Technical Guidance Note

Assessment of Birth Registration Completeness:
An Overview of Data and Methods

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UNFPA

CENTRE OF EXCELLENCE for CRVS Systems

IDRC · CRDI
International Development Research Centre
Centre de recherches pour le développement international

Canada

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The Centre of Excellence for Civil Registration and Vital Statistics (CoE-CRVS) is a global resource hub that actively supports national, regional and global efforts to develop, strengthen and scale up sustainable civil registration and vital statistics (CRVS) systems that work for all, especially women and girls. The CoE-CRVS facilitates technical assistance, global standards, tools, evidence, and good practice, with a strong commitment to gender equality, and strategic partnerships.

The CoE-CRVS was founded in 2015 at the International Development Research Centre (IDRC, Canada). In August 2021 the CoE-CRVS transitioned to UNFPA to expand the Centre's reach through UNFPA's global network with activities in over 150 countries. The CoE-CRVS is funded by Global Affairs Canada, IDRC and UNFPA.

UNFPA and the CoE-CRVS implement a life-course approach to CRVS support - from birth to death, including marriage and divorce - ensuring that a person's legal identity is progressively updated over the life-course. A life-course approach advances human rights principles and inclusive development strategies for official statistics and public accountability, as shown below. Civil registration and legal identity facilitate access to health care, primary and secondary education, and social support.

Table of **Contents**

List of
Figures & Tables

1 Objectives

The purpose of this Technical Guidance is to provide:

- An overview of the different data sources and methods that can be used to assess birth registration completeness;
- A comparative overview of the different input data, potential analytical outputs and accompanying assumptions associated with the different methods;
- A discussion of the relative strengths and weaknesses of these different methods;
- A synopsis of further resources, computational tools and technical readings on birth registration completeness assessment.

This technical guidance note is designed to support demographers and statisticians in national statistics offices, UNFPA country offices and partner institutions in the assessment of birth registration data. It is designed to help analysts at national statistics offices identify the different methods that can be used, given different data availability scenarios at the national and subnational levels.

2 Introduction

Civil Registration (CR) and Vital Statistics (VS) play a key role in facilitating progress towards the Sustainable Development Goals (SDGs).[1]

Complete and timely vital statistics provide policymakers with better data on which to base policies and SDG implementation plans. Indicator 17.19.2 of the SDGs includes a provision to achieve 100 per cent birth registration and 80 per cent death registration by 2030. As such, reliably estimating the completeness of vital events is critical for monitoring progress towards the targets of the SDGs.

The importance of completeness assessment of registration data is twofold: 1) it guides evidence-based improvements of the CR system and 2) it helps identify required statistical adjustments when constructing representative vital statistics.[2] Completeness assessments of registration data guide efforts to improve the quality and completeness of the CR system and can inform any adjustment of incomplete and deficient civil registration data when producing representative VS outputs.

This technical guidance note provides an overview of data sources and methods used to assess the completeness of birth registration data and presents worked examples and links to worked examples or UNFPA e-learning resources for some of the methods in this technical guide.

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1 Samuel Mills, Carla Abouzahr, Jane Kim, Bahie M. Rassekh and Deborah Sarpong. 2017. "Civil Registration and Vital Statistics (CRVS) for Monitoring the Sustainable Development Goals (SDGs)", paper prepared for the eLearning course on Civil Registration and Vital Statistics Systems. https://openknowledge.worldbank.org/bitstream/handle/10986/27533/115150.pdf.

2 *Principles and Recommendations for a Vital Statistics System* (United Nations Publication, Sales No. E.13.XVII.10, 2014). https://unstats.un.org/unsd/demographic/standmeth/principles/M19Rev3en.pdf.

3 Conceptual Overview of Birth Registration Completeness Assessment

Assessing the completeness of birth registration data entails comparison between the size, nature and attributes of registered births (live births that have been officially registered with the civil registration authority) and expected births. The term “expected births” refers to the number of births expected to occur in a geographic area during a specified time period, given the prevailing population dynamics.

