the ratio is 492/1756 = 0.2802 and the proportion is 492/2248 = 0.2189. These numbers are unweighted and are based on the complete birth histories of all respondents, not just the births in the past 5 years or since 1990. The

[9] The fitted lines in Figures A.1 and A.2 suggest that the ratio increased over time. That is indeed possible, because as child mortality declines, as it has done in Liberia since 1990, the earliest ages are less affected. However, the slopes in Figure A.2 are not significantly different from 0. For that reason, the approach to interviewer effects does not assume a trend in the ratio.

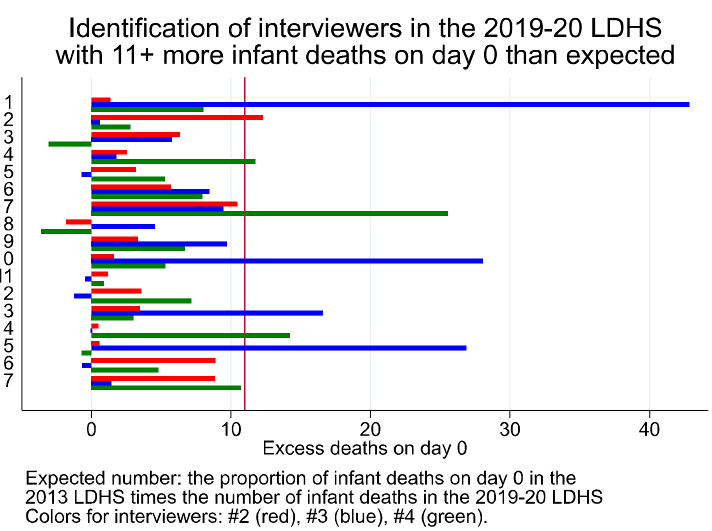
probability that an infant death would be reported for day 0 was about three times as great in the second survey as in the first.

The expected number of deaths on day 0 in the second survey, based on the pattern in the first survey, would be 2,248 (the number of infant deaths in that survey) times 0.0678, the proportion in the first survey. This product is 152.4. The reported number was 492. The difference, 492 - 152.4 = 339.6, can be described as the excess number of deaths on day 0 in the second survey. In some of the analysis we have assumed that these are correctly classified as infant deaths, but they should have been spread out during the first year and not all concentrated on the first day.

We can also borrow from the pattern in the 2013 survey to estimate an expected number of deaths on day 0 *for each interviewer* in the 2019–20 survey, given the number of infant deaths that the interviewer reported. This is done with a Poisson regression model (see Pullum et al. 2018), in which the two surveys are pooled, a model is estimated with the first survey, and that model is used to generate predicted or fitted numbers of deaths on day 0 for each interviewer in the second survey. We define "excess" to be the reported number of deaths on day 0 minus the expected number, calculated for each interviewer.

The 2019–20 LDHS included 55 interviewers, grouped into 17 teams. Occasionally the supervisor for the team would conduct an interview, but mostly there were three interviewers per team, with ID codes 2, 3, and 4. Figure A.3 gives an overview of the excess number of deaths for the full set of 55 interviewers, grouped by team. Most interviewers exceeded the expected value (only 8 reported *fewer* deaths on day 0 than expected, indicated by a horizontal bar that extends to the left of 0). Somewhat arbitrarily, we set a threshold of 11 for a conspicuous excess. The vertical red line in Figure A.3 intersects 8 horizontal lines—that is, it identifies 8 interviewers who exceeded their expect number by at least 11. These 8 interviewers would have been expected to report a total of 33 deaths on day 0, but instead they reported 178 deaths on day 0.

Figure A.3 Identification of interviewers in the 2019–20 LDHS who had at least 11 more infant deaths on day 0 than expected



The most egregious example is seen with team #1. On this team, interviewer #2 identified 54 infant deaths and reported 5 of them at day 0. Interviewer #4 identified 44 infant deaths and reported 11 of them at day 0. By contrast, interviewer #3 identified 91 infant deaths and placed 49 of them, more than half, at day 0.

In a sense the interviewer data provide a natural experiment. When comparisons are made between the extreme interviewer and the other members of the team, most other characteristics are controlled for, because within each cluster the interviewers are assigned randomly to households. Characteristics of the cluster that could potentially influence the true age pattern of infant mortality, such as the county in which it is located, or whether it is urban or rural, are controlled. Similarly, characteristics of the household, such as wealth quintile, or of the woman, such as her education, or of the child, such as whether a boy or girl, are controlled.

The remainder of this appendix compares the reporting of deaths on day 0 in the two surveys with other surveys. The reference surveys are all other standard DHS surveys conducted during phases 6, 7, or 8 of The DHS Program, with standard recode files available by January 1, 2022. For many countries, the list includes more than one survey.

