Journal of Population Research (2024) 41:4
https://doi.org/10.1007/s12546-023-09317-8

ORIGINAL RESEARCH

A global and regional assessment of the timing of birth registration using DHS and MICS survey data

Tim Adair[1] · **Hang Li**[1]

Accepted: 23 August 2023 / Published online: 29 November 2023

Abstract

Registration of birth within the first year of life is important to ensure children receive its full benefits and that fertility statistics derived from these data are informative for policy. This study provides an up-to-date global and regional assessment of the timing of birth registration by using all available birth registration data of children aged less than five years reported in Demographic and Health Surveys and Multiple Indicator Cluster Surveys from 2010 onwards. We calculated adjusted age-specific birth registration completeness by converting period age-specific completeness data into a hypothetical cohort. Timing of birth registration was analysed using ratios of adjusted age-specific completeness, with differentials by region, over time, and level of completeness assessed using bivariate and multivariate analyses. Almost 20% of registered births in countries with incomplete birth registration (less than 95%) were not registered until after 12 months, and this has not improved since 2010. In several countries this figure is greater than 50%, particularly in South Asia. There remains considerable scope to improve the timeliness of birth registration, particularly in countries where the overall level of completeness is lower. Strengthening and enforcing legislation for the mandatory registration of births before age 12 months and greater involvement of the health sector in registration processes are two ways which will improve birth registration timing.

Keywords Birth registration · Vital statistics · Civil registration · Fertility

✉ Tim Adair
timothy.adair@unimelb.edu.au

Hang Li
hang.li@unimelb.edu.au

[1] The Nossal Institute for Global Health, Melbourne School of Population and Global Health, The University of Melbourne, Level 2, 32 Lincoln Square North, Melbourne, VIC 3010, Australia

Introduction

The registration of births provides several benefits for individuals, families and government. For individuals and families, the registration of a birth and issuance of a birth certificate provides proof of age, legal identification and entitlements, and facilitates citizenship, voting rights, and access to health care, social security, and education (Cappa et al., 2014; Corbacho et al., 2017; Setel et al., 2007; Szreter, 2007;UNICEF, 2002; UNICEF, 2013; World Health Organization, 2013). Given this importance, birth registration has been described as a fundamental human right (Todres, 2003). As a part of a civil registration and vital statistics (CRVS) system, high quality birth registration data also provide a timely and routine source of fertility statistics for government. Such fertility statistics are necessary to accurately measure fertility levels and patterns, as the denominator to calculate key maternal and child mortality indicators, to monitor and assess the implementation of family planning programs, and as a key demographic measure to project population size which inform planning for future government services (Abouzahr et al., 2015; Adair & Lopez, 2021; Phillips et al., 2018; United Nations Population Division, 2015; Yaya, 2015).

Much of the focus of assessments of birth registration completeness is on whether births are registered before a child is five years of age. This approach has formed the basis of UNICEF's measurement of birth registration completeness in the *State of the World's Children* and *Every Child's Birth Right* reports (UNICEF, 2013; UNICEF, 2019). This is consistent with Sustainable Development Goal 16.9 that aims to provide legal identity for all by 2030, including birth registration, and whose indicator is the percentage of children under the age of five years whose birth is registered with a civil authority (United Nations Department of Economic and Social Affairs, 2016). UNICEF's latest estimate is that 27% of children under five years globally have had not had their birth registered (UNICEF, 2019), and they estimate that in 2012 nearly 230 million children under age five do not officially exist because their birth had not been registered (UNICEF, 2013). Although the registration of a child's birth by age five years is important for access to education, among other services, registration that is delayed until a significant period of time after their birth can adversely affect their access to more immediate services (e.g. vaccination). Furthermore, delayed registrations reduce the utility of CRVS as a source of fertility statistics in terms of the timeliness of data and the quality of information provided by the informant, as well as these statistics providing an accurate denominator of total births which is critical for the calculation of early age mortality indicators such as neonatal, perinatal, infant and under-five mortality rates (United Nations Statistics Division, 2014). The United Nations Principles and Recommendations for a Vital Statistics System state that it is preferable that the maximum allowable period "…between the occurrence and the obligatory registration of a vital event be as short as possible so as to facilitate current and accurate registration", and that a grace period up to one year after the event may be allowed for extenuating circumstances (United Nations Statistics Division, 2014, p. 81). Events registered after the grace period are defined as "delayed registrations" by the United Nations that should not be included in published vital statistics because they would result in underestimates of births, even if there is close to complete registration of births by age five years (United Nations Statistics Division, 2014).

Birth registration completeness and timing is impacted by both supply- and demand-side factors. Supply-side factors include adequacy of the legal framework for civil registration, extent of coordination between different CRVS stakeholders, cost of registration and/or certification, availability and quality of registration infrastructure especially in remote and rural areas, capacity of the CRVS system to register all births, and sufficiency of funding of the CRVS system, especially to facilitate system digitisation (Abouzahr et al., 2015; Cobos et al., 2018; Kasasa et al., 2021; Setel et al., 2007; UNICEF, 2019). Significant investment in strengthening the birth registration component of CRVS systems have occurred in recent years (UNICEF, 2019). Digitisation of the birth registration has been a prominent investment and can potentially improve the efficiency of the birth registration process. This can enable not only increase registration of births but also timeliness of registration and compilation, analysis and publication of fertility statistics. Demand-side barriers include the extent of gender equality, household income, knowing that birth registration is mandatory, knowledge of the benefits of birth registration for children, parents' education, sufficiency of information on how to register a birth, statelessness, migrant or refugee status, ability to afford transport to access registration services and registration fees (Harbers, 2020; Wodon & Yedan, 2019; World Bank, 2018).

A previous study showed that in several countries a higher proportion of children aged 4 years were registered as compared with children aged less than 1 year (UNICEF, 2013). This tendency towards higher levels of birth registration among older children may be because, in certain contexts, the lack of a birth certificate prevents them from accessing education or some health services and so may increase demand for birth registration as children mature (UNICEF, 2013; World Health Organization, 2014). In sub-Saharan Africa, about three-quarters of children live in countries where there is a fee to register a birth, and so an understandable response by families would be to delay registration until it is essential to access services (Centre of Excellence for CRVS Systems, 2020). In Bangladesh, however, despite birth registration being free, families commonly register the birth just before school enrolment (UNICEF, 2022).