Mathematically, the completeness of birth registration data in a given area a for a specified time period t, denoted as C(a,t), can be described as

$$C(a,t) = \frac{R(a,t)}{E(a,t)}$$

where ***R(a,t)*** is the number of births recorded on the CR system that occurred in area **a** during time period **t** and ***E(a,t)*** is the number of total births expected to occur in area **a** during time period **t,** given the prevailing population dynamics.

The numerator, R(a,t), is usually directly observed from the CR system. The denominator, E(a,t), is usually estimated either by a direct or indirect fertility estimation technique. In the following sections, the basic mechanics of estimating “expected births”, E(a,t), are described, including the standard data sources that can be used, the various direct and indirect estimation methods and their associated strengths and weaknesses.

First, we show three complementary visual assessments of birth registration data: aggregated counts of registered births relative to expected births; percentage completeness of registered births; and age-specific fertility rates (ASFRs) of unadjusted and adjusted birth registration data. These example visualizations are from a technical assessment of demographic data quality and completeness of birth and death registration in Tunisia by the Institute of National Statistics and the United Nations Population Fund (Heinonen, 2020). Figure 1 shows a comparison of annual sex-specific births derived from official birth registration data and those from reverse surviving the population 0–15 years of age enumerated in the 2014 census for Tunisia for 2000–2014. The figure shows that for both males and females, official birth registration in Tunisia has been approximately complete since 2000, a high level of birth registration for the country, at least using estimates from the reverse survival method.

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FIGURE 1 | Annual births by sex derived from birth registration and the reverse survival method, Tunisia 2000–2014

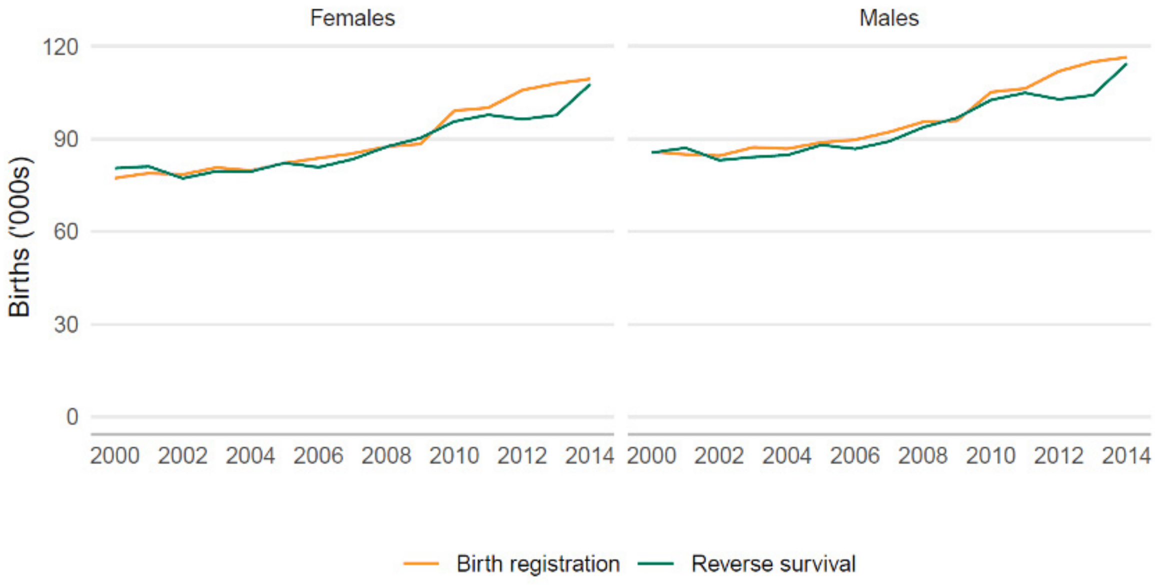
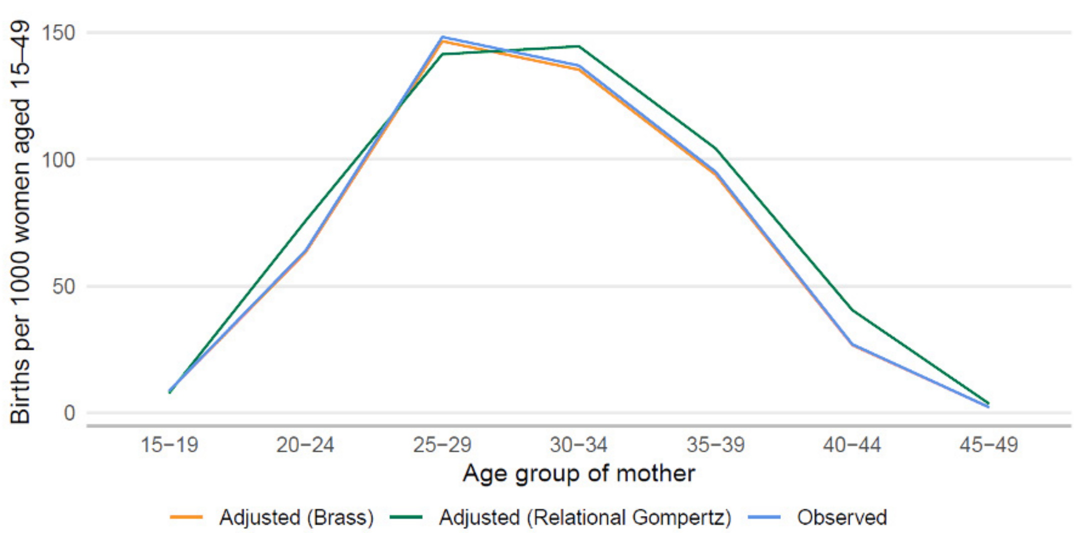


