Regional workshop on the Production of Population Estimates
and Demographic Indicators
Addis Ababa, 5-9 October

Evaluation and Analysis of Fertility Data

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Population Estimates and Projections Section

Outline

1. Fertility measures (some definitions)
2. Evaluation of fertility data
   - Data collection errors, coverage, completeness
   - Methods for deriving fertility estimates
   - Comparing estimates from multiple independent sources

Fertility measures (some definitions)

1. Crude Birth Rate (*CBR*)
2. Child/Woman Ratio (*CWR*)
3. General Fertility Rate (*GFR*)
4. Age-Specific Fertility Rates (*ASFR*)
5. Total Fertility Rate (*TFR*)
6. Children ever born (*CEB*)
7. Cohort Fertility (*CF*)
8. Parity progression ratios (*PPR*)

Crude Birth Rate (*CBR*)

- A simple ratio of the number of births in a particular period (usually a year) divided by the total population size

$$CBR = \frac{Births\ in\ stated\ period}{Mean\ population\ over\ that\ period}$$

- *CBR* is commonly expressed in 1,000 population
- Denominator needs to be an average population size for the period concerned and this is often estimated as a mid-year population (average of the population at the start of the period and at the end of the period).

–> Not a rate (but a ratio) as the denominator includes children, men, older persons that are not at risk of childbearing

Crude Birth Rate (*CBR*)

Advantages

- *CBR* is a useful measure to approximate numbers of births when limited information available.
  - For example, if population = 20 million, CBR = 13 per thousand, births next year ≈ 260,000

Disadvantages

- Denominator is the total population of all ages, but childbearing is concentrated among women aged 15-49 **>>** The proportional size of this group can vary considerably between populations, making comparison difficult
- *CBR* "is confounded by age structure" **>>** *CBR* is not used as an accurate measure of fertility

>> Need a fertility measure that is standardised for population structure and therefore would give a more precise measure of fertility

Child/Woman Ratio (*CWR*)

$$CWR = \frac{Living\ children\ aged\ 0-4}{Women\ aged\ 15-49}$$

- *CWR* is a simple, but also not accurate measure of fertility; more a measure of population structure
- Useful as easy to calculate in simple small area surveys **>>** quick assessment of the burden of support that young children place on families in a community

- ***Problem***

  Children who have died are not included in the numerator **>>** In high mortality settings, fertility will be underestimated

  - Normally, CWR < 1
  - in low fertility countries, well below 1;
  - in high fertility countries just under 1.

General Fertility Rate (*GFR*)

$$GFR = \frac{Births\ in\ a\ stated\ period}{Mean\ number\ of\ women\ aged\ 15-49\ in\ the\ same\ period}$$

- *GFR* gives total number of births for all women in the fertile ages

Problem

- GFR also affected by age structure **>>** substantial differences in age structure between populations. Because fertility is concentrated at certain ages, populations can appear to have different levels of fertility simply because they have different age structures between ages 15-49 years. Problematic for international or time comparisons

>> Age-Specific Fertility Rates (*ASFR*) and Total Fertility Rate (*TFR*)

Age-Specific Fertility Rates (*ASFR*)

- The age-specific fertility rate measures the annual number of births to women of a specified age or age group per 1,000 women in that age group

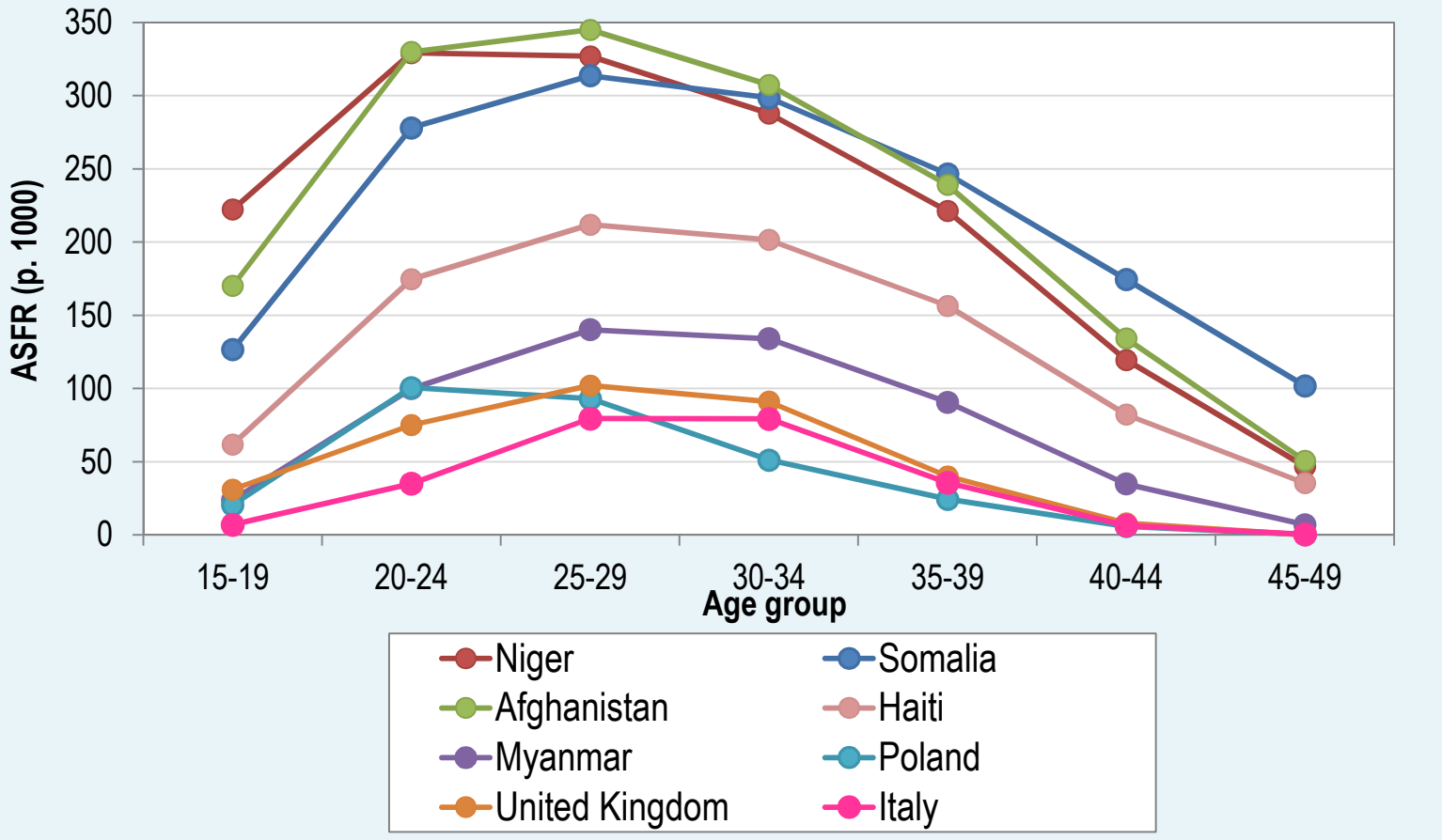
$$ASFR_{x,x+n} = {}_nF_x = \frac{Births\ to\ women\ aged\ x, x+n\ in\ a\ stated\ period}{Number\ of\ women\ aged\ x, x+n\ in\ the\ same\ period}$$

- Where x, $x+n$ refers to age, usually 5-year age groups, which cover the age range 15-49.
- ASFR informs on the ***age patterns of fertility*** or ***fertility schedules***

Age-Specific Fertility Rates (*ASFR*)

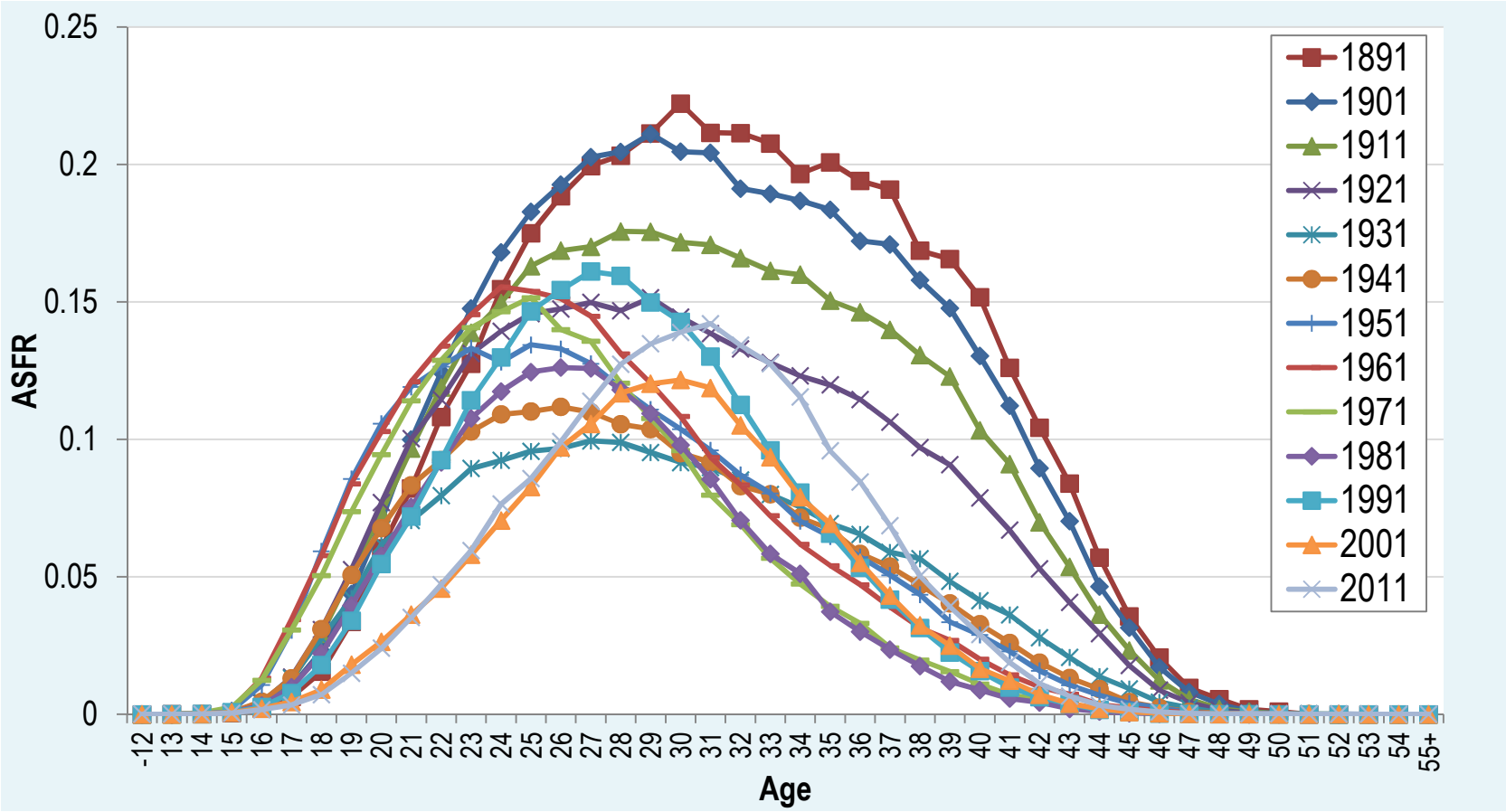
- Age pattern is important in demography
- If we know the **pattern** (*i.e.* the shape) of the phenomenon and recognize the distinct ways in which it changes under certain circumstances, but also recognize the stable features, then we can:
  a) check if data appears to be of good quality;
  b) attempt to correct irregularities that we suspect are due to poor data;
  c) make some predictions

Age-Specific Fertility Rates (*ASFR*), 1995-2000



Source: UNPD (2013)

Age-Specific Fertility Rates (*ASFR*) – Sweden



Source: Human Fertility Database

Total Fertility Rate (TFR)

- TFR is independent of the effect of the age structure.
- TFR gives the number of births that women give birth to.
- TFR is the standard way to compare fertility levels across countries and time.

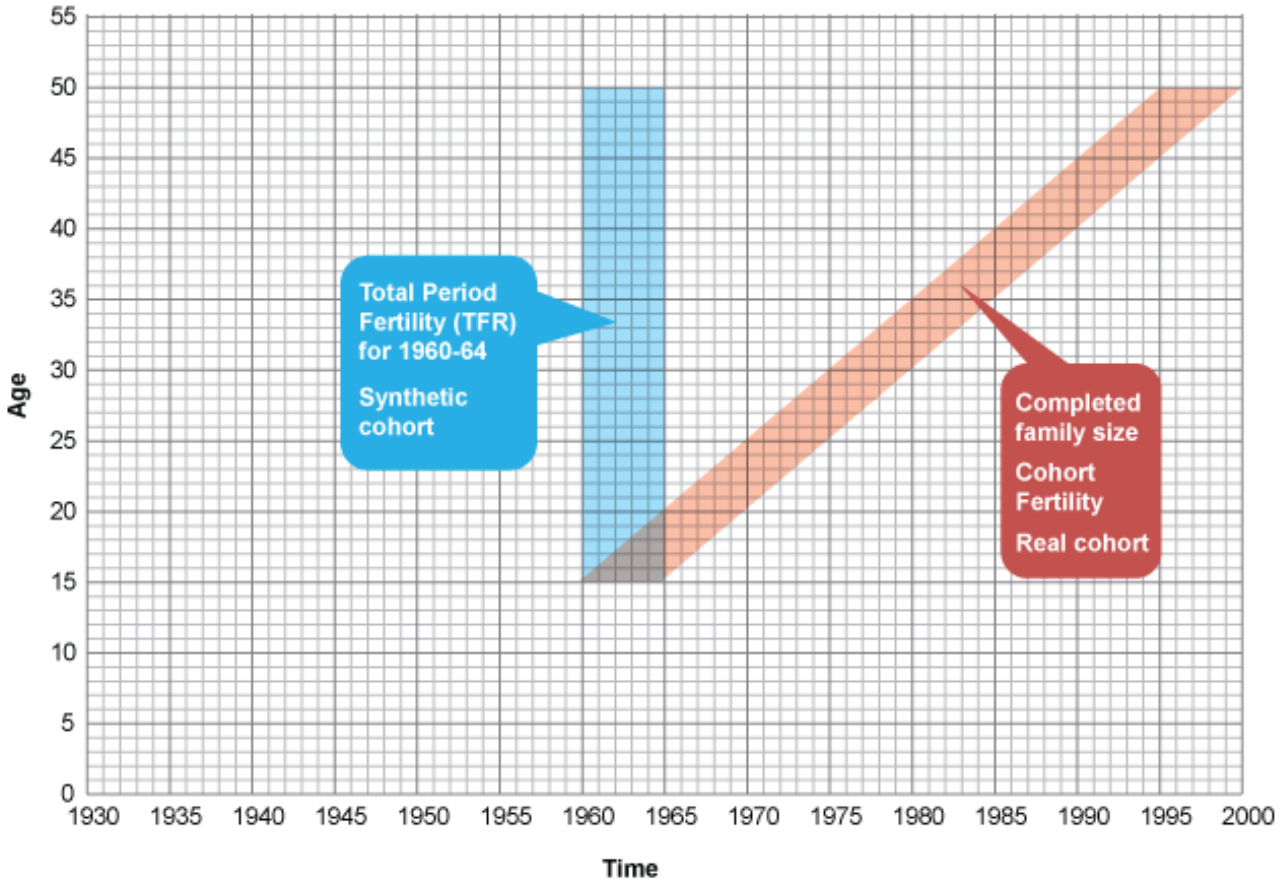
$$TFR = \sum_{x=15-19}^{45-49} ASFR \cdot 5$$

Interpretation

The number of children a woman ***would have if*** she lived from age 15 to age 50 and experienced the ASFRs of the period in question throughout her reproductive life.

