Mobile Phone Survey Estimates of Perinatal Mortality in Malawi: a Comparison of Data from Truncated and Tull pregnancy histories

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Abstract

Background: In many Low- and Middle-Income Countries, perinatal mortality estimates are derived retrospectively from periodically conducted household surveys. Mobile Phone Surveys (MPS) offer advantages in terms of cost and ease of implementation. However, their suitability for monitoring perinatal mortality is not well-established.

Methods: We use data from the Malawi Rapid Mortality Mobile Phone Survey (RaMMPS) to estimate stillbirth and perinatal mortality rates and compare these to estimates from the Malawi Demographic and Health Survey and estimates published by the United Nations Inter-agency Group for Child Mortality Estimation (UN-IGME). The Malawi RaMMPS sample was generated through random digit dialing (RDD) with active strata monitoring. Post-stratification weighting was used to counter possible sample selection bias, and estimates are reported with bootstrap uncertainty bounds. RaMMPS respondents were randomly allocated to a Truncated Pregnancy History (TPH) or a Full Pregnancy History questionnaire module. We estimated the stillbirth rate as the proportion of all foetal deaths with 28+ weeks of gestation over all pregnancies reaching the same gestational age. The perinatal and extended perinatal mortality rates were defined as the probabilities of dying between 28 weeks and 7 or 28 days of life, respectively.

Results: TPH and FPH were administered for 2093 and 2071 women, respectively. Weighted point estimates of the stillbirth (13.74 deaths per 1,000 pregnancies, 95%-CI: 8.93-21.03), perinatal (39.28, 95%-CI: 29.95-50.30), and extended perinatal mortality rates (45.32, 95%-CI: 35.08-56.54) from the FPH instrument are in line with other published estimates for Malawi. Estimates before and after post-stratification weighting are quasi equivalent. Mortality estimates derived from the TPH instrument are unrealistically high and sensitive to the post-stratification weighting procedure.

Conclusion. MPS are a promising method for collecting perinatal mortality data, and particularly so via the FPH instrument.

Keywords
Mobile phone surveys, stillbirth rate, perinatal mortality rate, Malawi

Manuscript draft [preliminary]

Introduction and background

Most perinatal deaths, including stillbirths, occur in countries where vital registration is insufficiently performant to produce estimates that are useful for monitoring progress towards the *Sustainable Development Goals* (1). In these settings, perinatal mortality estimates are derived from periodically conducted household surveys, including the Demographic and Health Surveys (MICS) and the Multiple Indicator Cluster Surveys (MICS). Most of these sources rely on face-to-face data collection and were interrupted during the early stages of the COVID-19 outbreak, limiting the scope of mortality surveillance during the epidemic. Mobile Phone Surveys (MPS) constitute an appealing alternative that can be deployed rapidly, more cheaply, and without the need for face-to-face contact. The latter also makes them more suitable to field in the context of epidemic outbreaks and other crisis situations (2). However, our experience with mortality MPS remains limited, sampling approaches and survey instruments are not extensively field-tested, and possible biases in the ensuing estimates are not well understood.

There are severable possible methodological pitfalls associated with mortality MPS, including acceptability, sample selectivity, and poor data quality. As our experience with MPS mounts, we are gradually gaining insight in some of these methodological complications and possible remedies. One recent randomised trial from Malawi–on the acceptability of a mortality MPS–suggests that survey completion rates are on par with an MPS focused on a socioeconomic topic (3). Another study, again from Malawi, indicates that MPS data quality is less dependent on interview duration than is often assumed (4). Data quality, however, remains a concern with MPS. For example, there is evidence of higher levels of age heaping in MPS compared to face-to-face surveys (5). Sample selectivity is another important systemic problem because mobile ownership is unequally distributed, response rates are often low, and sampling frames are not always readily available (6, 7). In practical applications sample selectivity can be alleviated by pre- and post-stratification procedures, but this may not equally apply to all indicators of interest (6, 8, 9).

In this contribution, we use data from the Malawi *Rapid Mortality Mobile Phone Survey* (RaMMPS) for estimating perinatal mortality indicators. In the Malawi RaMMPS, women of reproductive age were randomly allocated to answer *Full Pregnancy Histories* (FPH) or *Truncated Pregnancy Histories* (TPH). We present data quality assessments compare the RaMMPS stillbirth and perinatal morality estimates from both instruments with those from the DHS and the UN Inter-Agency group for Child Mortality Estimation (UN IGME).

