Rapid collection of adult mortality data from mobile phone interviews: an evaluation of surveys conducted in Burkina Faso, Malawi and the Democratic Republic of the Congo

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Reliable statistics regarding adult mortality in many low- and middle-income countries remain elusive due to the incompleteness of death registration. Mortality levels and trends are mainly derived from retrospective surveys and censuses conducted through in-person interviews. Face-to-face interviews are however expensive, time-intensive, and impractical during health crises or complex emergencies. The expansion in cell phone network coverage has opened up new possibilities for collecting demographic data through mobile phone surveys, but there is an important gap in our understanding of selection bias and reporting errors associated with this new interview modality. This study aims to assess adult mortality levels obtained through mobile phone surveys conducted in Burkina Faso, Malawi, and the Democratic Republic of the Congo during the period spanning 2021-2022. To limit respondent fatigue or network interruptions, we used a shortened version of the set of questions typically used in demographic surveys to ask about the survival of respondents' siblings. We found substantial discrepancies between the mortality levels obtained from mobile phone interviews and those extracted from censuses and previous demographic surveys conducted face-to-face, with survey estimates approximately half those expected from United Nations estimates. The observed underestimation can be attributed in part to errors in reporting of ages and the timing of death of siblings. After imputing ages and dates based on full sibling histories collected in previous face-to-face surveys, mortality rates were much higher and consistent with alternative data sources. Mobile phone surveys offer promising potential for the rapid measurement of adult mortality in settings where face-to-face surveys are challenging, but they are susceptible to substantial reporting errors, especially with regard to age and date-related data.

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1. Introduction

A comprehensive system of death registration is the ideal data source to provide accurate and timely data on mortality and causes of death. However, in many countries, a large proportion of deaths remain unregistered and progress in improving coverage and completeness has been slow (Timaeus, 1991; Yokobori et al., 2021). This is especially true in sub-Saharan Africa, where only a few countries, such as Zimbabwe and South Africa, stand out with a sufficiently high completeness rate in death registration (Mikkelsen et al., 2015). To compensate for the lack of death registration, sub-Saharan African countries resort to surveys and censuses. By pooling data sources together, it is now possible to monitor trends in child mortality with a relatively good precision (Sharrow et al., 2022). Data is comparatively much scarcer for adults. The key data sources on adult mortality are retrospective reports on sibling or parental survival collected in Demographic and Health Surveys (DHS), and reports on the deaths that occurred in the twelve months preceding the census operations. These data sources can help in reconstructing past trends in mortality, but they do not effectively capture abrupt changes related to crises or epidemics. This is in part because national surveys such as the DHS and censuses are conducted face-to-face and are highly resource-intensive and time-consuming. Consequently, they occur rather irregularly and at wide intervals. Moreover, they are challenging to conduct during natural disasters, health or security crises, or in situations where face-to-face contact is impossible. For instance, during the COVID-19 and Ebola health crises, the limitations of face-to-face surveys became evident when most survey programs and census operations had to be put on hold.

New approaches to data collection are therefore needed to monitor mortality in resource-constrained environments with limited physical access to respondents. The expansion of mobile phone network coverage offers a significant opportunity by facilitating cost-effective access to respondents, opening the door to mobile phone data collection in these countries. Previous research highlight the advantages of mobile phone surveys (MPS) over face-to-face surveys (Chasukwa et al., 2022; Kuehne et al., 2016; Soullier et al., 2022). For example, telephone interviews can be more cost-effective (Dabalen et al., 2016), offer greater flexibility in questionnaire design, quicker deployment, and consequently make it possible to collect data more frequently than traditional face-to-face surveys (Ben et al., 2015; Brubaker et al., 2021; Gibson et al., 2017; Labrique et al., 2017). Until recently, national-scale MPS were relatively uncommon in low-and-middle-income countries, with limited information on their feasibility in such settings, but the COVID-19 pandemic has greatly accelerated the adoption of MPS in these countries as well (Zezza et al., 2021, Marivoet et al., 2020; PMA, 2023; Vinceti et al., 2020; World Bank Group, 2020). Yet, MPS have been used mostly to collect socio-economic data or to track changes in health behaviors during the pandemic, with only some MPS dedicated to track changes in mortality. In Monrovia (Liberia), a study conducted by Médecins Sans Frontières showed that mobile phone data collection was a viable alternative for measuring excess mortality related to the Ebola crisis (Kuehne et al., 2016). In India, Jha and colleagues also used an independent MPS among adults to reveal that the cumulative number of COVID-19 deaths in September 2021 was six to seven times higher than officially reported (Jha et al., 2022). These two surveys were based on reports of household deaths, and experience is lacking around the feasibility of using other types of modules in MPS, such as the module on sibling survival histories which is frequently used in DHS.

Collecting mortality data over the phone presents a number of risks which need to be carefully examined before wide implementation. First, to be effective, MPS must be administered with a relatively short interview time and thus require the use of shorter questionnaires. For example, collecting full sibling survival histories would be impractical. In a study in Senegal, where each adult has roughly six siblings, the median duration of an interview to collect full SSH and some basic socio-demographic information was 30 minutes (Helleringer et al., 2014). Second, MPS could lead to more misunderstandings between interviewers and respondents, or less commitment to the survey. A recent study in six sub-Saharan African countries revealed that age misreporting errors were more frequent in MPS than in recent household surveys and censuses. Such age errors could have a significant impact on mortality indices (Helleringer et al., 2023). Third, respondents in telephone surveys may exhibit some reservation towards certain questions (Groves, 1979), and be more hesitant to provide sensitive information about the deaths of their relatives over the phone. Encouragingly, a randomized trial in Malawi showed that respondents in a telephone survey were as cooperative when asked about the mortality of relatives as when asked about their recent economic activity, and that questions about death did not generate negative reactions (Chasukwa et al., 2022). Previous research has also demonstrated that MPS can be better suited for addressing sensitive issues, as they provide a higher degree of confidentiality since respondents are free to choose where they wish to answer the questions (Aquilino, 1994; Dabalen et al., 2016; Groves, 1979). Fourth, MPS respondents could not be representative of the general population as they are important sociodemographic differences between respondents of mobile phone surveys and those interviewed face-to-face (Ben et al., 2015; Chasukwa et al., 2022; Ellis & Krosnick, 1999; Kreuter et al., 2010; Lau et al., 2019). Respondents in MPS samples are more likely to be young, well-educated, urban, and affluent, in part due to limited telephone coverage and lower purchasing power among poor populations (L'Engle et al., 2018). Post-stratification weighting can help mitigate selection bias, but mortality rates may remain inaccurate if there is a causal link between mobile phone ownership and survival of close relatives. This can occur, for example, owing to improved access to vital information and facilitated care seeking in case of emergencies.

In this context, this study aims to assess the feasibility of measuring adult mortality through MPS, using a shortened version of the questionnaire generally used to elicit information on maternal siblings in Demographic and Health Surveys. We collected data on siblings survival in three MPS conducted in Burkina Faso, Malawi, and the Democratic Republic of Congo (DRC) during the COVID-19 pandemic, as part of the Rapid Mortality Mobile Phone Surveys (RaMMPS) project. We asked respondents to report the total number of their maternal siblings, the number of such siblings who were still alive, and those who had passed away since the beginning of 2019. Additional information was collected for recent deaths, including the date of death, circumstances, and location of the death. Here we compare adult mortality estimates obtained from these summary sibling histories to those from UN agencies, as well as previous DHS surveys and census data in these three countries.

2. Data and methods

RaMMPS is a multi-country survey program designed to estimate excess mortality caused by the Covid-19 pandemic in the Democratic Republic of Congo (DRC), Malawi, Mozambique, Bangladesh, and Burkina Faso. Sibling survival histories were collected in DRC, Malawi and Burkina Faso. In Burkina Faso, the survey was coordinated by the Institut Supérieur des Sciences de la Population (ISSP) of Joseph Ki-Zerbo University; in DRC by the Ecole de Santé Publique de l'Université de Kinshasa (UNIKIN); and in Malawi, it was a joint collaboration between the Malawi Epidemiology and Interventions Research Unit (MEIRU, https://meiru.lshtm.ac.uk/) and the Institute for Public Opinion Research (IPOR, https://www.ipormw.org/). These surveys were conducted in partnership with the London

School of Tropical Medicine, New York University (NYU), and the Catholic University of Louvain-La-Neuve (UCLouvain).

2.1 Data collection

In Burkina Faso, the data collection lasted from September 2021 to October 2022. In the DRC, data collection occurred from August 2021 to August 2022, and in Malawi, it took place throughout 2022. The survey samples included 21,339 and 10,463 respondents aged 15 years and older in Burkina Faso and Malawi, respectively. In the DRC, the sample was limited to two provinces, Kinshasa and North Kivu, totaling 11,924 interviews, with 6,170 conducted in Kinshasa and 5,754 in North Kivu. All interviews were conducted via mobile phones, and responses were recorded using SurveyCTO on tablets. Eligibility was determined following an initial phone call. Participation was completely anonymous, and all individuals included in the surveys provided verbal informed consent before their interviews. The study protocol received approval from the national health ethics committee in each respective country.

Across the three countries, we opted for different sampling designs and introduced variations in the questionnaires to test for respondent selectivity and assess potential variations in data quality based on the recruitment approach.

In Burkina Faso, data collection was carried out through quarterly cross-sectional surveys conducted over a 12-months period. This approach was designed to mitigate biases associated with the seasonality of mortality. Two distinct sampling strategies were employed. The first sub-sample, referred to as the EHCVM arm, comprised approximately 6,000 individuals selected based on telephone numbers collected during a prior face-to-face survey known as the Harmonized Household Living Conditions Survey (EHCVM for *Enquête harmonisée sur les conditions de vie des ménages*). This original EHCVM survey took place in 2018-2019 and employed a two-stage stratified approach to generate representative indicators for each strata (administrative regions disaggregated by area of residence). In summary, this survey included a sample of 7,010 households, and in approximately 6,575 of them, they effectively obtained telephone numbers that allow us to establish direct or indirect contact with the household heads.. For the mobile phone survey, we re-contacted each head of household who had been previously interviewed in the face-to-face EHCVM survey and had provided a mobile phone number. Additionally, with the consent of the head of the household, a woman of reproductive age (between 15 and 49 years) residing in the household during the MPS survey was randomly selected for inclusion. The second sub-sample, referred to as the RDD arm, included 9,000 individuals randomly selected by drawing telephone numbers through a process commonly referred to as random digit dialing (RDD). Quotas were established from the outset to ensure the representativeness concerning key characteristics such as age, gender, and place of residence, which were informed by nationwide distributions based on the latest census data (Labrique et al., 2017). To achieve this, numbers were randomly generated from all potential phone numbers in Burkina Faso, taking into account the prefixes of the different cellular operators operating in the country, namely MoovAfrica, Telecel Faso, and Orange. Subsequently, non-functional numbers were removed with the technical assistance of VIAMO, an organization that made calls to all the selected numbers to verify their functionality. The estimate of the number of calls required to reach 9,000 individuals was determined based on a similar study involving women of reproductive age in Burkina Faso, which suggested a non-response rate of approximately 25% (Greenleaf et al., 2020). This second sub-sample also provides indicators representative of administrative regions and places of residence (urban and rural).

In DRC and Malawi, we resorted only to RDD. In both countries, we engaged external companies (Feroxus in DRC and Sample Solutions in Malawi) who provided a set of functional telephone numbers used in the 15 days preceding the listing. We also resorted to quotas informed by national data distributions on key characteristics to ensure representativeness.

In the three countries, respondents were informed that they would receive call credit upon completing the interview. Numerous studies have demonstrated that monetary incentives improve survey participation and enable the collection of a large sample within a short time frame (Cheung et al., 2019; Gibson et al., 2022; Singer & Ye, 2013). Furthermore, interviewers were instructed to make repeated attempts to contact individuals over a period of at least seven days at various times before determining that respondents were unreachable.

2.2 Post-stratification weighting

Cell phone ownership is generally higher among individuals with higher socioeconomic status and education (Dabalen et al., 2016; Sibai et al., 2016). In addition, households with more members are more likely to be included in the samples because there is a higher chance that someone can pick up the call, or there are more cell phones in the household (Sibai et al., 2016). To correct for these two sources of error, the most commonly used method is post-stratification weighting (Ben et al., 2015). This technique aims to (i) reduce variances and/or (ii) correct for insufficient sample coverage for certain target population groups (J. J. Kim, 2007). The choice of target populations depends on the data available and the survey results. In this study, the choice of target populations in our weighting process varies slightly by country (see Table 8 in the Appendix). In Burkina Faso, for example, data on basic household assets, place of residence, age and education of the respondent, collected during the MPS, were used to calculate the post-stratification weights, using the 2019-2020 census as a reference. The post-stratification weights also factored in the initial survey weights, which were originally based either on the face-to-face EHCVM sample weights or RDD sample quotas. In Malawi, the same variables were used for post-stratification except for area of residence and gender of respondent. The post-stratification weights were calculated so that the marginal distribution of the key variables listed above in the weighted sample matched the distribution in the 2015 Malawi Demographic and Health Survey. In DRC, we used the 2017-18 Multiple Indicator Cluster Survey (MICS) as the external source to obtain the target distributions for age groups (18-39 and 40+), education level (non-primary, secondary, and tertiary), a summary index of household asset ownership (based on whether the household had electricity, a durable roof, and access to an improved water source), household size (1-4, 5-8, and 9+ members), and urban/rural residence. We calculated separate sets of weights for Kinshasa and North Kivu, and combined them to obtain final weights based on the proportion of the population in Kinshasa (63.5%) and North Kivu (36.5%) among the total population of these two provinces (63.5% and 36.5%, respectively). To avoid high variability when using post-stratification weights, we limited the maximum weight to 2 in the three surveys.

2.3 Imputation to obtain full sibling histories

Survey modules used in sub-Saharan Africa to measure adult mortality usually take three forms: sibling survival histories (Masquelier et al., 2014), reports on recent household deaths (Bendavid et al., 2011), or questions on orphanhood (Timaeus & Jasseh, 2004). Demographic and Health Surveys mostly use sibling survival histories (SSH), whereby respondents are asked about the survival status of each of their maternal siblings, their current age if alive, and age and time elapsed since death if deceased (Helleringer et al., 2014). Given that mobile phone surveys require relatively short interview times, we developed a shortened version of the module used in DHS. Specifically, the questions focused on the total number of siblings, the number of siblings currently alive, and those who have passed away since the beginning of 2019. Additional information was collected for recent deaths, including the date, circumstances, and location of the death. Since the age at survey for surviving siblings and age at death for deceased siblings who died before 2019 were not known collected, we imputed these data based on the most recent DHS surveys with complete SSH available for each country (the 2021 DHS in Burkina Faso, 2015 DHS for Malawi, and 2013-14 DHS for DRC).

We used two types of imputation: partial and complete. For the partial imputation, we imputed only the ages and dates which had not been collected, thus keeping the age at death and time of death of the siblings who had died after 2019 as reported by respondents. For the full imputation, we only kept the number of siblings surviving and deceased, and imputed all dates of birth and dates of death based on the full sibling histories collected in the previous DHS.

