Measuring Child Mortality From a Census

Select Topics in International Censuses[1]

Released August 2022

INTRODUCTION

Child mortality is a fundamental indicator of child health and well-being. Child mortality levels are also considered to be indicators of a country's overall development. Along with vital registration, major global surveys like the Demographic and Health Surveys (DHS) and the Multiple-Indicator Cluster Surveys (MICS) can provide important information about levels of child mortality in a country. Compared to data collected from censuses—the subject of this brief—sample surveys often provide more accurate measures of child mortality because they can ask more detailed questions about mothers and their children. Surveys have further advantages because interviewer training is often more rigorous than for censuses, and women typically respond directly about their own fertility and child mortality. Whereas in a census, the respondent is often the head of a household. On the other hand, the reliability of estimates derived from survey data is limited by sample size (especially at the subnational level), as well as the quality and representativeness of the selected sample. Therefore, when vital registration is incomplete, census data often play a crucial role in confirming child mortality estimates.

RECOMMENDED QUESTIONS ON CHILD MORTALITY

The calculation of child mortality requires information on child deaths as well as births. To that end, United Nations' *Principles and Recommendations of Population and Housing* (United Nations, 2015) advise two sets of core questions in censuses and surveys:

- How many children were ever born alive and how many of those still survive?
- When was the last child born alive and is that child still alive?

The United Nations (UN) also recommends questions on all deaths in each household during the past 12 months. Although data from household deaths are generally used to measure adult mortality, they can also be used to estimate child mortality.

Children Ever Born Alive, Surviving, and Died

The inclusion of questions on children ever born alive is universally recommended, even in countries with good vital registration, to assess the completeness of vital registration and estimating lifetime fertility at older childbearing ages. All women aged 15 and over should be asked such questions regardless of their marital status. While there may be sensitivities to asking questions about fertility to never-married women, the UN recommends that efforts should be made to collect this information regardless of marital status. Doing so will improve the accuracy of the data. If it is not possible to ask the questions of women who never married, the questions should be put to all women who are or have ever been married or in a union including widowed, divorced, and separated. To avoid ambiguous interpretations of the results, be sure to make clear which groups of women were asked the questions.

[1] This technical note is part of a series on Select Topics in International Censuses (STIC), that explores matters of interest to the international statistical community. The U.S. Census Bureau helps countries improve their national statistical systems by engaging in capacity building to enhance statistical competencies in sustainable ways.

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The number of children ever born alive should include all children who were born alive to a woman during her entire lifetime up to the census date. It should include any child:

- Who showed any sign of life at birth even for a very short time.
- Regardless of whether the child was alive or dead at the time of the census.
- Regardless of whether born in or out of marriage or in the present or prior marriage.
- Regardless of whether the child lives with the mother, the age of the child, or the marital status of the child.

It should not include:

- Stillbirths or other fetal deaths.
- Adopted children.
- Stepchildren.

In the case of multiple births (such as twins), each child should be counted as a separate birth.

To estimate child mortality, questions about children ever born should be followed by questions about children surviving and who have died. The recommended set of questions can be found in Box 1.

Box 1.

Recommended Questions for Children Ever Born Alive, Surviving, and Died

a. Total number of sons ever born alive during the lifetime of the woman.

b. Total number of sons living (surviving) at the time of the census.

c. Total number of sons born alive who have died before the census date.

Then ask:

d. Total number of daughters ever born alive during the lifetime of the woman.

e. Total number of daughters living (surviving) at the time of the census.

f. Total number of daughters born alive who have died before the census date.

Asking about sons and daughters separately improves the accuracy of the data and allows for calculation of child mortality by sex. While the number of sons/daughters who have died can be calculated from those surviving (and vice versa), it is useful to ask both since they can serve as error checks. Census takers can add the number of children living and dead to compare against the total number of children ever born alive. If using a mobile device (like a tablet) to conduct the census, the calculation can be programmed into the data collection software application. The census takers can then resolve any discrepancies at the time of the interview.

These questions are used to derive summary birth histories, which are used in indirect estimates of child mortality.

Deaths in the Household Within the Past 12 Months

The questions on deaths within the past 12 months are asked of all household members who have died. The recommended questions can be found in Box 2.