Data and Methods

Data and survey instruments

We use data from the national Malawi RaMMPS conducted between 1February 2022 and 18July 2023. The fieldwork for this study was coordinated by the Institute of Public Opinion and Research in Zomba, Malawi. Using the mobile phone numbering structure in Malawi, a set of random numbers was generated by Sample Solutions and verified against the *Home Location Register* (HLR), which is a database of registered (including pre-paid) numbers on the GSM network. From this pool of numbers, *Random Digit Dialing* (RDD) was used to contact participants with active strata monitoring (10).

Strata were a-priori defined in terms of broad age groups (18-49 and 50-64), sex, region (North, Central, and South), and type of place of residence (urban/rural) and derived from the 2018 population and housing census (11). Once a stratum was filled, respondents with these attributes were no longer eligible to participate in the study. Fieldwork was divided into four blocks of 3 to 5 months each and quotas were re-set at the beginning of each fieldwork block. Minors below the age of 18 were not interviewed to ensure that all respondents were in a position to consent to the interviews themselves. Sampling was done without replacement (i.e., one survey per phone number).

Starting in the second fieldwork block (26 May 2022), consenting female respondents aged 18-49 were randomly allocated the TPH or FPH set of questions. The FPH questions were modelled after the instrument that was used in round VIII DHS, and solicit information on pregnancy dates, pregnancy outcomes, time of gestation, and the survival status of children who were born in recent past (12). TPH left censor the pregnancies with an end date more than seven years before the interview. Unlike FPH, the TPH were recorded in reverse chronological order, an approach that was adapted from the *Malaria Indicator Surveys* (MIS), albeit in that case focusing on births rather than pregnancies (13).

Post-stratification weights

The number of mobile phone subscribers per 100 individuals in Malawi is estimated at 60% and falls well short of the sub-Saharan African average where mobile phone penetration is estimated at 93% in 2021 (14). Mortality estimates from MPS may be affected by selection bias because mobile phone ownership – and possibly also respondent consent– is correlated with socio-demographic background characteristics that have a bearing on mortality. The imposition of quotas only partially alleviates this problem because this is limited to a number of key demographic (age and sex) and geographic (region and urban/rural place of residence) attributes. It is more challenging to impose quotas on educational background or wealth in the context of an RDD sample because little or no a-priori information is available about these those attributes. We therefore resort to post-stratification to ensure that the RaMMPS sample is representative of the entire population in terms of a wider number attributes.

Post-stratification weights were estimated by Iterative Proportional Fitting–also known as raking –; a method that is routinely used in MPS (15). Marginal distributions were matched to the female population aged 18-64 in the household roster of the Malawi DHS VII (2015-2016), which is the most recent nationally representative survey available at the time of writing. Weights were computed and applied for the following attributes: *i)* sex of the respondent; *ii)* age group (18-49 versus 50-64); *iii)* urban versus rural residency; *iv)* the region of residency (northern, central, or southern); *v)* the educational level of the respondent (primary or less, secondary, higher education or more); *vi)* household size (1-4, 5-8, or 9+); *vii)* drinking water source (safe/unsafe); *viii)* the roof material (durable or not); and *ix)* the use of electricity. Household amenities were compressed into a single index, using Principal Component Analysis. Post-stratification weights were capped not to be less than 0.06 or more than 5 times the value of an unweighted sample.

Stillbirth and perinatal mortality rate estimation

We calculate the–late–stillbirth rate as the probability of pregnancy termination with at least 28 weeks of gestational age $q(28w, Birth)$, and is reported as the number of stillbirths per 1,000 live and stillbirths combined. The TPH and FPH questionnaire module use the same set of questions to inform the day of birth/termination, as well as the gestational age. For the DHS estimates, we restricted our sample to women aged 18-49, and use the day of birth–as reported by the mother–and the approximate date of termination (month and year) as informed by the reproductive calendar.