In both cases, we first imputed an age difference between each respondent and their siblings. These age differences were sampled from distributions found in the DHS, categorized by the respondent's sex and age group, as well as the sex and survival status of their siblings. This allowed us to recalculate the ages of surviving siblings at the time of the survey. For siblings who had died, we cross-tabulated the siblings' age at death and time since death from the DHS surveys, once again categorized by the five-year age group of respondents. Utilizing these matrices, we proportionally sampled age at death and time since death while controlling for the respondent's age group and sibling sex. From the time since death and the date of the interview, we could then calculate the date of death and infer the date of birth for deceased siblings. For the partial imputation, we retained the imputed values only for those who had died before 2019.

2.4 Validation of the imputation methodology

To ensure that full imputation method produces acceptable results, we applied it to the last two DHS surveys conducted in 28 Sub-Saharan African countries (see table 9 in Appendix). For each country, we assumed that the last survey recorded only summary information on siblings born to the same biological mother of the respondent. That is, the total number of siblings, the total number of deceased siblings, and the total number of living siblings, for each respondent.
Because age at survey for surviving siblings or age at death for deceased siblings were not collected, we imputed birth dates based on information available in the most recent DHS survey (before the last survey), conducted in each country. To do this, we sampled from the complete sibling survival history an age difference between respondents and their siblings, using the distributions of age differences in the DHS, categorized by the respondent's sex and age group, and the sex and survival status of his or her siblings. These age differences allowed us to recalculate the ages of surviving siblings at the time of the survey. For deceased siblings, we crossed age at death of siblings with time since death from the previous DHS survey, again by five-year age group of respondents. From these matrices, we proportionally sampled age at death and time since death, controlling for respondent age group and sibling gender. From the time since death and the date of the interview, we then calculated the date of death and inferred the date of birth of the deceased siblings.

2.5 Refining sub-national mortality indicators in Kinshasa and North-Kivu

In order to have an indicator similar to that of the WPP at a sub-national level (Kinshasa, North Kivu), we have, on the basis of the mortality quotients provided by the WPP at the national level, proceeded to a readjustment, as follows

(i) we used the Brass logit system, with two parameters α and β ;

(ii) assumed that β is unity;

(iii) used the available child mortality level in Kinshasa and North Kivu, and then the mortality levels inferred from the WPP, to estimate the adult mortality level in Kinshasa and North Kivu, using the formula below;

$$ {}_nq_{15} = 1 - \frac{1 + \exp(2(Y(5) + \beta(Y^s(15) - Y^s(5))))}{1 + \exp(2(Y(5) + \beta(Y^s(15+n) - Y^s(5))))} \, . $$

(iv) we then evaluate the relative difference between this value and the value of the mortality level calculated from the DHS for each region;

(v) this relative difference is applied to the set of mortality quotients from the WPP to obtain the mortality level for Kinshasa and North Kivu by year.

2.6 Mortality estimation

As the summary SSH collected over the phone were expanded to full sibling histories after imputation, we then estimated adult mortality using a direct method, by dividing the deaths by the corresponding exposure times, by age and by period since data collection. We converted the mortality rates into survival probabilities, chained the survival probabilities together and converting these cumulative probabilities into ${}_{35}q_{15}$, the probability that an adolescent aged 15 years would die before reaching age 50 years. We used the "demogsurv" package of the statistical software R. Confidence intervals around the probability ${}_{35}q_{15}$ were obtained through the Jackknife method (Eaton and Masquelier, 2020).

3. Results

3.1 Application of full sibling imputation method in Sub-Saharan African

Figures 1a and 1b depict the relative and absolute disparities in adult mortality levels derived from imputed date data compared to mortality estimates calculated without imputation, categorized by country. We note that the absolute or relative differences in mortality between those calculated from actual and imputed data are negligible in most countries except for a few countries such as South Africa, Togo, and Mozambique, taking into account the relative differences. Further analysis of the data quality between the two DHS of each country in terms of the average number of siblings per generation shows that these exceptions can be explained partly by the number of years between the two DHS, partly by changes in the population structure, and partly by data quality problems (Figures 7 and 7bis in Appendix). For Togo and South Africa, for example, the number of years between the last two DHSs is 15 and 18 years respectively. In addition, the structure of the population has changed fundamentally between the two surveys, as shown in Figure 7bis (in the Appendix). For Mozambique, this is more related to poor data quality. Indeed, the average number of siblings in the last survey is lower than in the previous survey, which is not logical.

With the exception of a few countries, it appears that this imputation method is conclusive when recent data of good quality are available for the imputations, as is the case for our three study countries.

Figure 1a: Absolute gap in mortality levels between imputed and not imputed data

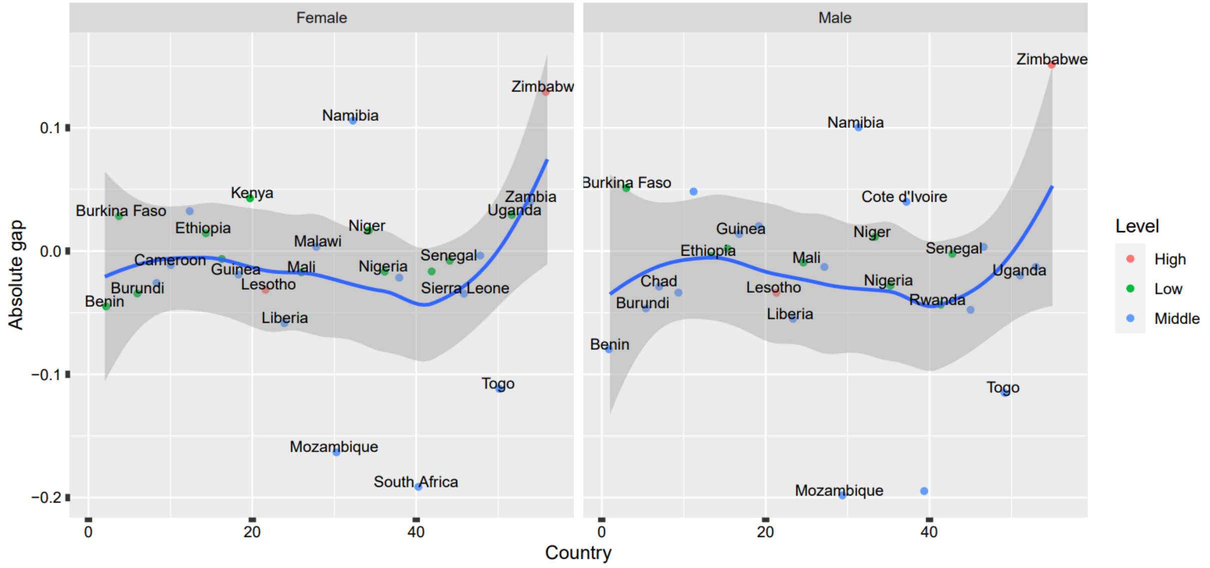
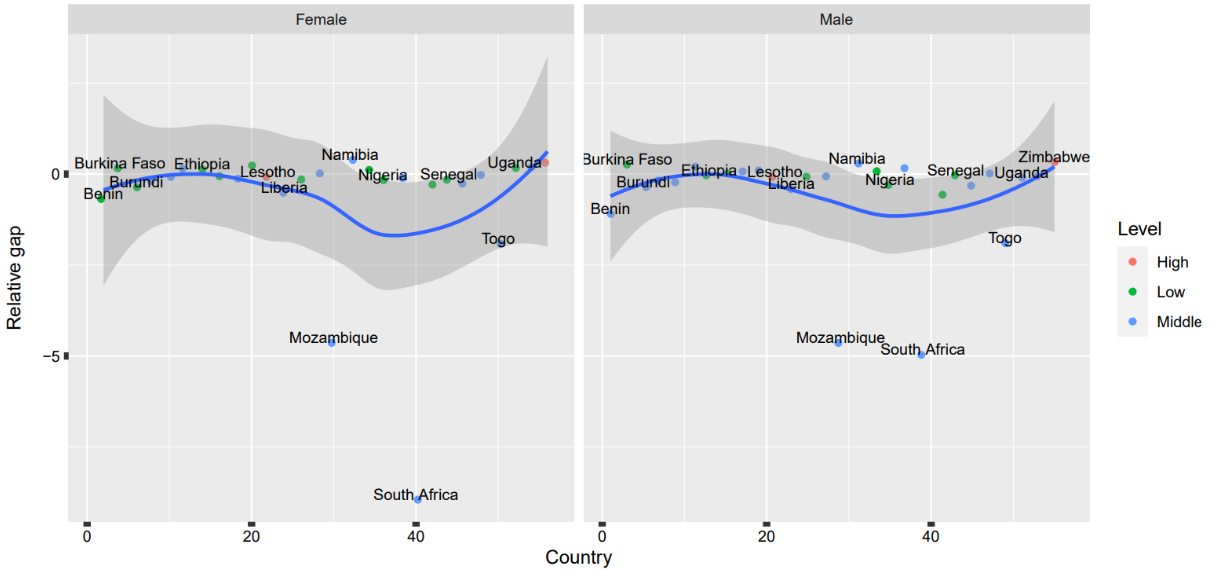


Figure 1b: Relative gap in mortality levels between imputed and not imputed data



3.2 Characteristics of the MPS samples

Table 1a, 1b, and 1c display the composition of the MPS samples, alongside a comparison with the characteristics of the general population in each country. Our comparator is the 2019-2020 census in Burkina Faso, the 2018 census in Malawi, and the MIS-2017-2028 survey n DRC. In Burkina Faso, the EHCVM study arm was compared to the population of heads of households in the census, while the RDD sample was compared to the population aged 15-64.

Upon analyzing the unweighted samples, several notable differences emerged when compared to the national population in each country.

First, in the three MPS, there was an under-representation of rural respondents. For instance, in Burkina Faso, rural respondents constituted approximately 43% and 63% of the EHCVM and RDD samples, respectively, while they accounted for 69% of the national population of

heads of households (and the same percentage of adults aged 15 to 64 in the census). In Malawi, rural respondents represented 74% of the surveyed population in MPS, compared to 83% of the rural population in 2018 census.
Second, the population with higher levels of education was overrepresented in all three countries. Notably, in the DRC, particularly in Kinshasa, the difference between the proportion of respondents with higher education in MPS and in the MICS survey was approximately 33 percentage points.
Furthermore, our samples from Burkina Faso, even with an overrepresentation of urban residents, exhibited a lower percentage of individuals living in small households (with fewer than 9 members) at 65% and 70%, respectively. This contrasted with the national census data, which reported 86% of the population residing in such small households. This situation is also observed in the DRC, regardless of the province of residence. However, in Malawi, this difference remains minimal, with less than a 10 percentage point gap.

Indeed, we conducted a comprehensive comparison between MPS respondents (from the EHCVM arm) and the heads of households who possessed cell phones in the original face-to-face survey conducted from 2018 to 2019 (see Appendix table 8). The results indicated that, in contrast to the cell phone owners in the 2018-2019 face-to-face survey, the individuals re-interviewed via telephone in 2021-2022 were characterized by being younger, more educated, residing in urban areas, living in larger households, and having access to improved household amenities like electricity, quality roofing, or reliable water sources. Consequently, a dual selection process took place, as among mobile phone owners, those who answered the calls and agreed to participate in the MPS represented a specifically chosen sub-sample.

Table 1a: Composition of the MPS sample in Burkina Faso, by study arm, compared with the population enumerated in the 2019-2020 census

Respondents characteristics	EHCVM arm (heads of households)				RDD arm (population aged 15-64 years olds)			
	Unweighted	**Weighted**		**Census**	**Unweighted**	**Weighted**		**Census**
	%	**%**	**95% CI**	**%**	**%**	**%**	**95% CI**	**%**
Sex								
Men	76.7	84.0	[82.0-85.7]	84.0	34.3	46.2	[44.7-47.8]	46.3
Women	23.3	16.0	[14.3-18.0]	16.0	65.7	53.8	[52.2-55.3]	53.7
Age group								
15-29 yrs	17.5	22.9	[20.7-25.1]	22.6	41.5	43.7	[42.2-45.3]	43.7
30-49 yrs	52.0	49.3	[46.8-51.9]	49.1	46.8	42.2	[40.7-43.8]	42.2
50 yrs &+	30.6	27.8	[25.6-30.2]	28.3	11.7	14.1	[13.0-15.2]	14.1
Education								
None	52.0	69.5	[67.1-71.8]	72.2	44.9	67.6	[66.1-69.0]	69.8
Primary	20.2	11.2	[9.7-12.9]	10.0	16.5	11.5	[10.5-12.5]	9.6
Secondary	21.4	13.7	[12.1-15.6]	13.5	29.5	15.7	[14.6-16.8]	15.9
Tertiary and higher	6.4	5.6	[4.5-6.9]	4.2	9.0	5.2	[4.6-5.9]	3.6
Marital status								
Married	83.6	83.3	[81.3-85.1]	84.2	75.4	77.5	[76.2-78.8]	72.5
Widowed	5.5	5.0	[4.0-6.2]	1.1	3.3	3.6	[3.1-4.3]	3.4
Divorced/sep	0.8	0.7	[0.4-1.3]	5.6	0.8	0.7	[0.5-1.0]	0.9
Single	10.1	11.0	[9.5-12.7]	9.1	20.4	18.2	[17.0-19.4]	23.2
Type of place of residence								

Ouagadougou	11.1	13.0	[11.4-14.8]	14.4	15.8	11.5	[10.6-12.4]	14.5
Bobo-Dioulasso	6.1	3.4	[2.6-4.4]	5.0	6.7	3.8	[3.3-4.4]	5.2
Other towns	40.2	13.5	[12.0-15.3]	11.9	14.3	9.3	[8.5-10.2]	11.4
Rural areas	42.6	70.1	[67.7-72.3]	68.7	63.2	75.4	[74.1-76.6]	69.0
Region of residence								
Boucle du Mouhoun	7.1	10.5	[9.0-12.2]	9.6	6.8	10.6	[9.6-11.7]	9.5
Cascades	7.4	4.3	[3.4-5.5]	3.9	4.1	4.1	[3.5-4.8]	4.1
Centre	15.7	16.8	[14.9-18.8]	18.4	24.3	13.4	[12.5-14.5]	18.0
Centre-Est	7.8	7.9	[6.6-9.4]	7.7	6.9	8.1	[7.3-9.1]	7.4
Centre-Nord	7.9	7.6	[6.4-9.1]	7.0	9.2	8.5	[7.6-9.4]	7.3
Centre-Ouest	6.8	7.4	[6.1-8.9]	7.8	7.6	8.3	[7.5-9.2]	8.0
Centre-Sud	5.6	4.5	[3.6-5.7]	4.0	4.3	4.6	[3.9-5.3]	3.9
Est	7.1	8.5	[7.2-10.1]	7.5	4.0	8.3	[7.5-9.3]	7.8
Hauts-Bassins	12.7	12.0	[10.4-13.7]	11.8	14.2	11.0	[10.1-11.9]	12.0
Nord	6.5	7.7	[6.4-9.2]	7.8	7.4	8.5	[7.6-9.4]	8.1
Plateau-Central	6.3	4.5	[3.6-5.7]	4.6	6.2	4.8	[4.2-5.6]	4.7
Sahel	2.9	3.8	[2.9-4.9]	5.3	1.7	5.4	[4.7-6.2]	4.6
Sud-Ouest	6.2	4.4	[3.5-5.6]	4.8	3.4	4.3	[3.7-5.0]	4.6
Household size								
1-4 members	21.5	32.9	[30.5-35.3]	49.4	28.5	39.2	[37.6-40.7]	49.4
5-8 members	43.0	37.4	[34.9-39.9]	36.5	41.9	33.7	[32.3-35.3]	36.5
9+	35.4	29.7	[27.4-32.1]	14.1	29.6	27.1	[25.7-28.6]	14.1

