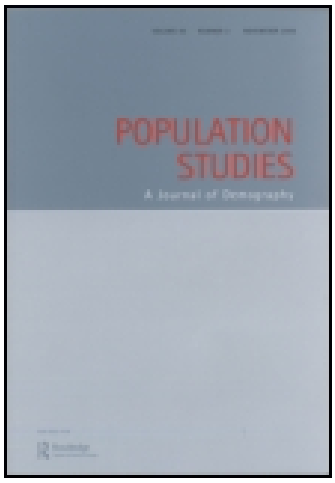

Population Studies: A Journal of Demography
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rpst20

The 'Own Children' fertility estimation procedure: A reappraisal

Christopher Avery [a] , Travis St. Clair [b] , Michael Levin [a] & Kenneth Hill [a]
[a] Harvard University
[b] George Washington University
Published online: 07 Mar 2013.

To cite this article: Christopher Avery , Travis St. Clair , Michael Levin & Kenneth Hill (2013) The 'Own Children' fertility estimation procedure: A reappraisal, Population Studies: A Journal of Demography, 67:2, 171-183, DOI: 10.1080/00324728.2013.769616

To link to this article: http://dx.doi.org/10.1080/00324728.2013.769616

Population Studies, 2013
Vol. 67, No. 2, 171–183, http://dx.doi.org/10.1080/00324728.2013.769616

Routledge
Taylor & Francis Group

The 'Own Children' fertility estimation procedure: A reappraisal

Christopher Avery[1], Travis St. Clair[2], Michael Levin[1] and Kenneth Hill[1]
[1]Harvard University; [2]George Washington University

The Full Birth History has become the dominant source of estimates of fertility levels and trends for countries lacking complete birth registration. An alternative, the 'Own Children' method, derives fertility estimates from household age distributions, but is now rarely used, partly because of concerns about its accuracy. We compared the estimates from these two procedures by applying them to 56 recent Demographic and Health Surveys. On average, 'Own Children' estimates of recent total fertility rates are 3 per cent lower than birth-history estimates. Much of this difference stems from selection bias in the collection of birth histories: women with more children are more likely to be interviewed. We conclude that full birth histories overestimate total fertility, and that the 'Own Children' method gives estimates of total fertility that may better reflect overall national fertility. We recommend the routine application of the 'Own Children' method to census and household survey data to estimate fertility levels and trends.

Keywords: fertility; total fertility rate; estimation; birth history; Own Children

[Submitted April 2011; Final version accepted September 2012]

1. Introduction

Many less developed countries lack the accurate civil registration of births needed to monitor fertility levels and trends over time. In such settings, fertility is generally estimated from household survey data, either by asking women about their childbearing or by inferring information from the age distribution of the population. In the first category, the dominant method has become the Full Birth History (FBH) method, first widely implemented by the World Fertility Survey in the late 1970s, and more recently and even more widely by the Demographic and Health Surveys (DHS) programme. In this procedure, each woman interviewed is asked for the date (usually month and year) of each of her live births plus other information such as the sex and survival status of the child. Since the FBH method requires highly detailed data, it is only possible to use it periodically in a given country, and it can be used only in fairly small samples.

In the second category, the most informative procedure is the 'Own Children' method, whereby mothers are linked to the children they have given birth to ('own' children) in each household. For this method, the age of the mother and the age of the child, taken together, provide information about the age of the woman at the birth of the child and about the calendar time period in which the birth occurred, and thus provide a basis for estimating an age pattern of fertility; fertility-level adjustments are then made to take account of children not living with their mothers and of the deaths of children and women.

The Own Children method was originally developed to generate estimates of differential fertility from population census data (Grabill and Cho 1965). It can be applied to any household survey that collects age and sex of household members, and offers the additional advantage of fertility estimates for single-year periods and for smaller population sub-groups. Examples of the application of the Own Children method include Rindfuss (1976), Abbasi-Shavazi (1997), Abbasi-Shavazi and McDonald (2000), Dubuc (2009), and Coleman and Dubuc (2010).

The rising popularity of the FBH method over the last 30 years has coincided with a decline in interest in the Own Children method, even though the latter can be applied at low cost to microdata from censuses to provide estimates at high levels of disaggregation (Childs 2004; Opiyo 2004). Although

the FBH method has come to be regarded as the 'gold standard' for estimating levels and trends in fertility, it has long been noted that typical reporting errors may bias estimates of fertility trends (e.g., Potter 1977).

The study reported here used survey data sets collected by DHS for 56 different countries to examine the relative performance of these two methods in estimating the total fertility rate, and decompose the components of the differences in order to understand their origins. DHS surveys collect both full birth histories from each woman aged 15–49 (in the individual questionnaire) and data on the age and sex of all residents of the same household (in the household questionnaire), facilitating a comparison of the results for the two methods. To help identify the origins of differences in fertility estimates from the two methods, we started by limiting our analysis to cases for which the results were by definition identical, and then in a step-wise process added cases or procedures that introduced differences between the two methods. We focused on fertility estimates for the 3-year period before each survey, since this is the period for which Measure DHS produces estimates of total fertility (Measure DHS accessed online).

The paper was inspired by the work of Retherford and Alam (1985) and Cho et al. (1986). Using data from eight countries and estimates for different time periods before the survey, Retherford and Alam concluded that the FBH and Own Children methods produced very similar results: 'In most cases the agreement between the fertility estimates derived alternatively from own-children data and birth histories is impressive' (1985, p. 28). Given access to a much larger set of survey data, we conducted a more systematic analysis; we also extended the analysis of Cho et al. (1986) by making use of linkage information between children in the household listing and births in the birth history to decompose the differences between the FBH and Own Children fertility estimates.

The paper proceeds as follows: Section 2 describes the data and provides motivating results. Section 3 presents a theoretical comparison of the estimation procedures and describes a method for pinpointing the sources of differences in their results. Section 4 reports an analysis of the results for an illustrative example in detail. Section 5 reports results for all 56 countries. Section 6 shows the results of a detailed analysis undertaken to identify the sources of difference in results for FBH and Own Children estimates. Section 7 discusses implications of the results and draws conclusions.

