Measuring childhood mortality through mobile phone interviews in Mozambique

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INTRODUCTION

Childhood mortality indicators are essential for monitoring progress in health and development in low- and middle-income countries (LMIC)(1), typically measured through face-to-face household surveys with women of reproductive age (2). These surveys collect detailed information on birth or pregnancy histories, including birth dates, child mortality, and pregnancy outcomes like stillbirths (3). Historically, the Demographic and Health Survey (DHS) program utilized full birth history modules, but this has shifted to pregnancy histories due to evidence of their superiority in generating mortality trends over a 15-year period (4, 5). The COVID pandemic and the lockdowns highlighted the challenges to conduct face to face surveys, causing data gap in global and national mortality monitoring for 2020-2021. The need for testing and validating approaches that use mobile phone interviews for obtaining similar mortality measures becomes critical as these approaches circumvent the need for face-to-face interviews and can also be fast (6, 7). Prior to the pandemic, mobile interviews were successfully conducted, but they had not been widely used for national-level childhood mortality surveys using rigorous tools like full or pregnancy histories(6, 8-11). Mobile phone data collection can take be implemented through various methods, including direct phone calls, SMS, and interactive voice response (8, 9). Sampling strategies range from using existing phone number databases to random digit dialing (RDD), each yielding different response rates and population coverage. This study explores the feasibility of national mobile phone-based childhood mortality assessments in Mozambique, providing insights into the effectiveness of such methods for mortality measurement in LMICs.

METHODS

Data

The RaMMPS project in Mozambique aimed to estimate childhood mortality rates using mobile phone interviews. Two sampling methods were used: one from the existing Countrywide Mortality Surveillance for Action in Mozambique (COMSA-Mozambique) database (12). COMSA-Mozambique is a nationally representative surveillance covering about 850,000 population and therefore the list of phone numbers covers all provinces. At total of 13,247 women aged 15-49 were successfully reached over the period of four months from March to June 2022. The other sample used random digit dialing (RDD) technique to generate a nationwide sample. An Interactive Voice Response (IVR) was developed and used for an initial screening. To reach a representative sample in each province, a quota sample was developed based on age groups (15-19, 20-29, 30-39, 40-49), province, and urban-rural residence distribution based on the 2017 population census (13). The RDD/IVR approach successfully reached 10,116 women over the period of seven months from June to December 2022.

Analysis

We assessed neonatal, infant, and under-five mortality rates (NMR, IMR and U5MR) at national and subnational levels using data from the COMSA subsample and the RDD/IVR sample. To understand any systematic distortion in the samples, we first compared the distribution of the sample of women in both surveys to the 2017 Population census data based on place of residence, age group, education, and province. The quality of mortality data was evaluated by examining trends in births and deaths over ten years, age at death, and neonatal death proportions. We computed mortality rates for two-year and five-year periods, from 2012-2021 then compared to national estimates from the United National Interagency Group for Mortality Estimation (14) , the Mozambique 2022 DHS estimates (15) and the

main COMSA study estimates (12). We computed standard errors of the estimates using the jackknife method (16). We adjusted the rates using the post-adjustment weighting based on the raking approach (17, 18). Distributional estimates for the raking were based on the distribution women by age group, place of residence, education, and household size (13), using the STATA package "svycal" (19).

RESULTS

Sample distribution

Overall, the mobile-phone samples raw distributions are not consistent with the population distribution from the 2022 Mozambique DHS (Figure 1). They overly represented in urbanized provinces such as Maputo City and Maputo Province while the most populous provinces according to the 2022 Mozambique DHS were Nampula and Zambezia, with 23% and 17% of women 15-49 years old population, respectively. Both mobile phone samples severely under-reached adolescents aged 15-19 while over-reached older women aged 30 years or more, especially in the COMSA subsample. Regarding formal education, women of secondary or more were more represented in mobile phone samples than those with no or primary education. Mixed patterns are observed by marital status and parity. Urban residents are overly represented in the mobile phone samples with 60% for the COMSA subsample and over 80% for RDD/IVR sample.