Date of Birth of the Last Child Born Alive and Survival Status

The UN recommends asking about the date of birth (day, month, and year) and sex of the last child born alive (as an addition to the children ever born alive questions discussed above) to women 15–49 years old regardless of marital status. The date of birth of the last child can be used to estimate fertility during the past year instead of asking about the number of births within the last 12 months. Estimates based on the latter are often flawed because of errors and omissions in the reporting of live births within a 12-month period. In rare cases where a woman has more than one birth in a 12-month period, using the date of birth of the last child to calculate births within the last 12 months could lead to underreporting. Since these cases are rare, fertility estimates should not be greatly affected.

The question about the date of birth of the last child born alive can be followed by whether the child is still alive to obtain information about deaths of children born in the last 12 months. While data on survival of children born in the last 12 months are useful for understanding child mortality patterns by age of mother or other characteristics, it should not be used to estimate infant mortality.[2]

[2] The number of deaths captured from this set of questions do not include all infant deaths in the past 12 months. They exclude deaths to babies under 1 year of age among children born 1–2 years before the census date.

Box 2.

Recommended Questions on Deaths in the Household Within the Past 12 Months

Has any member of this household died in the last 12 months?

If yes, record the following information about each deceased person:

Line number[1]	Name of deceased	Sex of deceased	Age at death (in completed years)	Date of death (day, month, and year)
1				
2				
3				

[1] Additional line numbers may be used for more people.

IMPROVING COLLECTION OF DATA ON CHILD MORTALITY

To improve the accuracy and completeness of child mortality data, ask questions on fertility and child mortality to the child's mother because she is likely to correctly recall specific details. Since inquiring about a child's death may be sensitive in many cultures, census takers should be trained to ask these questions appropriately. The training should also emphasize the importance of these questions so that census takers do not skip questions about death.

Census takers should also be trained to use techniques to help respondents recall vital events and when they took place. For example, respondents may name deceased household members who died before the 12-month reference period. Error checks are also a good way to improve data quality during data collection, especially for the questions on children ever born alive, surviving, and died. A simple arithmetic check can be done by adding up children that survived and children that died, then comparing the sum to the reported children ever born.

As noted earlier, estimating infant and child mortality requires not only information on deaths, but also on births. More information on how to better collect data on fertility can be found in the *Select Topics in International Censuses* brief, "Measuring Fertility in a Census" at <www.census.gov/library/working-papers/2019/demo/measuring-fertility.html>.

The *Select Topics in International Censuses* brief, "Measuring Maternal Mortality" <www.census.gov/library/working-papers/2015/demo/maternal-mortality.html> contains further information on improving collection of data on deaths in the household within the past 12 months.

MEASURES OF CHILD MORTALITY

Box 3 shows the commonly used child mortality measures that can be obtained from census data. Most census data can produce the infant mortality rate (IMR), under-5 mortality rate (U5MR) and age-specific death rate (ASDR). The IMR and U5MR are probabilities and the denominator for these measures is the number of live births. The ASDR is a rate and is calculated as the number of deaths in a particular age group per 1,000 population.

Box 3.

Common Child Mortality Measures From Censuses

Infant mortality rate (IMR, $_1q_0$): The probability of dying between birth and exact age 1, expressed per 1,000 live births.

Under-5 mortality rate (U5MR): The probability of dying between birth and exact age 5, expressed per 1,000 live births.

Child mortality rate, age 1–4 (CMR): The probability of dying between exact age 1 and exact age 5, expressed per 1,000 children at age 1.

Age-specific death rate (ASDR): The number of deaths in a year at age x divided by the mid-year population at age x. The ASDR may refer to single age or age groups (for example, 0–4, 5–9, 10–14). At age 0, it is often expressed as $_1M_0$—the number of deaths at age 0 over the past year divided by the mid-year population at age 0.

METHODS TO ESTIMATE CHILD MORTALITY

Before estimating child mortality using the methods mentioned below, data used to calculate the measures should be assessed for consistency and validity (Section VI—Data Quality Checks). The choice of methods used to estimate child mortality will depend on the availability and quality of the data. The first three measures in Box 1 are probabilities—the chance that those born will die by a certain age, the most accurate and intuitive measure for assessing child survival. However, without a vital statistic system or a specifically designed survey, it is difficult to calculate probabilities. For example, for IMR and U5MR, we would ideally have data that identifies not only those born at a particular time, but how many in that cohort died by a certain age. Such data are not available from censuses and surveys since they require follow-up of the birth cohort over time. Therefore, the methods below present good approximations to calculate these indicators using available data from censuses. It is good practice to calculate the indicators using all available methods and compare the estimates across methods.