Figure 2 shows estimates of birth registration completeness by sex as the ratio of registered births to the numbers of births estimated by reverse surviving the population 0–15 years of age enumerated in the 2014 census for Tunisia for 2000–2014. This figure shows that annualized birth registration completeness is approximately equivalent for males and females, although in some cases registration of male births was slightly higher than that of female births. However, completeness of above 100 for both male and female births may point to underestimation of the number of expected births by the reverse survival method.

FIGURE 2 | Ratio of registered births to births derived using the reverse survival method, by sex, Tunisia 2000–2014

Lastly, Figure 3 shows observed and adjusted ASFRs, based on official birth registration data, by age of mother in Tunisia, 2014. This also shows a similar story: completeness of birth registration in Tunisia is high, although the relational Gompertz method suggests there might be slight under-registration of births for older mothers (30–44 years of age).

FIGURE 3 | Observed and adjusted ASFRs by age of mother, Tunisia 2014



4 Description of Measurement Methods and Data Sources

This section briefly describes each of the methods used for completeness assessment of birth registration data. Table 1 summarizes the types of data required for the various methods that can be used in evaluating completeness of birth registration data.

TABLE 1 | Overview of measurement methods, data requirements and data sources for estimating expected births

Methods	Data requirements	Data sources
Direct estimation of fertility rates	• Number of women by five-year age group • Number of births by age group of mothers	• Census • Household surveys such as DHS, MICS
Cohort parity comparison with CR data (mean number of births vs average parity of the same cohort)	• Number of children ever born by five-year age group of mother • Number of women by five-year age group from two or more censuses • Registered births for 10–15 years	• Census (multiple) • Civil registration
Reverse survival	• Population data (under 20, 15 or 10 years of age) by single years (or five-year age groups) of age • Child survival probabilities from a life-table, e.g. ${}_5L_0$, ${}_5L_5$, ${}_5L_{10}$	• Censuses • Household survey • Life tables
Brass P/F ratio	• Number of women by five-year age group at census/survey • Number of births by age group of mothers	• Household surveys such as DHS and MICS • Census
Relational Gompertz	• Number of women by five-year age group at census/survey • Number of births by age group of mother • Total number of children born to women by five-year age group	• Household surveys such as DHS and MICS • Census
Direct questions on birth registration or birth certificate possession	• Direct question (to either head of household or woman of reproductive age), • Question usually added to full birth history module or main census module	• Census • Sample survey
Capture–recapture method	• Unique identifying variables from two independent sets of data	• Civil registration • Census or large sample surveys

More detailed descriptions of each method are given below.