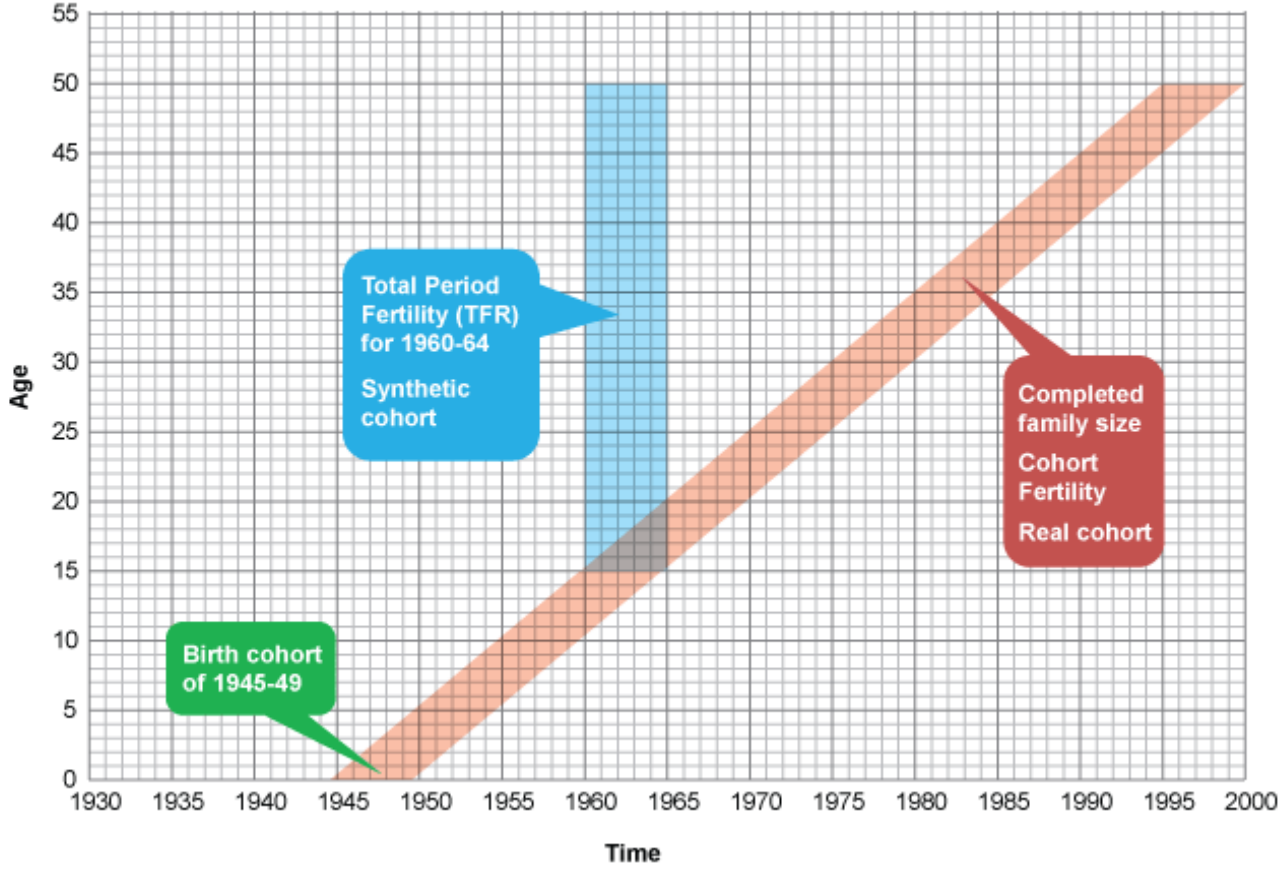
> It is an example of a synthetic cohort

Period Fertility vs. Cohort Fertility



Source: IUSSP & UNFPA (n.d.)

Period Fertility vs. Cohort Fertility



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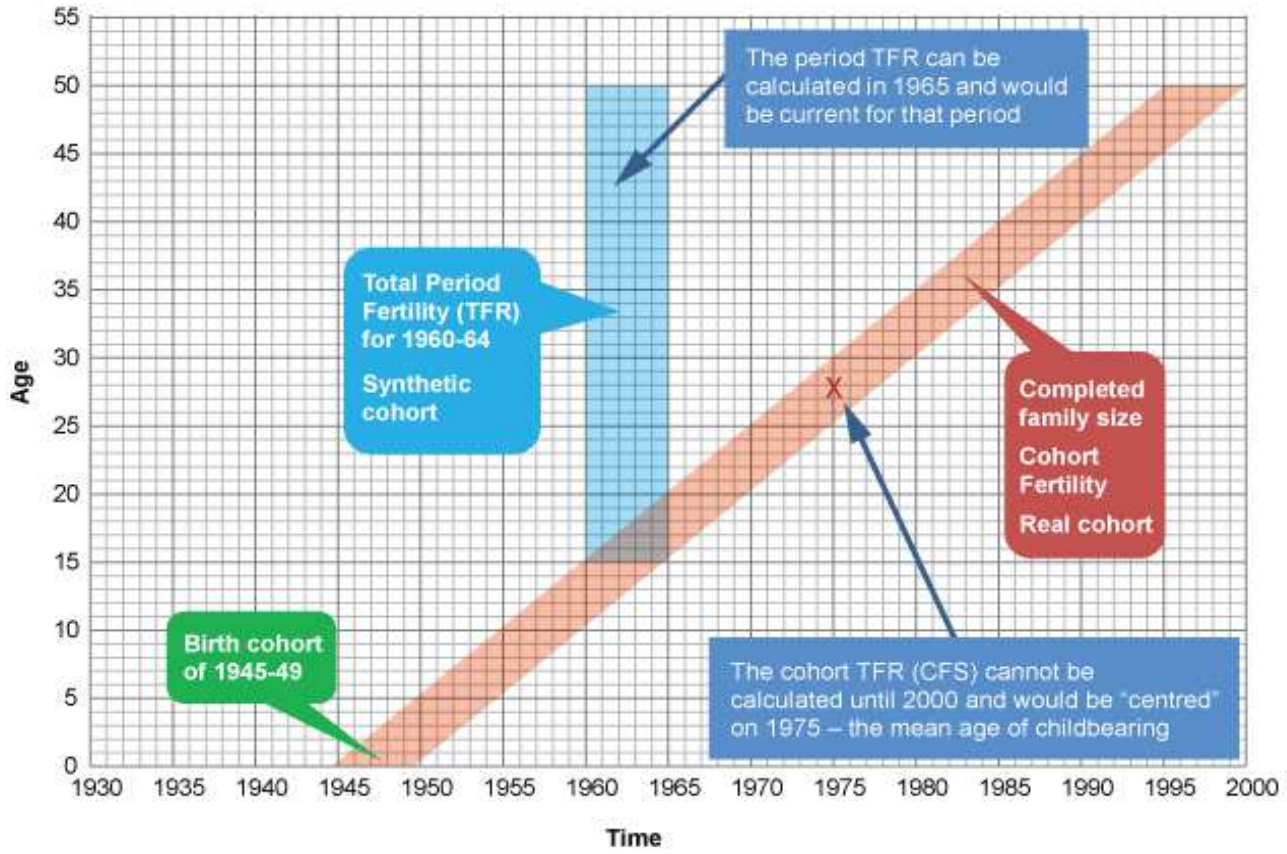
Period Fertility vs. Cohort Fertility



Source: IUSSP & UNFPA (n.d.)

Fertility measures (some definitions)

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4. Age-Specific Fertility Rates ($ASFR$)
5. Total Fertility Rate (TFR)

} Period Fertility

6. Children ever born (CEB)
7. Cohort Fertility (CF)
8. Parity progression ratios (PPR)

Children ever born (*CEB*) and Cohort Fertility (*CF*)

- Measure of **all live** births a woman has had in her lifetime
- Asked to all women age 15 and older (sometimes age 12)
- *CEB* also called Summary Birth Histories (*SBH*)
- *CEB* of women age 45 and older (sometimes 40 and older)

  >> Estimates of cohort fertility (*CF*) (as these women have completed their reproductive life)

Parity Progression Ratios (*PPR*s)

Proportion of women who have already had a certain number of children and go on to have another child = interesting and useful measure of fertility

Parity = Number of children a woman has already had

Parity progression ratio (*PPR*) = Proportion of women of a given parity who go on to have another child

$$PPR \text{ from } j \text{ births to } j+1 \text{ births} = \frac{\text{Number of women who have a } (j+1)\text{th child}}{\text{Number of women who have a } j\text{th child}}$$

*PPR*s are useful to understand the **distribution** of cohort fertility (i.e. proportion of women in a cohort who end up with exactly no children, exactly one, exactly two,…, at the end of the childbearing years)

Source: Hinde (1998)

Distribution of cohort fertility (CF) – Example

Parity	Cohort A		Cohort B	
	Number of women	Number of children at parity i	Number of women	Number of children at parity i
0	7	0	1	0
1	0	0	0	0
2	0	0	0	0
3	0	0	9	27
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	3	27	0	0
Total	10	27	10	27
Cohort Fertility		**2.7**		**2.7**

Same CF, but different **distribution** of births

Source: Hinde (1998)

Parity Progression Ratios (PPR)

Most widely used measures of fertility are period measures ($ASFR$; TFR)
> useful but cannot detect real changes in fertility in the short term, as they are affected by the *timing* of births (tempo effects)

PPRs are insensitive to tempo effects

PPRs measure the **proportion of women with n children who go on to have $n+1$ children**

PPRs are order-specific and come in sets (≠ single summary measure such as the TFR)

a_0 = proportion of women with 0 children who go on to have 1 child (i.e. become mothers)

a_1 = proportion of women with 1 child who go on to have 2 children

a_2 = proportion of women with 2 children who go on to have 3 children

a_3 = etc.

up to a suitable birth order, depending on the level of fertility.

Parity Progression Ratios (*PPR*)

Advantage

*PPR*s are free of tempo effects **>>** no change due to postponement of fertility

Disadvantage

Based on census data, *PPR*s are **cohort measures**

> completed (or nearly completed) fertility (younger women not included)

> Period PPRs (*PPPR*) can be computed but require data not collected in census (full birth histories collected in sample surveys)

Period Fertility vs. Cohort Fertility

Period fertility	Cohort fertility
Relates to short intervals of time	Relates to lifetime experience
Looks at births to women in all age groups	Follows real women over their reproductive life-times
Can produce very current estimates	Estimates typically relate to an earlier period
Data can be collected in a single time period or in a cross-sectional survey. For recent childbearing (last 10 years) recall of dates of birth is usually quite good	Requires either longitudinal data or retrospective questioning by means of a birth history from women aged 50+. In populations not conversant with recording of dates the latter may suffer from inaccuracies of age/date recall for distant births
Summary measure is Total Fertility Rate (TFR)	Summary measure is Completed Family Size (CFS) or Cohort Fertility (CF)
Refers to an artificial construct called a synthetic cohort	Reflects the lifetime behaviour and intentions of cohorts of real women
Highlights the yearly variations in fertility due to transient influences	Smoothes out temporal variations in fertility, since real women may live through periods of high and low fertility
Parity progression analysis complicated	Easy to describe family formation in terms of parity progression
Best way to study impact of crises and short term interventions	Best way to study childhood influences on childbearing outcomes

Outline

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1. Recent births

- Measure of recent fertility
- Asked to all women age 15–49 at the time of the census who reported at least one live birth in their lifetime
- **Preferred question:** Date of birth of last child born alive (day, month and year)
- **Alternative question:** Births in the last twelve months to the woman or in the household
  - More error-prone than exact date of birth, although both are subject to under-reporting
  - Date of birth can be converted to births in last 12 months during data processing (will miss only small percentage of cases in which woman had multiple births in a year)

2. Children ever born (summary birth histories (SBH))

- Measure of **all live** births a woman has had in her lifetime
- Asked to all women age 15 and older
- For every woman the following information is collected:
  - >Total number of female children she has borne in her lifetime
  - >Total number of male children she has borne in her lifetime
  - >Number of female children who are surviving
  - >Number of male children who are surviving
    - ▸ CEB/CS

2. Children ever born

Recommended question sequence to improve completeness of data:

1. Total number of sons ever born alive during the lifetime of the woman
2. Total number of sons living (surviving) at the time of the census
3. Total number of sons born alive who died before the census data
4. Total number of daughters ever born alive during the lifetime of the woman
5. Total number of daughters living (surviving) at the time of the census
6. Total number of daughters born alive who died before the census date

Source: United Nations (2008), *Principles and Recommendations for Population and Housing Censuses, Revision 2*, New York, United Nations, available online at: http://unstats.un.org/unsd/publication/SeriesM/Seriesm_67rev2e.pdf

2. Children ever born – When is it used?

- Widely used for over 50 years both for measures of fertility and for child mortality (next session)
- Very important for countries without or with incomplete birth registration
- Also important for countries with complete birth registration
  - > Allows for the study of fertility by detailed socio-economic characteristics

Fertility data – possible errors

Both methods (Recent births and CEB): enumerator's error

1. **Enumerators' failure to reach individuals**
   a) The not-at-home error: information provided by neighbors
   b) Coverage error: omission of an area or forgot to record the answer

2. **Recording error**
   a) Answer is recorded incorrectly by the enumerator
      e.g., childless women misclassified into parity not stated

Recent births – possible errors

1. **Reference period errors**
   a) Uncertain of the exact date of birth relative to the reference period
   b) Incorrectly moving birth into or out of the reference period

2. **Births missed because mother not located**
   a) Women had a birth recently but died or migrated before the census
   b) Household had a birth recently but the household dissolved before the census
   c) Not significant in most cases, however could become an issue when many deaths occurring in a short period (HIV/AIDS) or when there is significant migration

Children ever born – possible errors

1. **Errors because the respondent did not understand the question**
   a) Mortality error: reported only children living rather than ever-born
   b) Non-resident error: did not report surviving children living elsewhere
   c) Marriage error: women not reporting her children born from previous marriage or children born out of wedlock

2. **Errors because of respondents' lapse of memory or neglect**
   a) Memory error: respondent forgot some children
      >Believed to be more common among older women

3. **Age misreporting**
   a) Teenage mothers may exaggerate their age
   b) Age misreporting if this results in a systematic over- or under-stating of age

Standard fertility measures

Average Parity/Children Ever Born – average number of children had by women in an age group

Parity Distributions – distribution of women in each age group by number of children they have had

Age Specific Fertility Rates (ASFR) – indicates the age pattern of fertility in a society

$$ {}_nF_x = \frac{{}_nB_x}{{}_nW_x} $$

${}_nB_x$ =Births to women age x to x+n during period

${}_nW_x$ =Mid-period population of women age x to x+n

Total Fertility Rate (TFR) – number of children a woman would have in her lifetime if she lived her whole life under today's fertility conditions ($ASFR$s)

$$ TFR = n \cdot \sum {}_nF_x $$

Census fertility data – what can we get?