Using Data on Deaths in the Household Within the Last 12 Months

If the census asked questions on household deaths within the past 12 months, and the data are of good quality, child mortality measures can be calculated based on these data.

IMR

There are two ways to estimate the IMR. The first is to calculate IMR from deaths under the age of 1 and the number of live births. The second method is to calculate the age-specific death rates, which then can be converted to IMR or U5MR. These two methods are further described below.

Using births within the last 12 months as denominator

IMR is often calculated as the ratio of the number of deaths of infants under the age of 1 to the number of live births occurring that year multiplied by 1,000. The number of infant deaths can be obtained from household deaths within the last 12 months by age. The number of live births can be obtained from the data on the last child born alive where the child was born within 12 months before the census date.

Data required:

- Deaths in the household within the last 12 months by age.
- Number of births from data on the last child born alive, who was born in the past 12 months (for IMR).

Measure produced:

- Infant mortality rate.

Data required:

- Deaths in the household within the last 12 months by age.
- Population by age.

Measures produced:

- Age-specific death rate.
- Infant mortality rate.

Using life table methods

Another way to estimate the IMR is to first calculate ASDR, then convert them to IMR. ASDRs are calculated as the number of deaths in a particular age group per 1,000 population in the same age group. Once the ASDR for under the age of 1 is calculated, it can be converted to IMR or ${}_1q_0$ by applying life table methods using software tools such as DAPPS or Mortpak.[3] The ASDR for under the age of 1 is sometimes confused with IMR. It is important to remember that the denominators are different for ASDR and IMR. As described in Box 1, the denominator for the ASDR is the mid-year population. The denominator for the IMR is births. Methods to convert age-specific rates to IMR are described in many demographic methods literature (Arriaga, et al., 1994; Preston, et al., 2001; United Nations, 1983; Wachter, 2014).

U5MR and Child Mortality Rate (CMR)

U5MR and CMR are estimated using the life table method described above and applying them to ages 0–5 and 1–4. First, calculate the ASDR for ages 0–5 and 1–4, then use software tools, such as DAPPS or Mortpak, to convert them to U5MR and CMR.

Data required:

- Deaths in the household within the last 12 months by age.
- Population by age.

Measures produced:

- Age-specific death rate.
- Under-5 mortality rate.
- Child mortality rate.

Using Data on Children Ever Born and Children Surviving

Data on children ever born and children surviving can be used to indirectly estimate probabilities of dying between birth and certain ages. The number of children ever born and children surviving by age of mother are used to first calculate the proportions of children who died out of total

[3] Demographic Analysis and Population Projection System (DAPPS) is a tool developed by the Census Bureau and is available at <www.census.gov/data/software/dapps.html>. Mortpak was developed by the United Nations and can be downloaded at <www.un.org/en/development/desa/population/publications/mortality/mortpak.asp>.

children ever born by age of mother. Then, a set of multipliers are applied to the proportions of dead children by age of mother to estimate the probability of dying between birth and certain ages, which are then converted to estimates at given reference dates.

The original method was developed by Brass. Subsequent Trussell and Palloni-Heligman variations rely on model life tables. The Trussell variation uses the Coale-Demeny model regional life tables, while the Palloni-Heligman variation uses the United Nations model life tables. The Mortpak software package's QFIVE program can be used to produce these indirect estimates of child mortality. Detailed calculations for these methods are found in the UN *Step-by-Step Guide to the Estimation of Child Mortality* (United Nations, 1990).

Data required:

- Children ever born by age of women.
- Children surviving or died by age of women.
- Female population of reproductive age (15–49) with no missing data on children ever born or children surviving/died.
- Sex ratio at birth.
- Mean age at childbearing.[4]

Measures produced:

- Under-5 mortality rate by reference date.
- Infant mortality rate by reference date.
- Child mortality rate, age 1–4.

Women with missing data on numbers of children ever born, children surviving/died, or both should be excluded from the analysis. The inclusion of imputed data may also add bias.

Application of this method produces estimates of U5MR, IMR, and CMR that corresponds to specific reference dates prior to the census date. The rates for earlier reference dates are derived from data on older women, while those for the more recent reference dates are derived from younger women. Generally, rates derived from women aged 15–19 (and to some extent aged 20–24) tend to overestimate the population-level child mortality. Therefore, the rates for the most recent two reference dates using this method are often not used.

