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Research Article

Measuring fertility through mobile–phone based household surveys: Methods, data quality, and lessons learned from PMA2020 surveys

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Abstract

BACKGROUND
PMA2020 is a survey platform with resident enumerators using mobile phones. Instead of collecting full birth history, total fertility rates (TFR) have been measured with a limited number of questions on recent births. Employing new approaches provides opportunities to test and advance survey methods.

OBJECTIVE
This study aims to assess the quality of fertility data in PMA2020 surveys, focusing on bias introduced from the questionnaire and completeness and distribution of birth month and year, and to estimate TFR adjusted for identified data quality issues.

METHODS
To assess underestimation from the questionnaire, we simulated births that would be counted using the PMA2020 questionnaires compared to births identified from full birth history. We analyzed the latest Demographic and Health Surveys in ten countries where PMA2020 surveys have been implemented. We assessed the level of reporting completeness for birth month and year and heaping of birth month, analyzing 39 PMA2020 surveys. Finally, TFR were calculated and adjusted for biases introduced from the questionnaire and heaping in birth month.

RESULTS
Simple questions introduced minor bias from undercounting multiple births, which was expected and correctable. Meanwhile, incomplete reporting of birth month was relatively high, and the default value of January in data collection software systematically moved births with missing months out of the reference period. On average across the 39 surveys, TFR increased by 1.6% and 2.4%, adjusted for undercounted multiple births and heaping on January, respectively.

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CONTRIBUTION
This study emphasizes the importance of enumerator training and provides critical insight in software programming in surveys using mobile technologies.

1. Introduction

Performance Monitoring and Accountability 2020 (PMA2020) is a global survey project, developed to meet data needs for monitoring under the Family Planning 2020 (FP2020) partnership, which aims to enable 120 million additional women and girls to have access to modern contraceptive methods by 2020. With governments and stakeholders pledging to contribute to achieve the FP2020 goal, there is an increased need for more frequent monitoring of key family planning indicators especially in countries where political and financial commitments have been made. To meet these data needs, PMA2020 conducts both household and service delivery point surveys annually, after semiannual implementation during the first two years. PMA2020 employs innovative approaches to collect and disseminate data rapidly – by using mobile technologies and an open source software to capture and manage data. The survey project also aims data collection at a lower cost by working with female data collectors known as resident enumerators (REs) who live in or near the sampled enumeration areas with a minimum qualification of high school completion (Hawes et al. 2017; Zimmerman, OlaOlorun, and Radloff 2015). Employing local REs is one of the most unique features of PMA2020, since most large-scale surveys collect data using ‘stranger-interviewers’(Sana, Stecklov, and Weinreb 2016; Weinreb 2006), whereas electronic data collection with mobile technologies using phones or tablets has increased (Paudel et al. 2013).

Since its inception in 2013, over 40 surveys have been conducted in 11 countries. These are a subset of countries in which the government made an official commitment, during the first two years of the FP2020 partnership, to improve access to modern contraceptive methods by 2020. The surveys were introduced to the selected countries or, in a few countries, selected first-level administrative regions to monitor progress against the commitment and corresponding programmatic efforts. They are: Burkina Faso, Côte d’Ivoire, two provinces in Democratic Republic of Congo (DRC) – Kinshasa and Kongo Central, Ethiopia, Ghana, a state in India – Rajasthan, Indonesia, Kenya, Niger, Nigeria, and Uganda. Though generally considered low-resource settings, there is substantial variation among the survey countries in terms of fertility (total fertility rates ranging from 2.4 in Rajasthan, India to 7.4 in Niger), family planning program coverage, and economic development indicators (Gross National

Income per capita ranging from less than $1,000 in DRC and Niger to about $6,000 in Nigeria and India, to above $10,000 in Indonesia) (United Nations Department of Economic and Social Affairs Population Division 2017; World Bank 2017). The survey results have been used both at the country-level for family planning programming, including development of family planning costed implementation plans, and at the global-level for monitoring.

In addition to contraceptive use data, the main focus of the survey, PMA2020's household surveys collect fertility data and estimate the total fertility rate (TFR) for the two-year period before each survey, which was initially considered a core indicator under FP2020 monitoring framework (FP2020 2013). Contraceptive use is a key proximate determinant of fertility (Bongaarts 1982), which has implications for health of women and children, environment, and economic development as it relates with changes in population size and age structure (Starbird, Norton, and Marcus 2016). Adolescent fertility rates in particular have been adopted as an indicator to monitor the Sustainable Development Goal (SDG) 3, to "ensure healthy lives and promote well-being for all at all ages" (Inter-agency Expert Group on SDG Indicators 2016). However, while PMA2020 surveys have become a critical data source for family planning in many countries, its data on fertility has not been used as widely – partially because of new methods used in PMA2020 surveys and unanswered questions about its data quality implications. In particular, there are three potential issues with PMA2020 fertility data.

First, PMA2020 surveys do not collect full birth history data, a conventional approach to collecting fertility data in household surveys. Rather, to keep the interview short and to have questionnaires that can be more readily administered by REs, the surveys initially used a short list of questions to capture births in the last two years before the survey. Currently, the surveys use a list of questions to capture up to three births per women, regardless of the timing of birth. Second, in most countries, the sample is nationally representative,[3] and its sample size is calculated to estimate the modern contraceptive prevalence rate among all women with margin of error of 3% by sampling strata – typically urban/rural and, in some cases, aggregated administrative regions. The resulting sample size generates a larger sampling error for TFR estimates than that in other demographic surveys with larger sample sizes. Finally, while innovative features regarding data collection improved timeliness and cost-effectiveness, there has been no systematic assessment of survey implementation and data quality regarding fertility data.

This paper aims to address those issues through assessing the quality of fertility data in PMA2020 surveys, and estimating TFR adjusted for identified data quality

[3] In a few countries the survey sample is not representative at the national level, but at selected administrative regions.

issues. The study findings will be used to discuss implications of the methods used in PMA2020 surveys and recommend revisions in future PMA rounds and other surveys using mobile technologies.

2. Methodology to collect fertility data and estimate TFR in PMA2020[4]

2.1 Sampling

PMA2020 surveys are planned to occur every six months for the first two years in each country and then annually after that. A representative sample for the population is selected using a two-stage cluster sampling approach, comparable with approaches commonly used in large-scale demographic and health surveys. The national master sampling frame based on the latest census is used. In the first round, a sample of enumeration areas (EAs) is selected within each stratum using probability proportional to size, and the sampled EAs are used for four rounds of surveys. In each round, an independent random sample of households – typically 35, but ranging from 30 to 44 – is selected per sampled EA. All women 15–49 years of age living in sampled households are eligible for female interviews. Sample size is calculated to estimate modern contraceptive prevalence rates (MCPR) with a margin of error typically 3% points at the national level and 5% points at the subnational-level. Thus, depending on the expected MCPR and the number of strata, the number of EAs varies by country. Detailed information on the sampling methods are available elsewhere (Zimmerman et al. 2017). After four successive rounds, the sample of EAs is redrawn to avoid any potential bias introduced by repeated interviews (Hawes et al. 2017), while continuously employing the recruited and trained REs. Therefore, in round five, an EA adjacent to the initially sampled EA is randomly selected.

2.2 Resident enumerators

REs recruited by PMA2020 are required to have completed at least secondary school, but prior survey experience is not required. They should have a basic understanding of the use of smart phones. Paid healthcare workers are not eligible to avoid potential bias. Except attrition, the same REs will work in the same area for the life of the project.

[4] PMA2020 has two components: population-based household surveys and service delivery point surveys. In this paper only the population-based survey is discussed.

Further information on recruitment of REs are described in detail elsewhere (Hawes et al. 2017).

The REs complete two weeks of training initially and, before each subsequent survey, a two to three-day refresher training is conducted. The initial training focuses on the logistics of collecting data on a mobile phone, survey protocols, and content specific technical knowledge. Refresher trainings cover changes in the questionnaire and data quality issues from the previous survey. REs' knowledge is assessed using quizzes and a final exam. Only those who satisfactorily complete the training and assessments are hired. During training, for summary fertility questions, REs are instructed to ensure that they capture all live births, even if the child later died. When recording dates, REs are trained to probe using memorable historic events and seasons of the year when a respondent is unsure.