	Parity Distribution	Average Parity	ASFR	TFR
Children Ever Born	Y	Y	Y*	Y*
Recent Fertility	N	N	Y	Y

*With one census under constant fertility, otherwise with two censuses

Methods for Deriving Fertility Estimates

CEB – quality assessment (Step 1)

- Initial assessment of data quality and missing values
  - Any missing values in CEB data?
  - Missing value for any relevant variables? (age of mother, sex of child, survival status of the child)
  - Was imputation, hotdecking or any other method used to clean the data?
    - If so, should have a good understanding of the rules followed

Note: hot-deck imputation > a missing value imputed from a randomly selected similar record

CEB – quality assessment

Table 2.11 Proportion of women whose parity data was not subject to logical imputation or hotdecking, by age and population group, Census 2001

Age group	*African*	*Coloured*	*Indian/Asian*	*White*
12-14	65.2	53.5	61.4	46.2
15-19	73.5	63.7	68.8	55.9
20-24	82.5	78.5	79.1	73.9
25-29	88.2	87.6	88.0	85.4
30-34	90.9	91.2	92.2	90.2
35-39	91.9	92.6	93.5	91.3
40-44	91.4	92.5	93.3	91.5
45-49	89.9	91.3	91.9	90.4

Source: Moultrie T. & R. Dorrington (2004), *Estimation of Fertility from the 2001 South Africa Census Data,* Centre for Actuarial Research, University of Cape Town, available online at: http://www.hst.org.za/uploads/files/mono12.pdf.pdf

CEB – quality assessment (Step 2)

Tabulation of children ever born

- Number of children should not be grouped, except for the last open category (usually no lower than 9+ or 10+ children)
- Children ever born ***not stated*** should be distinguished from ***no children*** *(parity "0")*
- Are parities reasonable?
  - Quick rule-of-thumb: maximum parity should be one child every 18 months from age of 12
  - E.g. by exact age 20 (end of 15 – 19 age group) maximum children should be 5

Source: Moultrie et al. (2013) available online at: http://demographicestimation.iussp.org/

CEB – quality assessment

U.R. Tanzania, 2002 Census (Source: IPUMS)

Parity	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49
0	13	4	1247361	1375715	470499	169134	71561	38428	27060	19667
1	19	0	7355	251720	477337	197519	77230	38913	25461	16630
2	0	2	1823	62816	400908	292919	123590	60029	36192	22643
3	5	0	625	16667	193627	300738	158167	80723	47736	28924
4	0	0	0	7354	79765	233703	188783	102223	63125	36978
5	0	0	1	2988	29576	131234	168381	107037	68944	42593
6	0	0	0	1674	13297	65648	131614	111694	73587	47756
7	0	0	0	874	5723	30141	85411	95012	73460	51223
8	0	0	0	183	3772	15744	48801	73880	69464	51712
9	0	0	0	0	1918	7092	24218	47385	58792	49864
10	0	0	0	0	1511	4458	14033	30526	44344	40587
11	0	0	0	0	1062	2473	6404	17425	28303	29739
12	0	0	0	0	537	2019	4294	9898	18554	20764
13	0	0	0	0	232	1229	2920	5472	11030	11971
14	0	0	0	0	0	1030	1403	2873	6373	8252
15+	0	0	0	0	0	587	2458	4616	10450	13453
Unknown	0	0	888	6489	3320	2310	1676	1217	939	588

Parities obviously wrong

Unknown separated from parity '0'

CEB – quality assessment **U.R. Tanzania, 2002 Census** (Source: IPUMS)

Parity	15-19	20-24	25-29	30-34	35-39	40-44	45-49
0	1,375,715	470,499	169,134	71,561	38,428	27,060	19,667
1	251,720	477,337	197,519	77,230	38,913	25,461	16,630
2	62,816	400,908	292,919	123,590	60,029	36,192	22,643
3	16,667	193,627	300,738	158,167	80,723	47,736	28,924
4	7,354	79,765	233,703	188,783	102,223	63,125	36,978
5	2,988	29,576	131,234	168,381	107,037	68,944	42,593
6	1,674	13,297	65,648	131,614	111,694	73,587	47,756
7	874	5,723	30,141	85,411	95,012	73,460	51,223
8	183	3,772	15,744	48,801	73,880	69,464	51,712
9	0	1,918	7,092	24,218	47,385	58,792	49,864
10	0	1,511	4,458	14,033	30,526	44,344	40,587
11	0	1,062	2,473	6,404	17,425	28,303	29,739
12	0	537	2,019	4,294	9,898	18,554	20,764
13	0	232	1,229	2,920	5,472	11,030	11,971
14			1,030	1,403	2,873	6,373	8,252
15+			587	2458	4616	10450	13453
Unknown			2310	1676	1217	939	588
Total women			1,457,978	1,110,944	827,351	663,814	493,344
Total children			4,206,421	4,748,653	4,494,279	4,245,638	3,472,247
Proportion unknown			0.0005	0.0004	0.0003	0.0002	0.0002
Proportion childless			0.12	0.06	0.05	0.04	0.04
Average parity	0.28	1.50	2.89	4.27	5.43	6.40	7.04

Total children by age group = Parity * women at that parity

Proportion with unknown parity should stay constant

Proportion childless should decrease with age

Average parity should increase with age

CEB – quality assessment

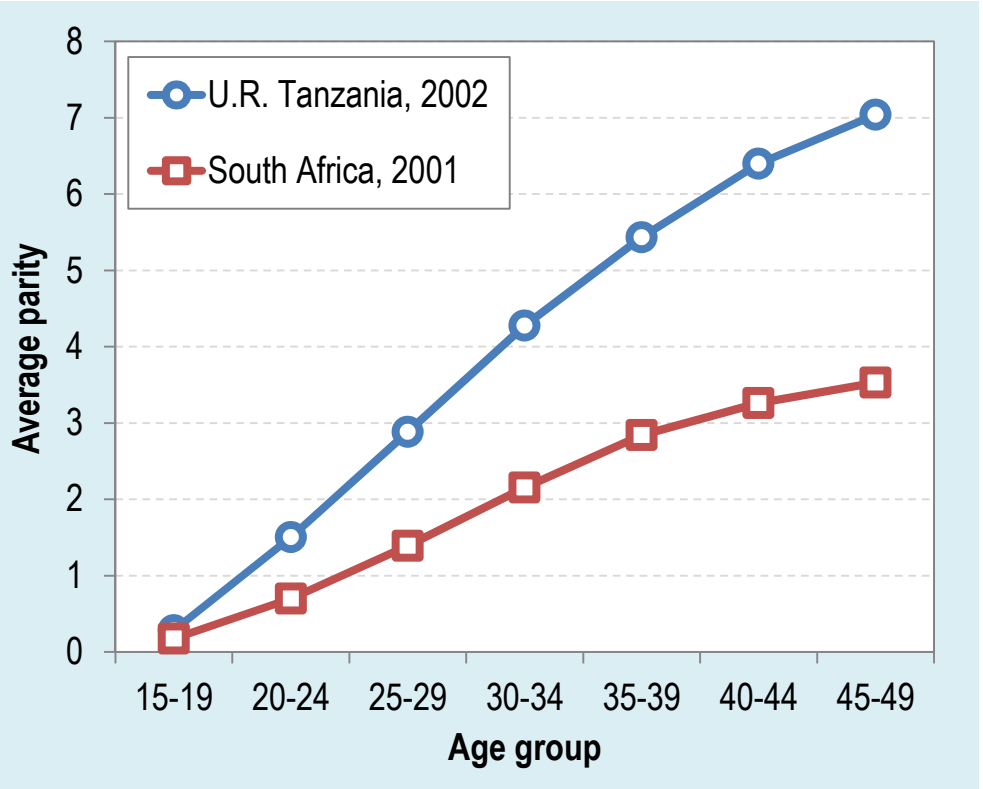
Average parity at age *x*:

$$P_x = \frac{B_x}{W_x} = \frac{\sum_j jW_{j,x}}{\sum_j W_{j,x}}$$

where

B_x = number of births by age x

$W_{j,x}$ = number of women of age x at parity j



Data source: IPUMS-International

CEB – quality assessment **U.R. Tanzania, 2002 Census** (Source: IPUMS)