Table 1b: *Composition of the MPS sample in DRC, by province, compared with the population enumerated in the MIS-2017-2018 survey*

	Kinshasa				**North Kivu**			
Respondents characteristics	**Unweighted %**	**Weighted %**	**95% CI**	**MIS-2017/18 %**	**Unweighted %**	**Weighted Percentage**	**95% CI**	**MIS-2017/18 %**
Sex								
Female	41.9	46.3	[44.8-47.9]	54.3	37.7	35.6	[33.8-37.5]	56.1
Male	58.1	53.7	[52.1-55.2]	45.7	62.3	64.4	[62.5-66.2]	43.9
Age group								
(17,40]	69.3	63.4	[61.9-64.9]	79.6	79.6	66.3	[64.5-68.1]	79.7
(40,100]	30.7	36.6	[35.1-38.1]	22.2	20.4	33.7	[31.9-35.5]	20.3
Education								
None/primary	2.6	5.3	[4.5-6.1]	11.8	19.1	37.6	[35.8-39.5]	41.7
Secondary	40.3	71.4	[70.2-72.5]	63.5	52.0	45.1	[43.2-47.0]	43.7
Superior	57.1	23.4	[22.5-24.3]	24.6	28.9	17.3	[16.0-18.7]	14.6
Marital status								
Married/Cohabiting	53.3	54.3	[52.8-55.8]		56.0	65.0	[63.2-66.8]	
Widowed	1.9	3.1	[2.6-3.8]		0.9	1.4	[1.0-1.9]	
Divorced/Separated	3.9	5.2	[4.5-6.0]		2.0	2.7	[2.1-3.5]	
Single	40.8	37.3	[35.9-38.8]		41.1	30.9	[29.1-32.7]	
Household assets								
No	0.7	1.0	[0.7-1.3]	0.0	18.6	38.5	[36.6-40.4]	4.1
Yes	99.3	99.0	[98.7-99.3]	100.0	81.4	61.5	[59.6-63.4]	95.9
Type of place of residence								

Urban	95.2	93.5	[92.6-94.2]	100.0	91.1	65.2	[63.1-67.3]	41.0
Rural	4.8	6.5	[5.8-7.4]	0.0	8.9	34.8	[32.7-36.9]	59.0
Household size								
1-4 members	32.8	29.3	[28.0-30.7]	42.3	20.3	18.1	[16.7-19.7]	32.0
5-8 members	49.2	50.7	[49.2-52.3]	45.0	47.1	45.8	[43.9-47.8]	50.5
9&+ members	18.1	19.9	[18.7-21.2]	12.7	32.5	36.0	[34.2-37.9]	17.5

Table 1c: *Composition of the MPS sample in Malawi, by province, compared with the population enumerated in the Census-2019 survey*

	Unweighted	Weighted		Census-2019
Respondents characteristics	**%**	**%**	**95% CI**	**%**
Sex				
Female	47.5	46.9	[45.6-48.2]	46.9
Male	52.5	53.1	[51.8-54.4]	53.2
Age group				
(17,49]	92.3	85.1	[84.1-86.1]	77.3
(49,100]	7.7	14.9	[13.9-15.9]	22.7
Education				
None/primary	22.5	44.3	[43.0-45.6]	72.7
Secondary	50.9	49.1	[47.8-50.4]	23.4
Superior	26.6	6.6	[5.9-7.3]	3.9
Marital status				
Married/Cohabiting	58.0	64.8	[63.6-66.0]	66.1
Widowed	2.4	3.5	[3.0-4.0]	7.2
Divorced/Separated	7.2	8.8	[8.1-9.6]	7.9
Single	32.4	22.9	[21.8-23.9]	18.8
Type of place of residence				
Urban	26.0	18.0	[17.1-19.0]	16.9
Rural	74.0	82.0	[81.0-82.9]	83.1
Region				
Central	39.9	40.7	[39.4-42.0]	43.1
Northern	15.5	12.9	[12.1-13.9]	12.2
Southern	44.6	46.4	[45.1-47.7]	44.7
Household size				
1-4 members	39.3	34.4	[33.2-35.7]	92.0
5-8 members	51.8	56.4	[55.1-57.7]	7.8
9&+ members	8.9	9.2	[8.5-9.9]	0.2

3.3 Quality of age reporting and summary sibling data in the MPS surveys

3.3.1 Quality of age reporting

The table below presents the levels of age quality indicators collected through both face-to-face and phone surveys, categorized by country and the data collection strategy employed. The attraction to round digits when respondents report their age is a good indicator of the overall data quality. Table 2 compares two indices (the Whipple and Myers indices) calculated in each MPS and the survey or census used as comparator. Whipple's index assesses the preference for ages ending with the digits 0 and 5, whereas Myers' composite index indicates the favorability and aversion for all digits from 0 to 9 (Siegel et al., 2004; Yadav et al., 2020). This comparison suggests that there was more heaping on round digits in the MPS than in the face-to-face surveys, pointing to lower data quality (with one exception being the EHCVM branch in Burkina Faso). For example, in Malawi, the Myers index value for MPS (20) was twice higher than in the face-to-face survey (9.9). This is consistent with observations made for MPS conducted in other African countries (Côte d'Ivoire, Ghana, Rwanda, Senegal) (Helleringer et al., 2023).

It is also worth noting that the quality of age reporting varies between the two study arms in Burkina Faso and the two provinces in DRC. Specifically, in Burkina Faso, the EHCVM arm displays an index of 18%, while the RDD arm registers a higher value of 33%, indicating a more pronounced age heaping within the RDD arm. This observation is corroborated by the Whipple index, which reveals a greater tendency for respondents in the RDD arm to report round ages. In DRC, the relative difference is particularly pronounced in Kinshasa (-60%) compared to Nord-Kivu (-40%). Additionally, both the Myers and Whipple indicators highlight significantly higher accuracy in age recording in Kinshasa compared to Nord-Kivu.

Table 2: Distribution of data quality indicators by country

Data quality on age of respondent	**Burkina Faso**		**Democratic Republic of Congo**		**Malawi**
			Kinshasa	Nord Kivu	
MPS strategy	**EHCVM**	**RDD**	**RDD**		**RDD**
Whipple index (MPS)	122	175	171	234	137
Myers index (MPS)	18	33	31	51	20
Whipple index (Face-to-Face)	142	145	105	140	110
Myers index (Face-to-Face)	18	19	12.3	22.1	9.9

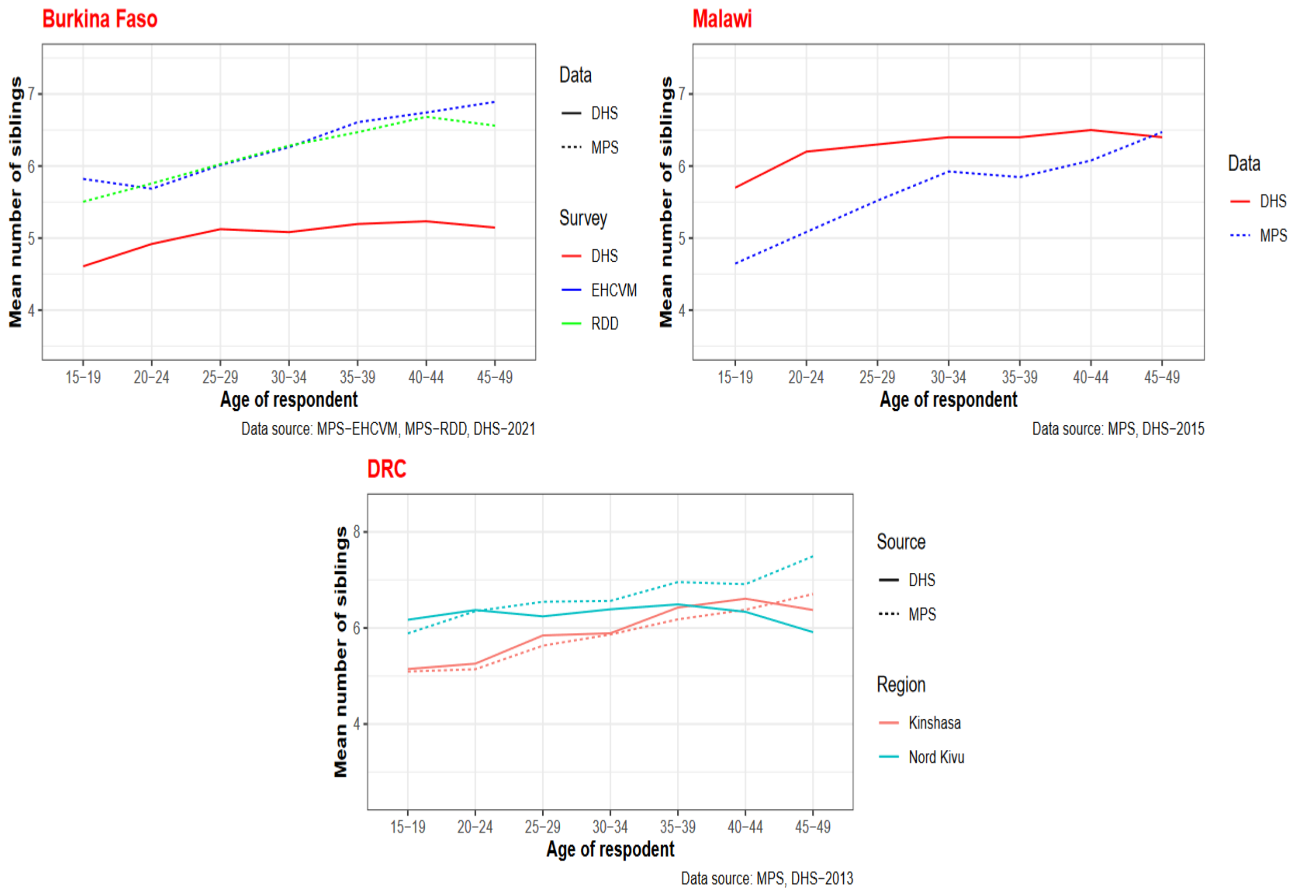
Note: In Burkina Faso, the Whipple and Myers indices in the census are calculated for heads of households for the EHCVM comparison, and among adults 15-64 when comparing to the RDD, face-to-face Whipple and Myers indices are calculated using survey data from MIS and DHS for the DRC and Malawi, respectively.

3.3.2 Summary sibling data in the MPS surveys

To evaluate the quality of sibling survival histories, we will first examine the mean number of reported siblings and the distribution of sibling survival status, categorized by gender, and compare each MPS with the last DHS survey with a full sibling history (Figure 2). It should be noted that the mean number of siblings reported is expected to be slightly lower in the MPS than in the DHS conducted a few years earlier, as a result of the fertility decline observed in each country. In Burkina Faso, the two surveys were carried out only a year apart, and participants in the MPS tended to report a higher number of siblings, irrespective of the respondents' age. In

Malawi, both surveys show the expected increase in mean number of siblings as the age of respondents rise, but with fewer siblings reported in the MPS (up to one less sibling in the MPS in respondents aged 15-19). In DRC, there was virtually no difference between the two data sources in Kinshasa, but in North Kivu, respondents in the MPS, particularly the older age groups, reported slightly more siblings. However, these differences remain relatively small, averaging less than 0.5 siblings. This is particularly remarkable considering the variations in data collection instruments employed by the two sources.

Figure 2. Mean number of maternal siblings by age of respondent in the MPS and DHS conducted in Burkina Faso, Malawi and DRC



In Figure 3, we present the proportions of surviving siblings categorized by the age group of respondents in each MPS, again comparing with the latest DHS with full SSH. As expected, there is a consistent decline in the proportion of surviving siblings as the age of respondent increases, regardless of the data source. However, the proportion of surviving siblings is notably higher in MPS surveys than in the latest DHS surveys with full sibling histories in the other two countries, unlike Burkina Faso. These differences are particularly pronounced in the DRC and Burkina Faso, while there is more agreement in Malawi.

Figure 4 focuses on the proportions of deceased siblings within the three years preceding the survey, classified by respondents' age group and country. The analysis reveals a consistent pattern. Regardless of the country, the proportions of deceased siblings among those who have passed away are lower in the phone survey data compared to the DHS data, except for sisters in the Kinshasa province. However, it's important to note that these differences are not statistically significant, as indicated by the associated confidence intervals. Additionally, the extent of these variances varies by country and the gender of the sibling. In essence, the proportion of recent deaths, for which additional questions were asked, is lower than in DHS surveys. This difference can be attributed to the fact that supplementary questions, such as those related to the circumstances of death, may have prompted interviewers to extend the reference period for certain deaths. It's also crucial to emphasize that while these disparities are relatively small in absolute terms, they carry significant implications, especially in the context of estimating recent mortality rates.