2.3 Questionnaire

PMA2020 surveys are conducted using household and female questionnaires. The household questionnaire collects information on the characteristics of the household which are used to report on water and sanitation indicators and to calculate a wealth index. The questionnaire also lists all household members by age and sex to screen for eligible females (all women 15–49 years of age in sampled households). The eligible women are then interviewed separately using a female questionnaire that collects data on a variety of indicators including age, marital status, education, fertility, contraceptive awareness and use, fertility intentions, sexual activity, and in alternating rounds, menstrual hygiene and diarrheal disease among children. A majority of the questionnaire is regarding contraceptive use.

The benchmark for collecting fertility information in a typical survey setting is to count all live births to the female respondent in the form of a retrospective birth history. First, a summary of the total number of births by sex and survival status is obtained and then each child is listed separately, including information on the date of birth, age, if the child was a multiple birth, and current survival status. Prompts ensure that no live births are missed as the children are listed in chronological order. From this information, age-specific fertility rates and TFR are calculated. This is the method employed by the Demographic and Health Surveys (DHS) and involves extensive training, especially around the determination of dates of birth and probing to ensure that children who died are still listed. However, even these full retrospective birth histories do not necessarily capture all births or provide unbiased estimates (Pullum and Becker 2014; Schoumaker 2014). Possible errors include the omission of births, usually children who died very young or before the date of interview, and systematic displacement beyond the reference period for the maternal and child health sections.

PMA2020 surveys have collected fertility information using different methods. Earlier surveys only asked women for the total number of births in their lifetime and if that last child was still alive (version 1). Subsequent surveys asked about the number of births separately for children who are currently living and those who have died with a confirmation check on the total number, and then if their last child was still alive (version 2). Questions regarding the summary of births have been replaced more recently with the conventional summary birth history questions (version 3). In each version, the woman was asked to provide the month and year of birth for up to three births, based on the total number of births determined from the summary birth questions: for the most recent birth if she has had only one birth; the most recent and first birth if she had two births; and the most recent, next most recent, and first birth if she has had three or more births. This information is used to calculate fertility rates, as described below. In PMA2020 surveys, multiple births are considered a single birth event with only one date recorded for that birth. Table 1 presents fertility questions by version.

Table 1: Questions regarding fertility in PMA2020 surveys

Version	Questions
1	How many times have you given birth? Were all of those live births? **When was your first birth?** **When was your most recent birth?** **When did you give birth before the most recent one?** Is your last baby/child alive? When did your last baby/child die?
2	How many times have you given birth? Were all of those live births? How many sons and daughters have you given birth to and who were born alive? Have you ever given birth to a boy or girl who was born alive, but later died? How many have died? Just to make sure I have this right: you had a total of ___ births(s) during your life, resulting in ___ son(s) or daughter(s) born alive. Is this correct? **When was your first birth?** **When was your most recent birth?** **When did you give birth before the most recent one?** Is your last baby/child alive? When did your last baby/child die?

Table 1: Questions regarding fertility in PMA2020 surveys

Version	Questions
3*	Have you ever given birth? Do you have any sons or daughters to whom you have given birth who are now living with you? How many sons live with you? How many daughters live with you? Do you have any sons or daughters to whom you have given birth who are alive, but do not live with you? How many sons are alive, but do not live with you? How many daughters are alive, but do not live with you? Have you ever given birth to a boy or girl who was born alive but later died? How many boys have died? And how many girls have died? Just to make sure that I have this right, you have had in TOTAL ___ births during your life. Is that correct? **When was your first birth?** **When was your most recent birth?** **When did you give birth before the most recent one?** Is your last baby/child alive? When did your last baby/child die?

Note: Questions in **bold** provide data to calculate TFR during the reference period and are the most relevant for main objectives of this paper.
* Subsequently, the question "How many times have you given birth?" was added just after "Have you ever given birth?" to differentiate multiple births.

2.4 Programming to record birth year and month reported by respondents

A customized version of Open Data Kit (ODK) called JHU Collect is programmed with the questionnaire and used on the RE's Android smart phone. The electronic questionnaire includes automatic skip patterns and validation checks. For example, the most recent birth cannot be prior to the next most recent birth. Dates of birth cannot be in the future or if the mother would have been ten years old or younger at the time of the birth. In recording dates, ODK uses a date spinner (Figure 1). On the left are the months January through December; on the right are the years. The default date that automatically appears is January 2021. Internal validation checks require that the date cannot be in the future except for January 2020, which is used when no response is given. A response option of 'don't know' was not given to encourage probing and because the assumption was that birth month and year reporting for recent births would be complete.

Figure 1: Screenshot for birth month and year question

Note: The wheel contains all months and years, including future years, but future dates cannot be selected except January 2020, as described earlier.

2.5 Calculation of TFR

The dates of respondents' two most recent birth events are used to calculate age-specific fertility rates and TFR for the preceding two years. The TFR is calculated using the tfr2 command in Stata (Schoumaker 2013). Since the questionnaire ascertains delivery events and not live births, the estimated age-specific fertility rates are subsequently adjusted for multiple births. Age-specific twinning adjustment factors were obtained from birth history data for children born in the five years prior to the latest DHS as of 2013 in each country.

3. Quality of fertility data in PMA2020 surveys

The above description of methods raises two data quality questions. First, is there bias in undercounting births in the two-year reference period for TFR due to the questionnaire – i.e., collecting and using the date of up to two delivery events, compared to all live births during the period. The other question is whether PMA2020's REs can ascertain quality data on births and timing of births, even using the simpler questionnaire. In this section, we present methods and results addressing both issues.

3.1 Magnitude of omission of births due to the questionnaire

To assess the level of underestimation due to the questionnaire, we identified births that would be counted using the current PMA questionnaires – hereinafter referred to as PMA births – in full birth history data from the DHS. We employed the latest DHS in ten countries where PMA2020 surveys have been implemented (Table 2). The number of PMA births in the two-year period would be lower than the total births captured in full birth history for two reasons: omission of a majority of multiple births, as PMA2020 counts delivery events that resulted in live births; and omission of births that would be missed by only using up to two most recent birth events for each woman.

Table 2: Distribution of births during two years before the survey by applying PMA questionnaire to full birth history data from the latest Demographic and Health Surveys in ten countries

Survey	Total number of births	Distribution of births (%)		
		PMA births	Omitted multiple births	Omitted births that are neither the most recent or penultimate birth
Burkina Faso 2010	6,164	98.0	1.98	0.000
DRC 2013	7,741	97.9	2.07	0.000
Ethiopia 2016	4,243	98.5	1.49	0.000
Ghana 2014	2,476	98.0	2.04	0.000
India, Rajasthan 2016	6,707	99.2	0.77	0.016
Indonesia 2012	7,498	99.2	0.78	0.000
Kenya 2014	8,389	98.6	1.40	0.005
Niger 2012	5,151	98.3	1.69	0.031
Nigeria 2013	13,285	98.2	1.77	0.000
Uganda 2011	3,233	98.3	1.67	0.000
Average (unweighted)	6489	98.4	1.57	0.005

Note: Percent estimates were adjusted for sampling design. The number of births is unweighted.

Importantly, this exercise assesses the downward bias, compared to the number of births captured using a full birth history questionnaire, but not necessarily compared to the true number of births, since even a full birth history approach may miss some births (Pullum and Becker 2014; Schoumaker 2014). All births in the two-year reference period (i.e., births born between 1–24 months before the survey) were classified into three types: PMA births, omitted multiple births, and omitted births that are neither the most recent nor penultimate. Distribution of the three birth types was examined in the most recent DHS survey in each of these ten countries.

On average, across the ten countries, 1.57% of births during the two-year reference period would be omitted by applying PMA questionnaire (range: 0.78% – 2.07%). The amount of underestimation is lower in populations with relatively low fertility (i.e., 0.78% in Rajasthan, India, and Indonesia). Underestimation due to the two-birth limit did not exist in most countries (n = 7) or was observed at an extremely low rate in three countries. Thus, practically all biases were due to omitted multiple births (Table 2) (mean = 1.57%, range: 0.77% – 2.07%, n = 10).

With longer reference periods the omission due to the two-birth limit became more prevalent – though still relatively low – and the level of omission was positively associated with fertility. However, the level of omitted multiple births remained relatively constant. For example, with a 5-year reference period, on average, 3.6% of births would be omitted due to the two-birth limit (range: 0.7% in Indonesia – 6.2% in Democratic Republic of Congo, n = 10) and 5.1% of births would be omitted overall (range: 1.5% in Indonesia – 8.1% in Democratic Republic of Congo, n = 10) (results not shown).