The next three figures have a similar structure. Each figure compares the death rate on day 0 with a rate that includes day 0. In figures A.4, A.5, and A.6, the rate for day 0 is compared with the early neonatal rate, the neonatal rate, and the infant rate, respectively. For example, in Figure A.4, in which day 0 is compared with the early neonatal rate, the vertical axis is the percentage of early neonatal deaths that are on day 0; the horizontal axis is the early neonatal death rate. In each figure, the black dots in the scatterplot represent observed combinations of those two values in the reference surveys. Each figure also includes a green dot for the 2013 LDHS and a red dot for the 2019–20 LDHS, and a red line connecting the two points. Each figure also includes horizontal and vertical black lines at the median values. The intersection of those two lines identifies the center of the cluster of black points (the LDHSs are excluded from the calculation of the two medians).

In the three figures the green dot, representing the 2013 LDHS, is well within the scatterplot and is surrounded by black dots for other surveys. The early neonatal (Figure A.4) and neonatal (Figure A.5) rates for the 2013 survey were close to the median levels for the other surveys, and the infant rate (Figure A.6) was not far above the median. In all three figures the red dot for the 2019–20 LDHS is conspicuously above and to the right of the green dot for the 2013 LDHS and is farther from the center of the figure. In all three figures, the red dot is displaced outside the overall scatterplot. There is no other survey with higher values on both the vertical and horizontal axes. There were higher values on one axis or the other but not on both axes.

In these figures the green dot for the 2013 LDHS was substantially below the horizontal lines, indicating that the reporting of day 0 may have been spuriously low in the 2013 survey. The increase on day 0 may be, in part, an over-correction for omission or under-reporting in the earlier survey. However, that increase raised the early neonatal, neonatal, and infant deaths by implausibly large amounts.

Figure A.4 Consistency of mortality rates in the 2013 LDHS and 2019–20 LDHS with other DHS surveys: deaths on day 0 versus early neonatal deaths

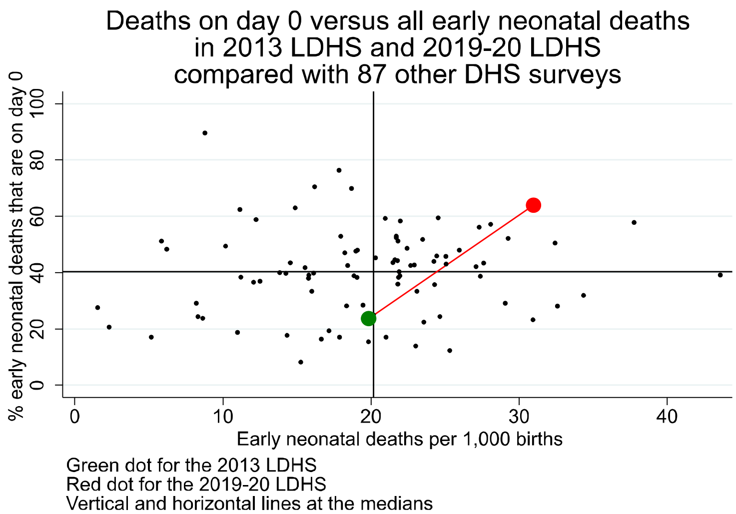


Figure A.5 Consistency of mortality rates in the 2013 LDHS and 2019–20 LDHS with other DHS surveys: deaths on day 0 versus all neonatal deaths

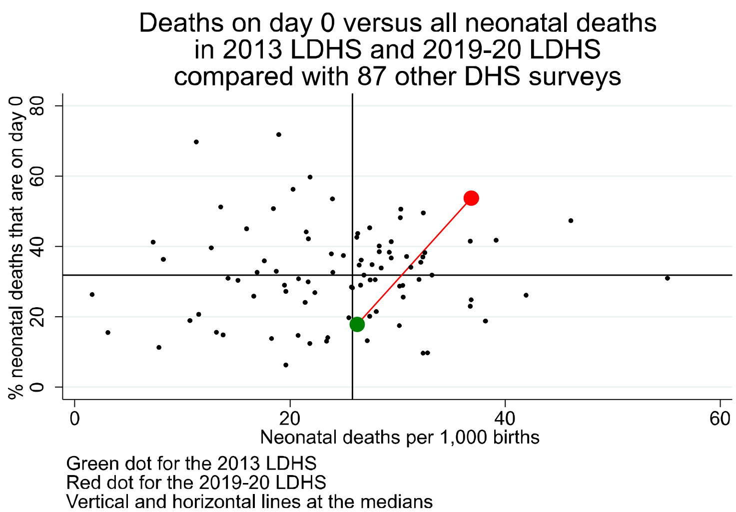


Figure A.6 Consistency of mortality rates in the 2013 LDHS and 2019–20 LDHS with other DHS surveys: deaths on day 0 versus all infant deaths