National childhood mortality trends – 2012 -2021

U5MR estimates from the COMSA-subsample and the DHS were similar in 2020 (60 deaths per 1000), both slightly lower than the UN-IGME and main COMSA but with overlapping confidence intervals (Figure 2a). The two-year national U5MRs were generally lower in each period in the RDD/IVR sample than the COMSA subsample, except for 2014-2015. However, the U5MR COMSA subsample estimates were comparable to the 2022 DHS estimates about 60 per 1000 [95% CI: 54-66] during 2018-2022 and 61 per 1000 [95% CI: 54-68] during 2013-2017 (15). While comparable to the DHS estimates, U5MR from the COMSA subsample did capture similar trends as the UN-IGME (as was the 2022 DHS). U5MR trend from the RDD/IVR was different from other sources.

For NMR, all sources appear to have comparable estimates in the recent period (year 2020) with rates ranging from 22 deaths per 1000 in the COMSA-subsample to 28 from UN-IGME (Figure 2b). Similarly, COMSA-subsample and DHS captured similar trends in NMR, unlike the RDD/IVR sample which shows a more irregular trend. A similar pattern is observed for IMR. Both RaMMPS samples produced similar IMR as the DHS in 2020 (ranging from 34 to 39 deaths per 1000 live births), but slightly lower than the UN-IGME (52 deaths per 1000), the main COMSA (46 deaths per 1000) and the population census projections (67 deaths per 1000) (Figure 2c). The COMSA-subsample captured a similar flat trend in IMR as the DHS, different from the higher levels and decreasing trends estimated by the UN-IGME.

The U5MRs for the COMSA subsample were estimated at 59.0 per 1000 [45.6-72.4] and 44.5 per 1000 [36.4-52.5] during 2017-2021 and 2012-2016, respectively (Figure 3a). Mortality rates from the COMSA subsample were comparable to the 2022 DHS estimates for the period of 5-year before the survey (2018-2022) showing a NMR at 24 per 1000, IMR at 39 per 1000 and U5MR at 60 per 1000 (15). Different patterns were observed in the RDD/IVR sample which predicted a decline in U5MR from 59.1 [33.2-85.1] to 40.4 [22.0-58.8], a decline in IMR from 42.6 [18.8-66.5) to 29.6 [13.2-46.0] and a stagnation in NMR at 22.1 [7.8-36.4].

Subnational childhood mortality rates trends – 2017 -2021

U5MR estimated from both RaMMPS samples varied between urban and rural in the expected direction, although the differences were not statistically significant (Figure 4). The rates by place of residence from the COMSA subsample were similar to those from the DHS (63.3 in rural areas for both sources and 49.1 and 50.2 in urban areas for the COMSA subsample and the DHS respectively). A similar result is observed for NMR with NMR of 24 in rural areas and respectively 20.4 and 24.3 in urban areas in the COMSA subsample and the DHS. U5MR Mortality estimates were higher in the COMSA subsample than the RDD/IVR sample in both urban and rural residences (Figure 4). This was not the case for NMR with the RDD/IVR sample gave a higher rate. The urban NMR was estimated at 20.4 per 1000 [11.5-29.3] for the COMSA subsample and 12.7 per 1000 [6.1-19.3] for the RDD/IVR sample. However, the rural NMR were estimated at 23.6 per 1000 [10.8-36.5] for the COMSA subsample and 27.4 per 1000 [1.7-53.0] for the RDD/IVR sample. Large variations were observed in U5MR and NMR at provincial level by samples (COMSA and RDD/IVR). The RDD/VR sample mostly underestimated compared to estimates from the COMSA-subsample. However, mortality estimates were not reliable for many provinces in the RDD/IVR sample particularly.

DISCUSSION

Recent expansion of mobile phone networks and ownership in LMICs offers an opportunity to test approaches for remote data collection through mobile phone interviews. The Rapid Mortality Mobile Phone Survey (RaMMPS) is the first of its kind to test the feasibility and accuracy of using standard mortality tools in mobile phone surveys for the measuring of mortality rates and trends. This study tests two strategies, one relying on sample of phone number drawing from an existing nationally representative mortality surveillance platform (COMSA) (12) and the other on random digit dialing with prescreening through IVR. While there are multiple studies using mobile phone interview strategy in LMICs (6, 8-11, 18, 20), no study has ventured to implement a full pregnancy module to women of reproductive age in large sample drawn nationally. The complexity and sensitivity of a full pregnancy history underscores the importance of testing the reliability of the mobile phone interview strategy as an approach for rapid child mortality monitoring.