3.2 Quality of data ascertained by resident enumerators

Quality of fertility data can be examined in various ways including: investigating completeness of reported birth year and month, displacement of birth year and month, and omission of live births (Pullum and Becker 2014). Given the PMA2020 questionnaire, there are no obvious reasons for interviewers or interviewees to systematically displace birth year and month to reduce workload, as there are no follow-up maternal and child health questions for specific births within a reference period. Omission of live births, especially those who died at a very early age, is a critical data quality issue in fertility as well as mortality estimation. Assessing the magnitude of the omission typically requires further data on sex, survival status, and age at death (Pullum and Becker 2014). With limited survival data and no information on age at death, in addition to a sample size that is not designed to measure child mortality, we are unable to assess potential omission of live births in this paper. However, we acknowledge that it is likely problematic in PMA2020 surveys since the questionnaire has less probing on missing live births than conventional full birth history questions.

Thus, we focus on the completeness of reporting in birth year and month. However, since PMA2020 surveys have not allowed a response category of 'don't know' for birth month/year questions, we are not able to assess month/year reporting completeness directly. Nevertheless, as REs were trained to select January 2020 when birth month and year were unknown, assessing distributions of birth month and year allows indirect examination of reporting completeness. All distributions were not adjusted for sampling weights, as the purpose was to study distributions among responses, not a nationally representative distribution. We analyzed all PMA2020 surveys that were publicly available as of May 2017.

A total of 39 surveys were included in the study. Two versions of fertility questions were used in the surveys, and Table 3 presents the list of surveys, the version of questionnaires, and summary statistics. Any major change in the total number of births collected in a country or region reflects either changes in the questionnaire or increased sample size.[4]

3.2.1 Reporting of birth year

On average, 1.5% of births across surveys had an unknown birth year (i.e., 2020 was recorded for the birth year).[5] The estimate, however, ranged from 0% in the Kinshasa, Democratic Republic of Congo Round 1 survey to 6.9% in the Kaduna, Nigeria Round 1 survey. Further analysis was conducted to assess the current age of mothers who reported at least one birth with an unknown birth year out of a maximum three births (Table A-1). The median age of those women was 37 years across the surveys, suggesting that births with a missing year likely occurred in the distant past. In addition, in most countries or regions where multiple rounds of surveys have been conducted, the level of unknown birth year has decreased over time (Table 3).

[5] Birth year is not imputed for those with unknown year, and all such births are excluded in fertility estimation in PMA2020.

Table 3: List of PMA2020 surveys included in the study, total number of births, and percent of births with unknown birth year

Survey[x]	Data collection		Fertility questionnaire version used in the survey	Total number of women interviewed in the survey	Total number of births collected in the survey	Percent of births with unknown birth year
	Start	End				
Burkina Faso R1	Nov-14	Jan-15	v1	2094	3629	4.0
Burkina Faso R2	Apr-15	Jun-15	v2	2150	3657	2.9
Burkina Faso R3[†]	Mar-16	May-16	v2	3353	5497	1.3
DRC, Kinshasa R1*	Oct-13	Jan-14	v1	2118	2225	0.0
DRC, Kinshasa R2	Aug-14	Sep-14	v1	2877	3819	0.5
DRC, Kinshasa R3	May-15	Jun-15	v2	2683	3654	0.4
DRC, Kinshasa R4	Nov-15	Jan-16	v2	2741	3636	0.2
DRC, Kongo Central R4	Nov-15	Jan-16	v2	1573	2726	2.0
Ethiopia R1*	Jan-14	Mar-14	v1	6514	7519	0.1
Ethiopia R2	Oct-14	Dec-14	v1	6713	9389	1.1
Ethiopia R3†	Apr-15	May-15	v1	7628	10844	0.7
Ethiopia R4	Mar-16	Apr-16	v2	7537	10823	0.9
Ghana R1*	Sep-13	Nov-13	v1	3708	2859	1.3
Ghana R2	Mar-14	May-14	v1	3974	5931	2.4
Ghana R3	Sep-14	Nov-14	v2	4621	6888	2.4
Ghana R4	May-15	Jul-15	v2	5234	7432	1.9
India, Rajasthan R1	Apr-16	Jul-16	v1	5454	8451	2.6
Indonesia R1	May-15	Aug-15	v1	10566	15682	0.7
Kenya R1	May-14	Jul-14	v1	3792	6834	1.3
Kenya R2	Nov-14	Dec-14	v1	4370	7503	1.7
Kenya R3	Jun-15	Jul-15	v2	4433	7603	0.8
Kenya R4	Nov-15	Dec-15	v2	4960	7836	0.4
Niger, Niamey R1	Jun-15	Aug-15	v1	1351	2114	1.5
Niger, Niamey R2**	Mar-16	Jun-16	v1	1281	1916	2.8
Nigeria, Kaduna R1	Sep-14	Nov-14	v1	2575	4381	6.9
Nigeria, Kaduna R2	Sep-15	Nov-15	v1	2943	5190	1.3
Nigeria, Kaduna R3	Apr-16	Jun-16	v2	2897	5327	0.4
Nigeria, Lagos R1	Apr-16	Jun-16	v1	771	1158	2.0
Nigeria, Lagos R2[†]	Sep-15	Nov-15	v1	1449	2234	0.7
Nigeria, Lagos R3	Sep-14	Nov-14	v2	1452	2132	0.9
Nigeria, Anambra R3	Apr-16	Jun-16	v2	1313	1715	0.5
Nigeria, Kano R3	Apr-16	Jun-16	v2	1689	3115	0.2
Nigeria, Nasarawa R3	Apr-16	Jun-16	v2	1654	2934	0.3
Nigeria, Rivers R3	Apr-16	Jun-16	v2	1284	1873	0.5
Nigeria, Taraba R3	Apr-16	Jun-16	v2	860	1490	1.0

Table 3: (Continued)

Survey[X]	Data collection		Fertility questionnaire version used in the survey	Total number of women interviewed in the survey	Total number of births collected in the survey	Percent of births with unknown birth year
Uganda R1	May-14	Jun-14	v1	3754	6778	2.0
Uganda R2	Jan-15	Feb-15	v1	3654	6289	2.1
Uganda R3	Aug-15	Sep-15	v2	3705	6529	2.7
Uganda R4	Mar-16	Apr-16	v2	3816	7115	2.0

Notes: [X] R1 refers to Round 1 surveys, R2 refers to Round 2 surveys, and so on.
* In these surveys only penultimate births in the two years before the survey were asked about birth year and month.
** Niger Round 2 was a national survey, including Niamey. To compare Rounds 1 and 2, we chose to analyze only Niamey data from Niger Round 2.
[†] In Burkina Faso the sample size increased from 1,855 households in Round 2 to 2,905 in R3. In Ethiopia the sample size increased from 6,813 households in Round 2 to 7,643 in Round 3. In Lagos, Nigeria, the sample size increased from 1,014 households in Round 1 to 1,777 in Round 2.

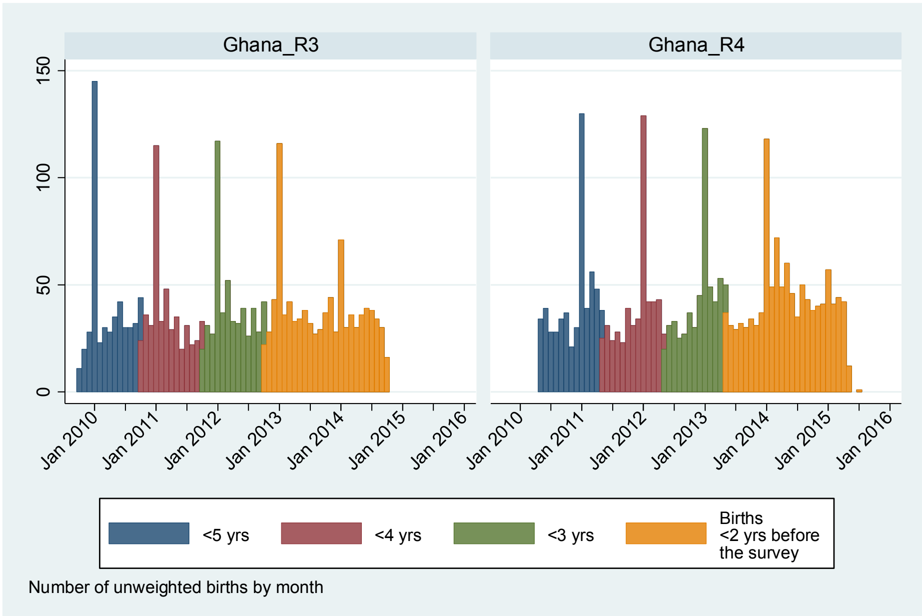
3.2.2 Reporting of birth month

To study the distribution of birth month, we restricted analyses to reported births in the last five years.[6] Across countries, it was noted that there was significant heaping in January, as shown in Figure 2. Further investigation with field staff revealed that, despite the instruction, many enumerators left January – a default response programmed in ODK – when respondents could not report birth months.