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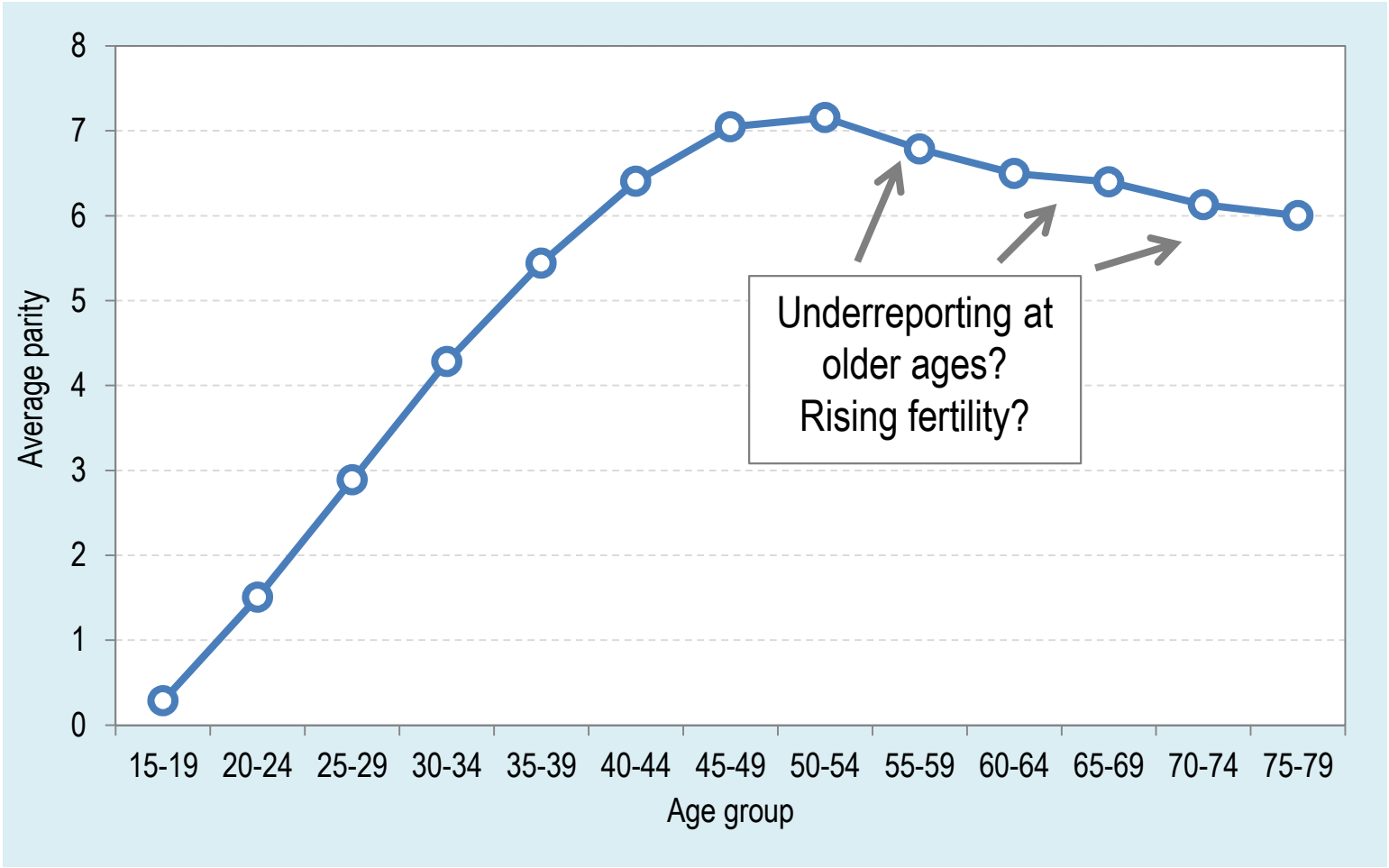
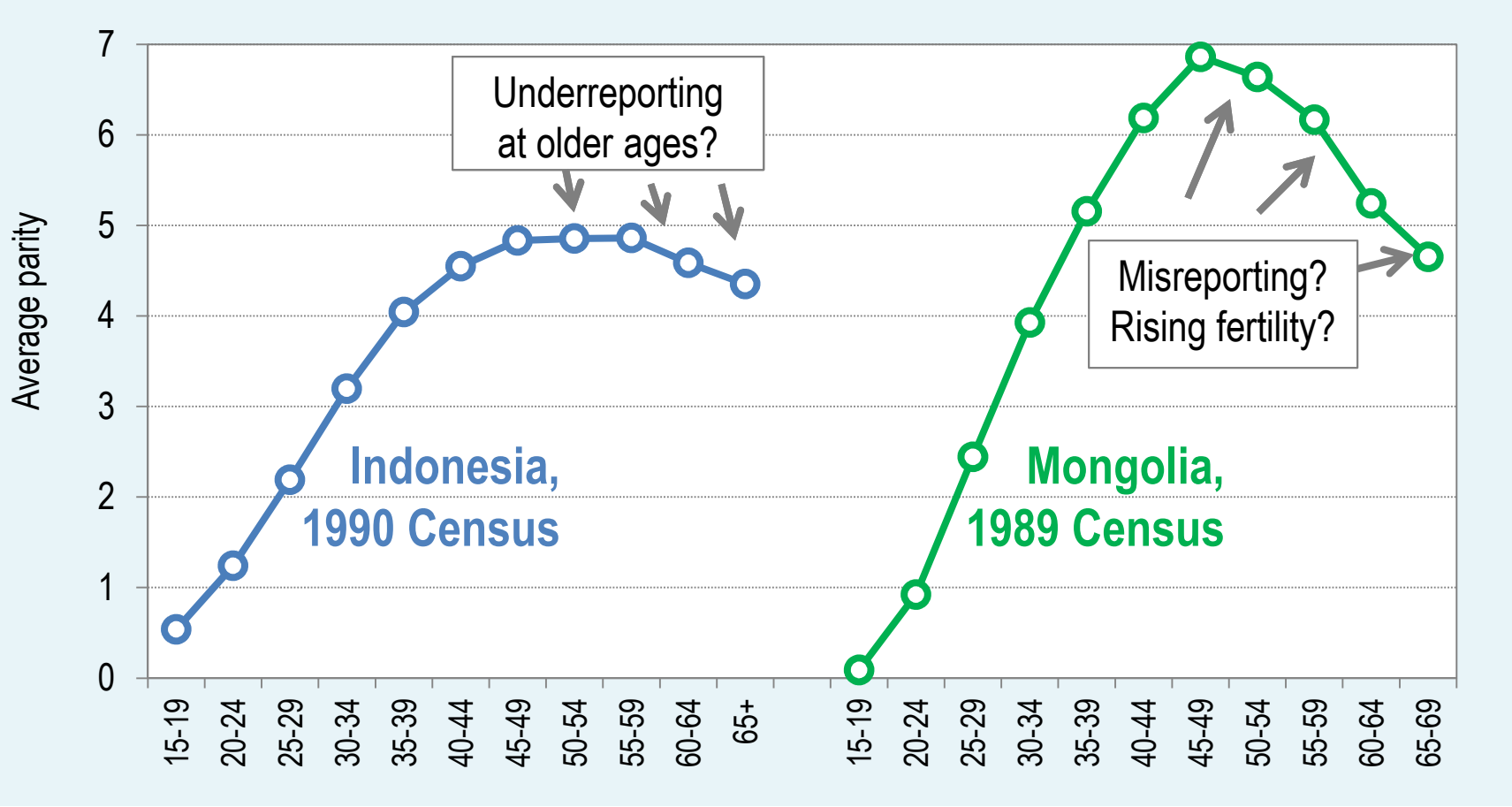
5	2,988	29,576	131,234	168,381	107,037	68,944	42,593
6	0	13,297	65,648	131,614	111,694	73,587	47,756
7	0	5,723	30,141	85,411	95,012	73,460	51,223
8	0	3,772	15,744	48,801	73,880	69,464	51,712
9	0	1,918	7,092	24,218	47,385	58,792	49,864
10	0	1,511	4,458	14,033	30,526	44,344	40,587
11	0	1,062	2,473	6,404	17,425	28,303	29,739
12	0	537	2,019	4,294	9,898	18,554	20,764
13	0	232	1,229	2,920	5,472	11,030	11,971
14	0	0	1,030	1,403	2,873	6,373	8,252
15+	0	0	587	2458	4616	10450	13453
Unknown	9,220	3,320	2,310	1,676	1,217	939	588
Total women	1,726,480	1,683,084	1,457,978	1,110,944	827,351	663,814	493,344
Total children	489,335	2,530,507	4,206,421	4,748,653	4,494,279	4,245,638	3,472,247
Proportion unknown	0.0133	0.0013	0.0005	0.0004	0.0003	0.0002	0.0002
Proportion childless	0.80	0.28	0.12	0.06	0.05	0.04	0.04
Average parity	0.28	1.50	2.89	4.27	5.43	6.40	7.04

CEB – quality assessment, U.R. Tanzania 2002 Census



Data source: IPUMS-International

CEB – quality assessment



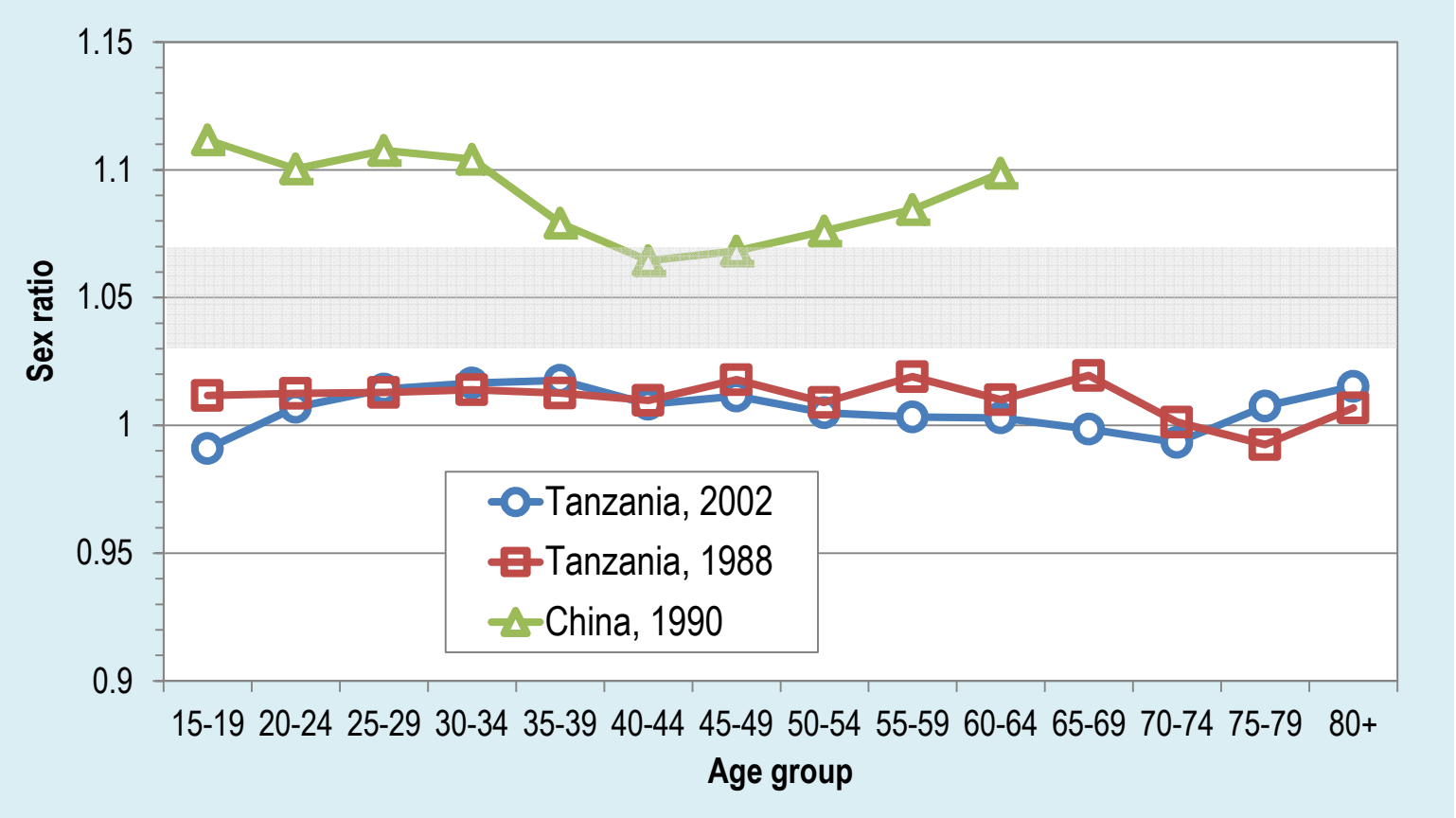
Data source: IPUMS-International

The el-Badry Correction

- To adjust reported data on children ever born
- A common problem with CEB data is that enumerators may incorrectly code women of zero parity as “parity unknown” or “parity not stated”
- The el-Badry method corrects for this
  - If parity unknown is less than 2% of each age group >> safe to assume that data are consistent and no correction needed.

- Detailed examples in:
  - United Nations (1983, pp. 230-235).
  - Moultrie et al. (2013, pp. 35-41).

CEB – quality assessment, sex ratio



Source: IPUMS-International
Note: The grey-shaded line indicates an expected sex ratio at birth of 1.03 to 1.07 (baby boy per one baby girl)

CEB checks, Parity distribution of women age 45-49

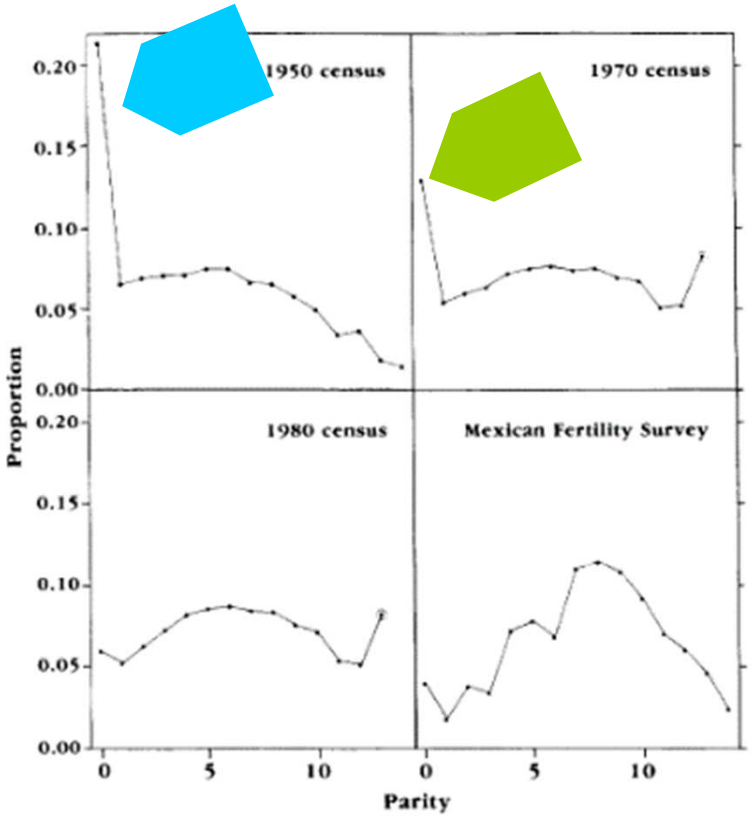
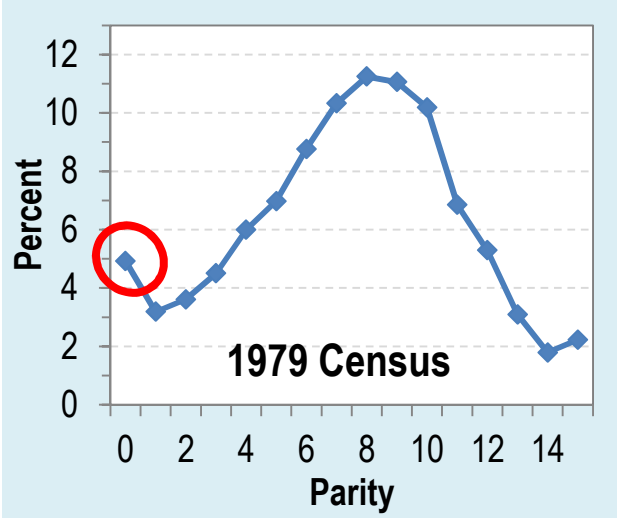


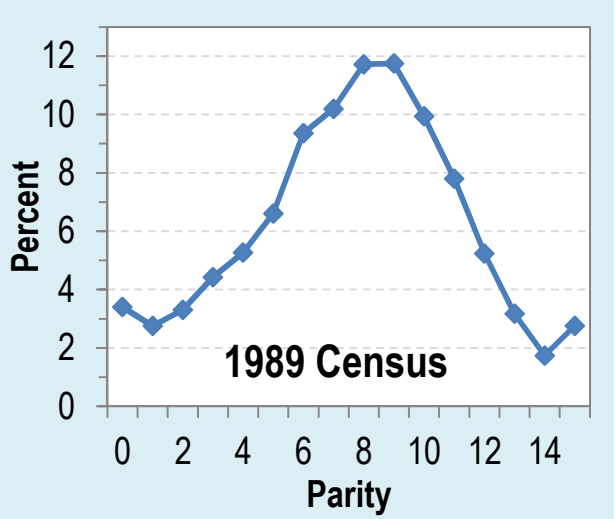
Figure 3. Completed parity distributions for Mexico, from the censuses of 1950, 1970, and 1980 and from the Mexican Fertility Survey

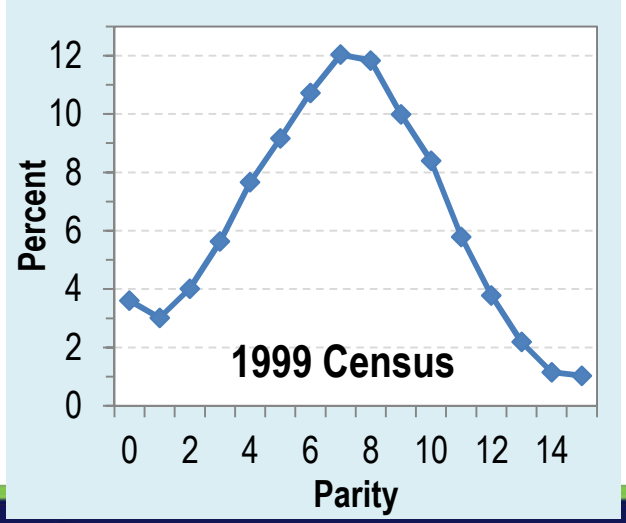
- High level of parity 0 in 1950 and 1970 censuses: possibly groups "not stated" and "0" parity combined. No separate groups unlike as in the 1980 census.
- Flat curve: probably some form of misreporting, seems to be improving over time
- Mexican fertility survey: shape of the curve more plausible (small sample size)