Respectively 13,247 and 5,059 women aged 15-49 were interviewed over the phone with a full pregnancy history tool in Mozambique. RaMMPS demonstrated that mobile phone surveys are a feasible approach for rapidly collecting mortality data during pandemics among women of reproductive age using standard mortality measurement tools. RaMMPS mean interview duration for the full pregnancy history tool only was about 10 minutes and comparable to a multi-country study conducted in Guinea-Bissau, Ethiopia, Uganda, Bangladesh and Ghana (4).

Our analysis found evidence of differences in data quality between the RaMMPS samples and the 2022 DHS. Specifically, three-quarter of neonatal deaths in the RaMMPS data occurred within the first week after the birth, with a particularly high concentration in the first two days. Additionally, the proportion of under-five deaths that were neonatal was notably high in the RaMMPS samples. Lastly, the average number of child deaths recorded in RaMMPS samples was lower compared to the 2022 DHS.

Our findings show strong promise of the approaches in measuring NMR, IMR and U5MR levels on recent periods when compared to current standard practices such as the DHS (15). In 2020, the U5MR were higher in the COMSA subsample than RDD/IVR sample, 59.0 per 1000 [95% CI: 45.6-72.4] and 44.9 [95%

CI: 22.0-58.8]. However, the COMSA subsample U5MR were comparable to 2022 Mozambique DHS (15). Overall, U5MR in the RaMMPS samples were lower than the UN-IGME estimates as well as the main COMSA study conducted in 2020 (12, 14). The two-year national U5MRs trends showed different patterns, with the RDD/IVR sample generally lower than the COMSA subsample, except for 2014-2015. Overall, the RDD/IVR U5MR trend was very low compared to Mozambique 2022 DHS and the UN-IGNE estimates (14, 15). Finally, NMR and IMR estimates and trends between COMSA subsample and RDD/IVR followed the same patterns as the U5MR. Therefore, those estimates were lower than the other comparison data sources (12, 14, 15), including the estimates from the population census projections in 2018-2021 (21).

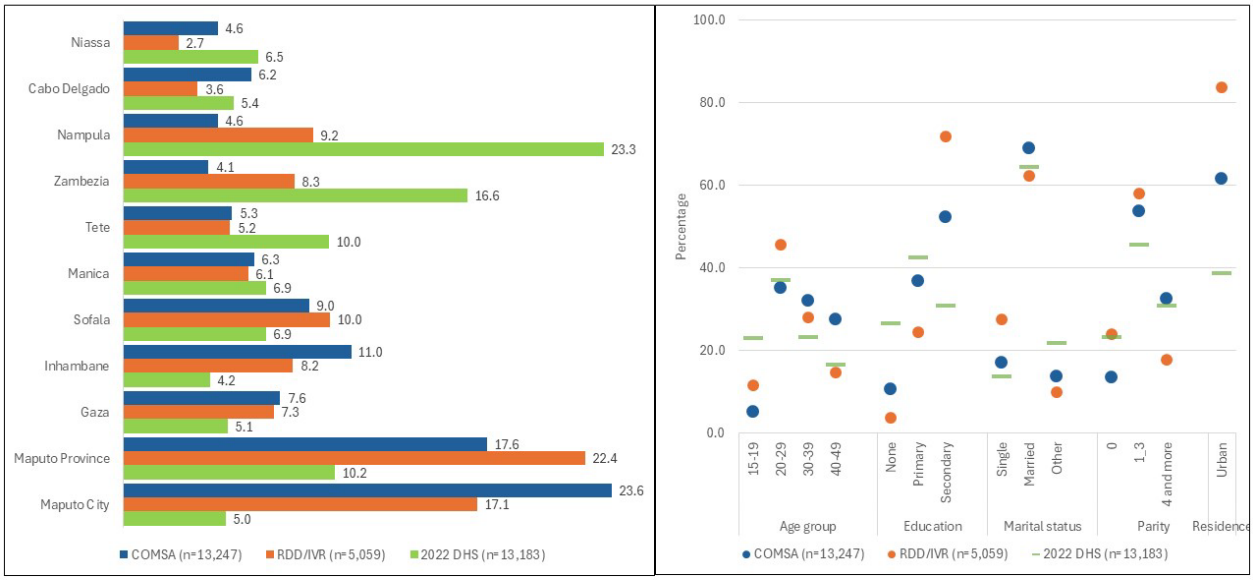
Our study demonstrated the feasibility of national mobile phone-based surveys and provided insights into the effectiveness of such methods for mortality measurement in LMICs. Our findings addressed data collection challenges and provided alternative ways to monitor child mortality trends when face-to-face surveys are not possible. However, further research is required to refine methods, especially with RDD, and to address potential errors and biases in data collection.