This excess of January births has implications for the TFR estimation. Since all births in a calendar year with an unknown birth month were recorded by default to be born in January, there can be a downward bias in estimating recent fertility. For example, in Ghana Round 4, suppose a woman interviewed in March 2016 had a birth in October 2014 (an orange bar in Figure 2), but reported only birth year, not birth month. If that birth was recorded to be in January 2014 (the green heaped bar), the birth would be excluded from estimating TFR during the two-year period preceding the survey. It is therefore important to identify the level of excess January births and to explore approaches to address this issue. In the following section, we quantify the magnitude of excess January births and illustrate a potential adjustment approach.

[6] Since PMA2020 collects data on up to three births, the annual number of births in 3–5 years before the survey may be slightly lower than actual number of births by sampled women. However, the distribution by birth month would not be affected in those years.

Figure 2: Distribution of birth months in Ghana Round 3 and Round 4 surveys



3.2.3 The magnitude of excess January births and adjustment approaches

In each full calendar year during the five years before the survey, we first calculated the percent of births recorded to be in January out of total births in the year. In the absence of heaping, it is expected to be roughly 1/12 or 8.3%. In each calendar year we also estimated the excess number of January births as follows:

Excess January births = January births – Monthly average births between February and December

Excess January births referred to the number of births reported in January that are above the monthly average **reported** births. Since it was not feasible to distinguish reported and assigned births in January, we calculated average births between February and December. When the excess January births is zero or negative, we assumed that there were no excess January births. Finally, the percent of excess January births out of total births in the calendar year was calculated, and the metric was used as a proxy for the level of births with unknown months, in the absence of the ‘don’t know’ category in the questionnaire.

We particularly focused on the level of excess January births during a transfer calendar year, i.e., during which the two-year reference period starts (the green heaped bars in Figure 2), because – at the aggregate level – excess January births in other calendar years do not lead to underestimation of TFR for the two years before a survey. Births recorded in January of the green heaped bar are outside the two-year reference window but might have been incorrectly recorded. If they are adjusted, some of those births would be shifted to other months during the year which are within the two-year reference period, leading to an increase in TFR.

Table 4 presents the results for the transfer calendar year. On average, 18.4% of births during the transfer year were recorded to have occurred in January (range: 6.4%–38.4%), far exceeding the expected 8.3%. The percent of excess January births out of total births was on average 11.9% (range: 1.0%–32.8%). In three surveys (DRC, Kinshasa Round 1; Nigeria, Lagos Round 2; and Nigeria, Lagos Round 3), the number of births in January was lower than the monthly average between February and December. When the level of excess January births was examined across calendar years, not just the transfer calendar year, there were notable decreases in years closer to the survey implementation within a survey – as the recall period was shorter – as well as decreases across surveys in a country/geography, indicating improved quality over time (Figure 3).

Table 4: Number of total annual births, recorded January births, and estimated excess January births during transfer calendar year, by survey

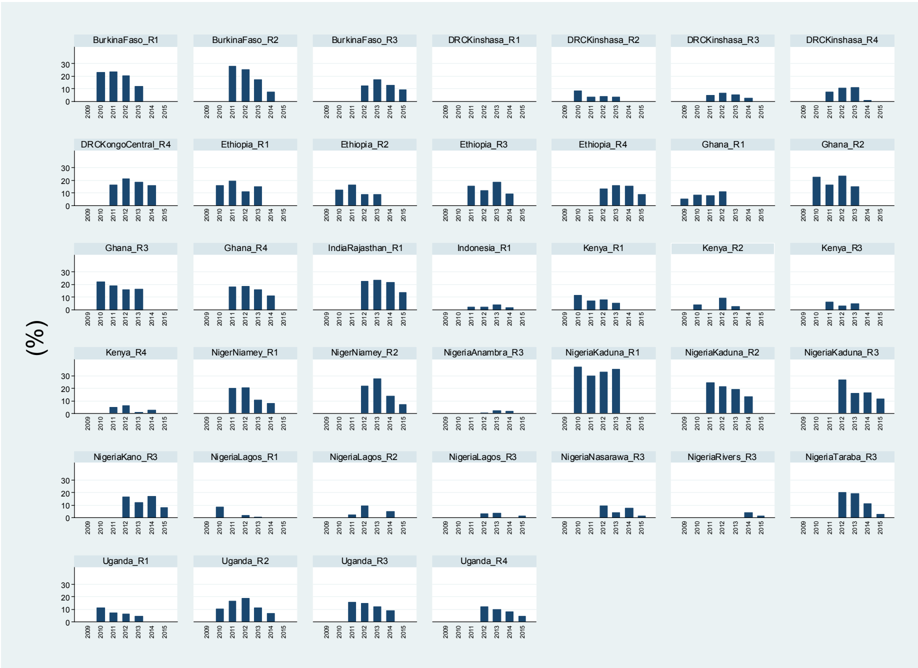
Survey^{X}	Transfer year	Number of births recorded in January	Number of births in the year	% of January births out of total births in the year	Number of monthly births, February–December	Difference between January births and monthly births (February–December)	% of excess January births out of total yearly births
Burkina Faso R1	2012	84	311	27.0	20.6	63.4	20.4
Burkina Faso R2	2013	70	292	24.0	20.2	49.8	17.1
Burkina Faso R3	2014	91	456	20.0	33.2	57.8	12.7
DRC, Kinshasa R1	2011	17	251	6.8	21.3	–4.3	n/a
DRC, Kinshasa R2	2012	37	311	11.9	24.9	12.1	3.9
DRC, Kinshasa R3	2013	41	311	13.2	24.5	16.5	5.3
DRC, Kinshasa R4	2013	58	314	18.5	23.3	34.7	11.1
DRC, Kongo Central R4	2013	62	244	25.4	16.5	45.5	18.6

Table 4: (Continued)

Survey[x]	Transfer year	Number of births recorded in January	Number of births in the year	% of January births out of total births in the year	Number of monthly births, February–December	Difference between January births and monthly births (February–December)	% of excess January births out of total yearly births
Ethiopia R1	2012	124	667	18.6	49.4	74.6	11.2
Ethiopia R2	2012	116	713	16.3	54.3	61.7	8.7
Ethiopia R3	2013	210	827	25.4	56.1	153.9	18.6
Ethiopia R4	2014	180	803	22.4	56.6	123.4	15.4
Ghana R1	2011	63	408	15.4	31.4	31.6	7.8
Ghana R2	2012	140	467	30.0	29.7	110.3	23.6
Ghana R3	2012	117	516	22.7	36.3	80.7	15.6
Ghana R4	2013	123	541	22.7	38.0	85.0	15.7
India, Rajasthan R1	2014	115	412	27.9	27.0	88.0	21.4
Indonesia R1	2013	86	721	11.9	57.7	28.3	3.9
Kenya R1	2012	80	511	15.7	39.2	40.8	8
Kenya R2	2012	115	522	22.0	67.8	47.2	9
Kenya R3	2013	70	556	12.6	44.2	25.8	4.6
Kenya R4	2013	52	564	9.2	46.5	5.5	1
Niger, Niamey R1	2013	37	202	18.3	15.0	22.0	10.9
Niger, Niamey R2	2014	38	181	21.0	13.0	25.0	13.8
Nigeria, Kaduna R1	2012	173	450	38.4	25.2	147.8	32.8
Nigeria, Kaduna R2	2013	130	496	26.2	33.3	96.7	19.5
Nigeria, Kaduna R3	2014	123	524	23.5	36.5	86.5	16.5
Nigeria, Lagos R1	2012	9	88	10.2	7.2	1.8	2.1
Nigeria, Lagos R2	2013	11	172	6.4	14.6	3.6	n/a
Nigeria, Lagos R3	2014	12	157	7.6	13.2	–1.2	n/a
Nigeria, Anambra R3	2014	15	146	10.3	11.9	3.1	2.1
Nigeria, Kano R3	2014	77	323	23.8	22.4	54.6	16.9
Nigeria, Nasarawa R3	2014	39	252	15.5	19.4	19.6	7.8
Nigeria, Rivers R3	2014	17	141	12.1	11.3	5.7	4.1
Nigeria, Taraba R3	2014	29	155	18.7	11.5	17.5	11.3
Uganda R1	2012	97	682	14.2	53.2	43.8	6.4
Uganda R2	2013	113	609	18.6	45.1	67.9	11.2
Uganda R3	2013	120	619	19.4	45.4	74.6	12.1
Uganda R4	2014	105	671	15.6	51.5	53.5	8
Average (unweighted)		**82**	**425**	**18.4**	**32.0**	**49.9**	**11.9**

Note: [x] R1 refers to Round 1 surveys, R2 refers to Round 2 surveys, and so on.