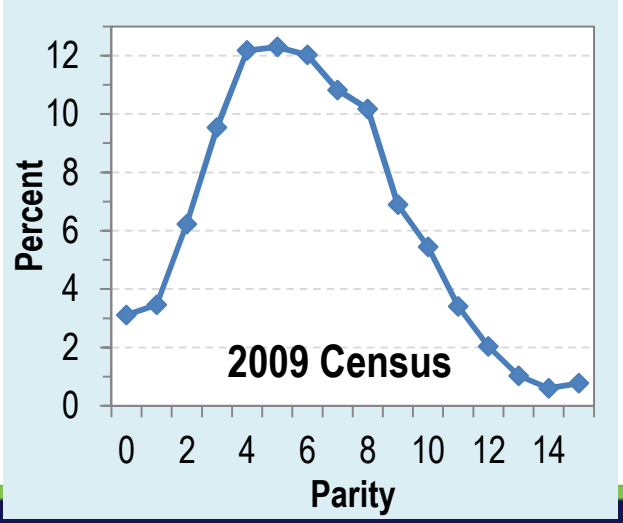
Source: Feeney (1991)

CEB Checks, Parity distribution of women age 45-49, Kenya, 1979-2009 censuses





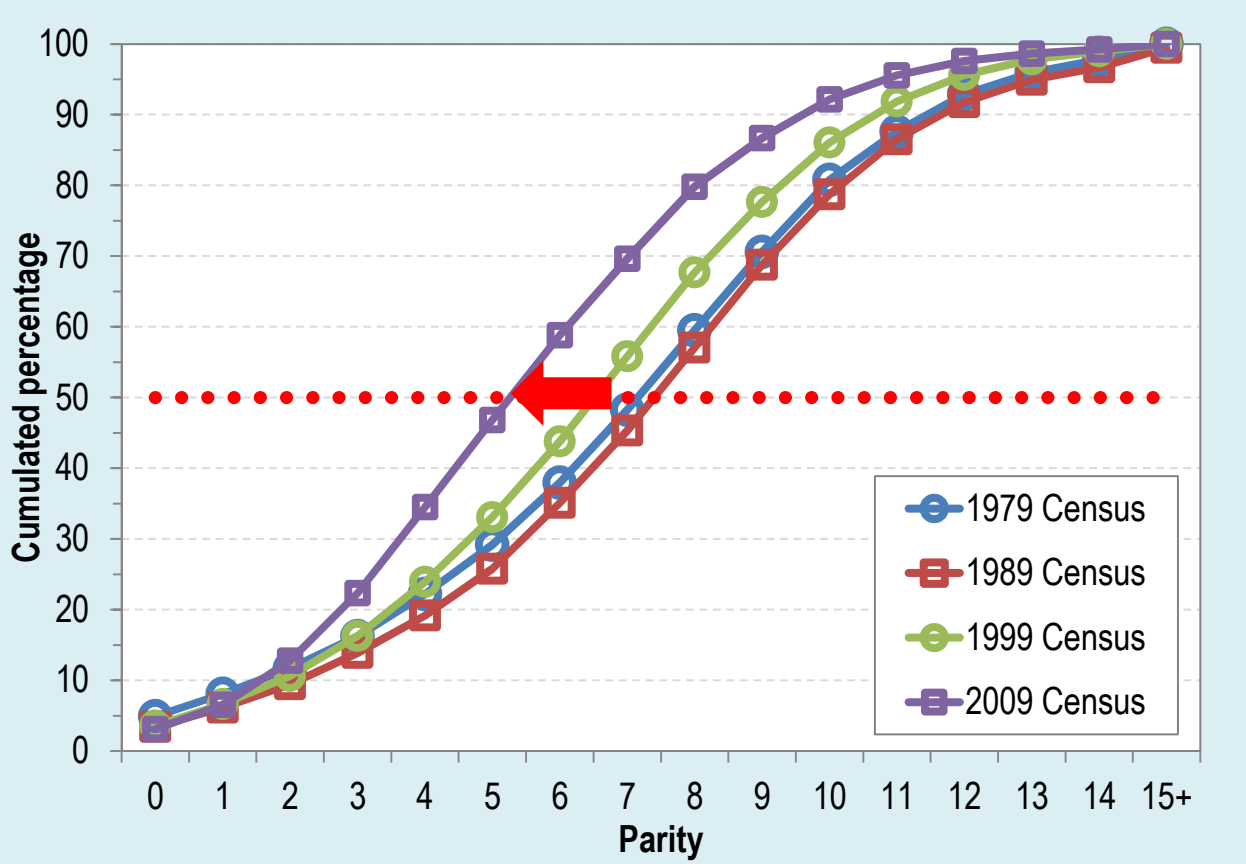




1979 census:
Women with non-stated parity included in 0 parity?

Source: IPUMS-International

CEB Checks, Parity distribution of women age 45-49 Kenya, 1979-2009 census



In 1979, about half of the women age 45-49 have had 7 children or less

In 2009, about half of the women age 45-49 have had 5 children or less

Source: IPUMS-International

CEB Additional Checks
Cohort analysis of mean number of *CEB*

- Simple test for quality of reporting among older women
- Time-plotting of CEB (introduced by Feeney (1988))
- Assumes mean age at childbearing is 28 or any other age
- Reference date = Census date – (age of women – 28)

  >> Census date should be in decimal format

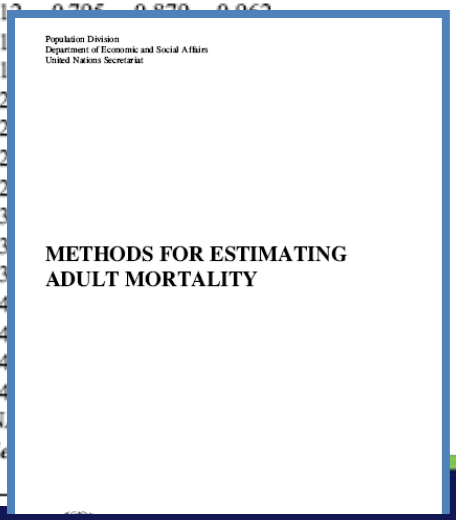
Census date in decimal format

ANNEX TABLE I-1. TRANSLATION TABLE FOR DECIMAL FORMS OF DATES

Day\Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.003	0.088	0.164	0.249	0.332	0.416	0.499	0.584	0.668	0.751	0.836	0.918
2	0.005	0.090	0.167	0.252	0.334	0.419	0.501	0.586	0.671	0.753	0.838	0.921
3	0.008	0.093	0.170	0.255	0.337	0.422	0.504	0.589	0.674	0.756	0.841	0.923
4	0.011	0.096	0.173	0.258	0.340	0.425	0.507	0.592	0.677	0.759	0.844	0.926
5	0.014	0.099	0.175	0.260	0.342	0.427	0.510	0.595	0.679	0.762	0.847	0.929
16	0.044	0.129	0.205	0.290	0.373	0.458	0.540	0.625	0.710	0.792	0.877	0.959
17	0.047	0.132	0.208	0.293	0.375	0.460	0.542	0.627	0.71			
18	0.049	0.134	0.211	0.296	0.378	0.463	0.545	0.630	0.71			
19	0.052	0.137	0.214	0.299	0.381	0.466	0.548	0.633	0.71			
20	0.055	0.140	0.216	0.301	0.384	0.468	0.551	0.636	0.72			
21	0.058	0.142	0.219	0.304	0.386	0.471	0.553	0.638	0.72			
22	0.060	0.145	0.222	0.307	0.389	0.474	0.556	0.641	0.72			
23	0.063	0.148	0.225	0.310	0.392	0.477	0.559	0.644	0.72			
24	0.066	0.151	0.227	0.312	0.395	0.479	0.562	0.647	0.73			
25	0.068	0.153	0.230	0.315	0.397	0.482	0.564	0.649	0.73			
26	0.071	0.156	0.233	0.318	0.400	0.485	0.567	0.652	0.73			
27	0.074	0.159	0.236	0.321	0.403	0.488	0.570	0.655	0.74			
28	0.077	0.162	0.238	0.323	0.405	0.490	0.573	0.658	0.74			
29	0.079	NA	0.241	0.326	0.408	0.493	0.575	0.660	0.74			
30	0.082	NA	0.244	0.329	0.411	0.496	0.578	0.663	0.74			
31	0.085	NA	0.247	NA	0.414	NA	0.581	0.666	N			
Day/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Se			

Where to find?

Annex Table I-1, p. 85 in United Nations Population Division (2002), *Methods for Estimating Adult Mortality*, New York, United Nations, DESA, Population Division, available online at:
http://www.un.org/en/development/desa/population/publications/mortality/estimate-mortality.shtml


Population Division
Department of Economic and Social Affairs
United Nations Secretariat

METHODS FOR ESTIMATING
ADULT MORTALITY

Census date in decimal format

Examples

The reference date of the 2012 Census of U.R. Tanzania is 26 August 2012

26 August in decimal date = 0.652

26 August 2012 in decimal date = 2012+0.652 = **2012.652**

Reference date of the 1989 Census of Kenya in decimal (24 August 1989) = **???**

CEB - Additional Checks
Cohort analysis of mean CEB

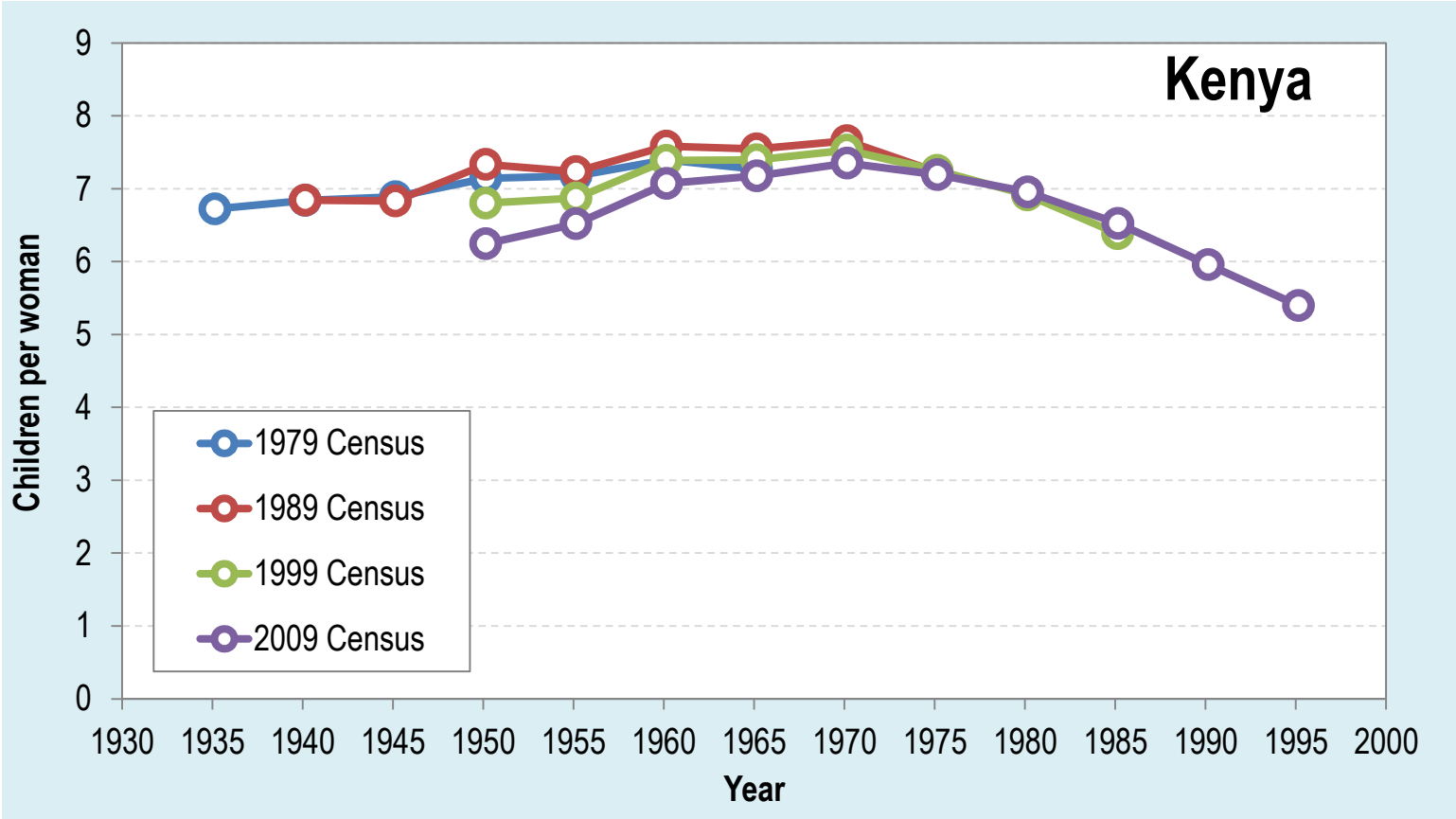
Example of Kenya: 1989 census

Year in time = Census year in decimal – (age of women – 28)

Age group	Total women	Total CEB	Average CEB	Mid-group age	Mean age at childbearing	Number of preceding years for which average CEB refers	Reference date of census	Reference date of average CEB
	(1)	(2)	(3) = (2)/(1)	(4)	(5)	(6) = (4) - (5)	(7)	(8) = (7) - (6)
40-44	350,140	2,532,140	7.23	42.5	28	14.5	1989.647	1975.147
45-49	280,920	2,151,920	7.66	47.5	28	19.5	1989.647	1970.147
50-54	230,080	1,736,540	7.55	52.5	28	24.5	1989.647	1965.147
55-59	173,260	1,314,140	7.58	57.5	28	29.5	1989.647	1960.147
60-64	158,140	1,143,740	7.23	62.5	28	34.5	1989.647	1955.147
65-69	111,360	816,820	7.33	67.5	28	39.5	1989.647	1950.147
70-74	82,080	560,520	6.83	72.5	28	44.5	1989.647	1945.147
75-79	54,220	371,060	6.84	77.5	28	49.5	1989.647	1940.147