There is a need for an up-to-date assessment of data of the timing of birth registration to identify the extent to which registrations are delayed, which can help understand the utility of CRVS systems as a source of fertility statistics. The main objective of this study is to provide an up-to-date measurement of the timing of birth registration, globally and regionally, using Demographic and Health Survey (DHS) and Multiple Indicators Cluster Survey (MICS) data.

Methods

We used DHS and MICS data to measure the timing of birth registration. The sampling and questionnaires of the DHS and MICS are highly comparable (Hancioglu & Arnold, 2013). DHS are nationally representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition (Croft et al., 2020). More than 300 DHSs in over 90 countries have been conducted over several decades. MICS is an international household survey programme developed and supported by UNICEF. MICS is designed to

collect estimates of key indicators that are used to assess the situation of children and women. Since the inception of MICS in the 1990s, more than 320 surveys have been carried out in 116 countries over six survey rounds (Khan & Hancioglu, 2019).

We used all available DHS and MICS with birth registration data from 2010 onwards. We did not use data prior to 2010 because this period includes the MICS2 and MICS3 rounds, which use a different set of questions for birth registration compared with later MICS rounds and the DHS. In these earlier MICS, respondents were asked whether the child has a birth certificate and, if the certificate was not shown or if they didn't have a certificate, they were asked if the birth was registered. In later rounds of the MICS and also in all DHSs, respondents were asked whether the child has a birth certificate and, if they didn't have a certificate, they were asked whether the birth is registered. If the respondent said they have a certificate but it was not shown, then no further birth registration questions were asked (i.e. the birth is assumed to be registered). This contrasts with the MICS2 and MICS3, where a further question about birth registration was asked in this situation. We excluded surveys that could not provide birth registration information (mainly because of a different definition of key birth registration variables that cannot be converted to the definition used in other surveys: e.g. Malawi 2013-14, Liberia 2013). Overall, 191 surveys from 97 countries (87 of DHS over 53 countries and 104 of MICS on 64 countries) were included in our analysis, ranging from both 2010 to 2020 for each survey type (Supplementary Figs. 1–2 show reasons for all deleted surveys). For DHS, the birth registration question from the household members data file was the key variable used in this analysis; for MICS, the birth registration questions (from the module for children under five years were the key variables used (Supplementary Table 1).

We used the definition of birth registration completeness as the percentage of children at a given age whose birth was reported to be registered, irrespective of whether the child has a birth certificate. This definition is consistent with that used by UNICEF (UNICEF, 2013). Some surveys used different wording for registration, however for these we ensured that our results matched those in the survey report; if not, we did not use these surveys. All responses that were missing or 'don't know' were classified as 'unregistered', consistent with the UNICEF reporting of these data.

For each survey, we calculated birth registration completeness by age group. DHS only collects data by single year of age (0 years or less than 12 months, 1, 2, 3 and 4 years) while MICS classifies deaths less than 12 months into less than 6 months and 6–11 months. Registration completeness according to age group, however, is not equivalent to the timing of completeness if birth registration completeness has been changing over time. For example, if a survey showed that birth registration completeness was 70% at 0 years (i.e. less than 12 months) and also 70% at 4 years (i.e. at least exact 4 years and less than 5 years), this could be interpreted that there is no issue with the timing of birth registration completeness in this population. However, if there had been increases in birth registration completeness in recent years, then the birth registrations of children aged 4 years would have occurred during a period of overall lower completeness than those of children aged 0 years. Hence, completeness of birth registration of children at age 4 years would be higher than those of children aged 0 years when compared to the prevailing overall level of completeness (at all ages) during the period within which the children's births could be registered. There-

fore, in this example, comparison of the timing of birth registration using completeness at age 4 years with aged less than 12 months would be biased.

To account for this potential bias caused by the trend in the overall level of birth registration completeness, we calculated adjusted birth registration completeness at each age. We did this by constructing a hypothetical cohort of children by converting period data of age-specific birth registration completeness using the rate of growth of birth registration completeness at ages 0–4 years. A hypothetical cohort estimates the timing of birth registration rather than differences in completeness by age of child. We firstly calculated the annual growth rate of birth registration completeness for each country over the entire period since 2000, which includes a period prior to our analysis to reduce fluctuation in growth rates for a country but excludes those earlier MICS for which the survey questions were different. We included DHSs prior to 2010 to provide a longer-term estimate of birth registration change rather than just the past few years, and to include more countries with multiple surveys. To calculate the annual rate of growth of birth registration completeness, we used a linear regression with a dependent variable of the natural log of completeness at age 0–4 years with a covariate of the mid-point of the survey data collection:

$$ln\left(C_{0-4}\right) = \beta_0 + \beta_1 t$$

where $C0-4$ is birth registration completeness at ages 0–4 years and t is the mid-point of the survey data collection period (in calendar years). The coefficient β_1 is the annual rate of growth of birth registration completeness at ages 0–4 years. For countries with only one survey, we could not adjust the actual completeness because we could not calculate the birth completeness growth rate.

The rate of growth of birth registration completeness was used to calculate adjusted completeness by age as follows:

$$\widehat{C_a} = C_a * e^{r(a-2.5)}$$

where C_a is reported completeness at age a years (the mid-point of the age group, so 0.5 for less than 12 months),$\widehat{C_a}$ is adjusted completeness at age a years, and r is the annual rate of growth (β_1 from the previous equation). This centres the hypothetical cohort around age 2.5 years, or the mid-point of the age group 0–4 years, so that the mid-point of the hypothetical cohort also matches the mid-point of the survey data collection. Figure 1 shows an example of a hypothetical cohort, where the survey data collection was the calendar year of 2015. The hypothetical cohort of ages 0–4 years spans the five-year period 2013-17, with a mid-point of mid-2015 matching the data collection mid-point of mid-2015. If the reported completeness at age 0 years is 70% and at age 4 years is also 70% (as in the example above), and the annual growth rate of completeness is 2.5%, the adjustment is as follows:

$$\widehat{C_{0.5}} = C_{0.5} * e^{0.025(0.5-2.5)} = 70\% * e^{0.025(-2.0)} = 66.6\%$$

$$\widehat{C_{4.5}} = C_{4.5} * e^{0.025(4.5-2.5)} = 70\% * e^{0.025(2.0)} = 73.6\%$$