In populations with high HIV prevalence, there may be underreporting of child deaths because HIV-positive children are more likely to die than HIV-negative children, and their HIV-positive mothers are more likely to have died as well—so they are not alive at the time of the survey to report the death of their children.[5]

DATA QUALITY CHECKS

It is important to consider the quality of the data before calculating child mortality measures. Both internal and external data quality assessments should be conducted.

Internal Data Quality Assessment

The following is a set of checks on tabulations by age of mother to assess the plausibility, consistency, and accuracy of collected data and associated processing.

- **Evaluate the extent of missing values:** Do a tabulation that shows the proportion of missing cases and, if data were edited, evaluate what proportion of data were edited.
- **Examine aggregate data for implausible irregularities**: Check for the following patterns in the tabulations:
  - Average number of children ever born by five-year age groups of women:
    - Unless fertility has been rising, the average number of children ever born should increase with each five-year age group.
  - Average number of children dead by five-year groups of women:
    - Unless child mortality or fertility has been increasing, the average number of children dead should also increase with age.
  - Sex ratios of births:
    - Sex ratios of births should not deviate far from 100 to 106 males per 100 females (unless there is sex-selective abortion).
    - Sex ratios of births should not rise with age (unless there is sex-selective abortion).
    - Sex ratios of births should not change based on the number of years before the census.
  - Ages at death:
    - Ages at death should be fairly smoothly distributed by age. Death ratios can be calculated to assess the smoothness across successive age groups.

$$Death\ Ratios = 2 * \frac{D_x}{D_{x-1} + D_{x+1}}$$

where D is the number of deaths at age x.

[4] Methods to estimate mean age at childbearing can be found on pages 224 and 295 in the United Nations Population Fund—International Union for the Scientific Study of Population *Tools for Demographic Estimation* manual at <http://demographicestimation.iussp.org/sites/demographicestimation.iussp.org/files/TDE_2013_2ndImpression_0.pdf>.

[5] Methods to adjust for bias due to HIV mortality are described in Walker, Hill, and Zhao (2012).

External Data Validation

In addition to internal data quality checks, comparisons of estimates to results from other data sources provide a good way to determine if there may be concerns with data quality.

- **Compare child mortality estimates to estimates from other data sources**. Once you have calculated the estimates, plot them and all available estimates from other sources (Figure 1 and Figure 2). Other sources of data include:
  - Surveys, such as the DHS or MICS.
  - Previous censuses.
  - Vital registration.
  - Estimates produced by other agencies, such as:
    - UN Inter-agency Group for Child Mortality Estimation.
    - U.S. Census Bureau International Data Base.
    - UN World Population Prospects.
- **Cohort comparisons of children ever born and children that died**. Compare average number of children ever born by women aged 30–34 reported in census to the same number by women aged 20–24 in the previous census (Table 1). Do the same for children that died. The average number of children ever born or died to women aged 30–34 in the more recent census should be greater than those to women aged 20–24 in the previous census.
- **Compare CMR against IMR and compare against values from model life tables and regional values**. Check for deviation from the regional or model patterns.
- **Compare ratio of IMR/U5MR and U5MR**. Check for deviation from the regional or existing country data.
- **Compare urban and rural**. Rural is normally higher than urban.
- **Compare by wealth quintile**. Poorest households normally show higher mortality.

Table 1.

Number of Women, Children Ever Born, Children Surviving, and Children Dead by Age of Women in Malawi Population and Housing Censuses: 2008 and 2018