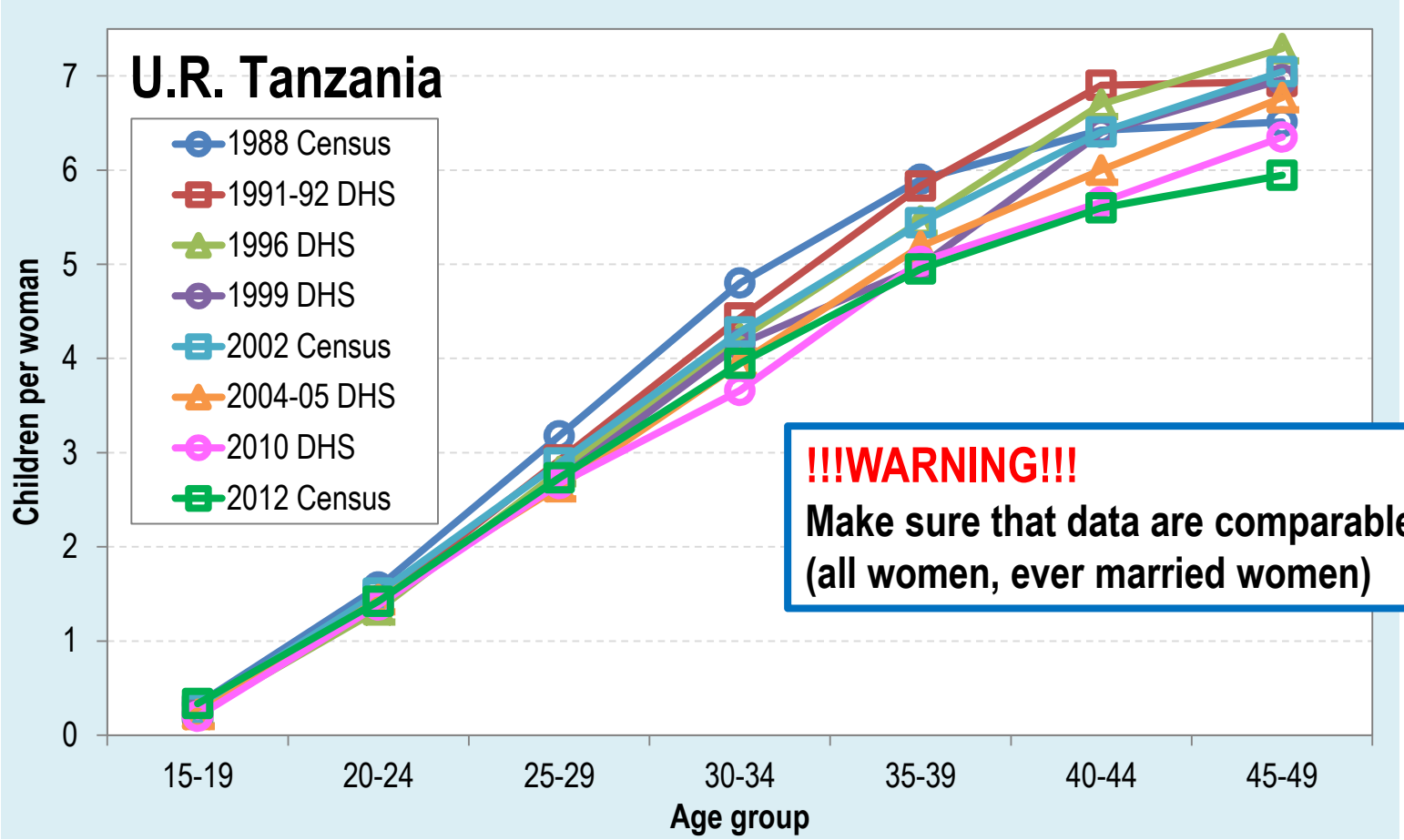
Source: IPUMS-International

CEB - Additional Checks
Cohort analysis of mean CEB



Source: Own computations using IPUMS-International

CEB – Additional checks
Multiple sources of data



Source: IPUMS-International and DHS STATcompiler http://www.statcompiler.com/

CEB - Parity progression ratios

From the CEB data, we can compute Parity Progression Ratios (PPR)

Parity Progression Ratio (PPR) = Proportion of women of a given parity who go on to have another child

>> useful to understand the **distribution** of cohort fertility (i.e. proportion of women in a cohort who end up with exactly no children, exactly one, exactly two,…, at the end of the childbearing years).

CEB - Parity progressions ratios, U.R. Tanzania 2002 Census

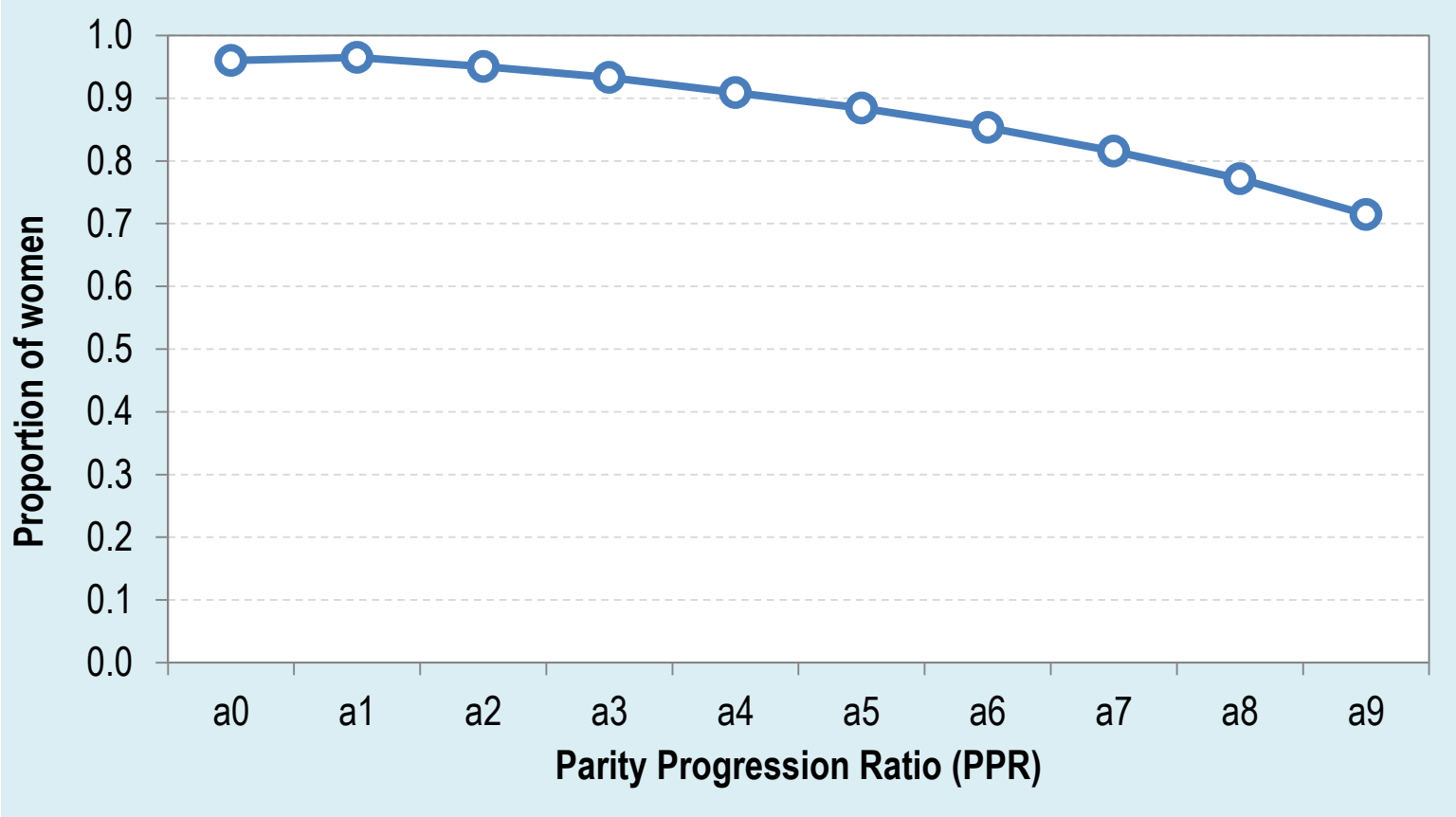
Children ever born N	Number of women age 45-49	Women 45-49 with at least N children	Parity progression ratio (PPR)	Symbol
0	19,667	492,756	0.960	a0
1	16,630	473,089	0.965	a1
2	22,643	456,459	0.950	a2
3	28,924	433,816	0.933	a3
4	36,978	404,892	0.909	a4
5	42,593	367,914	0.884	a5
6	47,756	325,321	0.853	a6
7	51,223	277,565	0.815	a7
8	51,712	226,342	0.772	a8
9	49,864	174,630	0.714	a9
10+	124,766	124,766		

Cumulate

0.960 = 473,089 / 492,756

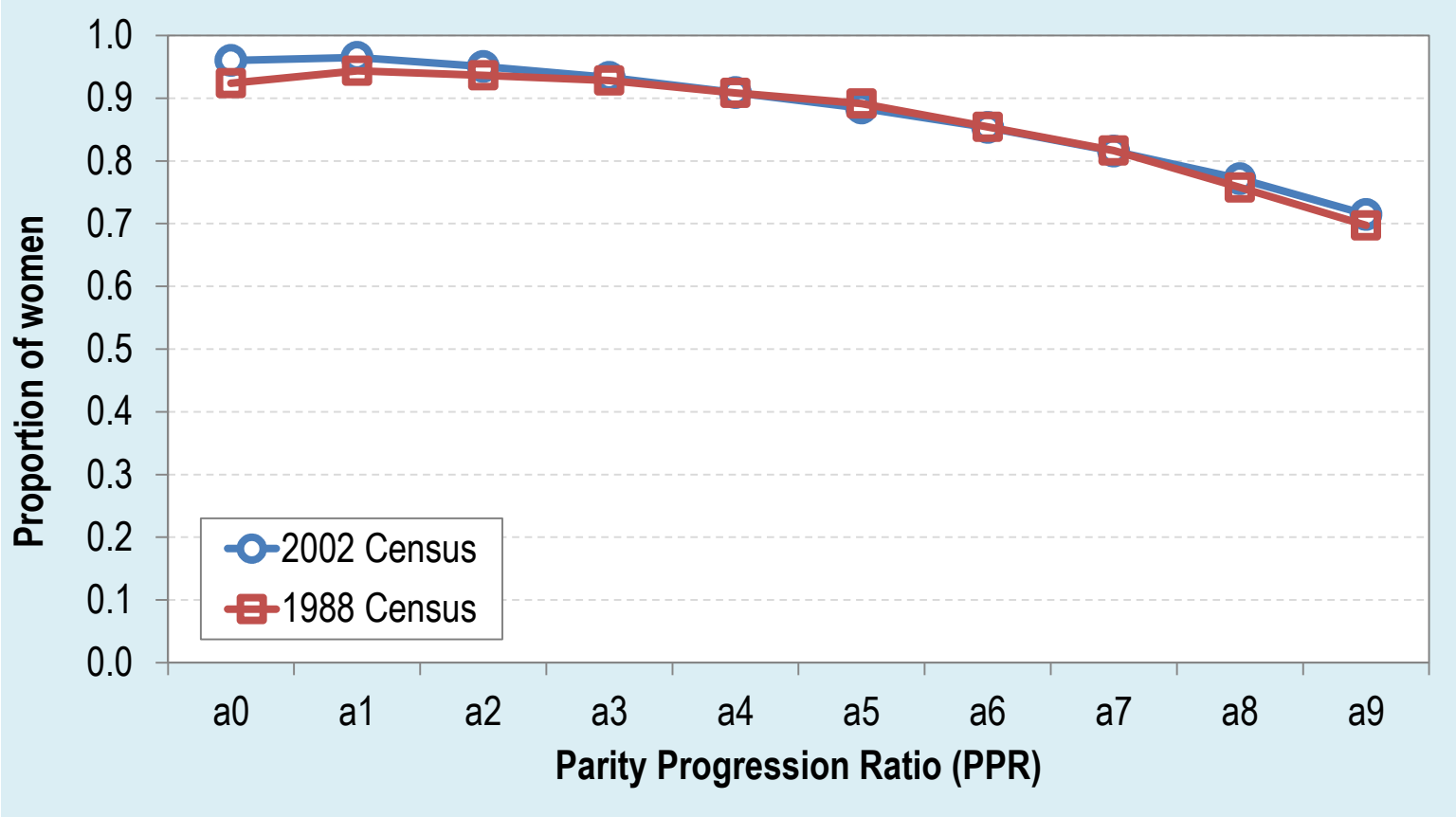
Source: Own computations using IPUMS-International

PPRs – U.R. Tanzania, 2002 Census



Source: Own computations using IPUMS-International

PPRs – U.R. Tanzania, 1988 & 2002 Census



Source: Own computations using IPUMS-International

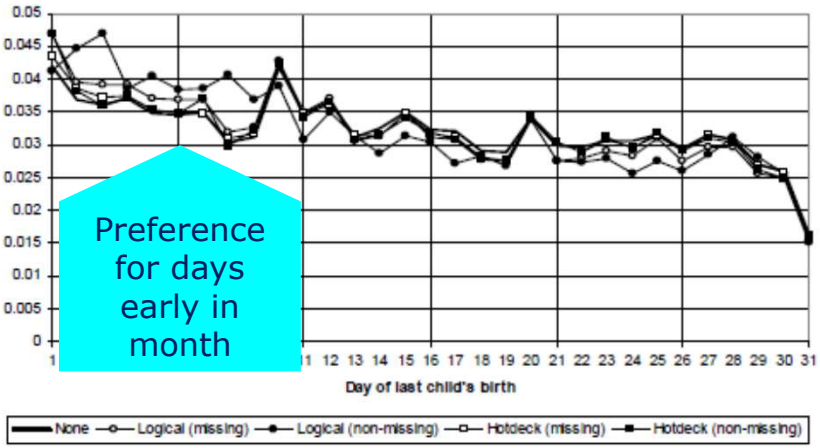
Recent births – quality assessment

Initial assessment

- Any missing values in data? (month/date/year of birth)
  - Missing data for any relevant variables? (age of mother, sex of child, survival status of the child)
- Is distribution of reported birth dates reasonable?
- If possible, compare with civil registration data on live births