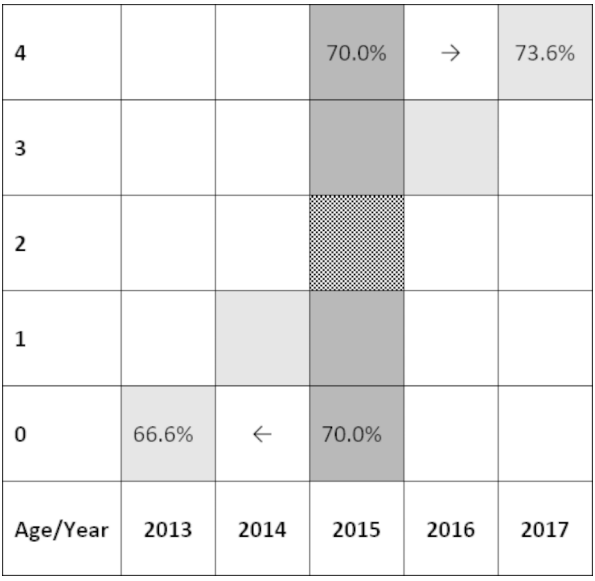

Fig. 1 Example of hypothetical cohort. Dark gray: Survey data collection period (2015). Light gray: Hypothetical cohort. Grid: Overlap of data collection period and hypothetical cohort.

For age group 4 years, the calculation projects completeness forward to 2017.

We present results for adjusted birth registration completeness by age for all surveys and also only for MICS surveys (to show for ages less than 6 months and 6–11 months separately). Different summary metrics of timing of birth registration used for all surveys are: (1) the ratio of births registered at 0 years to 4 years, (2) the ratio of births registered at 1 years to 4 years (to allow for registration of births by exact age 12 months) and, (3) for MICS surveys only, the ratio of births registered at 6–11 months to 4 years. Completeness at 4 years is used as the denominator because it shows completeness in the oldest age group, i.e. eventual birth registration completeness. We also present the inter-quartile range of ratios to demonstrate variation across surveys. Results are disaggregated by level of completeness at age 4 years (eventual birth registration) to assess whether timing of birth registration is better or worse at higher levels of completeness.

Results are analysed by Global Burden of Disease super region (Global Burden of Disease Collaborative Network, 2020) and, for each of the four regions of sub-Saharan Africa, the super region which has the most number of surveys. We conducted linear regressions with each of the three ratios (natural logarithm) as the outcome variable, with covariates of level of completeness at 4 years, year of survey and super region, to ascertain whether the timing of birth registration is significantly predicted by level of completeness, whether there has been an improvement in timing of registration over time, and whether timing varies by region. Each regression adjusted standard errors for clustering at the country level. We also analyse results by sex of child, to assess whether differences in timing of registration between male and female children exists. Results are also presented for Indian states to explore subnational differences in timing of birth registration, given that several states have populations equivalent to large countries.

Results

Overall, birth registration completeness increased with age, as expected, with the average adjusted completeness for all surveys being 66% at age 0 year and 78% at 4 years (Table 1). There was a lower ratio of completeness at ages 0 years to 4 years compared with higher levels of completeness at age 4 years. Where completeness at age 4 years was below 95% the ratio of completeness at 0 to 4 years was 78%, while if completeness at age 4 years was over 95% then this ratio was 96%. The ratio of completeness at 0 to 4 years was 72% where completeness at age 4 years was 50 < 75% and 78% where completeness was less than 50%. However, as demonstrated by the inter-quartile range, there was considerable variation in the ratios. By age 1 year, the ratio to completeness at 4 years was on average above 80% for each category of completeness level, with a narrower inter-quartile range. According to unadjusted data, the ratio of completeness at both 0 to 4 years (89%) and 1 to 4 years (95%) was higher than using adjusted estimates, because of higher completeness at 0 year and lower at completeness at 4 years (Supplementary Table 2).

Comparing the adjusted and unadjusted results, the adjusted completeness for all surveys changes from 65.8% to 0 years to 78.0% in 4 years, while unadjusted completeness changes from 67.2 to 76.2%, showing a slight narrowing of the difference. These narrower differences also can be found in unadjusted results in each sub-category group, as well as the ratio difference between 0 and 4 years and 1 to 4 years. Adjusted and unadjusted results for all surveys are shown in Supplementary File 2.

The results using MICS data show that the average ratio of completeness at 6–11 months to 4 years was 79% where the completeness level was below 95%, similar to that of 0 to 4 years from all surveys (Table 2). At more specific levels of completeness, the ratio of completeness at 6–11 months to 4 years was again similar to that at 0 to 4 years from all surveys, being 85% at completeness of 75 < 95%, 70% at 50 < 75% and 82% at less than 50% (Table 2). Again, this ratio was higher at 1 to 4 years.

Limiting the analysis to the most recent year of each included country, which removes the impact of multiple surveys in the one country, the ratio of completeness at 0 to 4 years at all completeness levels and also at completeness less than 95% was slightly higher than in Table 1 (83% for completeness less than 95%), as was the ratio 6–11 months to 4 years in MICS (81% for completeness less than 95%) (Supplementary Tables 3 & 4). Other patterns of difference between more specific categories of

Table 1 Average age-specific completeness and ratio of age-specific completeness (adjusted, %), by level of completeness at 4 years, all survey years, DHS and MICS

Completeness age 4 years (number of surveys)	Age (years)					Ratio (mean, 25th and 75th percentiles)					
	0	1	2	3	4	0 / 4			1 / 4		
All (191)	65.9	72.5	74.6	76.1	78.1	84.9	76.9	99.2	91.8	87.6	99.9
95+% (74)	92.9	97.3	98.0	98.7	99.2	95.8	95.4	99.9	98.0	98.1	100.0
<95% (117)	48.8	56.8	59.9	61.9	64.7	78.0	64.8	91.3	87.9	79.5	98.1
75 < 95% (46)	68.7	77.0	80.2	82.2	85.1	83.9	77.4	92.4	90.5	87.3	96.8
50 < 75% (41)	45.4	55.6	59.5	62.2	66.1	71.5	55.1	89.6	83.8	74.5	98.1
<50% (30)	23.0	27.6	29.1	30.3	31.6	77.9	63.9	94.4	89.4	80.4	99.4