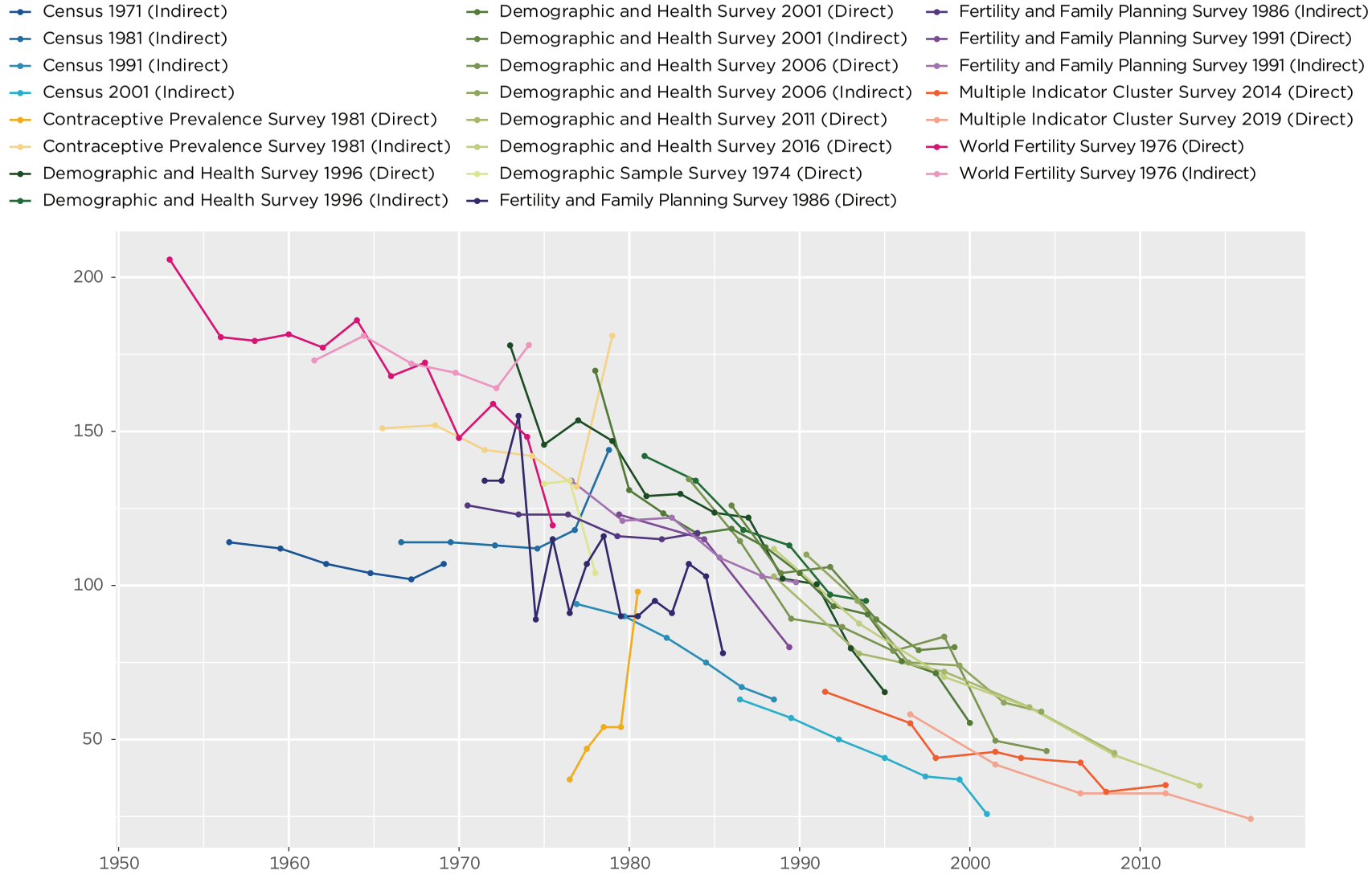
Age group	Number of women	Children ever born	Children still living	Children dead[1]
2008 Census				
15–19	635,927	92,586	83,469	9,117
20–24	678,071	530,394	471,367	59,027
25–29	566,350	821,168	713,287	107,881
30–34	405,602	864,523	725,772	138,751
35–39	298,004	791,692	643,167	148,525
40–44	221,274	682,588	528,898	153,690
45–49	174,875	577,412	430,784	146,628
2018 Census				
15–19	1,031,165	234,947	224,169	10,778
20–24	873,999	1,040,403	1,000,422	39,981
25–29	646,545	1,511,774	1,452,437	59,337
30–34	590,721	2,112,446	2,005,636	106,810
35–39	500,810	2,247,289	2,095,324	151,965
40–44	362,429	1,906,246	1,723,472	182,774
45–49	262,119	1,501,565	1,310,500	191,065

[1] The estimates of children dead from the 2008 Census were calculated by subtracting the number of children still living from children ever born.
Source: Source: Malawi National Statistic Office, 2008 Population and Housing Census Thematic Report: Mortality; 2018 Malawi Population and Housing Census Main Report; and 2018 Malawi Population and Housing Census Published Tables, Series K. Mortality Tables.

Figure 1.