Figure 3: Percent of excess January births out of total yearly births, by calendar year and survey



Note: The number of January births is less than the average number of monthly births between February–December in 11 out of 157 survey-calendar years. Those 11 survey-calendar years are not presented in this figure.

Given the high level of excess January births, we randomly selected January births by the amount of excess January births and distributed them evenly across the 12 months in the calendar year (hereinafter referred to as the Random Redistribution Approach). The adjustment was done to improve the estimation of the number of births in the two-year period (i.e., the numerator for the two-year age-specific fertility rate [ASFR] estimation). The redistribution assumes that not knowing the month of the birth is unassociated with the actual birth month. Considering seasonality in birth (Dorélien 2016; Dorélien, Ballesteros, and Grenfell 2013), a redistribution proportional to reported birth month can introduce another bias, depending on the month in which the two-year reference period starts, as explained further below.

Table 5 shows the total number of births falling in the two-year reference period after the adjustment. Adjustments were done in 36 surveys in which excess January births were identified during the transfer year. Applying the Random Redistribution Approach, the number of births did not change in two surveys (Ethiopia Round 1 and Uganda Round 2) where the reference period perfectly overlapped with full calendar years. Therefore, redistributing births within a calendar year does not affect the recent fertility estimation. On average, among the other 34 surveys, the adjusted number of births was 3.3% (range: 0.1%–11.2%) higher than the unadjusted.

Table 5: Total number of births in the two-year reference period: recorded vs. adjusted, by survey

Survey[x]	Beginning of the two-year reference period	Number of births in two years before the survey	Adjusted number of births in two years before the survey	% increase in the number of births: from unadjusted to adjusted
Burkina Faso R1	2012, Nov	655	665.6	1.6
Burkina Faso R2	2013, Apr	661	698.4	5.7
Burkina Faso R3	2014, Mar	1013	1061.2	4.8
DRC, Kinshasa R1	2011, Nov	569	n/a	n/a
DRC, Kinshasa R2	2012, Aug	671	676.0	0.8
DRC, Kinshasa R3	2013, May	686	697.0	1.6
DRC, Kinshasa R4	2013, Nov	613	618.8	0.9
DRC, Kongo Central R4	2013, Nov	475	482.6	1.6
Ethiopia R1	2012, Jan	1420	1420.0	0.0
Ethiopia R2	2012, Oct	1500	1515.4	1.0
Ethiopia R3	2013, Apr	1635	1750.4	7.1
Ethiopia R4	2014, Mar	1709	1811.8	6.0
Ghana R1	2011, Sep	865	875.5	1.2
Ghana R2	2012, Feb	905	1006.1	11.2
Ghana R3	2012, Oct	949	969.2	2.1
Ghana R4	2013, May	1099	1155.7	5.2
India, Rajasthan R1	2014, Jun	833	884.3	6.2
Indonesia R1	2013, Jun	1424	1440.5	1.2
Kenya R1	2012, May	995	1022.2	2.7
Kenya R2	2012, Nov	969	976.9	0.8
Kenya R3	2013, Jun	1057	1072.1	1.4
Kenya R	2013, Nov	1069	1069.9	0.1

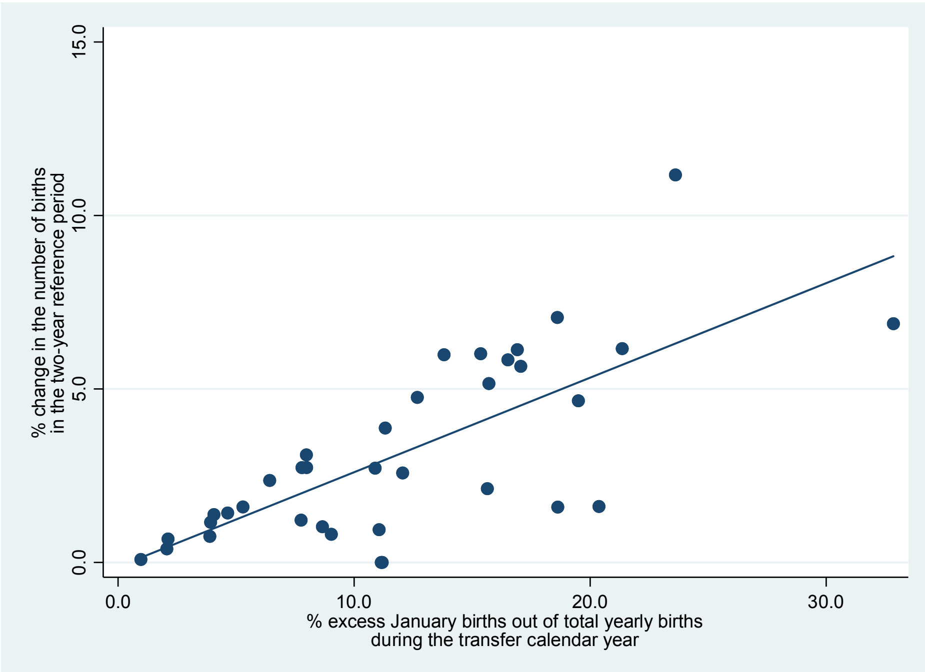
Table 5: (Continued)

Survey[X]	Beginning of the two-year reference period	Number of births in two years before the survey	Adjusted number of births in two years before the survey	% increase in the number of births: from unadjusted to adjusted
Niger, Niamey R1	2013, Jul	405	416.0	2.7
Niger, Niamey R2	2014, Mar	348	368.8	6.0
Nigeria, Kaduna R1	2012, Sep	716	765.3	6.9
Nigeria, Kaduna R2	2013, Aug	865	905.3	4.7
Nigeria, Kaduna R3	2014, May	988	1045.7	5.8
Nigeria, Lagos R1	2012, Sep	155	155.6	0.4
Nigeria, Lagos R2	2013, Sep	323	n/a	n/a
Nigeria, Lagos R3	2014, May	316	n/a	n/a
Nigeria, Anambra R3	2014, May	305	307.1	0.7
Nigeria, Kano R3	2014, May	594	630.4	6.1
Nigeria, Nasarawa R3	2014, May	479	492.1	2.7
Nigeria, Rivers R3	2014, May	277	280.8	1.4
Nigeria, Taraba R3	2014, May	302	313.7	3.9
Uganda R1	2012, Apr	1391	1423.9	2.4
Uganda R2	2013, Jan	1274	1274.0	0.0
Uganda R3	2013, Aug	1206	1237.1	2.6
Uganda R4	2014, Mar	1439	1483.6	3.1
Average (unweighted)*		**850**	**915.8**	**3.1**

Notes: [X] R1 refers to Round 1 survey, R2 refers to Round 2 surveys, and so on.
n/a: not applicable for surveys with no excess January births (Table 4).
* Average among 36 surveys