4.1 Direct Estimation of Fertility Using Full Birth Histories

Age-specific and total fertility rates can be directly estimated from survey data containing birth histories in a relatively straightforward manner using carefully collected and validated data, such as demographic and health surveys (DHS) or multiple indicator cluster surveys (MICS).

Fertility rates can be calculated for the period one year or three years before the survey (three-year period estimates are frequently used to avoid fluctuations due to small numbers of annual births from survey data). The numerator of the age-specific fertility rate is the number of births in the 36 months before the survey to women in the age group at the time of the birth. The denominator is the number of woman-years of exposure in the 36 months before the survey for women in the five-year age group. Depending on the length of the period, a woman can contribute exposure to several age groups in that period. See a detailed description of the method in the Guide to DHS Statistics [3] and another approach in the Tools for Demographic Estimation (TDE).[4]

3 Rutstein S.O. and G. Rojas. 2006. Guide to DHS Statistics: Demographic and Health Survey Methodology. https://dhsprogram.com/pubs/pdf/DHSG1/Guide_to_DHS_Statistics_29Oct2012_DHSG1.pdf

4 Moultrie T.A. et al., *Tools for Demographic Estimation* (Paris, International Union for the Scientific Study of Population, 2013). http://demographicestimation.iussp.org/

4.2 Cohort Parity Comparison with CR Data (Observed vs Expected Births)

This method uses the cohort nature of reported average parities and compares them with parity equivalents obtained from the recorded fertility rates pertaining to the relevant cohorts. If we consider women 30–34 years of age at a given census, then ten 10 before the census they were 20–24 years of age, and 20 years before they were 10–14 years of age. If we assume that women give birth from 15 years of age, children ever born reported by women 35 years of age and under at the time of the census reflect the cumulative fertility experience of these women over the preceding 20 years. If mortality and migration are assumed to be unrelated to the fertility experience of women and fertility rates can be calculated for those 20 years, average parity equivalents for each cohort can be constructed and compared with the reported average parity of women at the time of the census. A detailed description of this method is available in TDE (pp. 128–137). One challenge with this approach is that registration data from the past 20 years may not be available in most developing countries.

4.3 Expected Births Derived from Population Estimates or Projections: Reverse Survival Method

Reverse survival is a method for estimating the number of births directly from population counts by age. In a population that is closed to migration, the population of an age x is just the number of survivors of the births in that population that occurred x years ago.This implies that the number of births occurring x years ago can be estimated using survivorship probabilities available from a standard life-table to “reverse survive” the population to its birth year, provided it is possible to estimate the life-table survival probabilities from birth to age x.

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4.4 Estimation of Fertility Based on Comparison of Period Fertility Rates with Reported Average Parities

4.4.1 Brass P/F ratio

This method is based on the observation that if fertility has been constant for an extended period of time, cohort and period measures of fertility will be identical. In other words, the cumulative fertility of a cohort of women up to a given age will be the same as the cumulative period fertility up to that same age in any given period. Assuming that surviving women do not have significantly different levels of childbearing from deceased women, the cumulative fertility of a cohort of women up to any given age is the same as the average parity (cumulative lifetime fertility, or the average total children born to women) in that cohort.

The method aims to adjust the level of observed ASFRs because women tend to under-report recent births, meaning recent levels of fertility are lower than anticipated. It adjusts the fertility level to agree with the level of fertility indicated by the average parities of women in younger age groups from 20–30 or 20–35 years of age, which are assumed to be accurate. The value of the adjustment factor reflects the degree of under-reporting of recent births by women and values closer to unity suggest less deflated values of observed fertility rates and therefore more completeness in birth registration.

4.4.2 Relational Gompertz

WThe relational Gompertz model is a refined and more versatile version of the Brass P/F method. The model uses the same input data to compare lifetime and period fertility and seeks to estimate the true fertility schedule by determining its shape from data on observed fertility rates while determining its level from the reported average parities of younger women. This means the method adjusts both the level and shape of fertility schedules.The method relies on a cumulative Gompertz distribution, which captures with a reasonable degree of accuracy both the pattern of average parities of women by age and their cumulative fertility. The model can be expressed as a linear relationship between functions of a chosen fertility standard and the cumulative fertility schedule.