The perinatal mortality rate is defined analogously, but expands the exposure time to the first week of life: $q(28w, 7d)$. For analytical purposes, we also present the extended perinatal mortality rate that includes mortality during the first 28 days of life $q(28w, 28d)$. This definition of the perinatal mortality is a convenient solution to the problem of heaping at 7 days, and comes with the opportunity to contrast the MPS perinatal mortality estimates with those published by UN-IGME.

Confidence intervals (CIs) were calculated by means of a nonparametric bootstrapping, resampling the total number of interviews 1,000 times with replacement. For each sample, probabilities of selection were assumed to be proportional to the post-stratification weights. As one of the advantages of the bootstrapping method, empirical distributions of all indicators of perinatal mortality, were estimated without reliance on parametric assumptions. The 50th percentile is reported as the central tendency of these distributions; and percentiles 2.5 and 97.5 were used to report 95% CIs and to test for any statistical difference between the different survey instruments.

Results

Out of the 56,093 mobile phone numbers that were tried, a RaMMPS CATI interview was completed with 13,668 respondents. Response and refusal rates were 26.52 and 10.42 percent, respectively. These are defined as the number of completed interviews or refusals over the number of respondents who either met the inclusion criteria, or, whose eligibility for inclusion in the study could not be established. As described elsewhere, rates computed in this manner are a lower bound estimate{AAPOR, 2023 #26}. The analyses in this manuscript are restricted to 4,164 interviews with women aged 18-49. About half of these women were administered a Truncated Pregnancy History and about half received the Full Pregnancy History instrument.

Mobile phone owners are more frequently urban, better educated, and come from households with more amenities and this is also reflected in the distribution of these attributes in the unweighted sample (Table 1). Respondents in the mobile phone survey also appear to come from slightly larger households, and that may be due to the fact that larger households have a greater likelihood of being sampled via RDD. After weighting, these imbalances are largely rectified, and the marginal distribution on the RaMMPS background characteristics matches that in the DHS reference population. Post-stratification weighting was applied to each of the four fieldwork blocks separately.

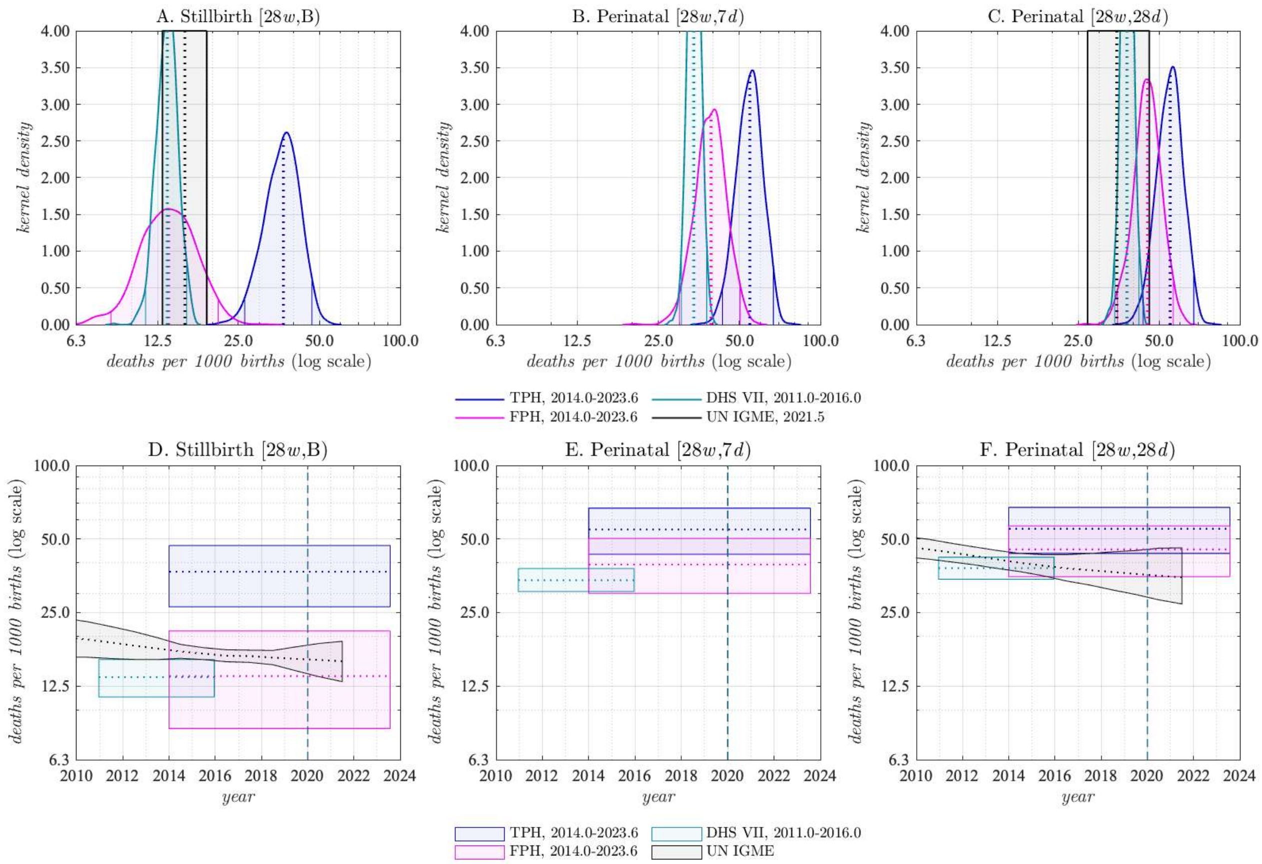
Table 1: Background characteristics of female respondents aged 18-49 in RaMMPS (weighted and unweighted) and the DHS