Infant Mortality Rates in Nepal: 1953–2016

(Deaths per 1,000 live births)

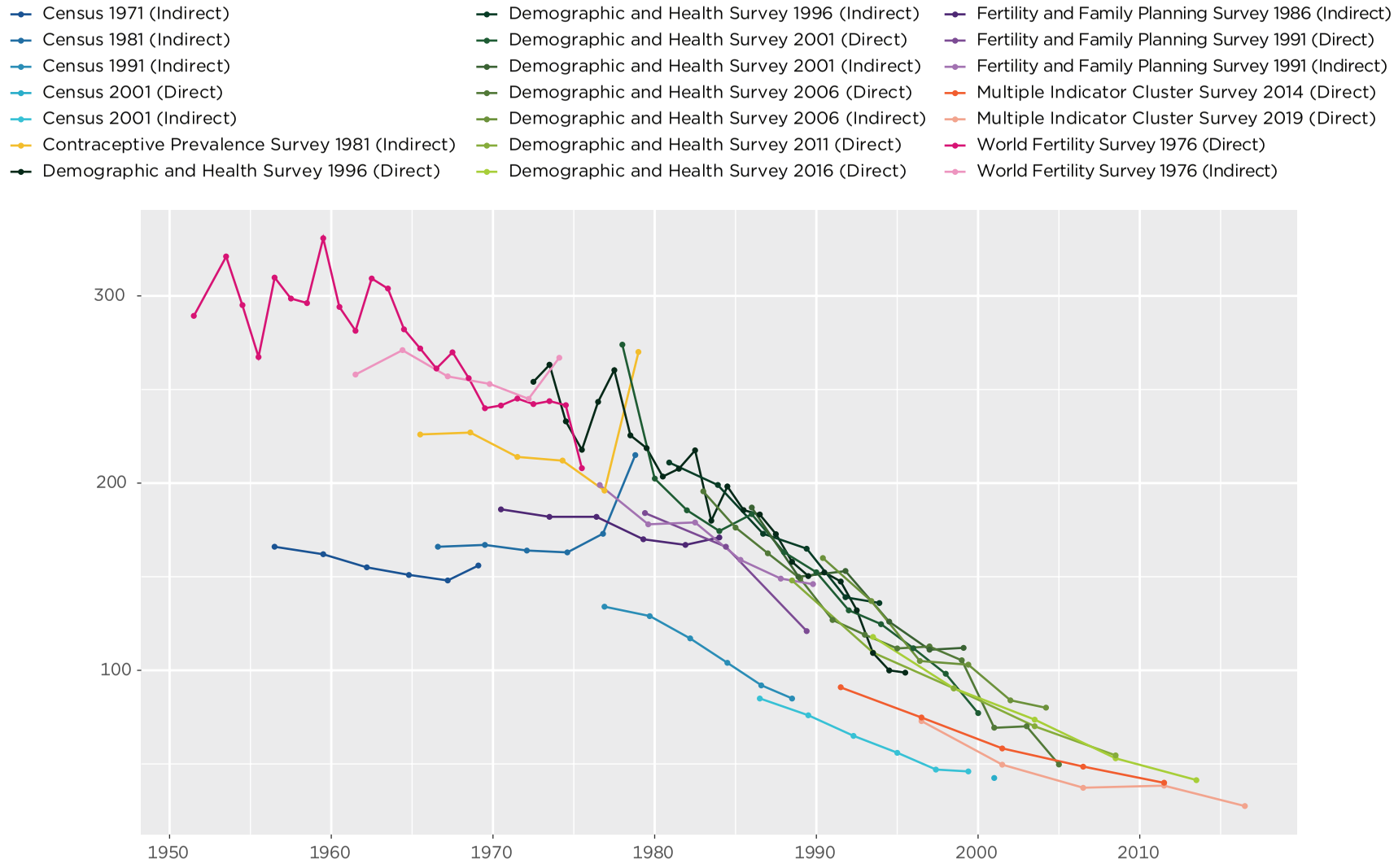


Source: United Nations Inter-Agency Group for Child Mortality Estimation, 2020.

Figure 2.

Under–5 Mortality Rates in Nepal: 1951–2016

(Deaths per 1,000 live births)



Source: United Nations Inter-Agency Group for Child Mortality Estimation, 2020.

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The Select Topics in International Censuses (STIC) series is published by International Programs in the U.S. Census Bureau's Population Division. The United States Agency for International Development sponsors production of the STIC series, as well as the bilateral support to statistical organizations that inform authors' expertise. The United Nations Population Fund collaborates on content and dissemination, ensuring that the STIC series reaches a wider audience.