4.5 Self-reported Registration of Deaths via Surveys and Censuses

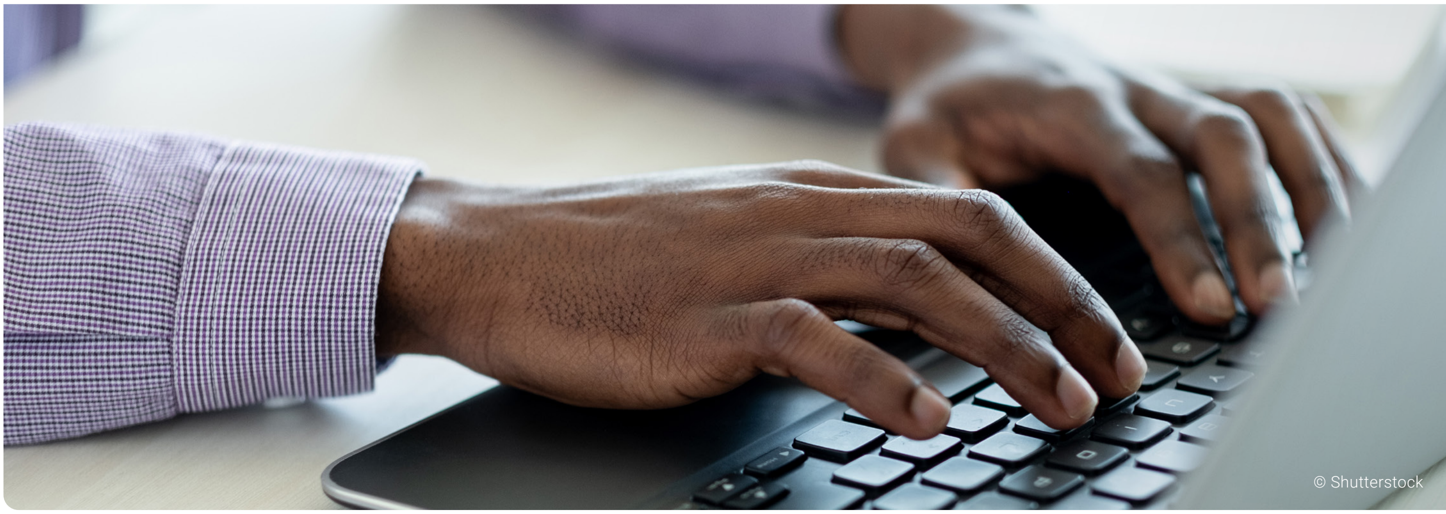
This approach involves adding specific self-disclosure questions to existing fertility modules in household surveys or censuses to ask if births reported in the survey or census have been registered with the local CR unit. The measure of completeness is taken as the proportion of self-reported births registered with the local CR authority to the total reported births captured in the survey. All data for this method is usually internal to the survey or census itself, without reference to any external data source. However, where feasible, respondents may also be asked to produce registration documents as proof in order to validate the completeness estimate.

4.6 Capture–recapture Estimation

The capture–recapture method is a record linkage analysis of completeness of death registration where two births reported from two different independent sources for the same population (one of which is events from the CRVS system) are linked using specific matching criteria. After linking all events of interest from the two data sources, completeness of birth registration is estimated as

$$C(reg) = \frac{N(reg)}{N(total)}$$

where ***C(reg)*** is the completeness of birth registration, ***N(reg)*** is the number of births registered with the CR system and ***N(total)*** is the total number of births from the two sources of data, i.e. birth registration and a second data source, plus births that are estimated to have been missed by the two sources (obtained by multiplying births recorded in source 1 but not in source 2 and those recorded in source 2 but not in source 1 divided by births recorded in both sources).