	TPH		FPH		DHS VII	
Attributes/Instrument & *method* :	*weighted*	*unweighted*	*weighted*	*unweighted*	W18 − 49	
A Type of household: urban	18.59 *[17.01, 20.38]*	37.08 *[34.83, 39.08]*	20.62 *[18.78, 22.36]*	37.90 *[35.85, 39.93]*	18.40 *[18.11, 18.69]*	A
B Region: North	13.33 *[11.94, 14.86]*	17.01 *[15.38, 18.68]*	10.53 *[9.27, 11.97]*	16.51 *[14.73, 18.03]*	11.68 *[11.55, 11.83]*	B
C Central	40.61 *[38.53, 42.81]*	36.55 *[34.50, 38.70]*	40.75 *[38.70, 42.97]*	37.42 *[35.39, 39.45]*	42.84 *[42.58, 43.10]*	C
D South	46.06 *[43.86, 48.14]*	46.44 *[44.19, 48.69]*	48.62 *[46.43, 50.77]*	46.11 *[43.99, 48.29]*	45.48 *[45.23, 45.73]*	D
E Education: primary or less	71.57 *[69.61, 73.39]*	23.27 *[21.43, 24.94]*	70.59 *[68.59, 72.48]*	22.55 *[20.69, 24.24]*	73.87 *[73.19, 74.53]*	E
F secondary	24.75 *[23.03, 26.66]*	51.70 *[49.64, 53.82]*	25.54 *[23.80, 27.52]*	51.47 *[49.40, 53.55]*	22.70 *[22.07, 23.40]*	F
G higher or more	3.68 *[2.87, 4.49]*	24.99 *[23.15, 26.85]*	3.81 *[3.04, 4.66]*	26.07 *[24.12, 27.88]*	3.41 *[3.11, 3.76]*	G
H Household size: 1-4	37.98 *[35.91, 40.16]*	35.59 *[33.59, 37.70]*	40.80 *[38.58, 42.90]*	39.40 *[37.28, 41.62]*	40.21 *[39.43, 41.09]*	H
I 5-8	54.32 *[52.15, 56.54]*	54.85 *[52.70, 56.95]*	52.58 *[50.53, 54.80]*	51.96 *[49.78, 54.13]*	52.85 *[51.92, 53.66]*	I
J 9+	7.69 *[6.48, 8.81]*	9.56 *[8.29, 10.82]*	6.57 *[5.55, 7.68]*	8.59 *[7.51, 9.87]*	6.92 *[6.45, 7.44]*	J
K Drinking water: safe source	81.46 *[79.79, 83.11]*	93.45 *[92.33, 94.46]*	81.75 *[80.20, 83.46]*	93.05 *[91.94, 94.16]*	88.21 *[87.75, 88.66]*	K
L Roofing: durable material	51.36 *[49.16, 53.46]*	81.32 *[79.62, 83.01]*	51.13 *[48.96, 53.52]*	81.22 *[79.55, 82.81]*	48.47 *[47.80, 49.17]*	L
M Electricity: use	36.26 *[34.11, 38.34]*	52.08 *[49.78, 54.18]*	35.88 *[33.75, 37.88]*	53.21 *[50.87, 55.21]*	13.74 *[13.22, 14.25]*	M
N Amenity Index 1: below p50	47.44 *[45.32, 49.69]*	17.73 *[16.10, 19.40]*	47.66 *[45.39, 49.88]*	17.38 *[15.91, 19.02]*	51.15 *[50.45, 51.80]*	N
O Amenity Index 2: below p50	53.99 *[51.98, 56.23]*	57.43 *[55.18, 59.55]*	53.07 *[50.89, 55.24]*	59.15 *[56.91, 61.13]*	57.37 *[56.71, 58.10]*	O
P Observations	2, 093	2, 093	2, 071	2, 071	21, 392	P