2. Data

We analysed data collected by the Measure DHS project (www.measuredhs.com), which uses standardized data collection methods and variable definitions in its household surveys. DHS collects data through a series of questionnaires, and for each survey provides data sets that link information across questionnaires. We used two of these data sets throughout our analysis. 'Household Survey' (HS) data include demographic information about each person living in each household covered by the survey. 'Individual Recode' (IR) data include full birth histories for women (in some cases limited to ever-married women) aged 15–49 who live in those households. The Appendix to this paper lists all the variables from the two questionnaires that we used in our analysis.

The linked nature of the HS and IR data collected by DHS facilitated our analysis. We developed a procedure for comparing these methods based on three different matches of observations for each country: (i) matching of women in the relevant age range (15–49) from the two (IR and HS) data sources; (ii) matching of children listed in the birth-history data to their mothers in the HS data; (iii) matching of children listed in the HS data to their mothers (if living in the same household and of appropriate age) in the birth-history data.

Since 2001, the DHS Household Survey data explicitly record the line number of the mother of each child (if she is listed in the same household) and thus provide the information required for all three types of matching. DHS surveys conducted before 2001 do not include this information, and thus usually provide enough information for the first two types of matching, but not the third. Even for DHS surveys before 2001, however, we were able to follow our analytic procedure under the assumption of consistent matches of children to mothers across the two data sources, at least in those cases where it was possible to distinguish children living in the same household as their mothers from children living apart from their mothers in the HS data.

We analysed data from 56 of the 61 countries for which DHS provides unrestricted data access for surveys conducted since 1990; the other five countries were excluded as a result of data limitations. For six of these 56 countries (Bangladesh, Egypt, Indonesia, Jordan, Pakistan, and Turkey), DHS solicited birth histories only from women who were 'ever married'. In these six cases, we also excluded 'never married' women from the HS data; our qualitative results for these six countries were

broadly consistent with those for the other 50 countries.

For each of these 56 countries, we used data from the most recent DHS survey for which we were able to apply our analytic method. Table 1 provides descriptive information about the countries included in the analysis. Slightly more than half of the countries are in sub-Saharan Africa (according to the regional classifications provided by DHS).

There are two important differences between the IR data and the HS data. First, IR data include birth histories for only a subset of women aged 15–49 in the HS data. Typically, about 10 per cent of the women of relevant age in the HS data do not provide birth histories, with this shortfall being largely due to two causes: the exclusion of resident women who did not spend the previous night in the household and the refusal of some eligible women to be interviewed.

Second, IR data list the month of birth while HS data list both month of birth and the (integer) age in years of mothers and children. As a result, it is not possible to determine the integer age of all children listed in the IR data. For example, a child listed with birth date of January 2001 in a birth-history interview from January 2003 could have been either 2 or 3 years old at the time of the interview depending on whether or not that child had just had a birthday.

3. Theoretical background

Since the FBH and Own Children methods are designed for the same purpose, they should be equivalent under some set of conditions. This section identifies the baseline case where the two estimates are identical and then identifies seven separate features of the methods that can yield differences in their results.

In the base case, we considered: (i) women who appeared in both the IR and HS data and whose ages (in years) matched across these two files; (ii) children listed as living in the same household as their mother, who could be matched across the two files, and who were listed as having the same age in years in both files. We used years of age as the unit of measurement in the base case because that is the most detailed information on age available in the HS data. To compute (integer) years of age from the month of birth in the IR data, we assumed that any child with a birthday in the month of the interview had already had that birthday before the interview. That is, for base-case analysis using a 3-year sample period of births in the IR data, we included births reported as occurring earlier in the month of the interview or in the 35 calendar months before the month of the interview.

The total fertility rate (TFR) is defined as the sum of age-specific fertility rates for women from ages 15 to 49 for a given sample period of births. Since the base-case data consisted of a fixed set of mothers and children for whom both sources recorded exactly the same ages, the Own Children and FBH methods would necessarily produce identical base-case estimates of TFR.

Theoretically these base-case TFR estimates would be correct under the following assumptions: (i) ages of children and mothers were recorded correctly in both surveys; (ii) all interviews were conducted on the last day of the month and on the day before each woman's next birthday; (iii) all women aged 15–19 listed in the HS provided birth histories for the IR data; (iv) all children lived in the same household as their mother, with no migration or mortality of mothers; (v) there was no possibility of child mortality.

We adjusted the base-case analysis in a cumulative series of steps, as listed in Table 2, to produce refined TFR estimates that distinguished between the results for the FBH method and those of the Own Children method. Steps 1 through 5 relaxed

Table 1 Descriptive statistics for countries included in the analysis

Region	All surveys *N* (%)	2001–07 *N* (%)	1990–2000[1] *N* (%)
Sub-Saharan Africa	31 (55.4)	23 (57.5)	8 (50.0)
Latin America and Caribbean	10 (17.9)	6 (15.0)	4 (25.0)
North Africa/West Asia/Europe	8 (14.3)	7 (17.5)	1 (6.3)
South Asian and South-east Asia	6 (10.7)	4 (10.0)	2 (12.5)
Central Asia	1 (1.8)	0 (0.0)	1 (6.3)
Total (100%)	56	40	16

[1]This column includes Chad (2004) and Peru (2004), for which the survey data did not include enough information to allow all three types of matching.
Source: DHS surveys.