5 Overview of Required Input Data and Expected Output for Respective Estimation Techniques

Direct estimation of fertility using DHS data

Standard DHS data is straightforward to use to produce estimates of fertility rates at national and subnational levels. With the individual recode of DHS data, the minimum input data required is given in the following table.

v005	v008	v011	b3_01	b3_02	b3_03	b3_04	b3_05	b3_06	b3_07	b3_08	b3_09
1767724	1328	991	1316	1280	1255						
1767724	1328	877	1238	1219	1182	1132	1105	1081			
1767724	1328	980	1324	1292	1258	1224	1201				
1767724	1328	1087	1313								
1767724	1328	937	1314	1274	1253	1221					
1767724	1328	808	1273	1227	1201	1184	1159	1058	1009		
1767724	1328	1105	1321								
1767724	1328	884	1312	1272	1225	1179	1153	1124			
1767724	1328	944									
1767724	1328	985	1303	1277	1255						
1767724	1328	1119	1322								
1767724	1328	746	1214	1168	1147	1120	1069	1047	1021	1003	961
1767724	1328	893	1294	1255	1226	1205	1180	1159	1134	1093	
1767724	1328	823	1251	1206	1105	1081	1064	1036			

Where **v005** is the sample weight of the data, **v008** is the date of the interview, **v011** is the date of birth in century–month code (CMC) for women, and **b3_01–b3_10** (or up to **b3_20**) is the date of birth in CMC for each child born to a woman. From these data, the approach produces the number of births by the age of the mother and women's exposure to the risk of giving birth in each calendar year, from which ASFRs are estimated. The total fertility rate is as shown in the below.

Age-group	ASFR
15-19	0.1301
20-24	0.2635
25-29	0.2687
30-34	0.2366
35-39	0.1888
40-44	0.0873
45-49	0.0232
TFR	5.9907

Cohort parity comparison

Input data from two or three censuses for women 15–34 years of age, mean parities for these women from the latest census and number of births from registration data for the 20 years before the most recent census are required to implement this method.

Because registration data are direct inputs for this method, results include the direct estimate of completeness of birth registration data.

The following are examples of input and output data for this method, the data is based on the Ecuador census.

Input data

		Population by age group			
Census Date		15-19	20-24	25-29	30-34
25.11.1990	1990.899	531,570	472,630	406,250	339,630
25.11.2001	2001.899	621,680	598,120	488,280	439,670
28.11.2010	2010.907	705,690	651,610	613,720	547,100
Mean Parity (2010 census)		0.21	0.86	1.58	2.19

Registered births by age group				
Year	**15-19**	**20-24**	**25-29**	**30-34**
1991	38,537	78,769	63,384	41,884
1992	41,501	81,749	64,884	42,874
1993	42,459	82,621	65,376	43,359
1994	42,755	81,884	63,049	43,252
1995	45,403	83,093	64,520	43,339
1996	46,938	81,250	64,384	42,726
1997	43,079	77,265	61,593	41,360
1998	54,053	91,270	69,797	46,183
1999	52,225	88,602	68,851	45,345
2000	50,478	86,418	66,184	43,628
2001	49,075	86,218	64,119	43,672
2002	46,806	82,565	60,118	40,760
2003	49,383	82,120	59,307	39,741
2004	46,481	76,685	55,838	36,934
2005	46,312	76,641	57,476	37,106
2006	49,179	79,691	62,022	39,510
2007	55,858	85,975	66,251	40,793
2008	57,299	86,563	67,238	43,221
2009	61,487	87,642	67,995	44,318
2010	60,999	86,238	69,006	46,415

Output data					
		Growth rates			
	Period/year	**15-19**	**20-24**	**25-29**	**30-34**
	1900-2001	0.0142	0.0214	0.0167	0.0235
	2001-2010	0.0141	0.0095	0.0254	0.0243
Parity equivalents	2010	0.13	0.66	1.29	1.86
Completeness		0.6185	0.7723	0.8142	0.8495
Average completeness		0.8318			

The results show that the average completeness of birth registration in Ecuador is 83 per cent.

Reverse survival method

This approach requires data for children 0–14 years of age and women 10–64 years of age from the last census, as well as ASFRs for either the last two censuses or the most recent one. Below is an example using data from 2008 Cambodia census.