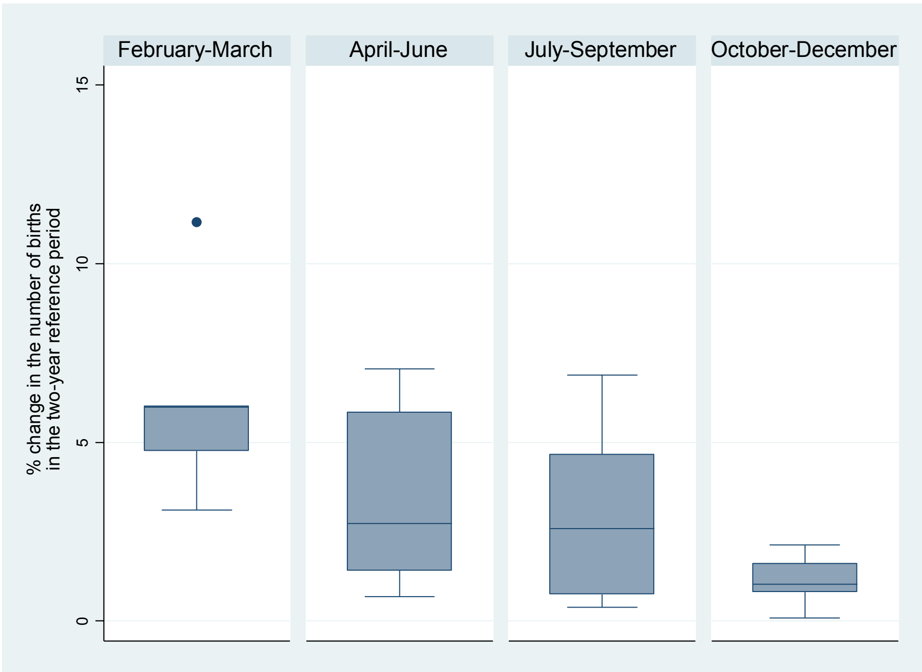
The relative change in the number of births was positively associated with the level of excess January births during the transfer calendar year (Figure 4). Another important factor explaining the level of relative change was the timing of the survey or, in other words, when the two-year reference period started in the transfer calendar year. Figure 5 shows a decreasing relative change in the number of births, as the reference period starts later in the year, i.e., as fewer number of months gained the excess January births that were evenly distributed across the 12 months.

Figure 4: Association between the relative change in births after adjustment and excess January births: 36 surveys with excess January births identified



Note: Solid line is the fitted line.

Figure 5: Relative change in number of births in two-year period based on Random Redistribution Approach, by beginning month of the two-year reference period



Note: Excess January births distributed across 12 months evenly.

4. Estimation of TFR addressing identified biases

This section presents the TFR estimates after addressing issues identified in previous sections. Particularly, we compare the TFR estimates from the following methods: (1) no adjustment; (2) adjusted for excess January births using the Random Redistribution Approach; (3) adjusted for multiple births (i.e., current PMA approach used to generate TFR in key findings briefs); and (4) adjusted for both multiple births and excess January births. All four estimates were adjusted for sampling weights.

In the adjustment for multiple births, we used the relationship below.

$$\frac{N}{N_{pma}} = \frac{N_s + 2 * N_m}{N_s + N_m}$$

$$N = N_{pma} * \frac{N_s + 2 * N_m}{N_s + N_m} = N_{pma} * \left(1 + \frac{N_m}{N_s + N_m}\right)$$

where N is true total number of live births; N_{pma} is total number of deliveries resulting in at least one live birth; N_m is the number of deliveries resulting in multiple births; N_s is the number of deliveries resulting in a single birth.

Here we consider all multiple births as twins. The percent of deliveries that result in more than two live births is extremely low,[7] and distinguishing different types of multiple births substantially complicates the adjustment formula. We obtained the adjustment factor, $\left(1 + \frac{N_m}{N_s + N_m}\right)$, for each five-year age range for women of reproductive ages for the PMA2020 countries from their most recent DHS surveys. All live births in the five years before the survey were used. Then we applied the adjustment factor to each corresponding ASFR and calculated TFR using the adjusted ASFR. All estimates were adjusted for sampling weights, addressing two-stage cluster sampling design of the surveys.

Table 6 compares unadjusted TFR with three types of adjusted TFR: adjusted for excess January births by using the Random Redistribution Approach; adjusted for multiple births; and, adjusted for both excess January births and multiple births. Among those 33 surveys with excess January births, the Random Redistribution Approach on average increased the TFR estimate by 2.4% (range: 0.4%–7.6%). In all 39 surveys the adjustment for multiple births leads to an increase of TFR by 1.6% (range: 0.7%–2.1%). The two adjustments together increase the TFR estimate by 3.9% (range: 0.9%–9.9%). It should be noted that, in no survey was the final adjusted TFR different from the unadjusted TFR with statistical significance. This is partially due to the large sampling error across surveys.

[7] Based on the latest DHS data from the ten countries, on average 0.013% of reported live births during the five years before the survey were the third of multiple births, ranging from 0% in Ethiopia and Kenya to 0.039% in Burkina Faso.

Table 6: Total fertility rate for the two years preceding the survey with 95% confidence interval: unadjusted and adjusted for excess January births, multiple births, and both, by survey

	Total fertility rate								% change compared to the unadjusted rate		
Survey[x]	Unadjusted	95% CI	Adjusted for excess January births	95% CI	Adjusted for multiple births	95% CI	Adjusted for both	95% CI	Adjusted for excess January births	Adjusted for multiple births	Adjusted for both
Burkina Faso R1	5.5	5.1–5.9	5.5	5.1–5.9	5.6	5.2–6.0	5.6	5.2–6.0	–0.6	1.8	1.2
Burkina Faso R2	5.7	5.2–6.1	5.9	5.4–6.3	5.8	5.3–6.2	6.0	5.5–6.4	3.7	1.9	5.6
Burkina Faso R3	5.5	5.2–5.9	5.8	5.5–6.2	5.6	5.3–6.0	5.9	5.6–6.3	4.8	1.9	6.8
DRC, Kinshasa R1	4.3	3.9–4.6	4.3	3.9–4.6	4.3	4.0–4.7	4.3	4.0–4.7	n/a	1.9	1.9
DRC, Kinshasa R2	3.8	3.5–4.1	3.8	3.5–4.1	3.9	3.6–4.2	3.9	3.6–4.2	0.4	1.9	2.4
DRC, Kinshasa R3	4.2	3.9–4.6	4.3	4.0–4.7	4.3	4.0–4.7	4.4	4.1–4.7	1.6	1.9	3.6
DRC, Kinshasa R4	3.6	3.3–3.9	3.6	3.3–3.9	3.7	3.4–4.0	3.7	3.4–4.0	0.0	2.0	2.0
DRC, Kongo Central R4	4.9	4.4–5.3	4.8	4.4–5.3	4.9	4.5–5.4	4.9	4.5–5.4	–1.0	1.9	0.9
Ethiopia R1	4.0	3.7–4.2	4.1	3.9–4.3	4.0	3.8–4.2	4.2	3.9–4.4	4.4	1.1	5.6
Ethiopia R2	4.3	4.1–4.5	4.4	4.2–4.6	4.4	4.2–4.6	4.4	4.2–4.6	1.2	1.2	2.4
Ethiopia R3	3.9	3.7–4.1	4.2	4.0–4.4	4.0	3.8–4.2	4.2	4.1–4.5	6.6	1.2	7.8
Ethiopia R4	4.1	3.9–4.3	4.3	4.1–4.5	4.2	4.0–4.4	4.4	4.2–4.6	4.4	1.2	5.6
Ghana R1	3.6	3.3–3.8	3.6	3.4–3.9	3.6	3.4–3.9	3.7	3.4–3.9	1.3	2.1	3.4
Ghana R2	3.4	3.2–3.7	3.7	3.4–4.0	3.5	3.3–3.8	3.8	3.5–4.0	7.6	2.1	9.9
Ghana R3	3.0	2.7–3.2	3.0	2.8–3.2	3.0	2.8–3.2	3.1	2.9–3.3	1.6	1.9	3.5
Ghana R4	3.2	3.0–3.4	3.3	3.1–3.5	3.3	3.0–3.5	3.3	3.2–3.6	2.9	2.0	5.0
India, Rajasthan R1	2.1	1.9–2.2	2.2	2.0–2.3	2.1	2.0–2.3	2.2	2.0–2.3	5.3	0.7	6.1
Indonesia R1	2.3	2.2–2.4	2.3	2.2–2.4	2.3	2.2–2.4	2.3	2.2–2.4	0.9	0.7	1.6

Table 6: (Continued)