Bootstrapping p50/[*p2.5*, *p97.5*]

Figure 1 contains two representations of the stillbirth and perinatal mortality indictors. The top row (panels A-C) compares the bootstrapping distribution of the estimates from the two RaMMPS pregnancy history modules along with the UN IGME estimates (for women aged 15-49, and including a forecast for 2021); and the 2011-2016 DHS estimates (restricted, as in RaMMPS, to women aged 18-49). The bottom row of Figure *** (panels D-F) shows the same estimates on a time scale to highlight differences in the reference period to which the estimates pertain. Figure 2 contains estimates after post-stratification. Both weighted and unweighted estimates are reported in Table 2.

Figure 1: Distribution of the stillbirth and the perinatal mortality rates in the Malawi RaMMPS (by instrument, weighted estimates) compared with UN IGME and DHS estimates



Notes: The UN-IGME estimates in panel F have been computed by the authors using estimates of stillbirth ratios and the neonatal mortality rate, and assuming a log-normal distribution of these parameters. UN IGME estimates are reported with 90% uncertainty bounds.

Table 2: Stillbirth and perinatal mortality rates by source, before and after post-stratification

		Stillbirth [28w,B)		Perinatal [28w,7d)		Perinatal [28w,28d)		
	Instrument/post-stratification	*weighted*	*unweighted*	*weighted*	*unweighted*	*weighted*	*unweighted*	
A	TPH, 2014.0-2023.6	36.76 *[26.41, 46.98]*	24.64 *[16.69, 33.15]*	54.68 *[43.30, 66.86]*	44.53 *[34.70, 55.65]*	55.04 *[43.66, 67.37]*	45.18 *[35.33, 56.24]*	A
B	FPH, 2014.0-2023.6	13.74 *[8.39, 21.03]*	18.90 *[12.76, 25.72]*	39.28 *[29.95, 50.30]*	42.34 *[33.17, 53.26]*	45.32 *[35.08, 56.54]*	46.55 *[36.97, 57.39]*	B
C	DHS VII, 2011.0-2016.0 Women 18-49	13.60 *[11.28, 16.06]*		33.89 *[30.49, 37.83]*		38.01 *[34.24, 42.14]*		C
D	DHS VII, 2011.0-2016.0 Women 18-49, mobile owners	15.70 *[11.32, 20.50]*	18.49 *[13.08, 24.64]*	35.55 *[29.06, 42.36]*	39.80 *[32.06, 47.99]*	38.56 *[31.79, 45.37]*	43.05 *[35.55, 51.35]*	D
E	UN IGME, 2019.5 Estimated and forecasted (2019-2021)	16.15 *[14.44, 18.10]*				35.98 *[29.63, 44.85]*		E
F	UN IGME, 2020.5 Estimated and forecasted (2019-2021)	16.00 *[13.66, 18.68]*				35.37 *[28.17, 45.86]*		F
G	UN IGME, 2021.5 Estimated and forecasted (2019-2021)	15.80 *[13.04, 19.06]*				34.84 *[27.11, 46.00]*		G