Age	ASFRs recent census	ASFRs earlier census	Census data from recent census			
			Age	Children	Age	Women
10-14	0.0000	0.0000	0	281,260	10-14	815,930
15-19	0.0418	0.0533	1	261,320	15-19	780,320
20-24	0.1535	0.1974	2	268,410	20-24	697,160
25-29	0.1482	0.2144	3	286,810	25-29	626,430
30-34	0.1118	0.1836	4	278,990	30-34	361,650
35-39	0.0708	0.1332	5	293,760	35-39	435,880
40-44	0.0301	0.0676	6	293,490	40-44	393,760
45-49	0.0032	0.0134	7	302,060	45-49	352,520
			8	315,970	50-54	294,280
			9	267,190	55-59	230,200
			10	326,980	60-64	160,590
			11	280,260		
			12	354,120		
			13	356,920		
			14	354,830		

The output of this method is the number of births for the past 15 years before the census, as shown below.

Reverse survival of children			
Mid-year	Births	Mid-year	Births
Year 1	295,328	Year 9	354,583
Year 2	281,062	Year 10	301,184
Year 3	290,118	Year 11	370,118
Year 4	312,409	Year 12	318,451
Year 5	306,453	Year 13	403,924
Year 6	324,644	Year 14	408,337
Year 7	325,997	Year 15	406,976
Year 8	337,355		

Brass P/F ratio method

The following input data is required to implement the Brass P/F ratio method: fi (period ASFRs for age group i) and Pi (average parity of women in age group i), as shown below.

Age group	Parity (Pi)	ASFR (fi)
15-19	0.075	0.022
20-24	0.512	0.092
25-29	1.160	0.111
30-34	1.808	0.099
35-39	2.420	0.070
40-44	2.899	0.031
45-49	3.372	0.009

ASFRs can be obtained from the direct estimation method presented above, whereas average parities can be calculated by dividing the total number of children ever born to women age i by the total number of women in that age group. Using these data and other parameters, the method produces cumulated parity equivalents (Fi), which are used to calculate the P/F ratios, which in turn are used to produce adjusted ASFRs as shown below.

Age group	Parity (Pi)	ASFR (fi)	Fi	P/F	Adjusted AFSR
15-19	0.075	0.022	0.044	1.703	0.031
20-24	0.512	0.092	0.372	1.3777	0.126
25-29	1.160	0.111	0.904	1.283	0.153
30-34	1.808	0.099	1.429	1.265	0.136
35-39	2.420	0.070	1.844	1.312	0.097
40-44	2.899	0.031	2.078	1.395	0.043
45-49	3.372	0.009	2.165	1.558	0.012
TFR		2.2			3.0

Relational Gompertz method

As an extension of the Brass P/F method, the relational Gompertz method uses the same data inputs as Brass P/F. In addition, there is a need to select points to be used in adjusting the shape and level of the observed fertility schedule. The output is the same as that obtained using the Brass P/F Ratio method.

6 Strengths and Weaknesses of Methods for Estimating Expected Births

This section outlines the advantages and disadvantages of the methods presented above.

TABLE 2 | Strengths and Weaknesses of the methods used in completeness assessment of birth registration

Methods	Data requirements	Data sources
Direct estimation of fertility rates	• Possible to draw direct estimates from survey data	• Covers the entire survey period, not a selected time point/annual estimate (while fertility rates are usually represented for each year)
Cohort parity comparison with CR data (mean number of births vs average parity of the same cohort)	• Method provides a direct estimate of completeness • Does not require assumption of constant fertility in contrast to Brass P/F method	• Computational procedure is onerous • Requires a fairly long series of annual birth registration data • Assumes mortality and migration are unrelated to the fertility experience of women
Reverse survival	• Easy to apply • Can provide fertility estimates for a number of years before the census	• Depends on the accuracy of the population census • Relies on strong assumptions of zero net migration • Assumes life-table survivorship probabilities have remained constant • Ineffective for producing reliable fertility estimates
Brass P/F ratio	• Produces reliable fertility estimates as it corrects for common errors in birth reporting	• Relies on strong assumption of constant fertility for a long period
Relational Gompertz	• Smooths ASFR, a major problem with subnational estimates • Does not assume constant past fertility, in contrast to Brass P/F ratio method	• Relies on a standard fertility distribution • Relies on strong assumptions
Capture–recapture estimation methods	• Computation procedure is straightforward • Completeness assessment can easily be applied to the subnational level or disaggregated by age and sex	• Data quality issues from either of the sources can affect the accuracy of the linking process
Internal/direct questions on death registration or death certificate possession	• Easy to compute and interpret • Input data can be collected in conjunction with existing and ongoing survey programmes • Method can collect and inform about contextual factors affecting completeness	• Relies on self-reported events which are subject to recall bias • Data limitations may prevent detailed understanding of overall completeness • No external validity • Usually small sample sizes