Table 2 Average registered age-specific completeness and ratio of age-specific completeness (adjusted, %), by level of completeness at 4 years, all survey years, MICS only

Completeness age 4 years (number of surveys)	Age						Ratio (mean, 25th and 75th percentiles)					
							6–11 months / 4 years			1 year / 4 years		
	<6 mths	6–11 mths	1 year	2 years	3 years	4 years						
All (104)	71.0	77.9	80.3	82.1	83.6	85.4	89.2	86.1	99.7	92.7	90.6	100.0
95+% (59)	90.9	96.6	97.8	98.4	99.0	99.4	97.2	97.1	99.9	98.3	98.5	100.0
<95% (45)	45.0	53.4	57.4	60.8	63.5	67.1	78.8	63.9	91.2	85.4	78.7	96.0
75<95% (18)	64.9	73.2	75.7	79.6	82.4	85.9	85.2	80.7	92.9	88.0	87.1	94.8
50<75% (17)	36.3	46.0	52.7	57.1	60.7	65.4	70.1	54.7	89.3	80.5	65.0	95.4
<50% (10)	23.9	30.2	32.4	33.2	34.2	36.3	81.8	76.9	94.6	88.9	82.3	100.8

mths: months

completeness levels remain similar, with the lowest ratio again being for 50<75% completeness.

The sex differences in the birth registration completeness and the ratio of completeness at 0 to 4 years is very small. For all surveys, the average birth registration completeness at each age there was less than 1% point difference between males and females, while the ratio of completeness at 0 and 1 to 4 years was also within 1% point between each sex (Supplementary Table 5). Very similar results were also found at 95+% and 75<95% completeness at 4 years, with a slightly higher ratio for females than males at 50<75% (ratio 0 to 4 years: males 71.6%, females 54.0%) and <50% completeness at 4 years (ratio 0 to 4 years: males 77.5%, females 81.5%). Very similar results were also found for MICS (Supplementary Table 6). Results for each survey are also shown in Supplementary File 2.

Based on the most recent survey data of 97 countries, the average ratio of completeness at 0 to 4 years was over 90% in High-income countries, followed by Central Europe, Eastern Europe, and Central Asia, Latin America and Caribbean and North Africa and Middle East (Table 3). The lowest average ratio was found in South Asia, at 71%, which increases to 80% for the ratio 1 to 4 years. In sub-Saharan Africa (where the level of completeness at 4 years was clearly lowest at only 66%), South-east Asia, East Asia, and Oceania, the average ratio at 0 to 4 years was between 80 and 90% and was slightly higher for the ratio at 1 to 4 years.

Specific to regions in Sub-Saharan Africa, the ratio at age 0 to 4 years was lowest in the four countries in Southern Sub-Saharan Africa at only 60% and was 78% for the ratio at 1 to 4 years. However, in other regions the ratio at 0 to 4 years was above 85%. Sex differences in the ratio of completeness at 0 to 4 years were minimal for each super-region and region, except for in Central sub-Saharan Africa where it was higher 10% points for females than males (Supplementary Table 7). In South Asia, the ratio at 0 to 4 years was 71% and for 1 to 4 years 81%. In India in 2019-21, the ratio of completeness at 0 to 4 years of 78% and at 1 to 4 years of 86% (Supplementary File 2), higher than the average ratios for the five surveys in South Asia. However, it was lower than the respective average ratios of 96% and 98% for all surveys in our study where completeness at age 4 years was at least 95% (see Table 1). Results for each Indian state and territory from the 2019-21 National Family Health Survey (NFHS) are presented in Supplementary File 3. Several states had a ratio of completeness at age 0 to 4 years below 75%: Andhra Pradesh (73%), Arunachal Pradesh (69%), Bihar (74%), Jharkhand (68%), Madhya Pradesh (69%), Meghalaya (69%), Nagaland (63%) and Rajasthan (72%).

Similarly, among 64 countries with MICS survey data, South Asia had the lowest ratio of completeness at age 6–11 months to 4 years of 72%, while in all other super-regions it was at least 83% (Table 4). The ratio was again also very low in the Southern Sub-Saharan African region 58%, but over 80% in other sub-Saharan African regions.

In the three regressions we conducted – with outcome variables of the ratio (natural logarithm) at 0 to 4 years, 1 to 4 years, and 6–11 months to 4 years (MICS only) – the variable of survey year was not significant, indicating that timing of birth registration has not improved since 2010, controlling for level of completeness (Tables 5 and 6, Supplementary Table 8). The ratio of completeness 6–11 months to 4 years for

Table 3 Average registered completeness at age 4 years and ratio of age-specific completeness (adjusted, %), by super region, most recent year, DHS and MICS

Super region	Number of surveys	Completeness (age 4 years)	Ratio 0 years / 4 years	Ratio 1 year / 4 years
Central Europe, Eastern Europe, and Central Asia	12	99.8	98.6	99.4
High-income	2	99.9	99.9	99.9
Latin America and Caribbean	17	98.7	93.9	97.6
North Africa and Middle East	9	84.5	102.4	103.8
South Asia	5	84.5	71.4	80.6
Southeast Asia, East Asia, and Oceania	13	89.9	83.6	92.3
Sub-Saharan Africa	39	65.6	84.9	92.1
Central Sub-Saharan Africa	*5*	*61.3*	*86.1*	*92.5*
Eastern Sub-Saharan Africa	*12*	*55.0*	*91.0*	*99.4*
Southern Sub-Saharan Africa	*4*	*63.4*	*60.1*	*78.3*
Western Sub-Saharan Africa	*18*	*74.3*	*86.1*	*90.2*
Total	97	82.3	89.2	94.6

MICS was positively associated with the level of completeness, but the ratios of 0 to 4 years and 1 to 4 years were not. Being a country in South Asia negatively predicted each ratio compared with the reference group of Central Europe, Eastern Europe, and Central Asia, while being in Latin America negatively predicted two ratios and Southeast Asia, East Asia and Oceania also negatively predicted two ratios, and being Sub-Saharan Africa negatively predicted one ratio. Whether the survey was a MICS was not a predictor of the ratio. Supplementary Tables 9 and 10 show that the sex covariate is non-significant for both all surveys and just MICS surveys.