Figure 3. Proportion of surviving siblings (brothers or sisters) by age in MPS and DHS per country

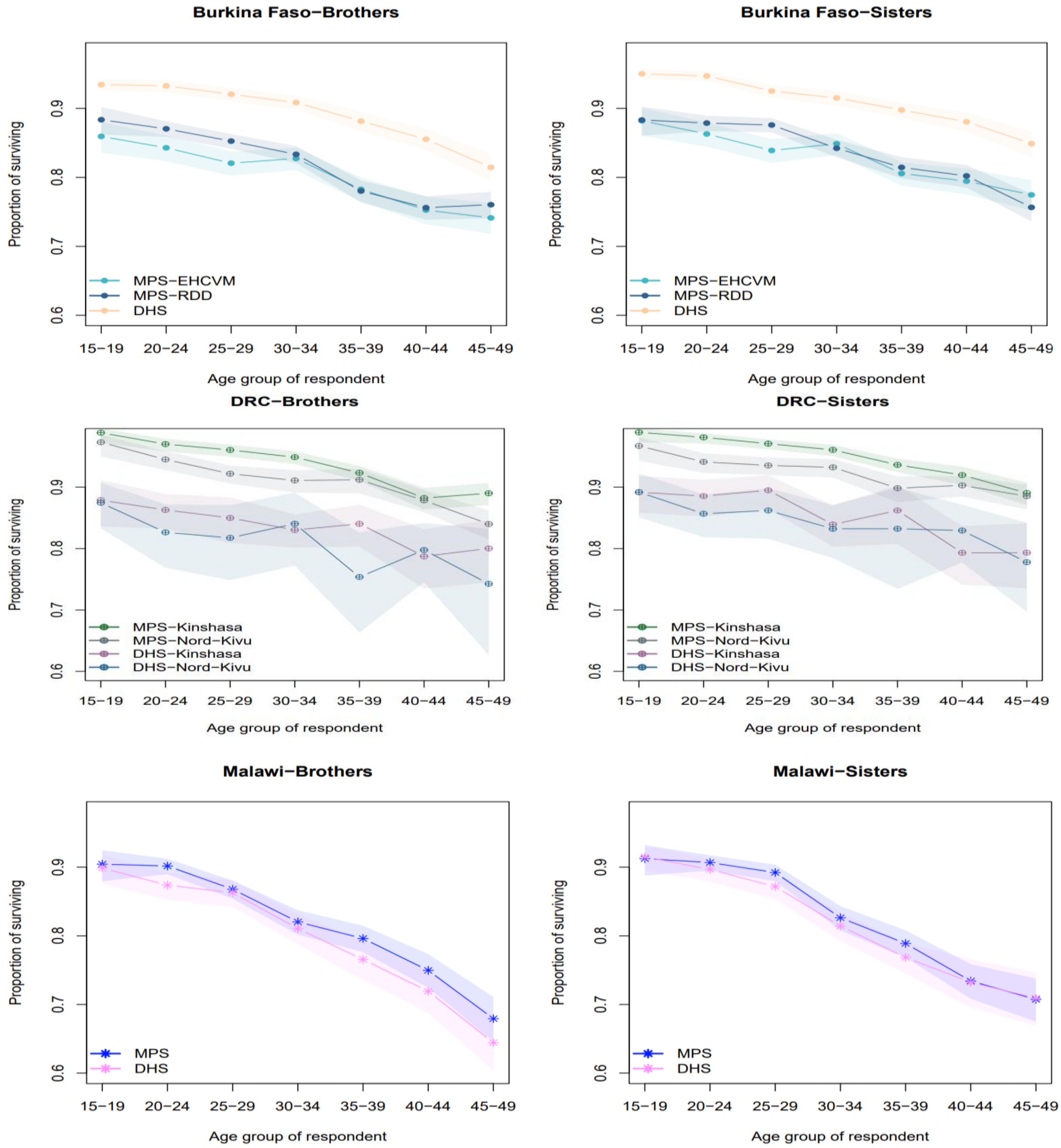
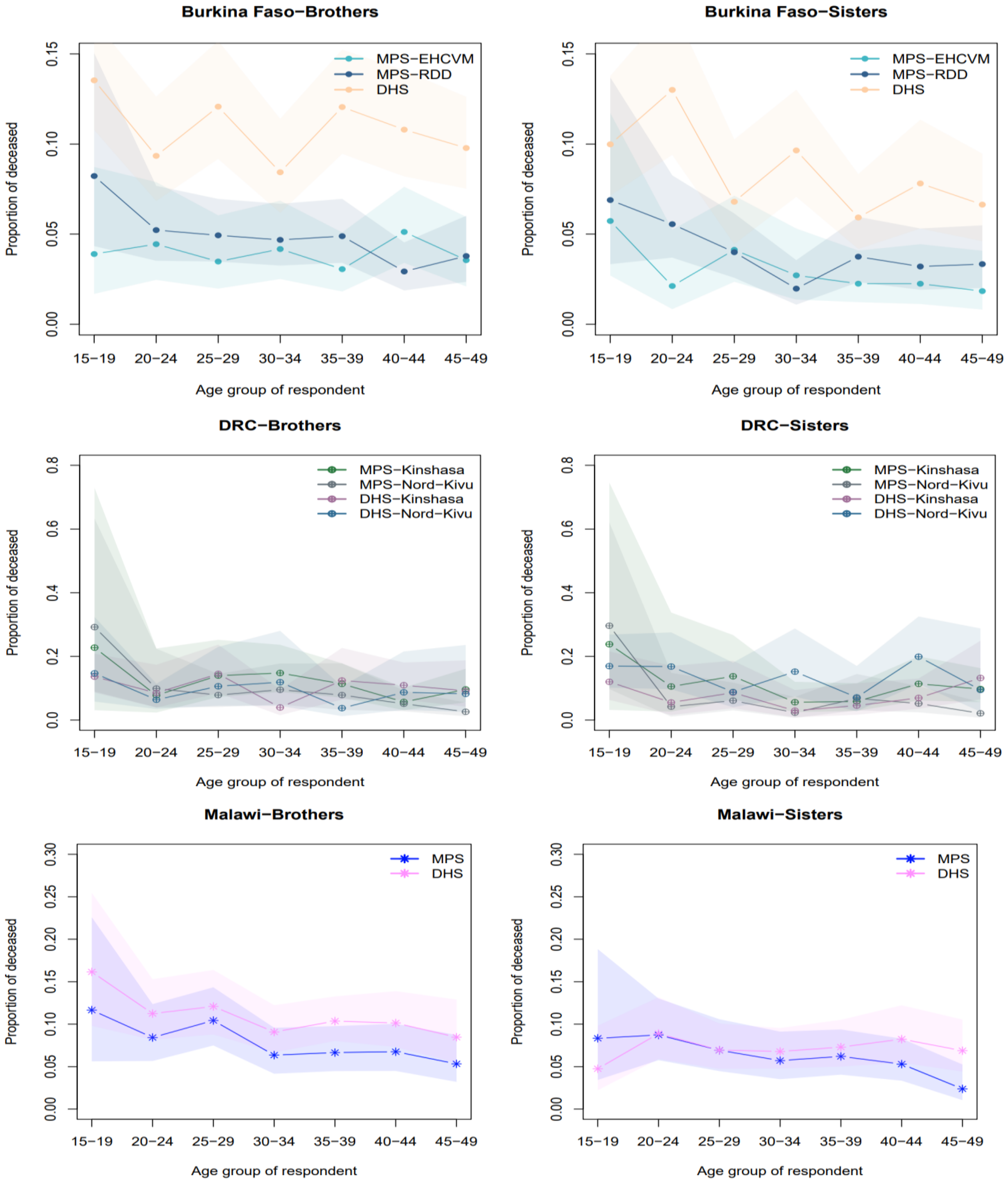


Figure 4. Proportion of deceased siblings who passed in the previous three years (DHS) and since January 2019 (MPS) by age group and country



This analysis shows that the summary data collected across countries on sibling size and proportions of surviving siblings are of acceptable quality, despite some important differences in timing of death.

3.4 Adult mortality rates in MPS based on the partial imputation

Table 3 presents estimates of the probability of a 15-year-old individual succumbing to mortality before reaching the age of 50 (denoted as 35q15). These estimates are categorized by the branch of study and the gender of the respondent. The data is derived from sibling information collected through the MPS study across three countries. To offer a comprehensive perspective, we juxtapose these MPS estimates with data extracted from the Demographic and Health Surveys (DHS) conducted within the same countries. It's important to note that the DHS estimates are based on complete sibling histories and specifically refer to the 0-3 year period preceding the data collection. Furthermore, we introduce more recent estimates from the World Population Prospects (WPP) for the year 2019, which draw on a multitude of sources encompassing sibling survival data, parental survival information, recent household deaths, and the interplay between adult and child mortality. These WPP estimates serve to provide a broader context and a longer-term perspective on the mortality patterns beyond the scope of our immediate study

Our analysis reveals that, on the whole, the mobile phone survey yields estimates of adult mortality that tend to underestimate mortality levels in comparison to the ratios obtained from the Demographic and Health Surveys (DHS), even when considering the possibility of a decrease in mortality since the last data collection, as well as when compared to estimates from the World Population Prospects (WPP).

Furthermore, the relative differences in mortality levels between the mobile phone survey and external sources display intriguing variations across countries. Specifically, in Burkina Faso, we observe that these differences are smaller for men than for women, indicating that the mortality level of men is relatively better estimated in this context.

Conversely, in the Democratic Republic of Congo (DRC) and Malawi, especially in the region of North Kivu, the inverse holds true. The relative differences in mortality levels between the mobile phone survey and external sources are more pronounced for women, suggesting that the mortality level of women is comparatively less accurately estimated in these areas.

These relative differences exhibit substantial variability across countries, spanning from a remarkable -72% in Congo to a modest +13% in Malawi. For example, in Burkina Faso in 2019, the WPP estimated the probability of a 15-year-old man and woman dying before their 50th birthday to be 178 and 138 deaths per 1,000, respectively. In contrast, the cell phone survey yielded estimates of 84 and 56 deaths per 1,000 for men and women, respectively, indicating relative differences in the 35q15 probability of -51% for men and -57% for women.

Moreover, when we disaggregate the estimates by the sex of the respondent, we discern that, in general, female respondents tend to provide higher mortality estimates than male respondents, with a few exceptions. Notably, Malawi, female respondents consistently provide higher mortality estimates compared to male respondents. However, in DRC and Burkina Faso estimates derived from male respondents are higher than those from female respondents.

Further granularity in our analysis of Burkina Faso reveals that for male mortality, when mobile phone survey estimates are segmented by the study arm (EHCVM or RDD) and the sex of the respondent, the downward bias in estimates is particularly pronounced for males in the RDD arm (-24%) and females in the EHCVM arm (-34%). Overall, mortality levels among men appear to be higher in the EHCVM group than in the RDD group.

Table 3: Estimates of the probability 35q15 over the period 0-3 years before data collection, by source and sex of respondent and 95% confidence intervals per country

	Sibling		Men			Women			Relative difference with DHS (%)		Relative difference with WPP (%)	
Country	**Source**	**Sex of respondents**	**$_{35}q_{15}$**	**ci_l**	**ci_u**	**$_{35}q_{15}$**	**ci_l**	**ci_u**	**Men**	**Women**	**Men**	**Women**
Burkina		Male	88	70	105	57	43	72	-9	-15	-54	-58

Burkina	Both arms combined	Female	83	64	102	56	39	72	-14	-16	-48	-56
Burkina		Both	84	72	98	56	46	67	-13	-16	-51	-57
Burkina		Male	105	74	135	59	36	81	8	-12	-46	-64
Burkina		Female	64	40	87	52	28	76	-34	-22	-57	-68
Burkina	EHCVM	Both	87	67	107	52	38	67	-10	-22	-52	-66
Burkina		Male	74	54	93	61	41	81	-24	-9	-59	-53
Burkina		Female	96	69	122	59	37	79	-1	-12	-41	-47
Burkina	RDD	Both	83	66	99	60	45	75	-14	-10	-51	-50
Burkina	DHS-2021		97	83	110	67	55	80	-	-	-	-
Burkina	WPP		178	-	-	138	-	-	-	-	-	-
Kinshasa		Male	46	27	64	67	40	93	-70	-25	-63	-43
Kinshasa		Female	72	43	99	35	12	57	-53	-61	-42	-70
Kinshasa		Both	57	40	73	52	35	70	-62	-42	-54	-56
Nord Kivu		Male	71	41	99	40	21	59	-51	-55	-25	-53
Nord Kivu		Female	57	28	86	25	6	43	-61	-72	-40	-71
Nord Kivu		Both	66	44	86	35	21	49	-55	-61	-31	-59
Kinshasa	DHS-2013		151	103	197	90	55	124	-	-	-	-
Kinshasa	WPP		123	-	-	118	-	-	-	-	-	-
Nord Kivu	DHS-2013		145	85	202	154	83	220				
Nord Kivu	WPP		95			85						
Malawi		Male	175	134	213	116	81	149	-56	-53	-21	-11
Malawi		Female	134	84	181	147	99	193	-66	-40	-40	13
Malawi		Both	158	127	188	128	101	155	-60	-47	-29	-1
Malawi	DHS-2015		393	321	458	244	179	303				
Malawi	WPP		222			130						

In the graph provided below, we present a temporal analysis of mortality quotients obtained from telephone surveys in comparison to data gathered through face-to-face surveys (specifically, DHS and WPP). The data is segmented by year and sex across different countries.

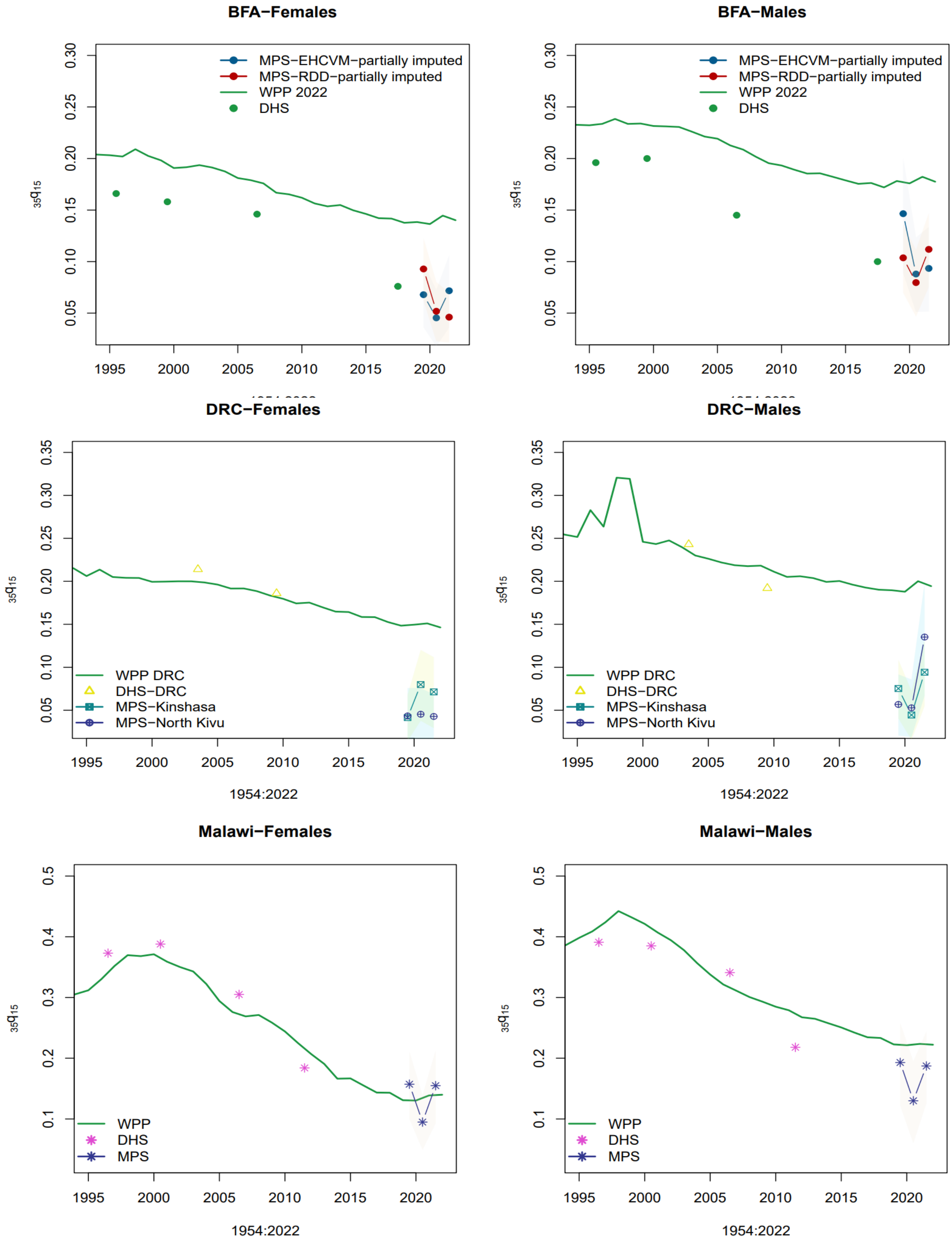
Our overarching observation reveals a consistent pattern: mortality levels derived from telephone surveys tend to be notably lower when contrasted with data from external sources such as the World Population Prospects (WPP) and Demographic and Health Surveys (DHS). This pattern holds true across the majority of countries under scrutiny, underscoring the potential differences in the accuracy and comprehensiveness of data collection methodologies.