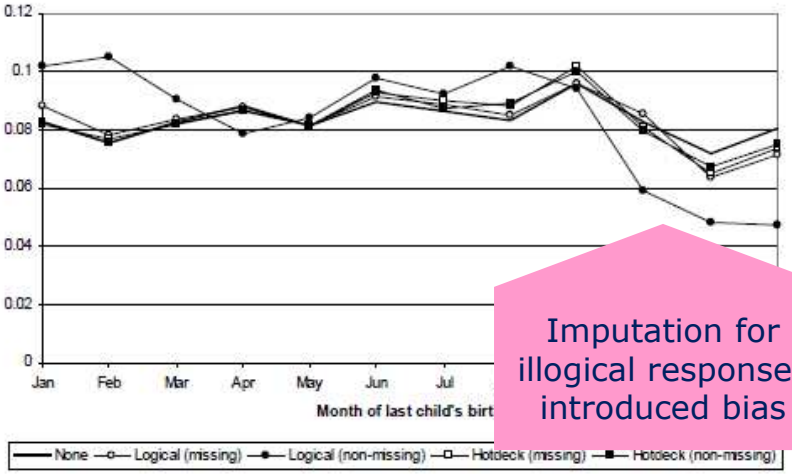
Recent births, quality assessment – missing and inconsistent data

Figure 2.3 Distribution of last child born's day of birth by imputation and cleaning method, Census 2001



Preference for days early in month

Figure 2.4 Distribution of last child born's month of birth by imputation and cleaning method, Census 2001



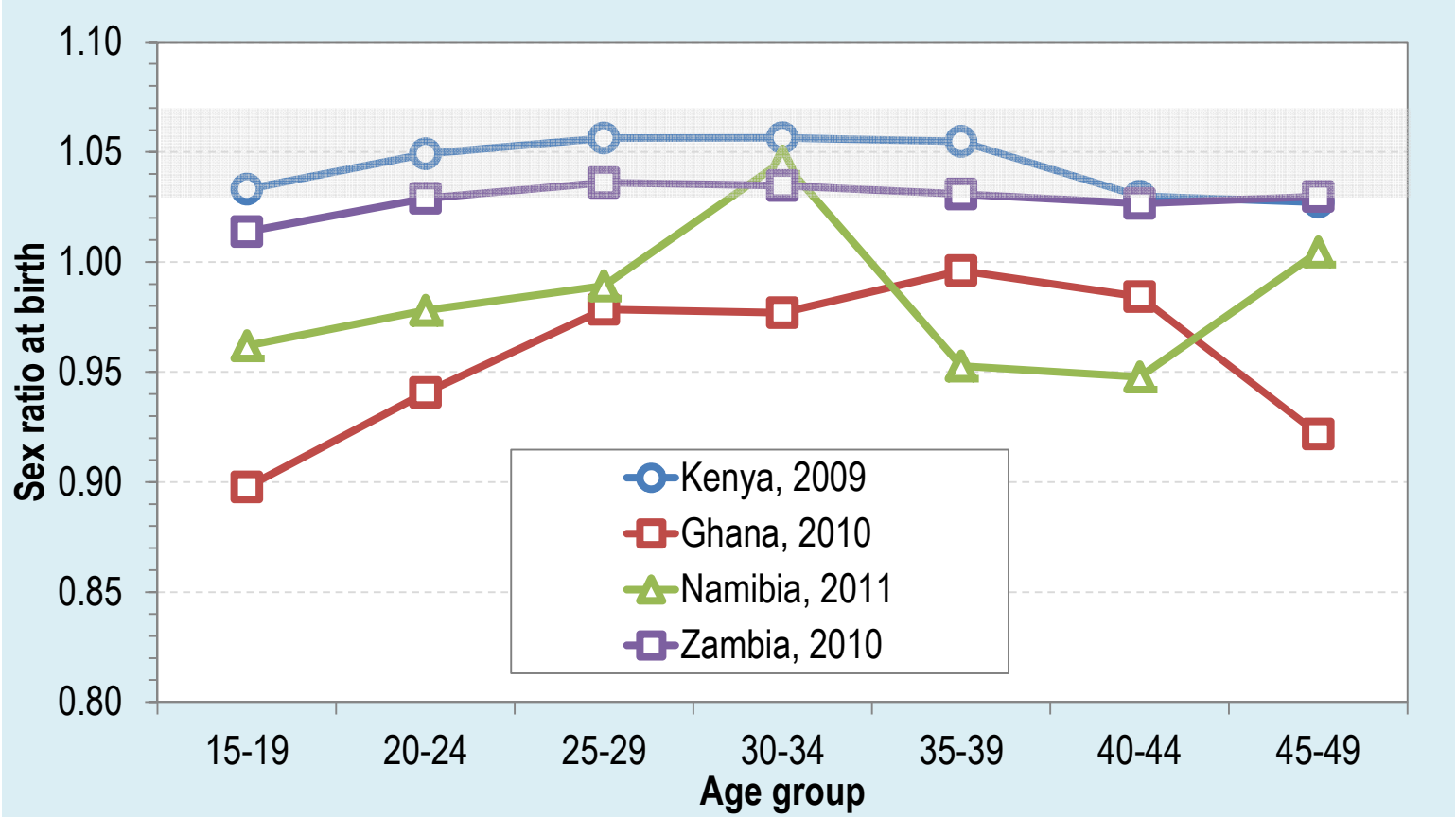
Imputation for illogical responses introduced bias

Table 2.9 Distribution of women aged 12 to 49 by imputation flag for response to question on year of last child's birth

	No imputation	*Logical imputation from missing response*	*Logical imputation from non-missing response*	*Hotdeck applied to missing response*	*Hotdeck applied to non-missing response*	*TOTAL*
Women	6560661	604260	391548	734257	165002	8455728
(per cent)	77.6	7.1	4.6	8.7	2.0	77.6

Source: Moutrie & Dorrington (2004)

Recent births, quality assessment – sex ratio at birth



Source: United Nations Demographic Yearbook database

Note: Gray-shaded area indicates a sex ratio at birth of 1.03-1.07 baby boys per one baby girl

Recent births, quality assessment – age specific fertility rates (*ASFR*)

Age Specific Fertility Rate (*ASFR*)

$$ {}_nF_x = \frac{{}_nB_x}{{}_nW_x} $$

${}_nB_x$ = Births to women age x to $x+n$ during period

${}_nW_x$ = Mid-period population of women age x to $x+n$

U.R. Tanzania, 2002 Census

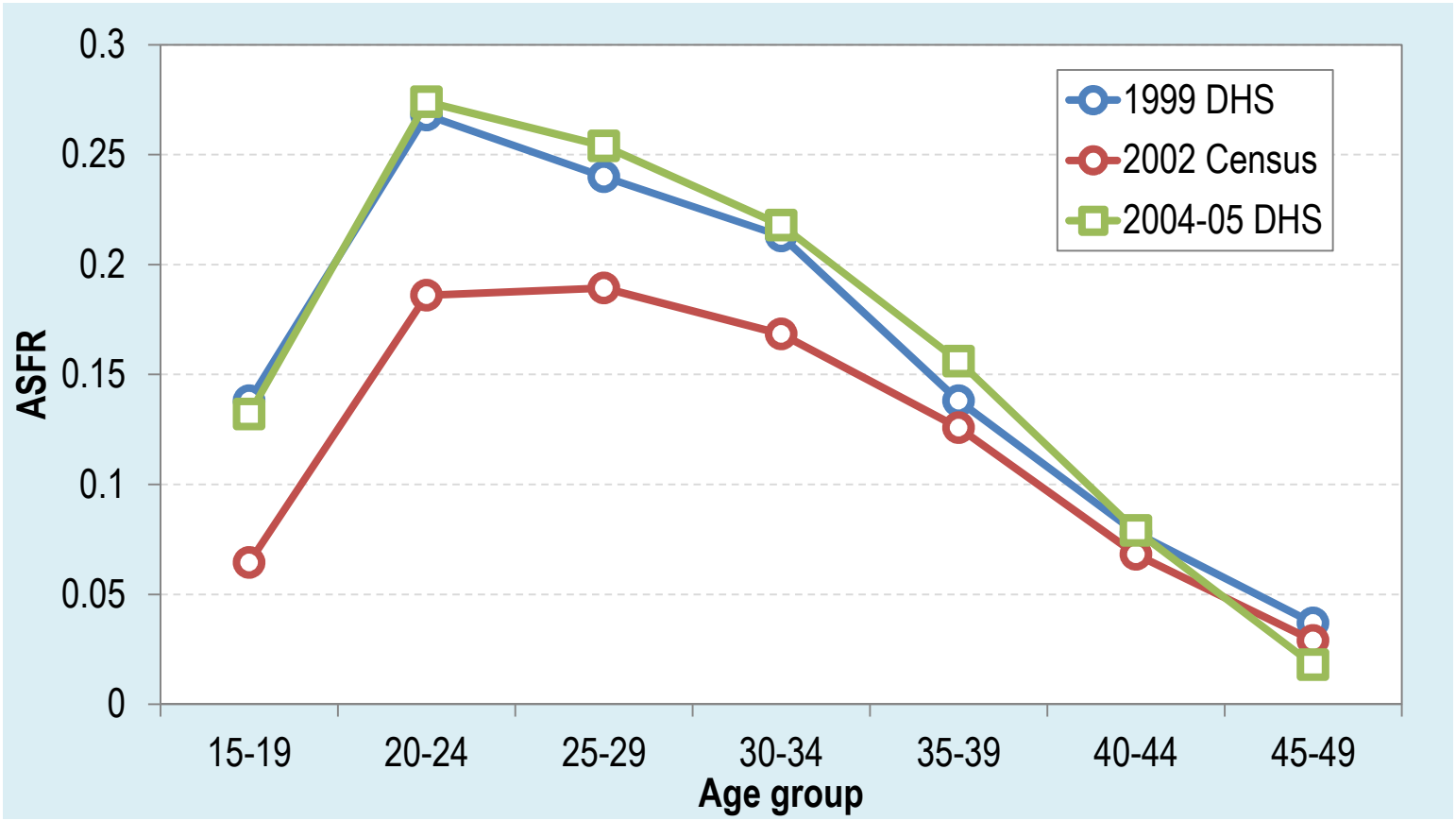
Age group	Births in 12 months preceding census	Total women in age group	ASFR
14.5 – 19.5	110,868	1,720,477	0.064
19.5 – 24.5	312,526	1,679,986	0.186
24.5 – 29.5	275,713	1,455,843	0.189
29.5 – 34.5	186,794	1,109,348	0.168
34.5 – 39.5	103,979	826,219	0.126
39.5 – 44.5	45,215	662,940	0.068
44.5 – 49.5	14,252	492,792	0.029

Source: Own computations using IPUMS-International

Are births classified by age of mother at birth of her child or by age of mother at the survey/census date?

If not known, assume the latter, almost universally, in censuses, data are classified by age of mother at time of census. In this case, ASFRs are shifted by ½ year as mothers were ½ year younger at the time of birth.

Recent births, quality assessment
Comparing *ASFR*s, U.R. Tanzania

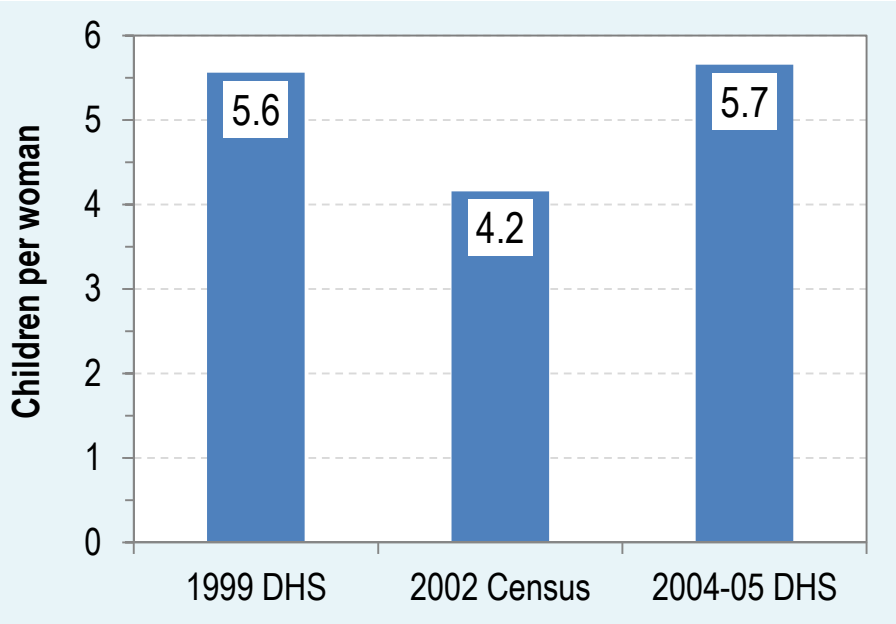


Sources: DHS STATcompiler and own computation based on IPUMS-International

Recent births, quality assessment
Comparing Total fertility rates (*TFR*)

U.R. Tanzania, *TFR*s comparison

Age group	1999 DHS	2002 Census	2004-04 DHS
15 - 19	0.138	0.064	0.132
20 - 24	0.268	0.186	0.274
25 - 29	0.240	0.189	0.254
30 - 34	0.213	0.168	0.218
35 - 39	0.138	0.126	0.156
40 - 44	0.078	0.068	0.079
45 - 49	0.037	0.029	0.018
TFR	**5.6**	**4.2**	**5.7**