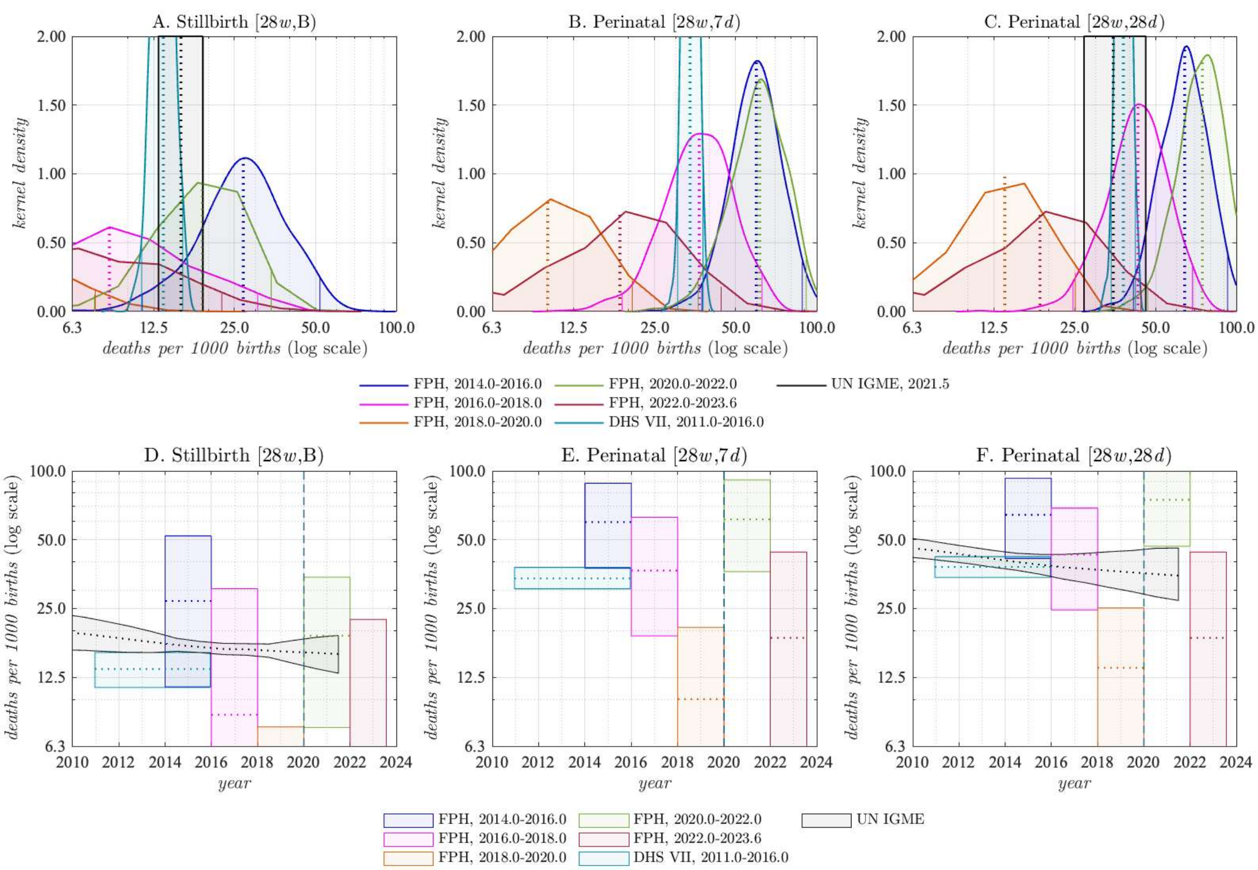
Bootstrapping p50/[*p2.5*, *p97.5*]

The RaMMPS FPH estimate for the stillbirth rate (13.74 per 1,000, 95%-CI: 8.39-21.03) is comparable to that of the DHS and UN-IGME estimate for 2019 (16.3, 90%-CI: 14.7-18.1). The RaMMPS TPH estimate (36.76, 95%-CI: 26.41-46.98) is considerably higher, and well above the range of published stillbirth rate estimates for sub-Saharan Africa [cite UN-IGME report]. Post-stratification weighting does not always produce an upwards adjustment in the stillbirth rate estimates. This is the case for the RaMMPS FPH data as well as the DHS subsample of mobile phone owners (Table 2). Weighted estimates from the RaMMPS TPH instrument are, in contrast, 12 points higher than the unweighted estimates, but this difference fails to reach the threshold of statistical significance.