Table 2 Seven distinct steps in the computation of total fertility rates using the Full Birth History and Own Children methods

Case	Definition
Base case	Include women listed with the same age in both IR and HS data. Include children living in the same households as those mothers and who are listed with the same ages in both files.
Step 1	Use ages from IR data for FBH computations. Use ages from HS data for Own Children computations.
Step 2	Divide past years into months.
Step 3	Include women age 15–49 who appear in the HS data but not in the IR data.
Step 4	Include 'Non-Own' Children in computations. Conduct 'reverse survival' for mothers in HS data.
Step 5	Account for child mortality.
Step 6	Weight the observations based on reported sample weights.
Step 7	Compute results based on 5-year age groups of mothers.

assumptions (i)–(v) above in order. Steps 6 and 7 added sample weights and grouped women by age to match the format of the standard DHS method for TFR computations. The results of Step 7 are the actual TFR estimates for the Own Children and FBH methods, respectively.

We noted above that it is not possible to identify the (integer) age in years of each child at the time of interview in the IR data because the birth history reports the month but not the day of each birth. To accommodate this ambiguity, the DHS rule for computing TFR defines the sample period as the 36 calendar months immediately preceding the interview, excluding the (partial month of) births occurring in the same calendar month as the interview. In contrast, the sample period in the Own Children method is based on the reported age of each child rather than the month of birth, and always includes births that occur in the same calendar month as the interview. For an interview conducted on 15 January 2003, the 3-year sample periods of births used to compute TFRs are 16 January 2000–15 January 2003 for the Own Children method and 1 January 2000–31 December 2002 for the FBH method.

In the base-case and Step 1 analysis, we computed an (estimated) integer year of age at time of interview for each child in the IR data, based on reported month of birth. In these two computations, we then used the same sample period to compute the Own Children and FBH TFRs. However, for Steps 2–7, we used different sample periods for these two methods, corresponding to the actual implementation of these methods in practice.

4. An illustrative example

We discuss the results for a single survey—Kenya 2003—in detail to illustrate the differences between the two methods and the mechanics of implementing each step in the analysis. To simplify exposition, we use a sample period of 1 year of births before the survey date in this example. Table 3 lists the numbers

Table 3 Number of births and mother-years in computations of total fertility for a 1-year sample of births, Kenya 2003, using the Full Birth History and Own Children methods

Step	Description	Full Birth History Mother-years	Own Children Mother-years	Full Birth History Births	Own Children Births
0	Base case	7,123	7,123	1,057	1,057
1	Assign ages by file	8,195	8,195	1,218	1,238
2	Identify months in past year	8,014.7	8,025	1,253	1,235.5
3	Add non-interviewed mothers	8,014.7	8,787.5	1,253	1,279.5
4	Add non-own children	8,014.7	8,848.2	1,257	1,298.5
5	Adjust for child mortality	8,014.7	8,848.2	1,323	1,362.7
6	Add sample weights	11,161.8[1]	12,283.8[1]	1,793.0[1]	1,847.5[1]
7	5-year groups for FBH	11,161.8[1]	12,283.8[1]	1,793.0[1]	1,847.5[1]

[1]The numbers in Steps 6 and 7 are weighted averages based on recorded sample weights and are not in units comparable to the numbers listed for Steps 0–5.
Source: DHS, Kenya 2003.

of births and mother-years considered in each step of the analysis for each of the two methods.

The HS file for Kenya 2003 included 8,974 women in the age range 15–49, and 8,195 of these women provided birth histories in the IR file. We restricted base-case analysis to the 7,123 of those 8,195 women (or 86.9 per cent of them) who were listed with the same ages in both HS and IR files. Similarly, we restricted base-case analysis to the subset of children recorded as age 0 and matched to the same mother in both files.

Step 1 expands the analysis to include all women who appear in both data files and are listed with ages in the range from 15 to 49 in each of them. This step yields fertility estimates based on the ages for mothers and children listed in each data file, even if those ages are not consistent across the files. The set of births included in the analysis is slightly different for the two methods in Step 1 because some children are listed with birth date in the sample period in one of the data files and outside the sample period in the other.

Dividing the past year into months in Step 2 distinguishes between the two TFR estimates in two ways. First and most important, as we note above, the sample time periods for births do not coincide for the FBH and Own Children methods in Steps 2–7, consistent with the fact that the sample periods for the two methods usually do not completely coincide. Second, the number of mother-years declines from Step 1 to Step 2, because women aged 15 at the time of interview typically spent some months of the previous year at age 14; we exclude those months (and associated births) at age 14 from the analysis. Strictly speaking, a similar adjustment should be made for the exposure time of women aged 50 at survey who spent some months in the previous year at age 49; however, such an adjustment cannot be made because the FBH does not include information for women aged 50.

Step 3 incorporates additional women (and the children born to those women) who are listed as aged 15–49 in the HS data, but who were not interviewed using the women's questionnaire and thus did not provide a birth history; this step changes results only for the Own Children method. In the example, the addition of these women increases the number of mother-years by about 10 per cent and the number of births by about 5 per cent from Step 2.

Step 4 adjusts the fertility estimates to incorporate children who do not live in the same household as their mothers. In the HS files, we identify children who cannot be matched to mothers in their households and include them in the fertility estimates. In the IR files, we identify children who are listed in a birth history, but are not currently living in the household where the mother was interviewed. In the case of Kenya 2003, there were only four children in the IR file who were born in the past year but did not live in the same household as their mother. In contrast, there were 19 children listed at age 0 in the HS whose mothers were not living in the same households.

In the absence of mortality or international migration, we would expect to find equal numbers of children not living in the same households as their mothers in the HS and IR data files. However, some children could not be matched to mothers in the HS file as the result of deaths of mothers. To account for this possibility, we used population mortality rates (extrapolated from recorded child mortality rates) to adjust the number of Own Children woman-years upwards in this step; this interpolation method is commonly described as 'reverse survival'. In the case of Kenya 2003, reverse survival of mothers for a 1-year sample period only increases the number of Own Children mother-years by about 0.5 per cent, from 8,787.5 in Step 3 to 8,827.9 in Step 4.