However, it's important to highlight an intriguing exception to this pattern, particularly in the case of Malawi among women. Here, we find that mortality levels derived from the telephone survey are not significantly lower than those reported in external sources, marking an interesting deviation from the general trend.

In the case of Burkina Faso, we observe that the mortality levels derived from telephone surveys are consistent with those from the latest DHS-2021. However, an increase in mortality levels is noted in the phone survey between 2020 and 2021, especially among men. Additionally, it's important to note that mortality rates were higher in 2019 (the truncation year) compared to other years.

Additionally, it is worth noting the strikingly low levels of mortality observed annually the Democratic Republic of Congo (DRC), particularly among women. These exceptionally low figures warrant further investigation to ascertain the underlying factors contributing to this unique trend.

Figure 5: Trends in adult mortality ($_{35}q_{15}$) according to sibling survival histories in the MPS survey or DHS surveys and in the World Population Prospects



The significant disparities in adult mortality levels observed between the Mobile Phone Survey (MPS) and the Demographic and Health Surveys (DHS) raise the possibility of reporting inaccuracies in identifying recently deceased siblings and their respective ages at the time of death. It is plausible that these inaccuracies led to the misallocation of deaths beyond the specified truncation window of 3 years. To address this potential bias and evaluate its impact on our estimates, we undertook an alternative approach. Rather than selectively imputing birthdates solely for surviving and recently deceased siblings while utilizing available data on time and age of death for those who passed away within the last 3 years, we opted to discard this specific information. Instead, we applied our imputation methodology uniformly across all siblings, including those who recently passed away. This modification allowed us to better assess the influence of potential reporting errors on our findings.

3.5 Adult mortality rates in MPS based on the full imputation

Figure 6 presents estimates of the 35q15 probability derived from the MPS surveys, with two distinct approaches illustrated. First, estimates obtained for the most recent 3-year period, using limited imputation, are represented as rectangles. Second, estimates derived by imputing all ages and dates from the previous DHS surveys are depicted as dots.

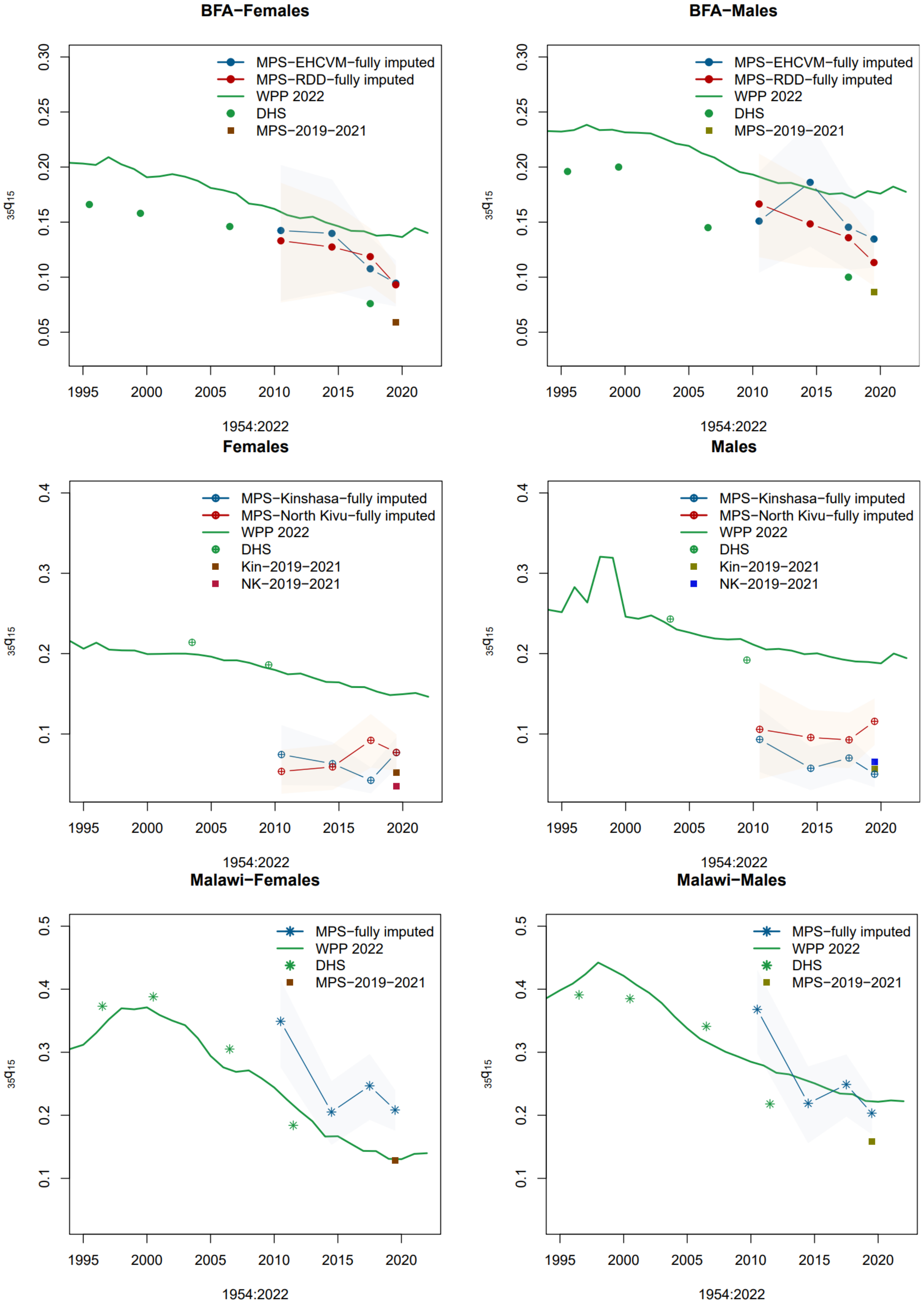
It's worth noting that the World Population Prospects (WPP) estimates, in several instances, tended to be higher than those obtained from sibling survival data in the DHS surveys conducted in Burkina Faso in 1998-1999, 2003, 2010, and 2021, as well as those conducted in Malawi in 2015. This hints at the possibility of an overestimation of adult mortality in the WPP estimates, as previously discussed by Masquelier et al. (2014).

However, the direct estimates derived from limited imputation, which are based on all available data from the MPS surveys across different countries, are conspicuously and surprisingly low. These underestimations of adult mortality are particularly pronounced in the Democratic Republic of Congo (DRC) and Burkina Faso compared to Malawi. Although we calculated annual estimates based on these recent deaths, it's essential to acknowledge that the associated confidence intervals are quite wide.

Intriguingly, we did not observe a statistically significant increase in mortality within this age group over the 2019-2021 period in Burkina Faso. However, in DRC and Malawi, we did observe a significant uptick in mortality levels between 2020 and 2021, as demonstrated in Figure 4.

The estimates based on imputed ages and dates, in contrast, align more closely with the findings of previous DHS surveys for Burkina Faso, the WPP for Malawi, and the adjusted mortality level estimates derived from our calculations for DRC. These results suggest that respondents may have provided inaccurate information regarding age at death and time of death when responding to the abbreviated sibling survival module.

Figure 6: Trends in adult mortality ($_{35}q_{15}$) according to sibling survival histories in the MPS survey or DHS surveys and in the World Population Prospects



4. Discussion

Our study used data from the Burkina Faso, Malawi, and DRC MPS surveys, collected with a short DHS model questionnaire, to assess the plausibility of mortality estimates extracted from telephone interviews. We compared adult mortality from MPS with adult mortality levels and trends derived from DHS and with mortality estimates from the United Nations Population Division. In this study, only direct estimation techniques were used. The limited scope of the short questionnaire constrained the collection of crucial information about the respondent's siblings, prompting the utilization of imputation methods to estimate data, including birthdates, ages, and dates of death. We employed two imputation techniques: partial imputation and full imputation. To assess the validity of this imputation method, we applied it to data from Demographic and Health Surveys conducted in a minimum of 28 sub-Saharan African countries. Our findings established the robustness of this imputation method, particularly when based on high-quality data from a prior survey that comprehensively documented sibling information.

Regarding adult mortality, our research indicates that the MPS tends to underestimate mortality levels when relying on sibling-based summary data gathered within the MPS project. There is a notable degree of uncertainty surrounding expected mortality rates among adults, which is evident in the disparities between estimates derived from Demographic and Health Surveys (DHS) and United Nations (UN) data. Similar trends have been observed in other West African nations, as reported by Masquelier et al. in 2014. However, it's worth noting that the MPS estimates exhibit an unusually low estimation of mortality. This underestimation may be attributed to the inclusion of sibling deaths that occurred before the reference period (2019-2022). Notably, the Covid-19 rapid cell phone excess mortality survey collects additional details on the date and circumstances of death for siblings who passed away after the commencement of 2019. Consequently, it is plausible that inaccuracies in dating these deaths result in the inclusion of deaths from the past three years in an earlier time frame. In particular, there might be an incentive to move deaths earlier in the timeline, a tendency that could be more pronounced in the case of female deaths. This inclination is likely due to the fact that women of childbearing age who passed away were subjected to additional inquiries concerning maternal deaths. This gender-based differentiation could elucidate the more pronounced underestimation observed in the context of female mortality. Furthermore, in Burkina Faso, the extent of the underestimation varied depending on the study arm used, with the Random Digit Dialing (RDD) method displaying greater underreporting. Our data quality assessment revealed that the quality of data was superior in the Enumeration and Household-Based Cell Phone Survey (EHCVM) arm compared to the RDD arm. A closer analysis of the recorded interviews between the interviewers and respondents showed that respondents who were interviewed earlier within the EHCVM arm exhibited higher engagement, resulting in the provision of higher-quality data. Previous studies have also affirmed that telephone surveys employing pre-collected numbers in the field tend to be more effective than those using random numbers, as demonstrated by Oldendick in 2004.

It is also possible that the low mortality rates recorded in phone surveys are the result of selection biases related to the characteristics of mobile phone users. Indeed, our analyses revealed several significant differences between the composition of the phone survey sample and that of face-to-face surveys. It appears that phone surveys in these countries underestimate the representation of respondents living in rural areas and overestimate that of individuals with higher levels of education, particularly in the Democratic Republic of Congo, where the disparity is significant. Furthermore, a detailed comparison between phone survey participants and household heads with mobile phones in the original face-to-face survey conducted in 2018-2019 showed that phone survey participants were generally younger, more educated, resided in urban areas, lived in larger households, and had better living conditions. These findings align with recent conclusions in some low- and middle-income countries (Ben et al., 2015; Kibria & Nayeem, 2023). It is well-established that there is a positive correlation between wealth, place of residence, and education levels, especially among women, and mortality (Chao et al., 2018; S. Kim & Kim, 2019; Yaya et al., 2016). Therefore, despite the weighting adjustments, it is not excluded that these differences may impact the recorded mortality rates.

Furthermore, direct estimates per year based on limited imputation, utilizing all available MPS survey data across different countries, are surprisingly low and significantly underestimate adult mortality. These underestimations are particularly pronounced in the Democratic Republic of Congo (DRC) compared to Burkina Faso and Malawi. It's important to note that the associated confidence intervals for these annual estimates are relatively wide.

An interesting observation is that we observe a statistically significant increase in mortality levels within this age group between 2020 and 2021 in Burkina Faso, Malawi, and the DRC among men. These results suggest that respondents may have provided inaccurate information regarding age at death and date of death when responding to the simplified sibling survival module. The increase in mortality levels between 2020 and 2021 can be partly explained by the indirect effects of COVID-19 prevention measures. Several studies in sub-Saharan Africa have shown that the COVID-19 pandemic had a negative impact on household living conditions, access to healthcare services (Botha et al., 2023; Chinkhumba et al., 2023; Owais et al., 2023).

It's conceivable that abbreviated sibling histories, lacking detailed counts of siblings with information regarding their age at the interview, age at death, and time since death, may be more susceptible to errors compared to complete sibling survival histories. Indeed, when we compare the aggregate results of the MPS data to the DHS data, we observe only marginal discrepancies between the two sources when assessing sibling size and the proportions of surviving siblings. Furthermore, the adult mortality estimates (specifically, the $_{35}q_{15}$ measure) achieved after imputing birth and death dates for all deceased individuals were closer to the figures anticipated from previous DHS or UN Population Division estimates than those calculated using reported ages and dates.

In summary, the use of a concise questionnaire in the context of a mobile phone survey has proven to be a viable and acceptable option when in-person data collection is not feasible, particularly when high-quality data from a previous survey is available for imputations. A similar study conducted in Malawi corroborates the feasibility of obtaining mortality information from adult respondents (Chasukwa et al., 2022). Nevertheless, several important limitations affect the mortality estimate through this method. The absence of additional sociodemographic information about customers using various cell phone networks in these countries introduces uncertainties about the sample's representativeness for the broader population.

Additionally, the location where respondents engage in the interview can influence the quality of data collected in cell phone surveys, as some participants may find it challenging to take part or experience connectivity issues. The literature presents varying perspectives on this matter, with some studies suggesting that the interview mode does not significantly impact data quality (NW et al., 2012), while others contend that the interview mode does affect data quality (Jäckle et al., 2010; Triga, 2019). Furthermore, the telephone survey employs relatively concise questionnaires, and the evaluation of these data collection tools is necessary. However, our approach demonstrates that, with recent data from an external source containing date information, data imputation techniques can enhance the accuracy of adult mortality estimates. Notably, response rates in our survey were notably higher than those in a similar survey of women of childbearing age in Burkina Faso (Greenleaf et al., 2020).

Despite these limitations, our analyses of mortality levels and trends in Burkina Faso, Malawi, and the Democratic Republic of the Congo (DRC) reveal the potential to conduct large-scale national surveys in Sub-Saharan Africa using randomly generated cell phone numbers or numbers obtained from face-to-face surveys for collecting mortality data. Our results demonstrate that adult mortality trends derived from the MPS align relatively well with estimates from face-to-face surveys. For future mobile phone surveys, addressing potential under-representation can be achieved through the implementation of an adjusted quota sampling strategy, contingent on the availability of sociodemographic and economic data on mobile phone network customers.

To ensure comprehensive and accurate information, we strongly recommend employing full sibling histories for collecting mortality data rather than shortened instruments. Additionally, an effective communication strategy informing the population about the data collection period and the survey's objectives will play a pivotal role in reducing interview time and enhancing respondent cooperation, thereby significantly enhancing the quality of the data collected.