The RaMMPS FPH estimate of the extended perinatal mortality rate (45.32, 95%-CI: 35.08-56.54) marginally exceeds estimates from other published sources, but the differences are not statistically significant. The UN-IGME estimate for 2019, for example, is 35.98 (90%-CI: 29.63-44.85). Post-stratification does not result in an important adjustment of the estimates. The RaMMPS TPH estimates again stand apart in the sense that they are considerably higher than other estimates, and are also more sensitive to post-stratification weighting.

Figure 3 (and Appendix Table A1) contains stillbirth and perinatal mortality estimates from the RaMMPS FPH instrument disaggregated by period (2 year intervals). Point estimates are indicative of a steady mortality decline between 2014 to 2020 for each of the indicators that are considered, but are also suggestive of a temporary mortality reversal in the calendar years corresponding with the COVID-19 outbreak (i.e., 2020-22). The uncertainty bounds around the period-specific FPH estimates are, however, large and overlapping. Further, the mortality estimates for the period just before and after 2020-22 are uncharacteristically low. While this may result from the stochastic variability in perinatal deaths, it is also possible that there is some displacement of events that artificially inflate the mortality estimates for 2020-22.

Figure 3: Distribution of the stillbirth and the perinatal mortality rates in Malawi by type of period of retrospection (FPH only).



Notes: Weighted estimates. UN IGME reports 90% uncertainty bounds. Panel F shows own calculations, using UN IGME data on stillbirth ratios, neonatal mortality rates, and assuming a log-normal distribution of these parameters.

Discussion

In this study, we have used --for the first time-- mobile phone survey data for estimating perinatal mortality via the Truncated and Full Pregnancy History (TPH and FPH) instruments. These questionnaires were adapted from instruments that have previously been used in face-to-face surveys fielded by the DHS program. In the Malawi RaMMPS, female respondents (aged 18-49) were randomly allocated to either the TPH or FPH instruments, and we used these data to estimate stillbirth and perinatal mortality rates. Elsewhere, we used these data for estimating under-five mortality (U5M) [cite: Romero Prieto et al 2024].

The FPH instrument produces point estimates of the stillbirth and (extended) perinatal mortality rates that are comparable to those from published by the UN IGME and the DHS. The TPH instrument estimates are much higher than those from the FPHs and those from external sources, and therefore less plausible. This conclusion will require confirmation in a bigger sample, but seems to corroborate earlier analyses that the TPH instrument produces biased estimates of U5M (Masquelier et al. 2023) [cite: Romero-Prieto et al 2024]. In addition, the TPH instrument is also very sensitive to the post-stratification weighting procedure.

Data from the FPH were also used to evaluate changes in perinatal mortality over time. These are suggestive of a reversal in the stillbirth and perinatal mortality rates during 2020-22. This possible mortality increase during the COVID-19 outbreak is most pronounced for the perinatal mortality estimates, and could be driven by changes in the utilization health services in the ante- and neonatal period, as observed in other studies (Hekimoğlu and Aktürk Acar 2022). The uncertainty around these estimates is, however, large and this interpretation remains hypothetical.

Selection bias is a systemic problem in mobile phone surveys, and particularly so in settings where mobile phone ownership is not universal and unequally distributed on characteristics that correlate with the outcomes of interest. To minimize or circumvent this problem, we have used a quota sample with active strata monitoring and used post-stratification weights to ensure that our sample represents the population of interest on a number of socio-demographic background characteristics. Because we imposed quotas by type of place or residence (urban/rural), the application of post-stratification weights does not make an important difference to the FPH estimates of perinatal mortality. [elaborate on causes of stillbirth and perinatal mortality and reference other studies (e.g., Sanchez-Paez) that selection bias varies by indicator]

Declarations

Ethics approval and consent to participate
The study protocol was reviewed Ethics Committee of the London School of Hygiene and Tropical Medicine (reference: 26393/RR/24486) and the University of Malawi Research Ethics Committee (reference: P.07/21/76). All participants provided oral consent for the survey, including consent for storing anonymized data in a public repository.

- *Consent for publication*
- *Availability of data and materials*
- *Competing interests*

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- Authors' contributions
- Acknowledgements
- Authors' information (optional)

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