Step 5 adjusts the fertility estimates to allow for child mortality. Only in the IR file is it possible to identify an exact set of children who were born in the past year but are not currently alive. Once again, we used recorded population mortality rates to estimate the total number of births for the Own Children computation from the actual number of children observed in the HS data. (Alternately, we could have estimated child mortality rates from the birth-history data and then used these mortality rates for the application of the Own Children method to the HS data. We repeated our computations for all countries using this alternate method and found similar results to those presented in Section 5.) Comparing the number of births found in Steps 4 and 5 for each method, child mortality accounts for about 5 per cent of births in Kenya based on exact computation for FBH and probabilistic adjustments for the Own Children method.

Step 6 weights observations according to sample weights, which differ slightly between HS and IR files (based on respondent's sample weight for the two questionnaires). For Kenya 2003, the weighted units used in Step 6 represent an increase of about 40 per cent relative to simple tabulations of births and mother-years. The number of births and mother-years remain the same for each method in Steps 6 and 7, because Step 7 differs from Step 6 only in the

way that it groups observations for computation of age-specific fertility rates.

Table 4 shows the fertility estimates that result from each step of the analysis for FBH and Own Children methods for the Kenya example. The last column in Table 4 lists the simple difference of the fertility estimates from each procedure after each of the seven steps of estimation. Three steps—Steps 2, 3, and 6—have a notable effect on the comparison; the implementation of each of these steps increases the TFR estimate from FBH relative to the TFR estimate for the Own Children method by at least 0.1 births.

5. Results

Figure 1 compares TFR estimates for the two methods across all 56 countries using the DHS standard of a 3-year sample period for births. Visual inspection indicates that the TFR yielded by the FBH lies above the Own Children TFR in the majority of instances. The mean TFR for the FBH method is 0.17 (95 per cent CI 0.12–0.22) births (nearly 4 per cent) higher than the mean Own Children TFR. Despite the relatively small sample of 56 countries, a null hypothesis that the two methods produce equal average TFRs can be rejected at any reasonable level of statistical significance. Given that there is such a considerable overlap in the data used by the two methods, it is surprising that their estimates diverge by such a large amount.

Table 5 lists the mean TFR at each step for each of the two methods. The difference in mean TFR is statistically significant at the 5 per cent level at every step, including Step 1. Moreover, Steps 1, 2, 3, 4, and 7 each produces a statistically significant change (at the 5 per cent significance level) in the comparison of TFRs for the two methods, as indicated by the 'Difference in Difference' results in columns 4 and 5. As with the Kenya example, the largest difference emerges at Step 3, which includes women not interviewed for the FBH. One difference from the Kenya example is that Step 6, which incorporates sample weights, does not produce a significant change in the comparison between the two estimates.

To clarify the origin of the discrepancies, we now focus on (i) the coding of ages in the two data sources in relation to the results of Steps 1 and 2, and (ii) the fertility results for the sub-group of women aged 15–49 from the HS data who were not included in the IR data in relation to the results of Steps 3 and 4. Our detailed analysis of Steps 1–4 relied on child-by-child comparisons between the HS and IR data. For this reason, the further analysis reported in this section included only the 40 surveys conducted since 2001 that provided sufficient data to match the children across the two files and compare their reported ages on a case-by-case basis. To facilitate exposition, we used unweighted data in all of our computations reported in the discussion below.

5.1. Analysis of results for Steps 1 and 2

There were two potential sources of differences in the TFR estimates in Steps 1 and 2. First, there was a difference in the timeframe of births used for TFR computations since the Own Children method includes and the FBH method excludes births in the same calendar month as the interview. Second, there may have been inconsistencies in the ages listed for children in the two surveys, so that even if the sample periods were identical for the two methods, some children would have been counted in TFR computations for one method but not the other. We considered the effects of each of these differences on

Table 4 Step-by-step estimates of total fertility for a 1-year sample of births, Kenya 2003, using the Full Birth History and Own Children methods

Step	Description	Full Birth History	Own Children	Difference between TFRs
0	Base case	4.511	4.511	0
1	Assign ages by file	4.485	4.528	−0.043
2	Identify months last year	4.632	4.532	+0.100
3	Add non-interviewed mothers	4.632[1]	4.292	+0.349
4	Add non-own children	4.647	4.327	+0.320
5	Adjust for child mortality	4.890	4.541	+0.349
6	Add sample weights	4.845	4.393	+0.452
7	5-year groups for FBH	4.876	4.433	+0.433

[1]By definition, this estimate is identical to that of Step 2 for the FBH method.
Source: As for Table 3.

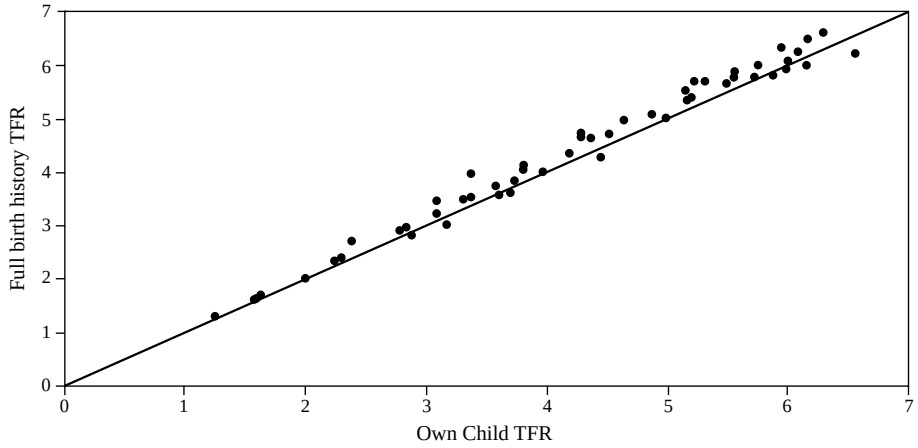

Figure 1 Full Birth History and Own Children TFRs for 56 countries
Source: DHS surveys.

the comparison of TFR estimates reported in Table 5 and discuss our findings below.