REFERENCES

1. Nations U. Transforming Our World: the 2030 Agenda for Sustainable Development. A/RES/70/1. 2015.
2. Organization WH. Global Reference List of 100 Core Health Indicators (plus health-related SDGs). Geneva: World Health Organization; 2018.
3. Croft TN, Aileen M. J. Marshall, Courtney K. Allen, al. e. Guide to DHS Statistics DHS-7 (version 2). Rokville, Maryland, USA: ICF; 2020.
4. Akuze J, Blencowe H, Waiswa P, Baschieri A, Gordeev VS, Kwesiga D, et al. Randomised comparison of two household survey modules for measuring stillbirths and neonatal deaths in five countries: the Every Newborn-INDEPTH study. Lancet Glob Health. 2020;8(4):e555-e66.
5. Akuze J, Cousens S, Lawn JE, Waiswa P, Gordeev VS, Arnold F, et al. Four decades of measuring stillbirths and neonatal deaths in Demographic and Health Surveys: historical review. Popul Health Metr. 2021;19(Suppl 1):8.
6. Ali J, Labrique AB, Gionfriddo K, Pariyo G, Gibson DG, Pratt B, et al. Ethics Considerations in Global Mobile Phone-Based Surveys of Noncommunicable Diseases: A Conceptual Exploration. J Med Internet Res. 2017;19(5):e110.
7. Pariyo G, Meghani A, Gibson D, Ali J, Labrique A, Khan IA, et al. Effect of the Data Collection Method on Mobile Phone Survey Participation in Bangladesh and Tanzania: Secondary Analyses of a Randomized Crossover Trial. JMIR Form Res. 2023;7:e38774.
8. Amaya A, Marks L, Cronberg A, Lau CQ. In search of the optimal mode for mobile phone surveys in developing countries: A comparison of IVR, SMS, and CATI in Nigeria. Survey research methods. 2019;13:305-18.
9. Pariyo GW, Greenleaf AR, Gibson DG, Ali J, Selig H, Labrique AB, et al. Does mobile phone survey method matter? Reliability of computer-assisted telephone interviews and interactive voice response non-communicable diseases risk factor surveys in low and middle income countries. PLoS One. 2019;14(4):e0214450.
10. L'Engle K, Sefa E, Adimazoya EA, Yartey E, Lenzi R, Tarpo C, et al. Survey research with a random digit dial national mobile phone sample in Ghana: Methods and sample quality. PLoS One. 2018;13(1):e0190902.