The countries with the lowest ratio of completeness at 0 to 4 years include Bangladesh, where each ratio was below 50%, ranging from 14% in the 2011 survey (where just 8% of children aged 0 years had their birth registered) up to 45% in 2012-13 (where 25% of children aged 0 years had their birth registered) (Table 7). Even at age 1 year, completeness was only about half that of 4 years. Similar results were found in another South Asian country, Nepal, where the ratio of completeness at 0 to 4 years is below 50%, being 35% in 2016, where only 29% of children at 0 years had their birth registered compared with 83% at 4 years. At 1 year, completeness is just over half that of age 4 years. There was also a very low completeness at age 0 years in three sub-Saharan African countries – Angola (12%), Guinea Bissau (12%) and Mozambique (27%) – and a ratio to 4 years of only about one-third. Timor Leste had a completeness at age 0 years of about half that at age 4 years, but this ratio did increase to 75% at age 1 year.

Using the ratio of completeness at 6–11 months to 4 years from MICS below a threshold of 70% also comprises multiple surveys from Bangladesh and Nepal, where

Table 4 Average registered completeness at age 4 years and ratio of age-specific completeness (adjusted, %), by super region, most recent year, MICS

Super region	Number of surveys	Completeness (age 4 years)	Ratio 6–11 months / 4 years	Ratio 1 year / 4 years
Central Europe, Eastern Europe, and Central Asia	9	100.0	99.7	99.8
High-income	2	99.9	99.9	99.9
Latin America and Caribbean	15	99.0	96.1	97.9
North Africa and Middle East	6	89.1	100.7	101.6
South Asia	3	90.7	71.9	79.0
Southeast Asia, East Asia, and Oceania	7	92.1	87.6	94.0
Sub-Saharan Africa	22	70.5	83.4	87.4
Central Sub-Saharan Africa	*3*	*62.4*	*97.8*	*97.1*
Eastern Sub-Saharan Africa	*2*	*57.9*	*96.9*	*101.3*
Southern Sub-Saharan Africa	*3*	*61.1*	*58.0*	*72.7*
Western Sub-Saharan Africa	*14*	*76.0*	*83.9*	*86.5*
Total	64	87.3	90.7	93.7

Table 5 Regression results of natural logarithm of ratio of completeness (adjusted) at age 0 to age 4 years, both survey types

	Coefficient	Robust Std. err.^	P>t
Completeness age 4 years (adjusted)	0.277	0.141	0.053
Survey year	0.005	0.005	0.301
Super region (ref. Central Europe, Eastern Europe, and Central Asia)			
High-income	0.005	0.017	0.790
Latin America and Caribbean	-0.078*	0.036	0.033
North Africa and Middle East	0.056	0.043	0.195
South Asia	-0.670**	0.176	0.000
Southeast Asia, East Asia, and Oceania	-0.148**	0.052	0.006
Sub-Saharan Africa	-0.097	0.055	0.081
Survey type (ref. DHS)			
MICS	0.039	0.047	0.412
Constant	-11.232	10.452	0.285

N = 191. Ref.: Reference group. Std. err.: Standard error

** p<0.01 * p<0.05 ^ Adjusted for clustering at country–level

the ratio ranged between 44% and 63% (Table 8). In almost all other countries in this list, the ratio was over 50%, although the actual level of completeness at 6–11 months was as low as 12% in Chad. In these countries, there were moderately higher ratios in these countries for 1 to 4 years, although it was still below 70% in most countries.

Table 6 Regression results of natural logarithm of ratio of completeness (adjusted) at age 6–11 months to age 4 years, MICS only

	Coefficient	Robust Std. err. ^	P>t
Adjusted registered completeness at age 4 years	0.410*	0.171	0.019
Survey year	-0.004	0.005	0.393
Super region (ref. Central Europe, Eastern Europe, and Central Asia)			
High-income	0.004	0.006	0.474
Latin America and Caribbean	-0.038**	0.012	0.003
North Africa and Middle East	0.030	0.026	0.249
South Asia	-0.463**	0.126	0.000
Southeast Asia, East Asia, and Oceania	-0.090	0.049	0.072
Sub-Saharan Africa	-0.103	0.054	0.061
Constant	7.629	9.271	0.414

N = 104. Ref.: Reference group

** p<0.01 * p<0.05 ^ Adjusted for clustering at country−level

Table 7 Surveys where ratio of completeness (adjusted) at 0 to 4 years was less than 50%

			Completeness (age in years)			Ratio of completeness	
Type	Survey	Super region	0	1	4	0 / 4	1 / 4
DHS	Bangladesh 2011	South Asia	7.9	17.7	57.6	13.7	30.7
MICS	Bangladesh 2012-13	South Asia	24.5	30.3	54.9	44.6	55.2
DHS	Bangladesh 2014	South Asia	8.5	15.3	32.5	26.1	47.2
DHS	Bangladesh 2017-18	South Asia	11.7	18.9	39.7	29.4	47.6
DHS	Nepal 2011	South Asia	17.4	37.1	66.3	26.2	55.9
MICS	Nepal 2014	South Asia	36.4	45.1	82.0	44.4	55.0
DHS	Nepal 2016	South Asia	29.4	44.6	83.4	35.2	53.5
DHS	Angola 2015-16	Sub-Saharan Africa	11.5	21.1	34.2	33.5	61.9
MICS	Guinea Bissau 2014	Sub Saharan Africa	11.7	19.2	40.4	29.1	47.4
DHS	Mozambique 2011	Sub-Saharan Africa	26.7	42.8	62.9	42.4	68.1
DHS	Timor-Leste 2016	Southeast Asia, East Asia, and Oceania	37.0	55.7	74.8	49.5	74.5