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6. Appendix

Table 4. Final disposition code and phone call outcome rates by study arm using American Association for Public Opinion Research standards.

	EHCVM	RDD
Total phone numbers used	8809	43841
I=Complete interviews (1.1)	5087	11176
P=Partial interviews (1.2)	100	4063
R=Refusal and break-off (2.1)	457	2181
NC =Non contact (2.2)	3039	15035
O =Other (2.0, 2.3)	46	736
UH =Unknown household (3.1)	0	0
UO =Unknown other (3.2–3.9)	60	881
Response Rates		
Response rate 1: I/(I+P) +(R+NC+O) +(UH +OU)	0,58	0,33
Response rate 2: (I+P)/(I+P) +(R+NC+O) +(UH+OH)	0,59	0,45
Cooperation Rates		
Cooperation rate 1[&3]: I/(I+P)+R+O)	0,89	0,62
Cooperation rate 2[&4]: (I+P)/((I+P)+R+O))	0,91	0,84
Refusal Rates		
Refusal rate 1: R/((I+P)+(R+NC+O) +UH +UO))	0,05	0,06
Refusal rate 3: R/((I+P)+(R+NC+O))	0,06	0,07
Contact Rates		
Contact rate 1: (I+P)+R+O /(I+P)+R+ O+NC+ (UH +UO)	0,65	0,53
Contact rate 3: (I+P)+R+O /(I+P)+R+ O+NC	0,65	0,55
Survey length, costs, and productivity		
Average survey length (mins)	23	17
Average estimated cost per interview (US $)	4	3
Telephone numbers used to get an interview	2	4
Data quality on age of respondents		
Whipple index	122	175
Myers index	18	33
Whipple index in the census	142	145
Myers index in the census	18	19

Note: The Whipple and Myers indices in the census are calculated for heads of households for the EHCVM comparison, and among adults 15-64 when comparing to the RDD.

Table 5: Composition of the EHCVM (mobile phone) sample in Burkina Faso, compared with the population enumerated in the face to face survey of EHCVM 2018-2019

Respondents characteristics	Household head in original face-to-face EHCVM survey						Household heads in mobile phone survey	
	No phone		Phone owner		Both		EHCVM	EHCVM
	%	No.	%	No.	%	No.	%	No.
Sex of respondent								
Men	68.7	298.0	86.2	5666.0	85.1	5964.0	76.7	3908.0
Women	31.3	136.0	13.8	909.0	14.9	1045.0	23.3	1189.0
Age group								
15-29 yrs	9.9	43.0	10.7	705.0	10.7	748.0	17.5	890.0
30-49 yrs	36.8	160.0	51.0	3355.0	50.1	3515.0	52.0	2649.0
50 yrs &+	53.3	232.0	38.3	2515.0	39.2	2747.0	30.6	1558.0
Education								
None	94.9	413.0	67.8	4456.0	69.5	4869.0	52.0	2649.0
Primary	3.9	17.0	14.4	950.0	13.8	967.0	20.2	1031.0
Secondary &+	1.1	5.0	17.8	1169.0	16.7	1174.0	27.8	1417.0
Marital status								
Married	73.8	321.0	85.7	5635.0	85.0	5956.0	83.6	4262.0
Widowed	21.4	93.0	8.2	539.0	9.0	632.0	5.5	279.0
Divorced/sep	2.5	11.0	1.6	106.0	1.7	117.0	0.8	41.0
Single	2.3	10.0	4.5	295.0	4.4	305.0	10.1	515.0
Type of place of residence								
Ouagadougou	0.2	1.0	8.2	539.0	7.7	540.0	11.1	566.0
Bobo-Douilasso	0.5	2.0	4.2	273.0	3.9	275.0	6.1	312.0
Others town	14.9	65.0	34.5	2269.0	33.3	2334.0	40.2	2048.0
Rural areas	84.4	367.0	53.1	3494.0	55.1	3861.0	42.6	2171.0
Region of residence								
Boucle du Mouhoun	9.0	39.0	8.3	548.0	8.4	587.0	7.1	361.0
Cascades	2.1	9.0	6.6	433.0	6.3	442.0	7.4	376.0
Centre	2.3	10.0	12.4	818.0	11.8	828.0	15.7	800.0
Centre-Est	11.7	51.0	8.0	525.0	8.2	576.0	7.8	400.0
Centre-Nord	5.7	25.0	7.3	479.0	7.2	504.0	7.9	405.0
Centre-Ouest	6.2	27.0	7.1	465.0	7.0	492.0	6.8	349.0
Centre-Sud	10.6	46.0	6.4	421.0	6.7	467.0	5.6	285.0
Est	8.3	36.0	7.7	503.0	7.7	539.0	7.1	360.0
Hauts Bassins	3.2	14.0	10.7	705.0	10.3	719.0	12.7	645.0
Nord	3.4	15.0	6.5	427.0	6.3	442.0	6.5	332.0
Plateau-Central	4.4	19.0	6.1	400.0	6.0	419.0	6.3	323.0
Sahel	11.7	51.0	6.2	405.0	6.5	456.0	2.9	146.0
Sud-Ouest	21.4	93.0	6.8	446.0	7.7	539.0	6.2	315.0
Household size								
1-4 pers	52.9	230.0	31.4	2066.0	32.8	2296.0	21.5	1098.0
5-8 pers	39.5	172.0	45.9	3020.0	45.5	3192.0	43.0	2193.0
9 pers&+	7.6	33.0	22.6	1489.0	21.7	1522.0	35.4	1806.0
Electricity								
Yes	3.2	14.0	29.0	1906.0	27.4	1920.0	32.4	1652.0

No	96.8	421.0	71.0	4669.0	72.6	5090.0	67.6	3445.0
Roof								
Improved	57.9	252.0	86.8	5704.0	85.0	5956.0	90.2	4598.0
Not improved	42.1	183.0	13.2	871.0	15.0	1054.0	9.8	499.0
Water								
Improved	76.1	331.0	83.9	5519.0	83.5	5850.0	86.7	4418.0
Not improved	23.9	104.0	16.1	1056.0	16.5	1160.0	13.3	679.0
Region and place of residence								
Boucle du Mouhoun urban	1.1	5.0	3.2	211.0	3.1	216.0	3.6	185.0
Boucle du Mouhoun rural	7.8	34.0	5.1	337.0	5.3	371.0	3.5	176.0
Cascades urban	0.7	3.0	3.2	211.0	3.1	214.0	4.0	206.0
Cascades rural	1.4	6.0	3.4	222.0	3.3	228.0	3.3	170.0
Centre urban	0.2	1.0	8.2	539.0	7.7	540.0	12.7	648.0
Centre rural	2.1	9.0	4.2	279.0	4.1	288.0	3.0	152.0
Centre-Est urban	2.3	10.0	3.0	194.0	2.9	204.0	3.5	178.0
Centre-Est rural	9.4	41.0	5.0	331.0	5.3	372.0	4.4	222.0
Centre-Nord urban	0.2	1.0	3.1	203.0	2.9	204.0	3.9	198.0
Centre-Nord rural	5.5	24.0	4.2	276.0	4.3	300.0	4.1	207.0
Centre-Ouest urban	0.7	3.0	3.1	201.0	2.9	204.0	3.5	178.0
Centre-Ouest rural	5.5	24.0	4.0	264.0	4.1	288.0	3.4	171.0
Centre-Sud urban	0.9	4.0	2.9	188.0	2.7	192.0	2.6	134.0
Centre-Sud rural	9.7	42.0	3.5	233.0	3.9	275.0	3.0	151.0
Est urban	1.1	5.0	3.6	234.0	3.4	239.0	4.3	217.0
Est rural	7.1	31.0	4.1	269.0	4.3	300.0	2.8	143.0
Hauts Bassins urban	0.5	2.0	4.9	321.0	4.6	323.0	8.1	415.0
Hauts Bassins rural	2.8	12.0	5.8	384.0	5.6	396.0	4.5	230.0
Nord urban	0.7	3.0	2.9	188.0	2.7	191.0	3.4	175.0
Nord rural	2.8	12.0	3.6	239.0	3.6	251.0	3.1	157.0
Plateau-Central urban	0.9	4.0	2.5	163.0	2.4	167.0	2.3	115.0
Plateau-Central rural	3.4	15.0	3.6	237.0	3.6	252.0	4.1	208.0
Sahel urban	1.8	8.0	3.2	208.0	3.1	216.0	2.1	105.0
Sahel rural	9.9	43.0	3.0	197.0	3.4	240.0	0.8	41.0
Sud-Ouest urban	4.4	19.0	3.3	220.0	3.4	239.0	3.4	172.0
Sud-Ouest rural	17.0	74.0	3.4	226.0	4.3	300.0	2.8	143.0
Total	100.0	435.0		6575.0		7010.0		5097.0

Table 6. Instrument used to collect Summary Sibling Histories in MPS

SUMMARY SIBLING HISTORIES (SSH)

SSH1	Now I would like to ask you some questions about your brothers and sisters who are born to your biological mother. Can you please tell me how many sisters were born to your biological mother? This includes sisters who are living with you, sisters who not living with you and those who have died?	0 NUMBER ………………… DON'T KNOW	SSH6

	INSTRUCTION: assist the respondent enumerating sisters by listing their (first) names		
SSH2	How many of these sisters are no longer with us today (have passed away)?	0 NUMBER DK	SSH6
SSH3	How many of your sisters have passed away since the beginning of 2019?	0 NUMBER DK	SSH6
SSH4	Can you give me the first name for these sisters?	S1 FName: S2 FName: S3 FName:	
SSH5	In which year/month did (NAME) die?	S1 Year: S1 Month: S2 Year S2 Month S3 Year: S3 Month:	D LOOP D LOOP D LOOP
SSH6	Now I would like to ask you some questions about your brothers who are born to your biological mother. Can you please tell me how many brothers you have or ever had? Please include brothers who are living with you, sisters who not living with you, and those who have died. INSTRUCTION: assist the respondent enumerating brothers by listing their (first) names	0 NUMBER DK	
SSH7	How many of these brothers are no longer with us today (have passed away)?	0 NUMBER DK	
SSH8	How many of your brothers have passed away since the beginning of 2019?	0 NUMBER:	
SSH9	Can you give me the first name for those brothers?	B1 FName: B2 FName: B3 FName:	
SSH10	In which year/month did [NAME] die?	B1 Year: B1 Month: B2 Year B2 Month B3 Year: B3 Month:	D LOOP D LOOP D LOOP

Table 7: Summary informations on sibling collected during MPS survey for each country

		Burkina Faso	DRC	Malawi
SSH1	Total number of sibling	Yes	Yes	Yes
SSH1_sex	Sex of sibling	Yes	Yes	No
SSH2	Total number of died sibling	Yes	Yes	Yes
SSH2_sex	Sex of sibling	Yes	Yes	No
SSH3	Total number of died sibling since the beginning of 2019	Yes	Yes	Yes
SSH3_sex	Sex of sibling	Yes	Yes	Yes
SSH5 year	Year of death	Yes	Yes	Yes
SSH5 month	Month of death	Yes	Yes	Yes
SSH5 age at death	Age at death	Yes	No	Yes

Table 8: Information collected during MPS data collection and used for weight calculation for each country

Variable	Variables labels	Burkina Faso	DRC		Malawi
			Kinshasa	Nord Kivu	
Education	None Primary Secondary and more	Yes	Yes	Yes	Yes
Age	Respondent's age	Yes	Yes	Yes	Yes
Sex	Respondent's sex	Yes	No	No	No
Region	Region of residence	Yes	No	No	No
Place of residence	Place of residence	Yes	No	Yes	Yes
Household size	Household size	Yes	No	Yes	Yes

Electricity	Electricity	Yes	No	No	Yes
Roofing	Roofing	Yes	No	No	Yes
Water	Water	Yes	No	No	Yes

Table 9: Distribution of Sub-Saharan countries by year of the last two DHS surveys

Country	Year1	Year2	Gap
Malawi	2010	2015	5
Zambia	2013	2018	5
Zimbabwe	2010	2015	5
Ouganda	2011	2016	5
Tanzania	2010	2015	5
Rwanda	2015	2019	5
Nigeria	2013	2018	5
Ethiopia	2011	2016	5
Lesotho	2009	2014	5
DRCongo	2007	2013	6
Burundi	2010	2016	6
Sierra Leone	2013	2019	6
Niger	2006	2012	6
Gambia	2013	2019	6
Kenya	2008	2014	6
Liberia	2013	2019	6
Mali	2012	2018	6
Burkina Faso	2003	2010	7
Cameroon	2011	2018	7
Senegal	2010	2017	7
Namibia	2006	2013	7
Guinea	2005	2012	7
Mozambique	2003	2011	8
Chad	2004	2014	10
Benin	2006	2017	11
Togo	1998	2013	15
Ivory Coast	1994	2011	17
South Africa	1998	2016	18

Figure 7: Distribution of the average number of siblings by generation between the last two DHS surveys in sub-Saharan African countries (part 1)