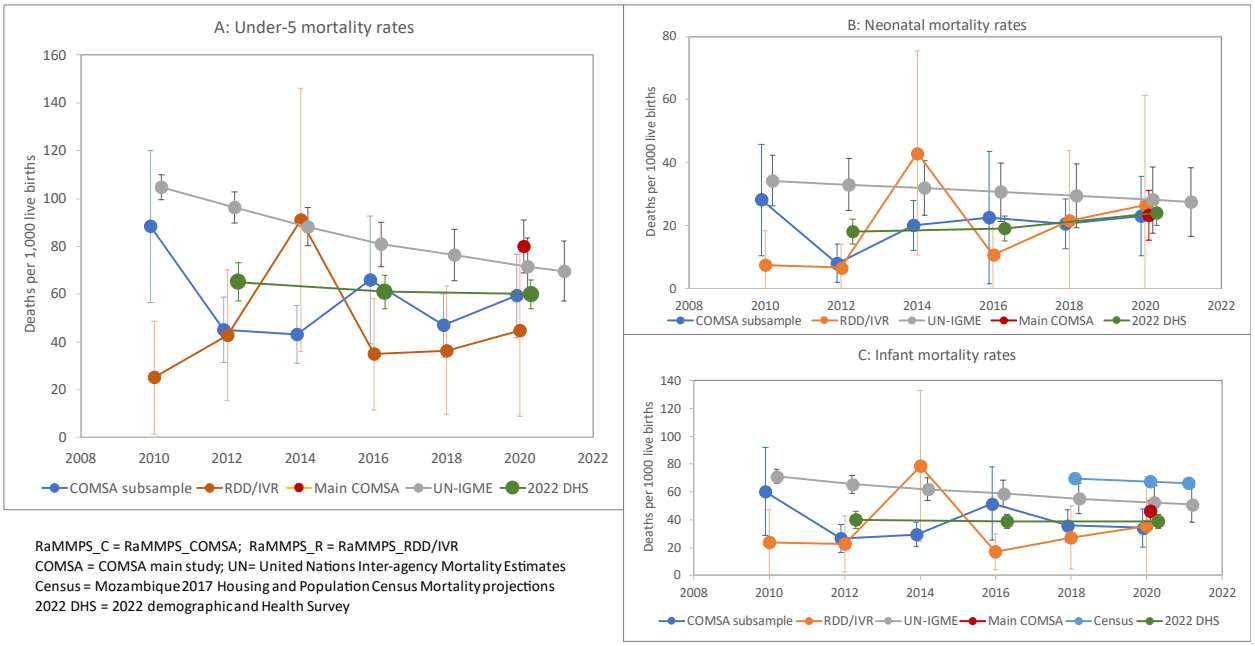
11. Gibson DG, Pereira A, Farrenkopf BA, Labrique AB, Pariyo GW, Hyder AA. Mobile Phone Surveys for Collecting Population-Level Estimates in Low- and Middle-Income Countries: A Literature Review. J Med Internet Res. 2017;19(5):e139.
12. Macicame I, Kante AM, Wilson E, Gilbert B, Koffi A, Nhachungue S, et al. Countrywide Mortality Surveillance for Action in Mozambique: Results from a National Sample-Based Vital Statistics System for Mortality and Cause of Death. Am J Trop Med Hyg. 2023;108(5_Suppl):5-16.
13. (INE) INdE. IV Recenseamento Geral da Populacao e Habitacao. Resultados Definitivos. Maputo - Mocambique: INE; 2019.
14. United Nations Inter-agency Group for Child Mortality Estimation (UN IGME). Levels & Trends in Child Mortality: Report 2022, Estimates developed by the United Nations Inter-agency Group for Child Mortality Estimation. New York: United Nations Children's Fund; 2023.
15. Instituto Nacional de Estatística , The DHS Program. Moçambique IDS 2022-2023 - relatório definitivo. Rockville, Maryland, USA: ICF; 2024.
16. Berger YG, Skinner CJ. A Jackknife Variance Estimator for Unequal Probability Sampling. Journal of the Royal Statistical Society Series B: Statistical Methodology. 2004;67(1):79-89.
17. Deville JC, Särndal CE, Sautory O. Generalized Raking Procedures in Survey Sampling. Journal of the American Statistical Association. 1993;88(423):1013-20.
18. Sanchez-Paez DA, Masquelier B, Menashe-Oren A, Baruwa OJ, Reniers G. Measuring under-5 mortality and fertility through mobile phone surveys: an assessment of selection bias in 34 low-income and middle-income countries. BMJ Open. 2023;13(11):e071791.
19. Valliant R, Dever JA. Survey Weights: A Step-by-Step Guide to Calculation. First ed: Stata Press; 2018.
20. Labrique A, Blynn E, Ahmed S, Gibson D, Pariyo G, Hyder AA. Health Surveys Using Mobile Phones in Developing Countries: Automated Active Strata Monitoring and Other Statistical Considerations for Improving Precision and Reducing Biases. J Med Internet Res. 2017;19(5):e121.
21. Estatística INd. Censo 2017: Projecções da População 2017 - 2050 2019 [Available from: https://www.ine.gov.mz/web/guest/d/censo-2017-brochura-dos-resultados-definitivos-do-iv-rgph-nacional.

Figure 1: Distribution of samples by selected characteristics



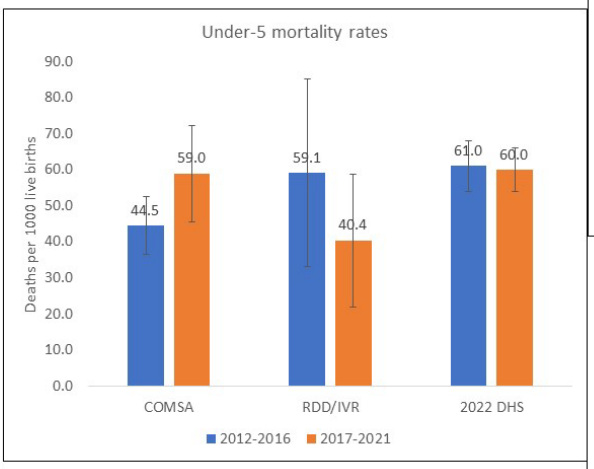
COMSA = RaMMPS_COMSA; RDD/IVR = RaMMPS_RDD/IVR; 2022 DHS = 2022 Demographic and Health Survey