Discussion

Our analysis demonstrates that, globally, the timing of birth registration has considerable scope for improvement. Although we could not precisely measure completeness by age 12 months, in line with United Nations recommendations (United Nations Statistics Division, 2014), it is clear that, on average, over 20% of births in countries with incomplete registration (less than 95%) that were registered by age five years were not registered until after 12 months. Furthermore, analysis of trends shows that this ratio has not improved since 2010. There is also considerable variation in the timing of birth registration. The results reveal that, in South Asia in particular and to a lesser extent Southeast Asia, East Asia and Oceania, Latin America/Caribbean and southern sub-Saharan Africa, timing of birth registration is relatively poor. Some countries such as Nepal, Bangladesh, Mozambique, Angola, Guinea Bissau and

Table 8 MICS where ratio of completeness (adjusted) at 6–11 months to 4 years was less than 70%

		Completeness (age)			Ratio of completeness	
Survey	Super region	6–11 months	1 year	4 years	6–11 months / 4 years	1 year / 4 years
Bangladesh 2012-13	South Asia	24.5	30.3	54.9	44.6	55.2
Bangladesh 2019	South Asia	39.4	48.2	74.9	52.6	64.4
Nepal 2014	South Asia	36.4	45.1	82.0	44.4	55.0
Nepal 2019	South Asia	61.4	70.7	97.2	63.1	72.7
Chad 2010	Sub-Saharan Africa	11.9	15.9	18.6	63.9	85.3
Guinea Bissau 2014	Sub-Saharan Africa	11.7	19.2	40.4	29.1	47.4
Guinea Bissau 2018-19	Sub-Saharan Africa	33.1	40.3	63.8	51.9	63.3
The Gambia 2010	Sub-Saharan Africa	42.2	52.6	66.8	63.1	78.7
The Gambia 2018	Sub-Saharan Africa	40.8	50.4	73.2	55.7	68.9
Lesotho 2018	Sub-Saharan Africa	30.1	39.4	55.9	53.8	70.4
Zimbabwe 2019	Sub-Saharan Africa	37.0	46.6	56.4	65.6	82.7
Samoa 2019	East Asia, and Oceania	46.3	63.4	80.9	57.2	78.3
Eswatini 2010	Sub-Saharan Africa	38.8	40.6	70.4	55.1	57.7
Eswatini 2014	Sub-Saharan Africa	38.9	46.2	71.1	54.7	65.0

Timor Leste, showed late registration. In these countries, the benefits of birth registration may be focused on those where registration within the first year of life is not necessary, such as enrolment for education and/or other social requirements, rather than for benefits that require birth registered in infancy, such as access to child health services. There are however only very small differences in timing of birth registration according to sex of child, which confirms findings of previous analysis of these data sources of very similar levels of birth registration completeness between male and female children (UNICEF, 2013).

Previous research has explored barriers to birth registration using the Three Delays Framework, which assesses factors affecting (1) the decision to register a birth (e.g. knowledge, financial resources), (2) access to registration facilities (e.g. distance, transport), and (3) service provision at the registration facilities (Bennouna et al., 2016). It is likely all three sets of factors have affected timing of registration in various countries. High levels of late registration are likely to be due to difficulties that many families face in registering births – such as remoteness from registration offices or cost – that may make it especially difficult in the first year of life, as well as lack of knowledge among families about the benefits of timely registration (Wodon & Yedan, 2019; World Bank, 2018). These difficulties can explain much of the regional differences in the timing of registration. In sub-Saharan Africa, fees for birth registration are common in most countries and can be very expensive for families, while lack of proximity to the nearest registration office and lack of knowledge about the process of birth registration are frequently cited as barriers to birth registration (Centre of Excellence for CRVS Systems, 2020; UNICEF, 2017). In Tanzania, an additional reason that may explain late registration is that some families mistakenly believe the birth notification form provided by a hospital is the birth certificate (Reed et al., 2021). The late registration in Bangladesh corresponds with previous literature that families commonly only register the birth just before school enrolment (UNICEF, 2022). In Nepal, the poor timing of registration may reflect the government's focus on increasing the number of births registered irrespective of whether they occur in the first year of life, as shown by the almost doubling of registration from 42% in the 2011 DHS to 77% in the 2019 MICS. Timing of registration can also be distorted by other government programs; in the Nepalese province of Karnali, a project to provide cash grants for children under five years of age led to a rapid increase in birth registration completeness from 40% to 2010 to 90% in 2013 because the child's birth was required registered at any age less than five years in order to access the grant (Rabi et al., 2015).

Globally and in particular in certain regions and countries, a higher proportion of births need to be registered in the first year of life to facilitate the access of children to the full benefit of services enabled by birth registration and for the potential of birth registration data to be realized as a source of data for fertility statistics. More timely registration could be achieved by strengthening and enforcing legislation for the mandatory registration of births before age 12 months. Enabling greater involvement of the health sector in registration of births occurring at health facilities and attended by trained midwives by notifying the civil registry office of the occurrence of the birth, and also improving access of more rural and remote populations to birth registration, including through the use of mobile registration agents, can also lead

to more timely birth registration (Adair et al., 2020; Jackson et al., 2018). Financial incentives to families to register births may also be an effective option, however, as in Nepal, these can potentially lead to more untimely registrations if they do not stipulate registration within the first 12 months (World Bank, 2018). The results in this study do make it clear however that not only the timing of birth registration needs to be improved, but that registration before age five years also remains sub-optimal as so can be considerably strengthened from the current average of just 62% in the 117 surveys where registration was incomplete (less than 95%). Undoubtedly continued digitisation of CRVS processes will improve timeliness of registration. This will help ensure that data of registered births are compiled, assessed for quality and analyzed and reported as fertility statistics in a timely manner by the national statistics office.