7 Computational Tools for the Estimation of Expected Births and Completeness Assessment of Birth Registration

Table 3 presents some of the tools, including Stata and R packages, that can be used to easily implement the methods presented in this technical brief.

TABLE 3 | Tools for estimating the expected number of births or fertility rates for assessing completeness of birth registration

Method	MS Excel workbook	Stata	R	Other
Direct estimation of fertility rates		TFR2	DHS.rates::fert() (this requires v021 (PSU) and v022 (Strata) in addition to the input data presented above)	
Cohort parity comparison with CR data (mean number of births vs average parity of the same cohort)	FE_CohortVR_1			
Reverse survival	TDE, FE_Reverse_9 PAS, REVCBR			
Brass P/F ratio	Mortpark, FERTPF PAS, PFRATIO1		Fertestr::fertBrassPF()	
Relational Gompertz	TDE, FE_RelationalGompertz PAS, REL_GMPZ		Fertestr::fertGompPF()	
Record linkage			RecordLinkage	Open Rec Link

8 Conclusions

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This technical guidance note provides a general overview of the data and methods used for completeness assessment of birth registration data. It showcases the different methods that can be used to assess the completeness of birth registration.

We have emphasized the value and importance of assessing the completeness of birth registration, where possible, using multiple assessment methods and multiple data sources. The use of multiple data sources and methods is important to ensure the robustness of the assessment and identify any data inconsistencies and limitations of the assessment methods.

Data availability shapes the type of methods that can be used to assess birth registration completeness. As such, this note is designed to assist analysts, given available data and the country context, to identify the methods they can use to systematically assess birth registration completeness.

In addition to the links to computational resources in section 7, section 9 provides detailed technical references and suggested further reading.

9 List of Technical References and Suggested Further Reading

The following sources provide more comprehensive information on the implementation of various methods and their technicalities, including assumptions and detailed examples:

T. A. Moultrie and others, ***Tools for Demographic Estimation*** (Paris, International Union for the Scientific Study of Population, 2013). http://demographicestimation.iussp.org/.

Manual X: Indirect techniques for demographic estimation (United Nations Publication, Sales No. E.83.XIII.2, 1983). https://www.un.org/en/development/desa/population/publications/pdf/mortality/Manual_X.pdf.

The following resource describes an integrated and systematic procedure for census or survey data taking into account the nature of errors and deficiencies common in African data:

Brass W, United Nations Economic and Social Council, United Nations Economic Commission for Africa, "Uses of census or survey data for the estimation of vital rates," UN. ECA African Seminar on Vital Statistics (1964, Dec. 14–19: Addis Ababa, Ethiopia), 1964. https://hdl.handle.net/10855/9560.

The following resource provides more information on the implementation of the reformulated relational Gompertz method that addresses the weaknesses of the original method proposed by Brass:

B. Zaba, U***se of the relational Gompertz model in analysing fertility data collected in retrospective surveys*** (London, Centre for Population Studies, 1981).

The following guide provides more information on the direct method of estimating fertility as implemented in the DHS reports:

T.N. Croft and others, ***Guide to DHS Statistics***, (Rockville, Maryland, ICF, 2018). https://dhsprogram.com/publications/publication-dhsg1-dhs-questionnaires-and-manuals.cfm.

The following article provides a comprehensive implementation of birth registration completeness assessment using all available data in Brazil and details the strengths and weaknesses of different data sources and the plausibility of estimates from different assessment techniques:

E.E.C. Lima, B.L. Queiroz and K. Zeman, "Completeness of birth registration in Brazil: an overview of methods and data sources", ***Genus***, vol. 74, No. 11 (2018). https://doi.org/10.1186/s41118-018-0035-9.

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