Survey[X]	Total fertility rate								% change compared to the unadjusted rate		
	Unadjusted	95% CI	Adjusted for excess January births	95% CI	Adjusted for multiple births	95% CI	Adjusted for both	95% CI	Adjusted for excess January births	Adjusted for multiple births	Adjusted for both
Kenya R1	3.6	3.3–3.8	3.6	3.4–3.9	3.6	3.4–3.8	3.7	3.4–3.9	1.9	1.2	3.0
Kenya R2	3.3	3.1–3.5	3.3	3.1–3.5	3.4	3.1–3.6	3.4	3.2–3.6	0.3	1.2	1.5
Kenya R3	3.5	3.3–3.7	3.5	3.3–3.7	3.5	3.3–3.7	3.5	3.3–3.8	0.5	1.3	1.8
Kenya R4	3.3	3.1–3.5	3.3	3.1–3.5	3.3	3.1–3.5	3.3	3.1–3.5	0.2	1.2	1.3
Niger, Niamey R1	4.6	4.1–5.1	4.7	4.2–5.2	4.7	4.2–5.2	4.7	4.3–5.3	0.9	1.8	2.7
Niger, Niamey R2	4.5	4.0–5.0	4.8	4.2–5.3	4.6	4.1–5.1	4.9	4.3–5.3	5.9	1.8	7.8
Nigeria, Kaduna R1	3.9	3.6–4.2	4.1	3.9–4.5	4.0	3.6–4.3	4.2	3.9–4.6	5.0	1.6	6.7
Nigeria, Kaduna R2	4.5	4.1–4.8	4.7	4.3–5.0	4.5	4.2–4.9	4.8	4.4–5.0	6.1	1.6	7.9
Nigeria, Kaduna R3	5.0	4.7–5.4	5.3	5.0–5.8	5.1	4.7–5.5	5.4	5.1–5.8	6.1	1.6	7.8
Nigeria, Lagos R1	3.1	2.6–3.7	3.1	2.6–3.7	3.2	2.7–3.7	3.2	2.7–3.7	0.0	1.7	1.7
Nigeria, Lagos R2	3.4	3.0–3.8	3.4	3.0–3.8	3.5	3.1–3.9	3.5	3.1–3.9	n/a	1.8	1.8
Nigeria, Lagos R3	3.4	3.0–3.7	3.4	3.0–3.7	3.4	3.0–3.8	3.4	3.0–3.8	n/a	1.8	1.8
Nigeria, Anambra R3	3.6	3.2–4.0	3.6	3.2–4.0	3.6	3.2–4.1	3.7	3.2–4.1	1.0	1.8	2.7
Nigeria, Kano R3	5.9	5.4–6.4	6.1	5.6–6.7	6.0	5.5–6.5	6.2	5.7–6.8	3.1	1.7	4.9
Nigeria, Nasarawa R3	4.4	3.9–4.8	4.5	4.0–4.9	4.5	4.0–4.9	4.6	4.1–5.0	2.6	1.6	4.2
Nigeria, Rivers R3	3.0	2.6–3.3	3.0	2.6–3.4	3.0	2.6–3.4	3.0	2.6–3.4	0.4	1.8	2.2
Nigeria, Taraba R3	4.7	4.1–5.3	4.8	4.3–5.5	4.8	4.2–5.4	4.9	4.4–5.6	2.4	1.6	4.0

Table 6: (Continued)

Survey[X]	Total fertility rate								% change compared to the unadjusted rate		
	Unadjusted	95% CI	Adjusted for excess January births	95% CI	Adjusted for multiple births	95% CI	Adjusted for both	95% CI	Adjusted for excess January births	Adjusted for multiple births	Adjusted for both
Uganda R1	5.8	5.5–6.1	5.9	5.6–6.2	5.9	5.6–6.2	6.0	5.7–6.3	1.9	1.6	3.5
Uganda R2	5.7	5.3–6.0	5.7	5.4–6.1	5.7	5.4–6.1	5.8	5.5–6.2	1.0	1.6	2.7
Uganda R3	5.0	4.7–5.3	5.1	4.7–5.3	5.1	4.8–5.4	5.1	4.8–5.4	1.8	1.7	3.4
Uganda R4	6.0	5.7–6.3	6.1	5.8–6.5	6.1	5.8–6.4	6.2	5.9–6.6	1.8	1.6	3.4
Average (unweighted)									**2.4***	**1.6**	**3.9**

Notes: [X] R1 refers to Round 1 surveys, R2 refers to Round 2 surveys, and so on.
n/a: not applicable for surveys without excess January births (Table 4).
CI: confidence interval
*Average among 36 surveys

5. Discussion

PMA2020 surveys – as rapid turnaround, lower cost surveys to monitor family planning progress – have employed innovative approaches such as mobile technologies for data collection and transfer by local REs. Regarding fertility, PMA202 has collected a relatively limited amount of information compared to a full birth history, but does provide data to measure a two-year TFR. Applying the PMA questionnaire to full birth history data from DHS suggests that only about 1.5% births would be not captured by employing the simpler questionnaire during a two-year reference period. Virtually all bias in most surveys is due to multiple births that were missed, which can be and has been corrected by adjusting the TFR by the multiple birth rates. With proper training and supervision, the questions used in PMA2020 surveys may be sufficient – though unconventional – for monitoring fertility, although we were not able to assess the magnitude of omitted live births in this paper.

However, assessment of completeness of birth year and month revealed challenges in administering the questions during interviews. The level of incomplete or unknown years and especially months was high, although it has improved over a short period, especially in settings where the problem was initially severe. Considering the cultural context of the countries where the surveys were conducted, it is not surprising that correct reporting and recording of birth year and month is challenging. Other surveys conducted in the same study countries also have faced the challenge, but have reduced incomplete reporting over time (Table A-2), potentially through intensive training and supervision on birth history data collection. This is partially because a main objective of such surveys is to measure demographic outcomes, fertility, and mortality, and collecting complete birth year and month information is one of the highest priorities. Enumerator training for the first round of PMA2020 is two weeks, and then two to three days of refresher training before each subsequent round, which is substantial considering that the survey focuses on a limited number of topics. However, the data suggest that training and supervision on fertility data was not optimal to ascertain month and year of birth. Much of the focus during training is on understanding contraceptive methods and use of the smart phones. The high level of incomplete reporting might be exacerbated by employing REs with minimum qualifications and the fact that the enumerators had to familiarize themselves with the mobile phone system at the same training session as the questionnaire. Although there is little incentive for the REs to incorrectly report birth dates, there is also not as much cross-checking compared to a DHS survey where a team works together in an assigned cluster. A DHS field team may have one person conducting the household questionnaire, identifying members by age and gender, while another team member may interview the eligible women, obtaining the ages of her children. Finally, a separate team member might weigh and measure the children and, in the process, confirm their ages. These inherent opportunities to correct and probe for precise ages are not available in PMA with one RE working alone in a cluster. To account for this the field supervisor does reinterview ten percent of households in the enumeration area. However, this would not capture children of eligible women if those children no longer live in the household, e.g. older, grown children or children who have died. Ultimately, it will require strategic and careful tradeoffs between resources and data quality, within an acceptable range, considering that the main goal of PMA2020 is to monitor family planning indicators that are expected to change rapidly (e.g., annually) given political, financial, and programmatic commitment in a country.

In addition, given relatively high incomplete reporting of birth month, the choice of a default month in data collection software and its impact was another lesson learned. Analysis suggested the underestimation was in large part due to this programming and data management decision. PMA2020 has revised the questionnaire to allow 'don't know' for birth month, instead of assigning a default month. It will enable a more direct assessment of data quality. It will also allow analysts to address the incomplete month data differently, as needed, in their research and estimation of fertility rates. Another analytical strategy to address a high percent of unknown birth months would be to calculate TFR in calendar years, rather than in a reference period retrospectively from the survey implementation. Such approach would be especially useful for full birth history data with high incomplete birth month. In PMA2020, which limits data collection up to three births, it should be applied with caution since the omission of births due to the three-birth limit increases as the reference period in years increases.

We also acknowledge that our data quality assessment was limited. For example, without data on the sex of the children, we were not able to assess simple data quality indicators such as sex ratio at birth. In addition, perhaps most importantly, the omission of live births especially by children who died early in life, is a critical and common reporting bias that can be addressed to some extent with intensive training and supervision during fieldwork – regardless of questionnaire design (Pullum and Becker 2014). Assessment of the issue requires survival status and age at death with a sufficient number of deaths in the sample. In attempt to assess this issue indirectly we compared the final adjusted TFR against the estimates in DHS using PMA2020 surveys that were conducted most closely in time to the latest DHS in each country. Even after adjusted for excess January births (reflecting differences in enumerator training and supervision and imputation of incomplete birth month) and multiple births (reflecting differences in questionnaires), PMA2020 estimates were systematically lower than DHS estimates, on average by 10% (n = 7),[8] ranging from 3% in Uganda and 26% in Ghana (Table 7). In

[8] The comparison was restricted to either when both surveys were conducted at the national level (Burkina Faso, Ethiopia, Ghana, Indonesia, Kenya, and Uganda) or when both surveys had sufficient sample sizes

four cases the difference was statistically significant. We speculate a large component of the difference is due to higher omission of births in PMA2020 surveys than in DHS. However, it should be noted that comparing estimates from different surveys requires careful review of comprehensive factors, including timing of surveys, sampling method, sample size (both the number of enumeration areas as well as the number of household per EA), questionnaires, enumerator training and supervision, imputation of incomplete information, and computation methods (Pullum, Assaf, and Staveteig 2017).