Differences in sample periods in Steps 1 and 2. Averaging across the 40 countries for which we can match children in the two surveys, the IR files included an average of 133.4 births for each month between 1 and 35 calendar months before the interview and 134.1 births in the 36th calendar month before the interview. The Own Children computation includes both births from the calendar month of the interview and some births from the calendar month 36 months before the interview. For example, a child listed in the HS data with a birth date of January 2000 and an age of 2 for an interview conducted in January 2003 would have had a third birthday still to come in the same calendar month as the interview. This child would have been included in the Own Children TFR computation.

With randomly distributed dates of interviews and births, we would have expected interviews to take place on average exactly in the middle of the calendar month, translating to an average of 0.5 months of births in the Own Children TFR computation for both the current month and the calendar month 36 months before the interview. In practice, we find an average of 78.4 births in the HS data—approximately 0.59 months of births—in the same calendar month as the interview, but only 36.6 births of children reported as age 2 in the HS data—approximately 0.27 months of births—from the calendar month 36 months before the interview. These two separate periods were expected to combine to contain a full month of births in the Own Child TFR computation, but in fact only produce 0.86 months of births on average. This deficit of 0.14 months of births in the 36-month sample period translates to a bias (an underestimate) of magnitude of $-0.14/36 = -0.4$ percentage points in the Own Children TFR estimate.

Asymmetries in coding errors in the ages of children. As a result of inconsistencies in the ages reported for the same child in the HS and IR data, some children were included in only one of the two TFR computations in Step 2. On average, 69

Table 5 Total fertility rates for Steps 1 through 7 for full sample of 56 countries, using the Full Birth History and Own Children methods

Step	Full Birth History Mean TFR	Own Children Mean TFR	Difference of means	Difference in Difference of TFRs from previous step	*t*-statistic: H_0: Difference in Difference = 0 for hypothesis test
1	3.998	3.958	+0.040	+0.040	3.89
2	4.043	3.954	+0.089	+0.049	11.71
3	4.043	3.820	+0.223	+0.134	11.34
4	4.121	3.934	+0.187	−0.037	−2.84
5	4.425	4.259	+0.166	−0.021	−1.28
6	4.432	4.274	+0.158	−0.008	−0.87
7	4.455	4.288	+0.167	0.009	2.25

Source: DHS surveys.

children per country were included in the FBH but not the Own Children TFR computation, while 30 children per country were included in the Own Children but not the FBH TFR in Step 2. (The total of nearly 100 inconsistencies per country represents about 1 per cent of total births in 36 calendar months.)

The average difference of approximately 39 more births excluded from Own Children computations than from FBH computations corresponds to approximately 0.29 months of births (since we find an average of 133.4 births per calendar month). This deficit translates to a difference of magnitude of $-0.29/36 = -0.8$ percentage points between the TFRs for the two methods.

Retherford and Alam (1985) observed greater variation in the number of births reported each year in the HS data than in the IR data. They conclude from this observation that the reported ages in the IR data (used for the FBH) are more likely to be correct than in the HS data (used for Own Children estimation). If this line of thought is correct, we would attribute much or all of the 0.8 percentage point difference in estimated TFR between the two methods to age misreporting in the Own Children method that causes inconsistencies in ages reported in the two surveys.

5.2. Steps 3 and 4: selection bias in choice of women interviewed for FBH

Step 3 for the Own Children method incorporates women who were not interviewed for the IR file. Women who were long-term residents of a household but who did not sleep there the night before the interview were generally listed as 'Ineligible' for a birth-history interview and did not appear in the IR file. In addition, some women reported in the HS data as 'Eligible' did not appear in the IR data file.

On average, more than 90 per cent of women in the relevant age range in the HS data file provided birth histories in the IR file. Yet, as shown in Table 5, the Own Children TFR declined by an average of 0.13 births from Step 2 to Step 3 when we included that small set of women who did not provide birth histories in the Own Children computation. This sharp change in outcome for a seemingly small change in sample is a strong indication of sampling bias.

The household questionnaire provides sufficient information to match mothers to children living in the same household, whether or not these women provided birth histories for the IR data. Thus, we were able to compute a Step 2 TFR separately for subsamples of women who appear in the HS data but not the IR data. (Note that the Step 2 TFR does not include births of children who did not live in the same households as their mothers.)

Figure 2 graphs the Step 2 (Own Children) TFRs for the women who appear in the IR file and for the women who do not appear in the IR file for each country. With just one exception, the TFR for women who did not provide birth histories is lower than the TFR for women who did so. The difference in TFR for these two groups is nearly 40 per cent on average (3.96 for women who were interviewed and provided birth histories and 2.54 for women who were not interviewed for the IR file); the difference in these values is significant at the 0.1 per cent level.

Figure 3 graphs the TFRs for two further subgroups of women who appear in the HS data—those who were not eligible for a birth-history interview

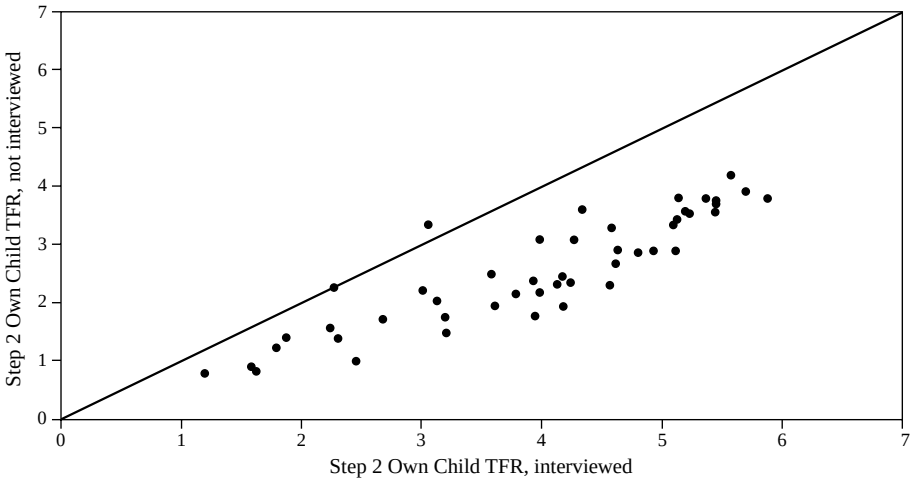

Figure 2 Selection bias in Individual Recode file
Source: DHS surveys.