There are some limitations of our study. Firstly, the birth registration data are reported by survey respondents and so there is no certainty that the births have indeed been registered with the government; many respondents who reported a birth has registered could not show a birth certificate as evidence. A previous analysis found that levels of birth registration reported in surveys are consistently higher than birth statistics generated from registration data; reasons for this may include that respondents are concerned that reporting non-registration may lead to them being penalised, that reporting that a child's birth has been registered may be seen as socially desirable, and also because data are only collected for live children and registration levels of deceased children are likely to be lower (Adair & Lopez, 2021; Kumar & Saikia, 2021). For these reasons, over-reporting of birth registration may be more common among older children rather than younger children (especially for concerns about being penalised) or among higher socio-economic groups (who may have greater knowledge of the need to register a child). We adjusted completeness of registration to account for the fact that it is a period rather than cohort measure, and as such it is dependent on the accuracy of our estimate of the rate of change in the level of completeness at 0–4 years. This adjustment had a moderate impact on the measurement of the timeliness of birth registration, with the adjusted ratio of completeness at 0 to 4 years being 78% compared with the unadjusted ratio of 84%. While we do not know for sure what the true level of completeness is for these specific cohorts around the time of each country's survey, the adjustment was necessary to remove any bias where the rate of growth was particularly strong. The Peru continuous DHS and Senegal continuous DHS, that have been conducted annually, allow for more detailed construction of cohorts of children and therefore closer assessment of timing of their birth registration. Such an analysis is beyond the scope of this study, which is a global assessment of timing of birth registration, but would be informative in understanding the consistency of reporting of age-specific birth registration over successive surveys.

As mentioned, there was no available data to specifically measure "timely birth registration", which the United Nations does not specifically define but they describe as being as short as possible after birth with "a grace period up to one year after the event may be allowed for extenuating circumstances" (United Nations Statistics Division, 2014, p. 81). As a result, we had to use age 0 years for DHS, which is an average age of 6 months, and 6–11 months for MICS which is an average age of 9 months. However, in conjunction with data at age 1 years, we were still able to gain

a strong understanding of the percentage of births registered at age 4 years which are registered by age 1 year. Some DHS, for example the Indonesia 2012 and 2017 DHS, have asked respondents to report what age the child's birth was registered, however the results of this question have neither been published nor available in publicly available survey datasets (National Population and Family Planning Board et al., 2018; Statistics Indonesia et al., 2013). Either this question, or a question of the date of registration that can be used with date of birth to calculate age at registration, would be helpful to understand timing of birth registration, but the utility of such data would be reliant on its accuracy. Finally, although DHS and MICS altogether covered many countries around the world, some countries still not be included. Moreover, for some countries the most recent survey was several years ago, therefore the completeness levels used in this analysis may differ from their present level.

This study has found that there remains considerable scope for birth registration to be more timely, particularly in countries where the overall level of completeness is lower. Concerted efforts should be made by governments to increase the proportion of births registered in the first year of life to increase the ability of families to benefit from having their child's birth registered in a timely manner and also to improve the accuracy of fertility statistics.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions.

Declarations

Competing interests The authors have no relevant financial or non-financial interests to disclose.

References

Abouzahr, C., de Savigny, D., Mikkelsen, L., Setel, P., Lozano, R., Nichols, E., Notzon, F., & Lopez, A. (2015). Civil registration and vital statistics: Progress in the data revolution for counting and accountability. *Lancet*, *386*, https://doi.org/10.1016/S0140-6736(15)60173-8.

Adair, T., & Lopez, A. (2021). How reliable are self-reported estimates of birth registration completeness? Comparison with vital statistics systems. *PloS ONE*, *16*, e0252140. https://doi.org/10.1371/journal.pone.0252140.

Adair, T., Rajasekhar, M., Bo, K., Hart, J., Kwa, V., Mukut, M., Reeve, M., Richards, N., Ronderos-Torres, M., de Savigny, D., Cobos, D., & Lopez, A. (2020). Where there is no hospital: Improving the notification of community deaths. *BMC Medicine*, *18*, https://doi.org/10.1186/s12916-020-01524-x.

Bennouna, C., Feldman, B., Usman, R., Adiputra, R., Kusumaningrum, S., & Stark, L. (2016). Using the three delays model to examine civil registration barriers in Indonesia. *Plos One*, 11(12), e0168405.

Cappa, C., Gregson, K., Wardlaw, T., & Bissell, S. (2014). Birth registration: A child's passport to protection. *The Lancet Global Health*, *2*, e67–e68. https://doi.org/10.1016/S2214-109X(13)70180-3.

Centre of Excellence for CRVS Systems (2020). *Improving birth registration for an inclusive Africa*. Centre of Excellence for CRVS Systems. https://crvssystems.ca/blog/improving-birth-registration-inclusive-africa.

Cobos, D., Abouzahr, C., & de Savigny, D. (2018). The 'Ten CRVS milestones' framework for understanding Civil Registration and Vital Statistics systems. *BMJ Global Health*, *3*, e000673. https://doi.org/10.1136/bmjgh-2017-000673.

Corbacho, A., Brito, S., & Osorio, R. (2017). Does Birth under- registration reduce Childhood Immunization? Evidence from the Dominican Republic. *Inter-American Development Bank Health Economics Review*, *7*, https://doi.org/10.1186/s13561-017-0149-3.

Croft, T. N., Aileen, M. J., Marshall, C. K., Allen, et al. (2020). *Guide to DHS statistics*. Rockville.

Global Burden of Disease Collaborative Network (2020). *Global Burden of Disease Study 2019 (GBD 2019) Results*. https://www.healthdata.org/gbd/gbd-2019-resources.

Hancioglu, A., & Arnold, F. (2013). Measuring Coverage in MNCH: Tracking Progress in Health for Women and Children using DHS and MICS Household surveys. *PloS Medicine*, *10*, e1001391. https://doi.org/10.1371/journal.pmed.1001391.

Harbers, I. (2020). Legal identity for all? Gender inequality in the timing of birth registration in Mexico. *World Development*, *128*, 104778. https://doi.org/10.1016/j.worlddev.2019.104778.

Jackson, D., Wenz, K., Muniz, M., Abouzahr, C., Schmider, A., Braschi, M., Kassam, N., Diaz, T., Mwamba, R., Setel, P., & Mills, S. (2018). Civil registration and vital statistics in health systems. *Bulletin of the World Health Organization*, *96*, 861–863. https://doi.org/10.2471/BLT.18.213090.