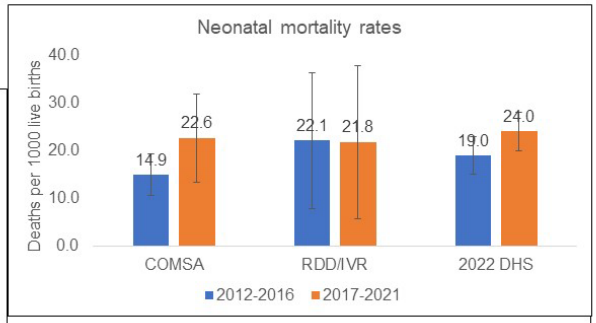
Figure 2: Trends in childhood mortality rates, 2010 – 2021 (2-year period rates)

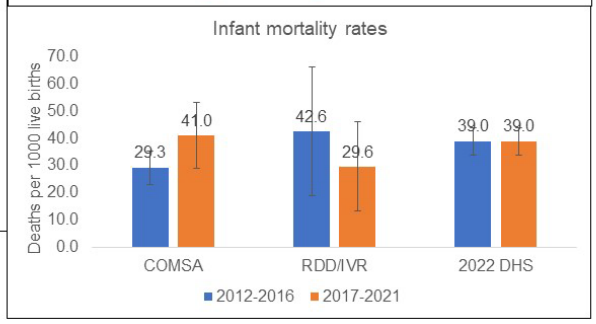


RaMMPS_C = RaMMPS_COMSA; RaMMPS_R = RaMMPS_RDD/IVR
COMSA = COMSA main study; UN= United Nations Inter-agency Mortality Estimates
Census = Mozambique 2017 Housing and Population Census Mortality projections
2022 DHS = 2022 demographic and Health Survey

Figure 3: National neonatal, infant and under-5 mortality rates in 2012-2016 and 2017-2021 by samples

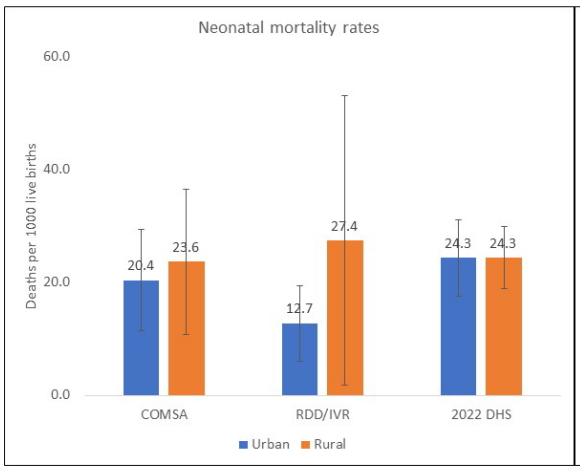


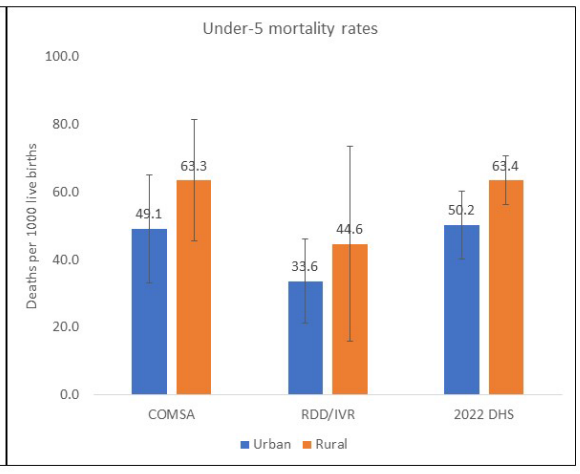




COMSA = RaMMPS_COMSA; RDD/IVR = RaMMPS_RDD
2022 DHS = 2022 Demographic and Health Survey

Figure 4: Residence area neonatal and Under-5 mortality rates in 2017-2021 by samples





COMSA = RaMMPS_COMSA; RDD/IVR = RaMMPS_RDD; 2022 DHS = 2022 Demographic and Health Survey