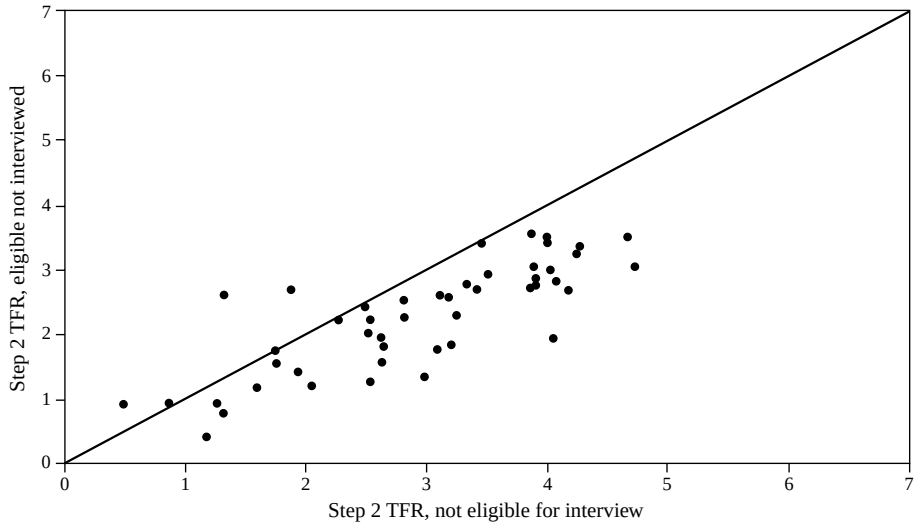

Figure 3 TFRs for groups not interviewed
Source: DHS surveys.

and those who were eligible but were not interviewed. In most cases, the TFR values are larger for women who were not eligible for interview than for women who were eligible. The average TFR is 2.84 for women who were not eligible and 2.27 for women who were eligible but not interviewed; the difference between these averages is significant at the 0.1 per cent level.

It is reasonable to suppose that women with children living in their household travel less than women without children in their household. Thus we might expect to find lower TFRs for women who were not eligible than for women who were eligible for the interview but not interviewed. The fact that Figure 3 finds the opposite relationship provides strong evidence of sampling bias—women listed as eligible to be interviewed but who were not actually interviewed have unusually few children living in the household with them.

A related possibility is that women who were not eligible for interview (because they did not sleep in the household last night) would be more likely than others to have children living in other households. If so, the apparent sampling bias introduced in Step 3 could be eliminated in Step 4 computations when we account for children who do not live in the same house as their mothers. However, as shown in Table 5, Steps 3 and 4 combined to produce an increase of 0.098 in the FBH's TFR relative to the TFR yielded by the Own Children method; this combined difference is statistically significant at the 1 per cent level. Given our Step 7 estimate of a TFR of approximately 4.3 from the Own Children method, the difference of 0.098 in TFR translates into a bias of $0.98/4.3 = 2.3$ percentage points in the FBH estimate of TFR.

6. Robustness check with different sample periods

To assess the robustness of our results, we repeated our analysis with varying sample periods of births from 1 to 10 years. Table 6 compares the average (Step 7) TFRs for the two methods. We observe two conspicuous patterns in these results.

First, the TFR estimates for both methods systematically increase as we increase the sample period of births from 2 to 10 years. This pattern is generally consistent with the findings of Retherford and Alam (1985), who attribute this relationship to minor but systematic misreporting of ages and birth dates. The decrease in TFR estimates for more recent sample periods of births is also consistent with the fact that fertility has on average been decreasing in recent years in the countries included in these DHS surveys.

Second, the FBH and Own Children TFR estimates converge as the sample period of births increases. The two estimates are almost identical on average for a sample period of 8 years, and in fact the Own Children TFR is larger on average than the FBH TFR for sample periods of 9 and 10 years. These findings suggest that the selection bias we noted earlier in the IR data dissipates with a lengthening of the sample period. Intuitively, we might expect that the correlation between eligibility for an interview (i.e., sleeping in the household last night) and (lack of) fertility would hold for recent births only. Similarly, we might expect that some of the women who were eligible for interview but not interviewed were unable to participate owing to physical or mental incapacity; if this incapacity developed recently, once again, it would have its

Table 6 Total fertility rates for 55 countries by sample period,[1] using the Full Birth History and Own Children methods

Sample period of births (years)	Full Birth History Mean TFR	Own Children Mean TFR	Difference of means	*t*-statistic: H_0: Difference in Difference = 0 for hypothesis test
1	4.617	4.322	0.296	10.36
2	4.495	4.260	0.235	9.19
3	4.473	4.306	0.167	6.70
4	4.514	4.408	0.106	4.03
5	4.545	4.486	0.060	2.14
6	4.570	4.508	0.062	2.13
7	4.684	4.646	0.038	1.23
8	4.755	4.751	0.004	0.12
9	4.821	4.853	−0.032	−0.90
10	4.847	4.892	−0.044	−1.18

[1]These computations use data from 55 of the 56 counties included in the analysis in Table 5. We exclude Bangladesh because it is impossible to compute Own Children fertility estimates for sample periods longer than 6 years using those data.
Source: As for Table 5.

largest effect on TFR estimates for more recent sample periods of births.

However, even as one source of selection bias appears to diminish, we should expect another source to gain importance as we lengthen the sample period of births. By definition, the IR file excludes adult women who died during the sample period of births. As a mechanical rule, as the time before survey of the sample period increases, so does the number of adult women excluded owing to death. Thus, the IR file becomes less representative of the relevant adult population as the sample period increases. Any association between mortality risk and fertility will introduce a bias that will increase with the length of time since the sample.