Table 7: Comparison of total fertility rates for the two years preceding the survey: DHS and PMA2020

	DHS			PMA2020*			
Country	Survey year	Estimate	95% CI	Round	Survey year	Estimate	95% CI
Burkina Faso	2010	6.0	(5.8–6.1)	1	2014	5.6	(5.2–6.0)
Ethiopia	2016	4.6	(4.5–4.8)	4	2016	4.4	(4.2–4.6)
Ghana	2014	4.2	(4.0–4.4)	3	2014	3.1	(2.9–3.3)
India, Rajasthan	2016	2.4	(2.3–2.4)	1	2016	2.2	(2.0–2.3)
Indonesia	2012	2.6	(2.6–2.7)	1	2015	2.3	(2.2–2.4)
Kenya	2014	3.8	(3.7–3.9)	2	2014	3.4	(3.2–3.6)
Uganda	2011	6.2	(6.0–6.4)	1	2014	6.0	(5.7–6.3)

Notes: CI: confidence interval
*Estimate adjusted for excess January births and multiple births

We did not assess any impact of different questionnaires used within PMA on TFR estimation. Such assessment is possible with observational data, though ideally with a randomized controlled study. One potential approach could be the interrupted time series analysis (Bernal, Cummins, and Gasparrini 2017), but it is not necessarily applicable due to large sampling error of TFR estimates, the relatively short time period during which the changes were made, and the fact that the enumerators conduct the survey over time gaining experience in asking difficult questions.

In the latest PMA2020 surveys since late 2017, questions to measure fertility level have been eliminate in order to include questions to monitor family planning programmatic aspects such as postpartum family planning, implant removal, and method switching (PMA2020 2017). Nevertheless, moving forward PMA2020 may consider collecting truncated birth history data if fertility needs to be measured in a

(Rajasthan, India). Relative error (i.e., sampling error/estimate) was substantially smaller in DHS than in PMA, on average by about 40% (results not shown).

survey. It will eliminate underreporting of multiple births and may reduce any confusion among data users who are familiar with full or truncated birth history data and potentially among data collectors as well. It will further provide a basis for collecting any data related to maternal and child health by identifying index children or pregnancies explicitly. By employing a 5-year or 3-year truncated birth history, the number of births collected will reduce substantially – by 58% and 74%, respectively, compared to births that would be captured by current PMA questionnaire – potentially reducing the fieldwork burden for enumerators. By collecting a truncated birth history and the first birth, which is used currently to measure and monitor age at first birth, the reduction will be 25% and 39%, if a 5-year or 3-year reference period is used, respectively (results not shown).[9] Incorporating local events in the questionnaire may also improve data quality on timing of event (Helleringer et al. 2014a; Helleringer et al. 2014b).Adding simple questions such as sex of child will enable certain data quality assessment.

Finally, while this study focuses on births, another potential data quality issue is relevant for fertility rate estimation: age displacement of eligible respondents. However, unless displacement is systematically done differentially by recent fertility, the impact is likely minimal. Further, fertility rates among age groups that are potentially exposed to displacement (i.e., 15–19 and 45–49) are typically low in most settings.

In summary, this paper documents methods used to collect and analyze fertility data in PMA2020 surveys. According to data quality assessment, any undercounting of births introduced by not using the full birth history approach is almost exclusively due to undercounting of multiple births, which have been adjusted during data analysis in all PMA2020 publications. However, it was also identified that there is relatively high level of incomplete reporting of birth month. Use of the default 'January' in the case of a missing birth month also inadvertently led to underestimation of TFR, the magnitude of which depends on the timing of the survey in a calendar year. Separately addressing the two issues – undercounting of multiple births and excess January births – TFR estimates were upward adjusted on average by 1.6% and 2.4%, respectively. Combined adjustment resulted in an increase of TFR by 3.9%, on average. Implications for training of REs and data collection programming will inform future surveys in PMA2020 and can be beneficial for other surveys using mobile technologies. In addition, regardless of data collection methods and questionnaires, high-quality field implementation remains critical.

[9] Unweighted average across the ten studied countries, when such questionnaires are applied to full birth history data in the latest DHS in each country.

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Appendix

Table A-1: Level of missing birth year and age of women who report at least one birth with missing birth year, by survey

Survey[X]	Number of births with missing year	Number of women who reported at least one birth with missing year	Current age of the women who reported at least one birth with missing year	
			Mean	Median
Burkina Faso R1	146	118	36.8	38.0
Burkina Faso R2	106	101	36.9	37.0
Burkina Faso R3	73	68	35.8	35.0
DRC, Kinshasa R1	0	0	-	-
DRC, Kinshasa R2	19	15	35.4	41.0
DRC, Kinshasa R3	16	14	36.7	38.5
DRC, Kinshasa R4	7	6	34.9	38.0
DRC, Kongo Central R4	54	40	36.4	37.0
Ethiopia R1	10	9	34.6	36.5
Ethiopia R2	99	84	34.1	35.0
Ethiopia R3	73	59	37.4	40.0
Ethiopia R4	95	68	34.2	35.0
Ghana R1	36	23	38.9	41.0
Ghana R2	145	101	36.0	37.0
Ghana R3	164	126	38.5	39.5
Ghana R4	142	105	37.4	39.0
India, Rajasthan R1	218	179	37.2	38.0
Indonesia R1	113	93	42.5	45.0
Kenya R1	91	70	33.7	34.0
Kenya R2	124	76	36.0	36.0
Kenya R3	64	54	38.8	40.0
Kenya R4	34	29	38.6	41.5
Niger, Niamey R1	31	20	35.4	37.0
Niger, Niamey R2	54	40	37.7	39.0
Nigeria, Kaduna R1	301	215	30.8	30.0
Nigeria, Kaduna R2	69	61	30.8	30.0
Nigeria, Kaduna R3	23	20	29.4	27.0
Nigeria, Lagos R1	23	14	35.1	35.0
Nigeria, Lagos R2	16	13	40.1	40.0
Nigeria, Lagos R3	20	14	35.7	40.0
Nigeria, Anambra R3	8	7	35.8	36.0
Nigeria, Kano R3	7	7	31.9	30.0
Nigeria, Nasarawa R3	8	8	39.9	38.5
Nigeria, Rivers R3	10	8	40.7	41.0
Nigeria, Taraba R3	15	12	33.7	35.0
Uganda R1	135	92	33.2	32.0
Uganda R2	135	101	35.1	35.0
Uganda R3	174	123	34.5	34.0
Uganda R4	143	107	35.5	35.0

[X] R1 refers to Round 1 survey, R2 refers to Round 2 surveys, and so on.

Table A-2: Levels and trends of births with complete year and month in Demographic and Health Surveys (DHS)

Country	First DHS					Latest DHS				
	Survey year	Total number of births	Percent of births with complete birth month and year reported	Percent of births with complete birth month reported	Percent of births with complete birth year reported	Survey year	Total number of births	Percent of births with complete birth month and year reported	Percent of births with complete birth month reported	Percent of births with complete birth year reported
Burkina Faso	1992	20,597	70.7	70.7	99.6	2010	56,031	98.9	98.9	100.0
DRC	2007	29,463	97.1	97.1	99.9	2013	59,081	99.0	99.0	100.0
Ethiopia	1992	44,064	89.3	89.3	99.9	2016	41,290	95.3	95.4	99.8
Ghana	1988	14,169	75.2	92.9	82.1	2014	23,077	97.0	97.1	99.9
Rajasthan, India	1992	16,329	95.6	95.7	99.8	2016	83,422	99.0	99.0	99.9
Indonesia	1987	39,656	75.9	93.2	82.7	2012	83,484	93.8	93.8	99.5
Kenya	1988	25,106	96.5	98.6	97.6	2014	83,421	98.5	98.5	100.0
Niger	1992	23,745	57.1	57.2	99.8	2012	44,052	82.3	82.3	99.8
Nigeria	1990	28,040	84.6	84.6	99.9	2013	119,101	99.1	99.1	99.9
Uganda	1988	16,030	99.9	99.9	100.0	2011	28,516	97.8	97.8	99.8
Average			84.2	87.9	96.1			96.2	96.3	99.9