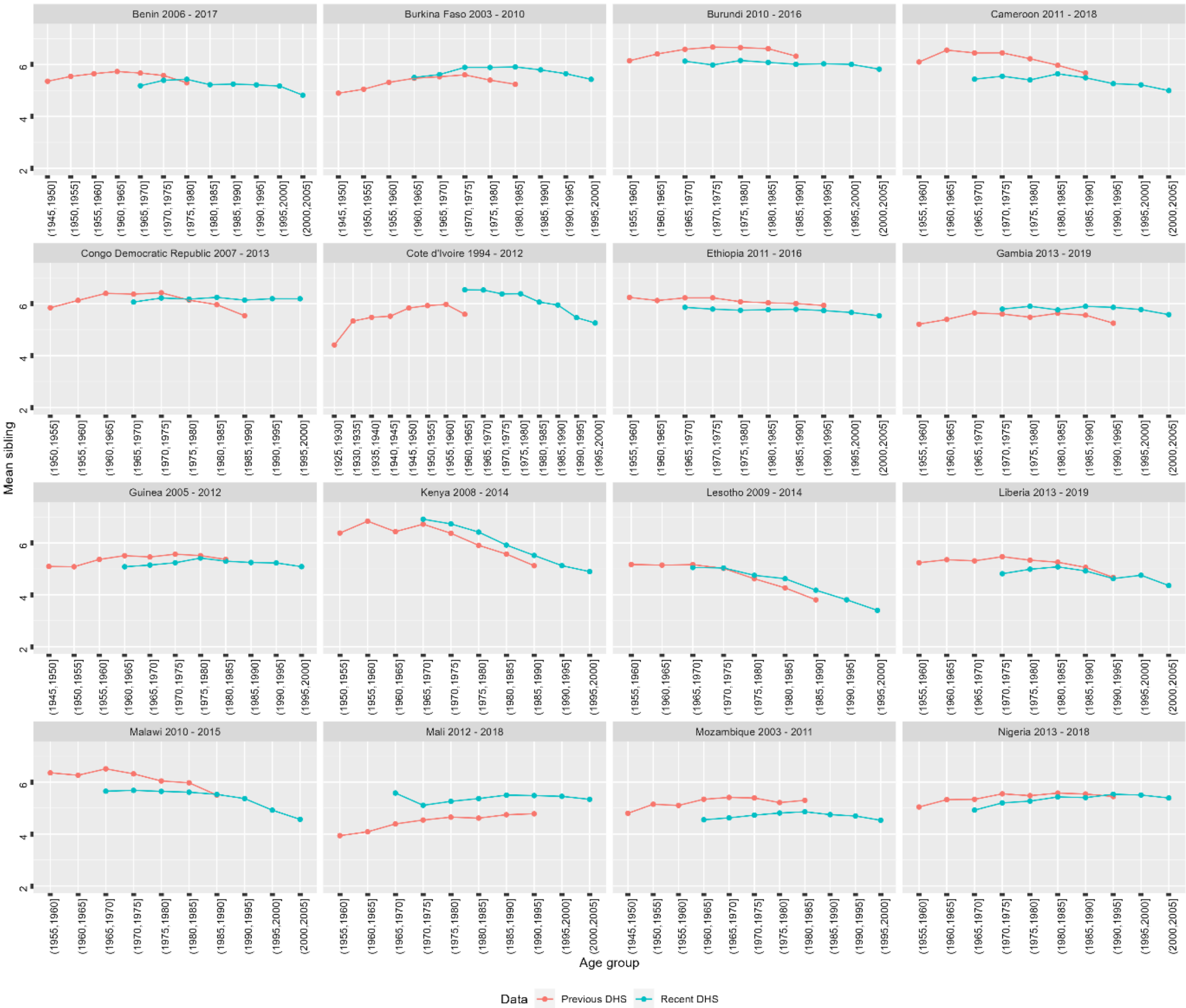
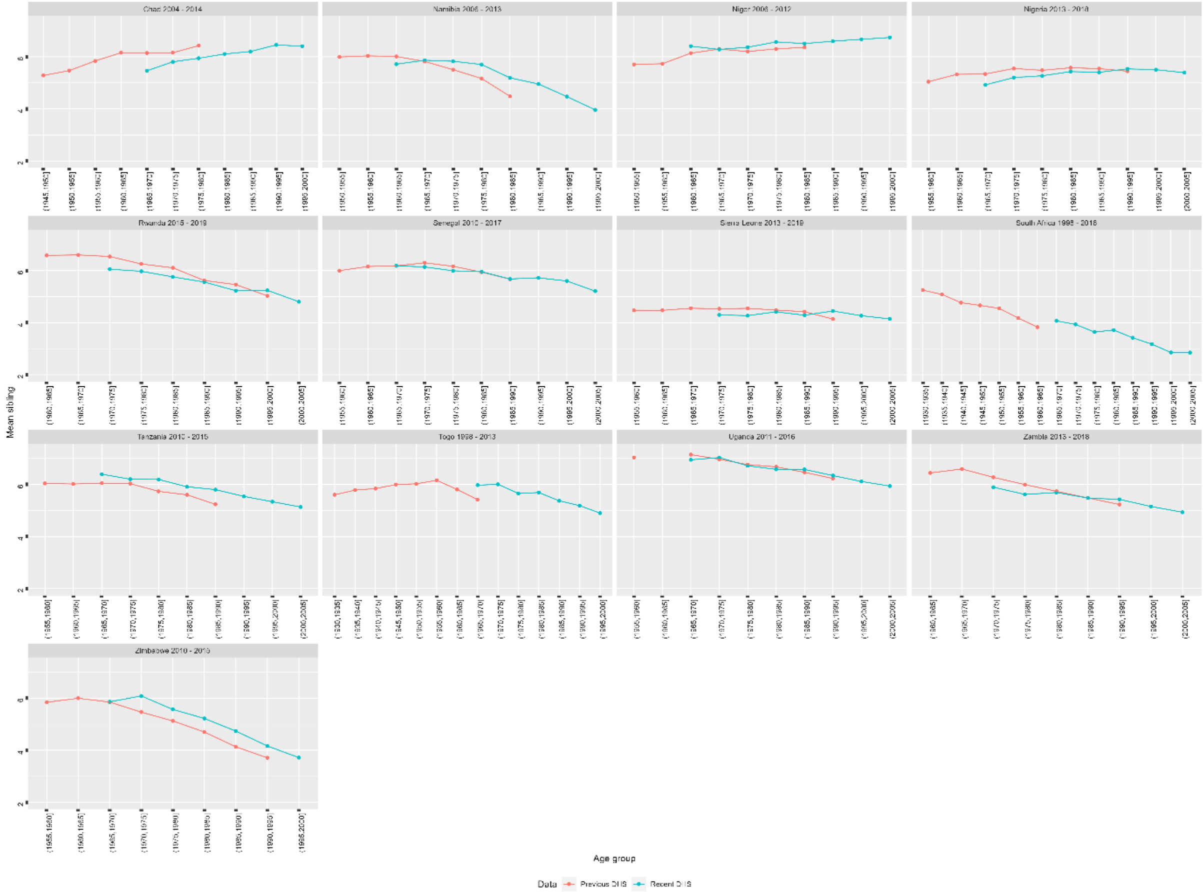
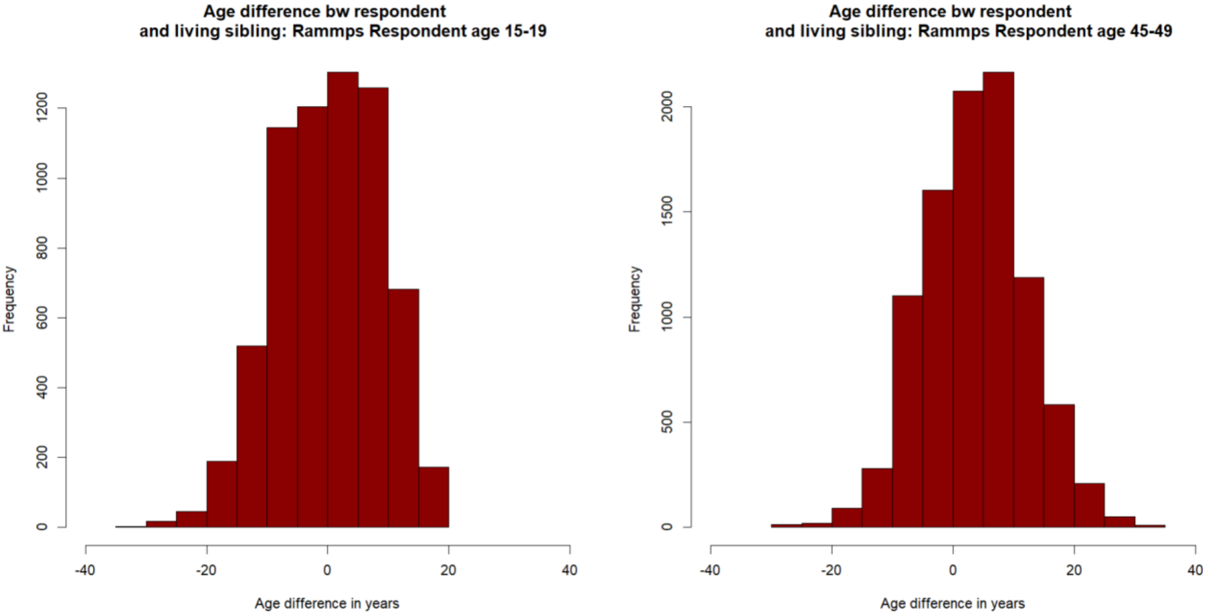


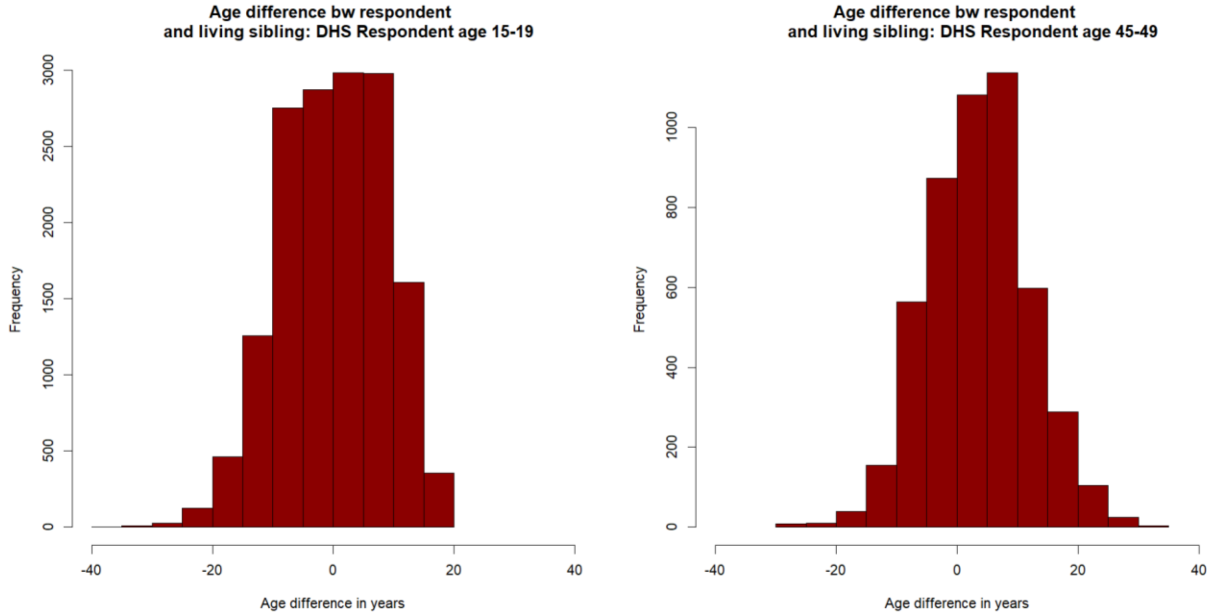
Figure 7bis: Distribution of the average number of siblings by generation between the last two DHS surveys in sub-Saharan African countries (part 2)



Burkina Faso

Figure 8a. Age differences between respondent and living siblings by data source and age at Burkina Faso

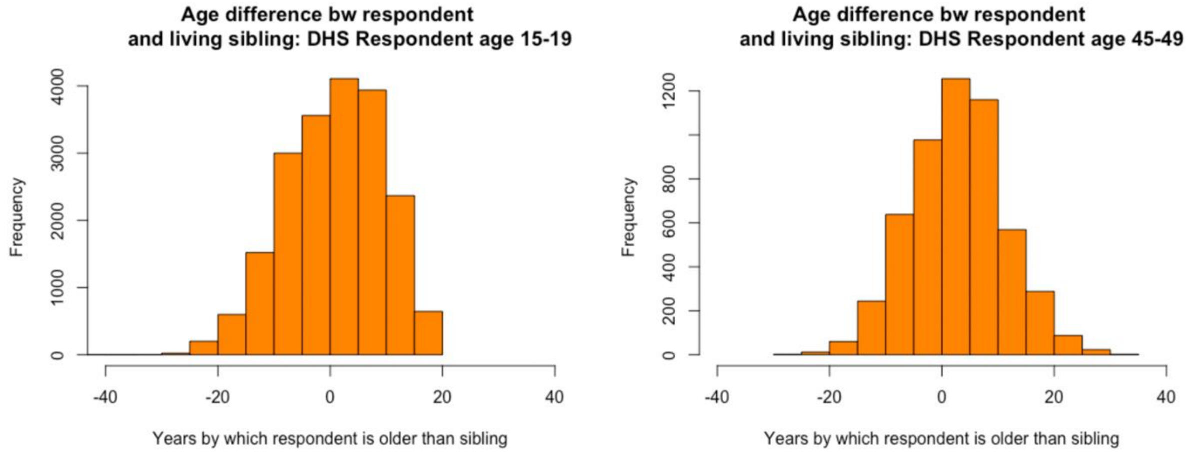


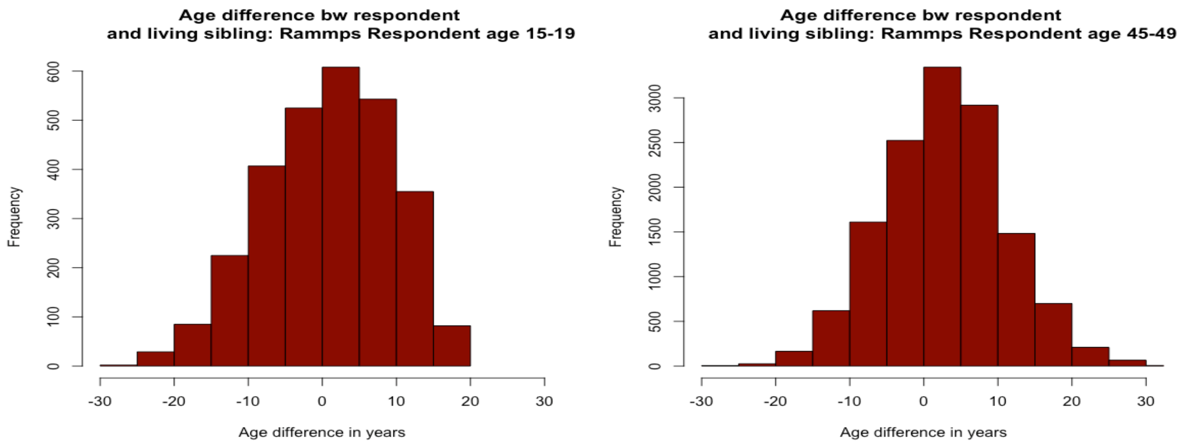


Age differences between respondents and their siblings are randomly sampled from the DHS 2013 DRC data, based on the respondent's age (for MPS respondents aged 50 years or more, age differences are sampled from the 45-49 – i.e., the oldest age groups – from the DHS), sex and sibling survival status. Below we plot a histogram of age differences between respondent's and living siblings in the DHS 2013 and in MPS after the assignment of these differences. As expected in the DHS the younger respondents have a larger number of elderly living siblings and vice versa. Age differences of respondents from DHS 2013 were randomly assigned based on the respondents age group, sex of the sibling, and death status. This same shape is therefore mirrored in the MPS data.