The Own Children method formally accounts for past mortality of adult women by counting children who do not live in the same household as their mothers in the TFR numerator, and by using population mortality rates to adjust the number of woman-years probabilistically in the TFR denominator. In fact, we suspect that the Own Children TFR estimates reported throughout this paper may be systematically inaccurate. We extrapolated from known child mortality rates to estimate and apply adult mortality rates on a country-by-country basis in Own Children computations in Step 4 throughout the analysis. However, since, for example, HIV has increased adult mortality substantially in many of the countries included in our analysis, our extrapolation rule may well have underestimated adult mortality. If so, the TFR estimates reported for the Own Child method may be overestimates, with bias increasing with the length of the sample period. According to this line of thought, if we had adjusted our methods to correct adequately for the adult mortality of females, then (i) the Own Children TFR estimates would not have increased with length of the sample period at the high rate indicated by the results in Table 6, and (ii) the FBH TFR estimates might have continued to be larger than the Own Children TFR estimates even as the sample period increased.

7. Conclusion

In this paper we examined only FBH and Own Children methods of fertility estimation. There are of course other methods of estimating fertility level, for instance, by asking questions about births in some recent period, but such methods do not provide estimates of fertility trends from a single application, and also have well-known patterns of data errors (United Nations 1983).

Our results demonstrate systematic differences between the TFRs for the 3 years before the survey for the FBH and Own Children methods, using DHS survey data for 56 countries; the FBH TFRs generally exceed the Own Children TFRs. We specify seven different possible sources of discrepancy in these estimates, identifying two of them as the primary sources of difference.

First, in what we labelled Steps 1 and 2 of our analysis, we estimated a bias of −0.4 per cent in the TFR estimate for the Own Child method as a result of the difference in sample periods between this method and the FBH method. We found that inconsistencies in age coding across the two surveys created an additional 0.8 per cent difference between the two estimates. Retherford and Alam (1985) offer suggestive evidence that this 0.8 per

cent difference might be attributed to bias in the Own Children TFR estimate, but we cannot be certain that this is correct.

Second, in what we labelled Steps 3 and 4 of our analysis, we found strong evidence of selection bias in the collection of birth histories for the IR file. While approximately 90 per cent of women aged 15–49 who appear in the HS file also provide complete birth histories, the selection of women from the HS file to provide birth histories for the IR file systematically favours women with more children. Even after allowing for the possibility that women excluded from the IR file may have more children living in other households than the included women, we estimated that selection bias caused the FBH method to overestimate TFR by 2.3 per cent on average.

We conclude that the Own Children method is at least as accurate as the FBH method and that, in fact, as a result of selection bias, the Own Children method is probably more accurate than the FBH method when applied to DHS surveys for the standard sample period of 3 years of births. As the reference period moves further back in time, we found that the two methods tend to converge in their estimates of TFR. One implication of this finding is that downward trends in fertility are likely to be exaggerated by the FBH method when applied to DHS data, a problem exacerbated by the fact that, because birth histories for women over 50 are not collected, the IR file provides no information about fertility over age 40 for 10 years or more before a DHS survey.

Surveys collecting full birth histories could address the problem of selection bias by collecting a summary birth history for all women of reproductive age in the household questionnaire. Although many such reports would be by proxy respondent (for example, the household head), the differences between summary histories of interviewed vs. non-interviewed women would provide a basis for estimating potential selection bias.

An issue not explicitly addressed by our analysis but of wider importance is the potential performance of the Own Children method when applied to data sets lacking birth histories, for example data from a population census. Our conclusion applies only to DHS data, and it is unknown whether the quality of data collected by a DHS household questionnaire is favourably affected by the survey design, including the subsequent FBH itself. Thus, we cannot draw definitive conclusions about the use of the Own Children method with census data, though Retherford and Alam (1985) included in their analysis five countries with small birth-history surveys nested within much larger household surveys similar to censuses, and still found close agreement between the two methods.

More generally, the Own Children method is affected (modestly) by assumptions about child mortality, by age misreporting or differential undercount by age, and by possible matching errors; all these problems may be greater in census data than DHS data. However, the application of the Own Children method to census data is a costless way of collecting additional data, and offers major advantages, particularly in allowing estimates for small population sub-groups. We conclude that the method should be used to estimate fertility levels and trends from surveys in all countries lacking complete registration of births.

Note

1 Christopher Avery is at the Harvard Kennedy School, Harvard University; Travis St. Clair is at George Washington University; Michael Levin and Kenneth Hill are at the Harvard Center for Population & Development, Cambridge, MA 02138, USA. E-mail: kenneth_hill_1@yahoo.com

References

Abbasi-Shavazi, M. J. 1997. An assessment of the own-children method of estimating fertility by birthplace in Australia, *Journal of the Australian Population Association* 14(2): 167–185.

Abbasi-Shavazi, M. J. and P. McDonald. 2000. Fertility and multiculturalism: immigrant fertility in Australia, 1977–1991, *International Migration Review* 34(1): 215–242.

Childs, G. 2004. Demographic analysis of small populations using the own-children method, *Field Methods* 16(4): 379–395.

Cho, L. J., R. D. Retherford, and M. K. Choe. 1986. *The Own Children Method of Fertility Estimation*. Honolulu: East West Population Institute.

Coleman, D. A. and S. Dubuc. 2010. The fertility of ethnic minorities in the UK, 1960s–2006, *Population Studies* 64(1): 19–41.

Dubuc, S. 2009. Application of the own-children method for estimating fertility by ethnic and religious groups in the UK, *Journal of Population Research* 26(3): 207–225.

Grabill, W. H. and L. J. Cho. 1965. Methodology for the measurement of current fertility from population data on young children, *Demography* 2: 50–73.

Opiyo, C. 2004. Fertility levels, trends and differentials, Chapter 4 in *Kenya Demographic and Health Survey 2003*. Nairobi: Central Bureau of Statistics and ORC Macro.

Potter, J. E. 1977. Problems of using birth history analysis to estimate trends in fertility, *Population Studies* 31(2): 335–364.