Kasasa, S., Natukwatsa, D., Galiwango, E., Nareeba, T., Gyezaho, C., Fisker, A., Mengistu, M., Dzabeng, F., Haider, M., Yargawa, J., Akuze, J., Baschieri, A., Cappa, C., Jackson, D., Lawn, J., Blencowe, H., & Kajungu PhD, D. (2021). Birth, stillbirth and death registration data completeness, quality and utility in population-based surveys: EN-INDEPTH study. *Population Health Metrics*, *19*. https://doi.org/10.1186/s12963-020-00231-2.

Khan, S., & Hancioglu, A. (2019). Multiple Indicator cluster surveys: Delivering Robust data on children and women across the Globe. *Studies in Family Planning*, *50*(3), 279–286. https://doi.org/10.1111/sifp.12103.

Kumar, K., & Saikia, N. (2021). Determinants of birth registration in India: Evidence from NFHS 2015–16. *Plos One*, *16*(9), e0257014.

National Population and Family Planning Board (BKKBN), Statistics Indonesia (BPS), Ministry of Health (Kemenkes), and ICF. (2018). *Indonesia Demographic and Health Survey 2017*. Jakarta, Indonesia. BKKBN, BPS, Kemenkes, and ICF.

Phillips, D., Adair, T., & Lopez, A. (2018). How useful are registered birth statistics for health and social policy? A global systematic assessment of the availability and quality of birth registration data. *Population Health Metrics*, *16*, 21. https://doi.org/10.1186/s12963-018-0180-6.

Rabi, A., Koehler, G., Okubo, T. (2015). Strategies and options for scaling-up and enhancing the Child Grant nationally in Nepal. UNICEF Nepal Working Paper. https://www.un.org/esa/socdev/csocd/2016/Nepalchildgrant-GK.pdf.

Reed, S., Shabani, J., Boggs, D., Salim, N., Ng'unga, S., Day, L. T., Peven, K., Kong, S., Ruysen, H., Jackson, D., Shamba, D., Lawn, J. E., & Group, E. B. S. (2021). Counting on birth registration: Mixed-methods research in two EN-BIRTH study hospitals in Tanzania. *BMC Pregnancy and Childbirth*, *21*(1), 236. https://doi.org/10.1186/s12884-020-03357-1.

Setel, P., Macfarlane, S., Szreter, S., Mikkelsen, L., Jha, P., Stout, S., & Abouzahr, C. (2007). Who Counts? 1 – A scandal of invisibility: making everyone count by counting everyone. *Lancet*, *370*. https://doi.org/10.1016/S0140-6736(07)61307-5.

Statistics Indonesia (Badan Pusat Statistik—BPS), National Population and Family Planning Board (BKKBN), and Kementerian Kesehatan (Kemenkes—MOH), and ICF International (2013). Indonesia Demographic and Health Survey 2012. Jakarta, Indonesia. BPS, BKKBN, Kemenkes, and ICF International.

Szreter, S. (2007). The Right of Registration: Development, Identity Registration, and Social Security—A historical perspective. *World Development*, *35*, 67–86. https://doi.org/10.1016/j.worlddev.2006.09.004.

Todres, J. (2003). Birth Registration: An essential first step toward ensuring the Rights of all children. *Human Rights Brief*, *10*, 32–35. https://digitalcommons.wcl.american.edu/cgi/viewcontent.cgi?article=1422&context=hrbrief.

UNICEF. (2013). *Every child's Birth Right: Inequities and trends in birth registration*. UNICEF. https://www.un.org/ruleoflaw/files/Embargoed_11_Dec_Birth_Registration_report_low_res.pdf.
UNICEF. (2017). *A snapshot of Civil Registration in Sub-Saharan Africa*. UNICEF. https://data.unicef.org/resources/snapshot-civil-registration-sub-saharan-africa/.
UNICEF. (2019). *The state of the world's children 2019. Children, food and nutrition: Growing well in a changing world*. UNICEF. https://www.unicef.org/reports/state-of-worlds-children-2019.
UNICEF (2019). *Birth Registration for Every Child by 2030: Are we on track?* UNICEF. New York, USA. https://data.unicef.org/resources/birth-registration-for-every-child-by-2030/.
UNICEF (2022). *Timely and accessible birth registration*. UNICEF. Retrieved May 24 from https://www.unicef.org/bangladesh/en/timely-and-accessible-birth-registration.
UNICEF, & Florence (2002). *Birth Registration: Right from the start*. UNICEF. https://www.unicef-irc.org/publications/pdf/digest9e.pdf.
United Nations Population Division (2015). *Demographic Components of Future Population Growth: 2015 Revision*. United Nations Department of Economic and Social Affairs. Retrieved May 11 from http://www.un.org/en/development/desa/population/theme/trends/dem-compchange.shtml.
United Nations Statistics Division (2014). *Principles and Recommendations for a Vital Statistics System, Revision 3*. Department of Economic and Social Affairs, UN Statistics Division. Retrieved May 11 from http://unstats.un.org/unsd/demographic/standmeth/principles/M19Rev3en.pdf.
United Nations Department of Economic and Social Affairs (2016). *Sustainable Development Goals*. Retrieved May 11 from https://sdgs.un.org/goals/goal16.
Wodon, Q., & Yedan, A. (2019). Obstacles to birth registration in Niger: Estimates from a recent household survey. *Journal of Health Population and Nutrition*, *38*, https://doi.org/10.1186/s41043-019-0185-1.
World Bank (2018). *Incentives for improving birth registration coverage: A review of the literature*. *World Bank Group*. https://documents1.worldbank.org/curated/en/928651518545413868/Incentives-for-Improving-Birth-Registration-Coverage-A-Review-of-the-Literature.pdf.
World Health Organization. (2013). *Strengthening civil registration and vital statistics for births, deaths and causes of death: Resource kit*. World Health Organization. https://apps.who.int/iris/handle/10665/78917.
World Health Organization. (2014). *Covering every birth and death: Improving civil registration and vital statistics (CRVS)*. WHO Regional Office. https://apps.who.int/iris/handle/10665/129387 for South-East Asia.
Yaya, Y. (2015). Maternal mortality in Rural South Ethiopia: Outcomes of community-based Birth Registration by Health Extension Workers. *Plos One*. https://doi.org/10.1371/journal.pone.0119321.