DRC

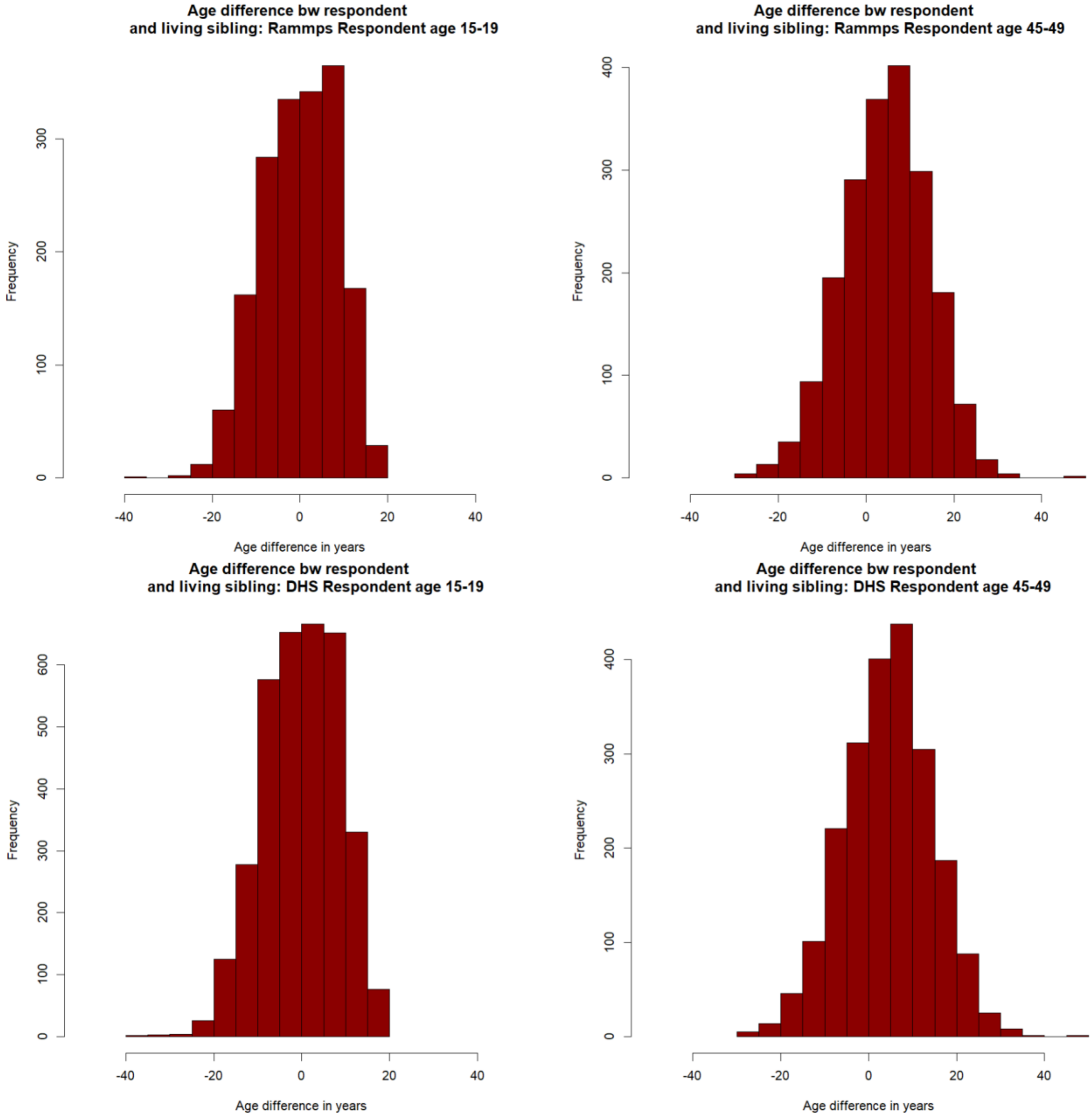
Figure 8b. Age differences between respondent and living siblings by data source and age at Democratic Republic of Congo





Malawi

Figure 8c. Age differences between respondent and living siblings by data source and age at Malawi



Below we plot histograms of the date of death and date of birth from the DHS and the MPS data.

Figure 9a. Sibling Date of death in Burkina Faso DHS and MPS

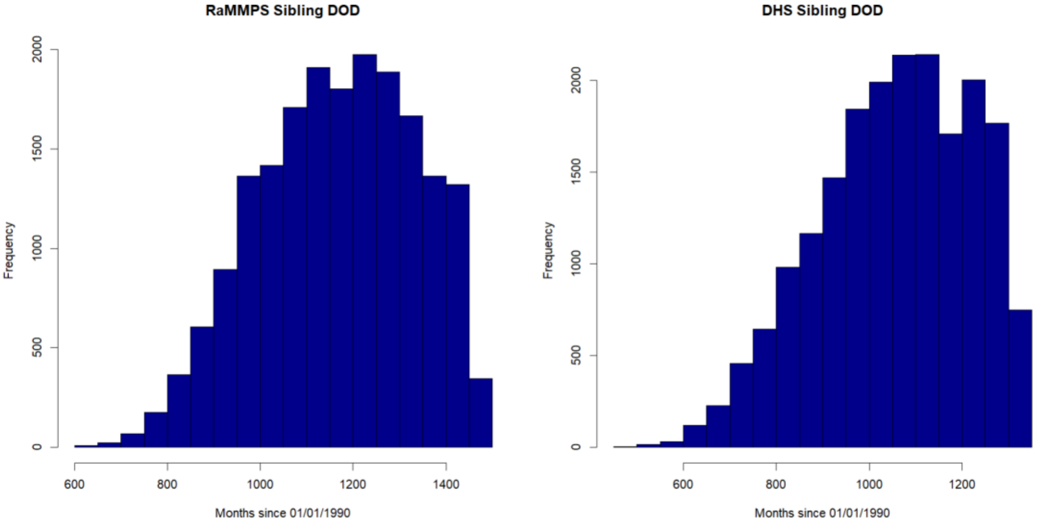


Figure 9b. Sibling Date of death in DRC DHS and MPS

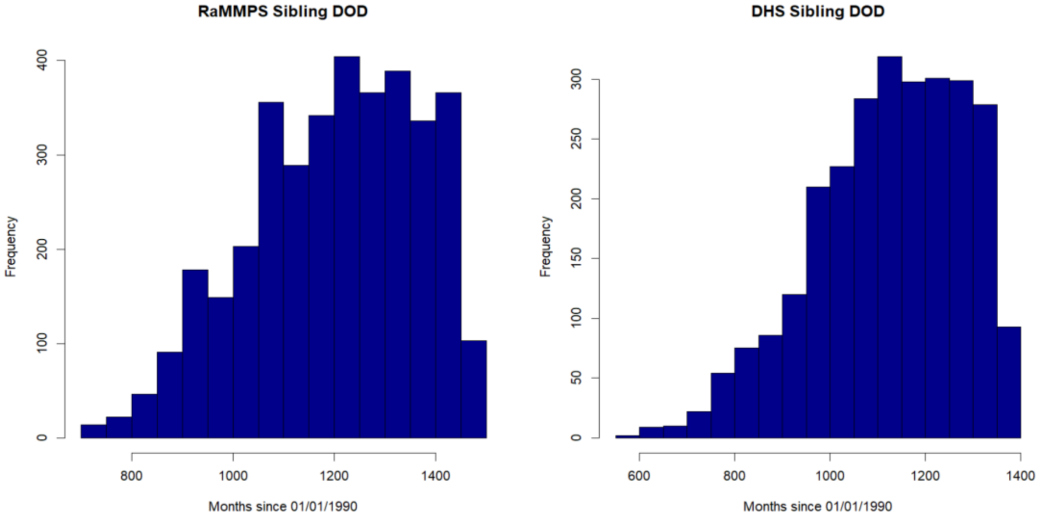
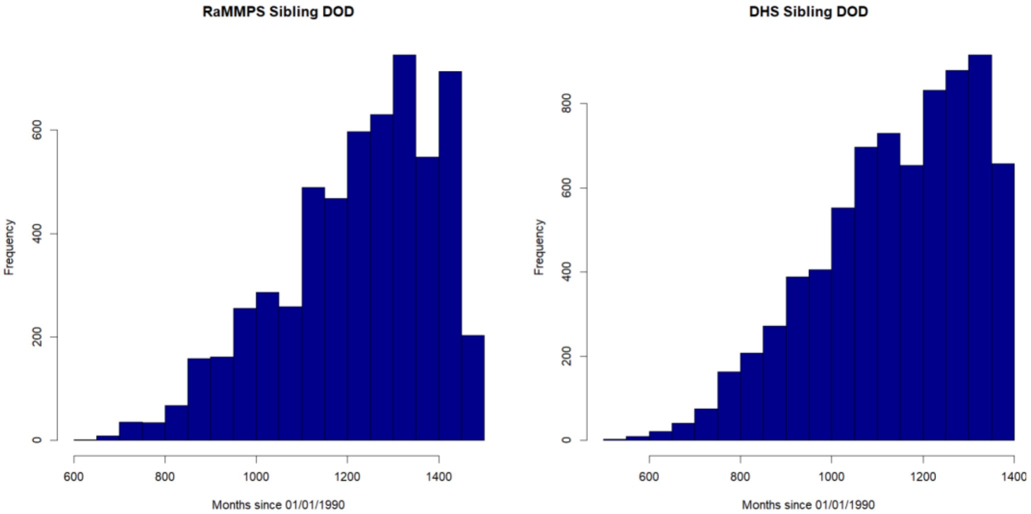


Figure 9c. Sibling Date of death in Malawi DHS and MPS



Sibling date of birth in MPS is calculated as the respondent's date of birth plus the age difference between the respondent and the sibling. The age difference was sampled from the DHS data, and consequently, a somewhat similar shape of the distribution of dates of birth are realised, with the positioning of the distribution of MPS dates of deaths shifted rightwards.

Figure 10a. Sibling Date of birth in Burkina Faso DHS and MPS

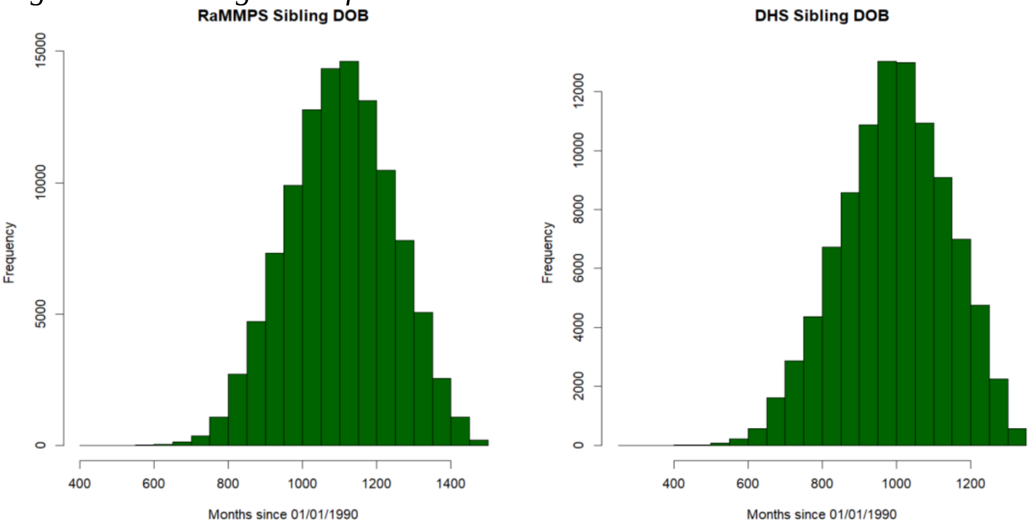


Figure 10b. Sibling Date of birth in DRC DHS and MPS

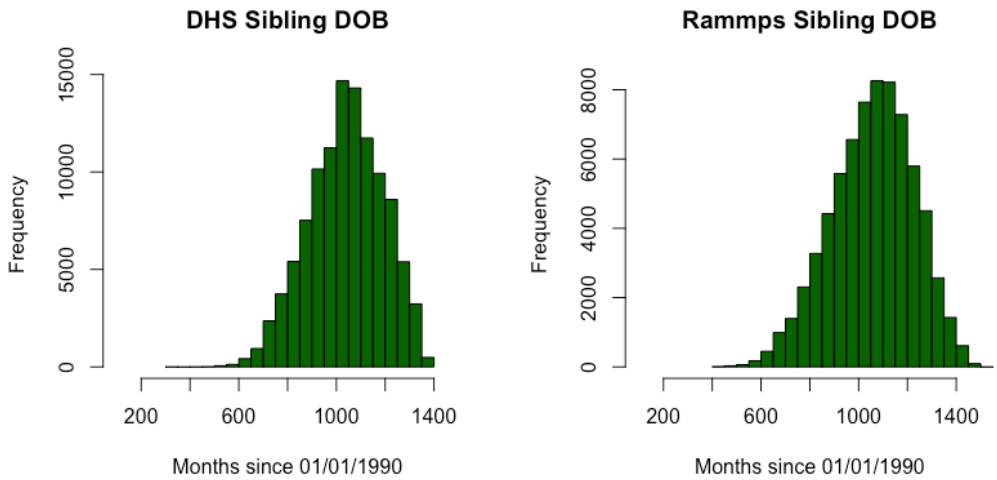


Figure 10c. Sibling Date of birth in Malawi DHS and MPS

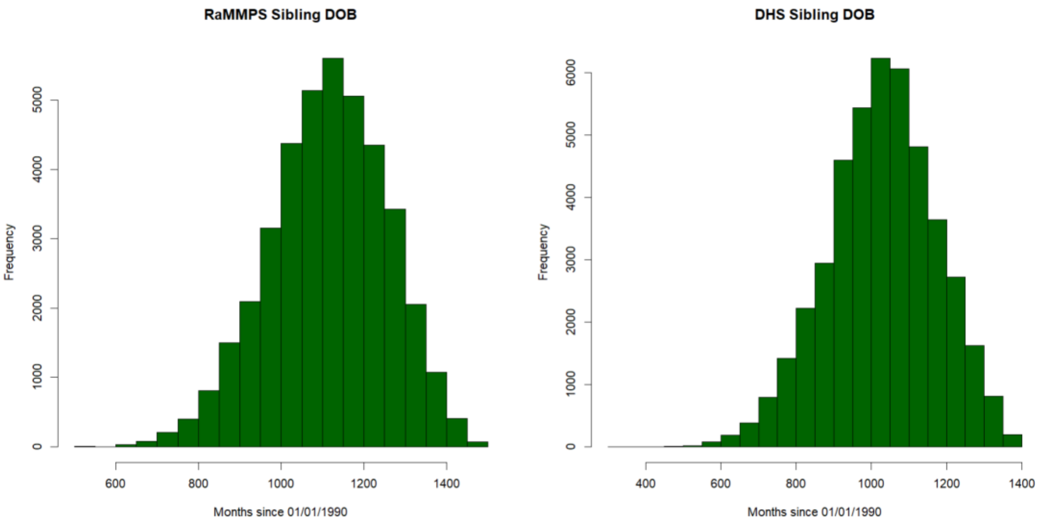


Figure 11 focuses on the proportions of siblings who have passed away, categorized by the age group of the respondents and country. The analysis reveals a consistent pattern, where, irrespective of the country, the proportions of siblings who passed away prior to the survey are significantly lower in the telephone survey data as compared to the DHS data. This discrepancy strongly implies a higher likelihood of reporting errors within this specific aspect of the study, with the magnitude of the discrepancy varying by country. It is important to note that although these differences are relatively small in absolute terms, they hold considerable significance, especially when estimating recent mortality rates. Notably, the Democratic Republic of Congo (DRC) stands out once again as having more substantial disparities compared to the other two countries. Furthermore, it is important to mention that there is no discernible consistent pattern of difference concerning the age of respondents when compared to the DHS data.

Figure 11. Proportion of deceased siblings who passed in the previous three years (DHS) and since January 2019 (MPS) by age group and country