Retherford, R. D. and I. Alam. 1985. *Comparison of Fertility Trends Estimated Alternatively from Birth Histories and Own Children Method*, EWPI Series No. 94. Honolulu: East West Population Institute.

Rindfuss, R. 1976. Annual fertility rates from census data on own children: comparisons with vital statistics data for the United States, *Demography* 13(2): 235–249.

United Nations. 1983. *Manual X: Indirect Techniques for Demographic Estimation*. Population Studies No.81. New York: UN Department of International and Social Affairs.

Appendix

Variables used from each type of data file

We used the following variables from the IR file:

V001 Sampling cluster
V002 Household number within cluster
V003 Respondent's line number within household
V005 Respondent's sample weight (with base value of 1,000,000 and where higher values represent lower sample weights)
V008 Month of interview (indexed numerically)
V011 Month of respondent's birth
V012 Age of respondent in years at time of interview
B3_'*i*' Month of birth of child *i*
B5_'*i*' Binary variable for whether child *i* is alive (value 1) or dead (value 0)
B8_'*i*' Age of child '*i*' in years at time of interview
B9_'*i*' Binary variable for whether child *i* lives in household with mother (value 0) or not (value 4)
B16_'*i*' Line number of child '*i*' within household.

We used the following variables from the HS file:

HV001 Sampling cluster
HV002 Household number within cluster
HVIDX Person's line number within household
HV005 Person's sample weight (with base value of 1,000,000 and where higher values represent lower sample weights)
HV102 Usual resident of household
HV103 Slept in household during the night before the interview
HV104 Binary variable for sex of person (1 = male, 2 = female)
HV105 Age of person in years at time of interview
HV112 Line number for person's mother within household (recorded for children ages 0–14 only)
HV117 Eligibility for inclusion in IR file (1 = person is a woman who slept in the household last night and is in the relevant age range between 15 and 49; 0 = otherwise).

Matching of observations across files

(1) We matched (potential) mothers across these two files using the combination of 'Cluster' (V001 and HV001)
'Household Number' (V002 and HV002)
'Line Number within Household' (V003 and HVIDX).
(2) We matched the mothers in the IR file to their children in the HS file (for children living in same household as mothers) using the combination of
'Cluster' (V001 and HV001)
'Household Number' (V002 and HV002)
'Child's Line Number within Household' (B16_'*i*' and HVIDX).

For surveys conducted in 2000 or before, (and on occasion for more recent surveys) variable B16 is not included in the IR file. We then used variable B9_'*i*' in place of B16_'*i*' to distinguish 'Own Children' from 'Non-Own Children' in the IR File. Although we could not formally match mothers in the IR file to their children in the HS file, we assumed that this match could take place for every child listed as an 'Own Child' (B9_'*i*' = 4) and performed computations for Steps 1 and 2 in our analysis for 'Own Children' of mothers listed in both IR and HS data.

(3) We matched the children in the HS file to their mothers in the IR file (for children living in same household as mothers) using the combination of
'Cluster' (V001 and HV001)
'Household Number' (V002 and HV002)
'Mother's Line Number within Household' (V003 and HV112).

When variable HV112 was missing or incomplete, we could not complete this match or even identify own children/mothers' ages within the HS data file. Under these conditions, we could not proceed with the analysis.

List of countries and conditions

For 40 countries, we were able to match data fully from the HS file to the IR file and complete our standard analysis for both FBH and Own Children fertility methods. These countries were as follows: Armenia (2005), Azerbaijan (2006), Bangladesh (2004), Benin (2006), Bolivia (2003), Burkina Faso (2003), Cameroon (2004), Colombia (2005), Congo-Brazzaville (2005), Congo-Dominican (2007), Dominican Republic (2007), Egypt (2005), Ethiopia (2005), Ghana (2003), Guinea (2005), Guyana (2005), Haiti (2005), India (2005), Indonesia (2007), Jordan (2007), Kenya (2003), Lesotho (2004), Liberia (2007), Madagascar (2003), Malawi (2004), Mali (2006), Moldova (2005), Mozambique (2003), Namibia (2006), Nepal (2006), Nicaragua (2001), Niger (2006), Nigeria (2003), Rwanda (2005), Swaziland (2006), Tanzania (2007), Turkey (2003), Uganda (2006), Ukraine (2007), and Zambia (2007).

For 16 additional countries, we were able to complete our analysis using the B9 variables rather than B16 variables to identify own children in the IR data. Because we could not match children across the HS and IR data for these countries, we could not identify an appropriate subsample or compute TFRs for the base case. However, we could compute results for Steps 1–7. These countries were as follows: Brazil (1996), Central African Republic (1994), Comoros (1996), Chad (2004), Côte d'Ivoire (1994), Gabon (2000), Guatemala (1998), Kazakhstan (1999), Morocco (1992), Pakistan (1991), Paraguay (1990), Peru (2004), Philippines (1993), Senegal (1992), South Africa (1998), and Togo (1996).

In the following cases, we could not use a survey and either had to use a previous survey for the same country or exclude that country entirely from the analysis.

(1) DHS household surveys for the following countries did not include variable HV112, the line number for the mother, making it impossible to match children to mothers within households: Angola (2006), Bangladesh (2007), Côte d'Ivoire (1999), Morocco (2003), Pakistan (2006), Philippines (1998, 2003), and Senegal (2006).
(2) DHS IR files for Kyrgyz Republic (1997) and Uzbekistan (1996) did not include variable B9_01, making it impossible to determine which children lived in the same household as the mother.
(3) DHS Household Survey data for Morocco (1995), Senegal (1995), Sudan (1990), and Uzbekistan (2002) followed an earlier format with one line per household rather than one line per person; these surveys could not be easily matched to birth-history data.
(4) DHS Household Survey data for Côte d'Ivoire (2005), Honduras (2005), and Senegal (2005) have unusual numbering schemes for ID numbers that made it impossible to match observations between HS and IR files.