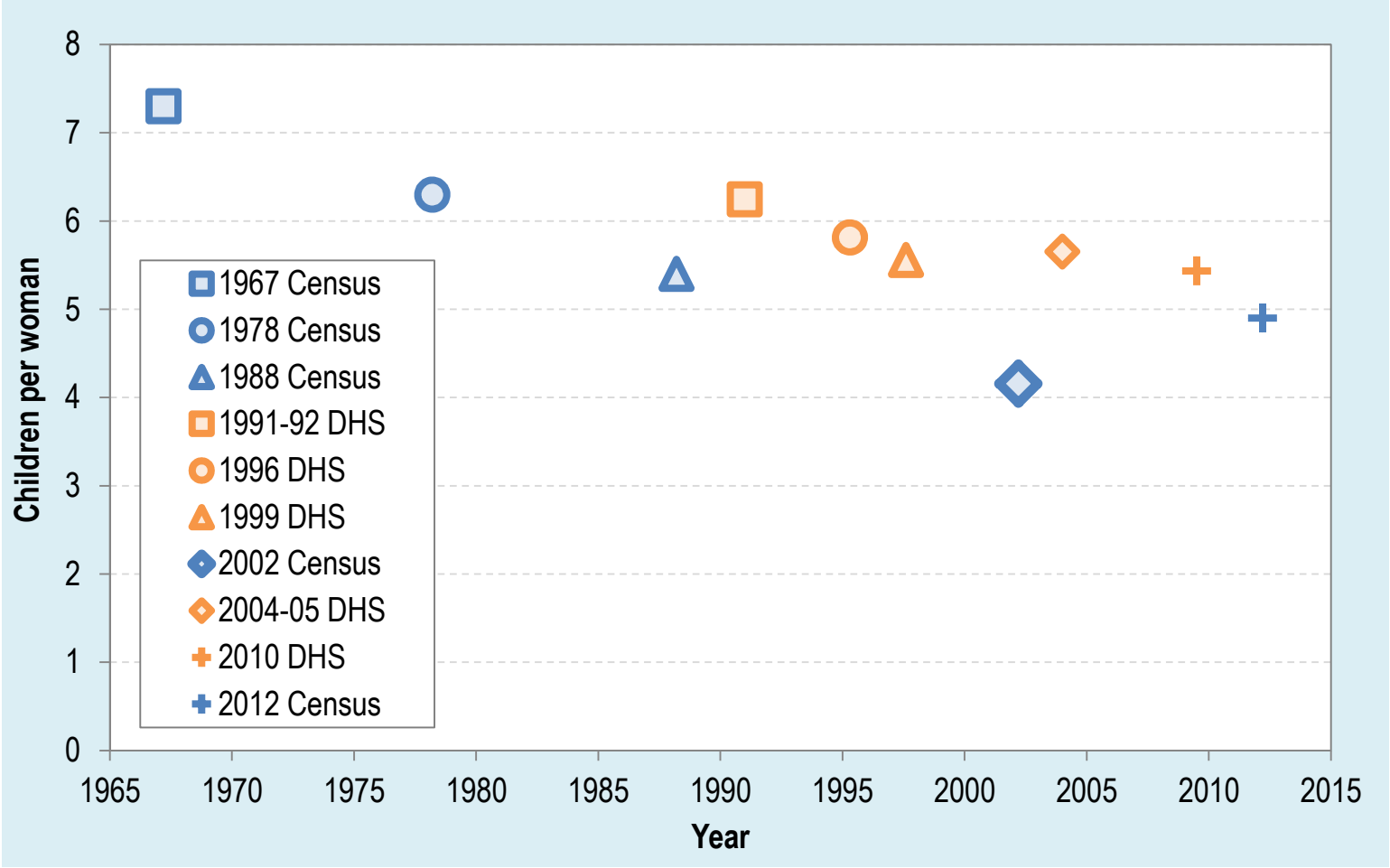
$$TFR = 5 \cdot \sum_{x=15-19}^{45-49} {}_5F_x$$

Estimating fertility from data collected in censuses

- To obtain new estimates of fertility

- To compare estimates from the current census with estimates available from other sources e.g. surveys

U.R. Tanzania, TF estimates from different sources



Methods for estimating fertility

- Interpolation of average parities (Mortara, 1949)
- Brass P/F method and its variations and extensions, e.g. Arriaga (1983), Relational Gompertz model
- Methods based on population structure: Reverse Survival Method and Own Children Method
- Methods based on data from two or several censuses: Arriaga (1983), synthetic relational Gompertz model, parity increments

Interpolation and backdating average parities

Average parity at ages *x*, *x*+*n* by definition:

$$ {}_nP_x = \int_x^{x+n} F(a)da $$

where *F* is cohort cumulative fertility function.

- By using interpolation one can compute age-specific fertility rates from average parities, P, assuming that fertility was more or less constant before the census
- For ages with completed fertility, e.g. age > 45, we can assume that P ≈ TFR, total fertility for a given cohort
- By plotting P ≈ TFR at years defined by the census date and mean age at childbearing, one can produce estimates of historical TFR trends (Feeney, 1991, see slide presented before)
- Software: **FERTCB** application in MORTPAK

The P/F ratio method: Rationale

- The P/F method aims to balance out the strengths and weaknesses of CEB and recent fertility data by comparing:
  - Cumulative fertility equivalent derived from recent fertility data “F” (trusting the age pattern of fertility but not level)
  - Life-time average parities “P” (trusting the overall level but not the age distribution)
- The method is typically used to adjust estimates of current fertility level (computed from data on recent births or from incomplete civil registration)
- The method is also used to assess the quality of CEB data and, sometimes, the age reporting of the mother
- Works well if:
  - fertility was constant before the census (improbable now);
  - no severe problems with the data

Source: United Nations (1983)

P/F Method: Data requirements

1. Total number of children ever born by 5-year age group of mother
2. Recent fertility by 5-year age group of mother, measured either by:
    a) Births in past year question on census
    b) Births registered in year of census from vital registration
3. Total number of women in each 5-year age group

P/F Method: Assumptions

- Misreporting of current fertility is constant across all age groups
- Increasing under-reporting of parity (children ever born) by age of women
- Constant fertility (most important for youngest age groups up to 35 or so)
  - > Can be relaxed through a modification of the original P/F ratio method that uses two consecutive censuses or fertility rates derived from vital registration or another data source

P/F Method: Computational procedure

Procedure described here follows Arriaga (1983) implemented in MortPak

0	1	2	3	4	5		6
Age Group	p(i)	f(i)	p*(i)	f*(i)	P(i)	F(i)	P/F
	Average CEB as shown	ASFRs as shown	CEB transformed into age-specific rates	ASFR adjusted for time of census	Cumulated P(i) and F(i)		Adjustment factor for fertility rates, usually ages groups 20-24, 25-29 or 30-34 as the most reliable

P/F method: Interpretation

- Typical “look” of P/F ratios:
  - With perfect data, ratio should be the same for all age groups and close to 1
  - In practice, ok if ratios for 20-24, 25-29 and (less important) 30-34 are close
- Typically, P/F ratio will decrease with women’s age
- Deviation from the above typical pattern: indicates either violations of the assumptions or different patterns of under-reporting

P/F Method: Interpretation

- Example 1: a **declining trend in the P/F ratios** by age of women could indicate that
  a) fertility has been increasing or
  b) reported data on children ever born suffer from progressively increasing omissions of children as age of women increases
- Example 2: **large fluctuations in the P/F ratios** may reflect either differential coverage by age or selective age misreporting by women
- Example 3: a **rising trend in the P/F ratios** by age of women indicates that fertility could have been decreasing in the past

Example in MortPak, FERTPF: U.R. Tanzania 2002 Census

Estimation of age-specific fertility rates fro

TITLE: U.R. TANZANIA

Arraiga's approach for estimation of ASFR for one point in time and the age pattern of fertility (Brass)

	First Enumeration
Month	August
Year	2002
Fertility pattern is tabulated by age of woman at:	enumeration

p*(i) f*(i) P(i) F(i)

Age Group of Woman	Children Ever Born	Age Specific Fertility Pattern (A.S.F.P.)	Fertility Consistent with C.E.B. (A.S.F.R.)	Fertility Pattern by Age at Survey Date	Fertility Pattern by Age at Birth of Child	Cumulation of A.S.F.R.	Cumulation of Fertility Pattern by Age at Birth	Adjustment Factors	Age Specific Fertility Rates Based on Adjustment Factor for the Age Group 20 - 25	25 - 30	30 - 35
August 2002				Recorded	Calculated						
15 - 20	0.28	0.0644	0.1595	0.0644	0.0778	0.1595	0.0778	2.0516	0.1268	0.1217	0.1242
20 - 25	1.50	0.1860	0.2804	0.1860	0.1921	0.4399	0.2698	1.6305	0.3131	0.3006	0.3069
25 - 30	2.89	0.1894	0.2776	0.1894	0.1886	0.7175	0.4584	1.5653	0.3075	0.2952	0.3013
30 - 35	4.27	0.1684	0.2608	0.1684	0.1649	0.9782	0.6233	1.5694	0.2689	0.2582	0.2636
35 - 40	5.43	0.1258	0.2054	0.1258	0.1214	1.1837	0.7447	1.5894	0.1979	0.1900	0.1940
40 - 45	6.40	0.0682	0.1365	0.0682	0.0627	1.3201	0.8074	1.6350	0.1022	0.0982	0.1002
45 - 50	7.04	0.0289	0.0489	0.0289	0.0238	1.3690	0.8312	1.6470	0.0388	0.0373	0.0380
Mean Age of Childbearing:			27.7923		27.6730						
Total Fertility Rate:			6.8450		4.1560				6.7764	6.5053	6.6408

Variants on the P/F method

- P/F method for first births – not affected by fertility decline through higher-parity control
- Two-census methods, deriving age schedule of fertility from the two censuses or an additional source (such as vital registration)
  - Can be implemented in MortPak FERTPF by adding optional data for second census
- The Relational Gompertz model uses the same data as the P/F model, but
  - Does not require an assumption of constant fertility
  - Compares/replaces recent fertility data with model fertility schedules to check accuracy
  - Relies on parity data for all age groups (not just younger ones)

Relational Gompertz model

- An improved and more versatile version of the Brass P/F method with the same input data
- Shape of fertility distribution adheres to Gompertz relational model
- Level is estimated from average parities
- Robust
- Can be used for smoothing and extrapolation of fertility schedule
- Can be used with different standard patterns
- Software:
  - Excel Sheet "**FE_RelationalGompertz.xlsx**" in Moultrie (2013), available online at: http://demographicestimation.iussp.org/content/relational-gompertz-model
  - Excel Sheet "**REL-GMPZ.xls**" in PASEX, available online at: http://www.census.gov/population/international/software/uscbtoolsdownload.html

Reverse Survival method of fertility estimation

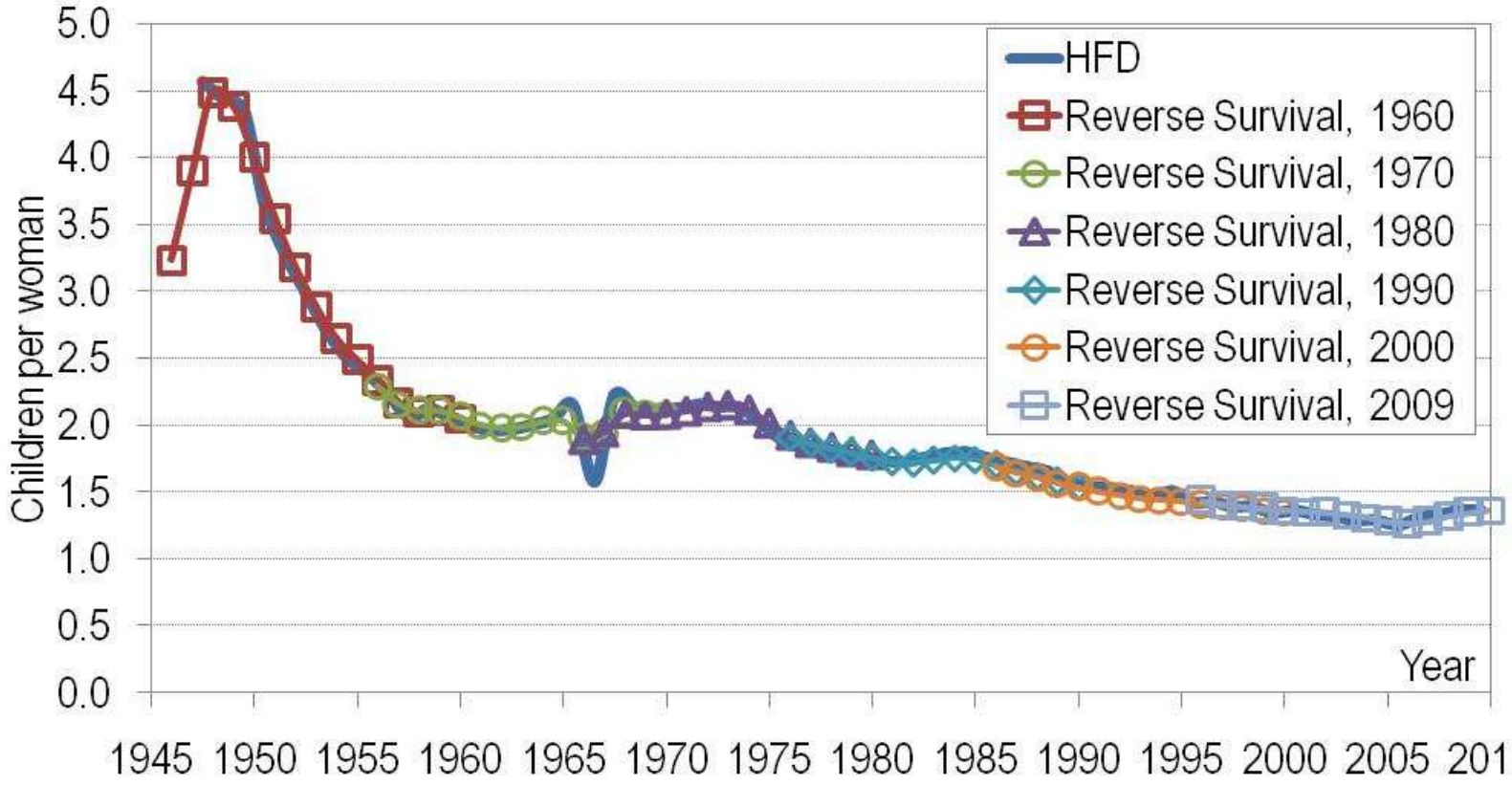
- Population by single age and sex is 15-year back projected (reverse survived)
- *TFR* for years *y0*, *y-1*, *y-2*, … *y-14* computed to match births obtained by reverse survival
- Assumptions:
  - Population by single age and sex is free of errors
  - Estimates of mortality are available for the period before census
  - Reasonably good assumptions can be made about age patterns of recent fertility and mortality

Reverse Survival method of fertility estimation

- **Software**: Excel Sheet "**FE_reverse_9.xlsx**" in Timæus & Moultrie (2013), available online at: http://demographicestimation.iussp.org/content/reverse-survival-methods

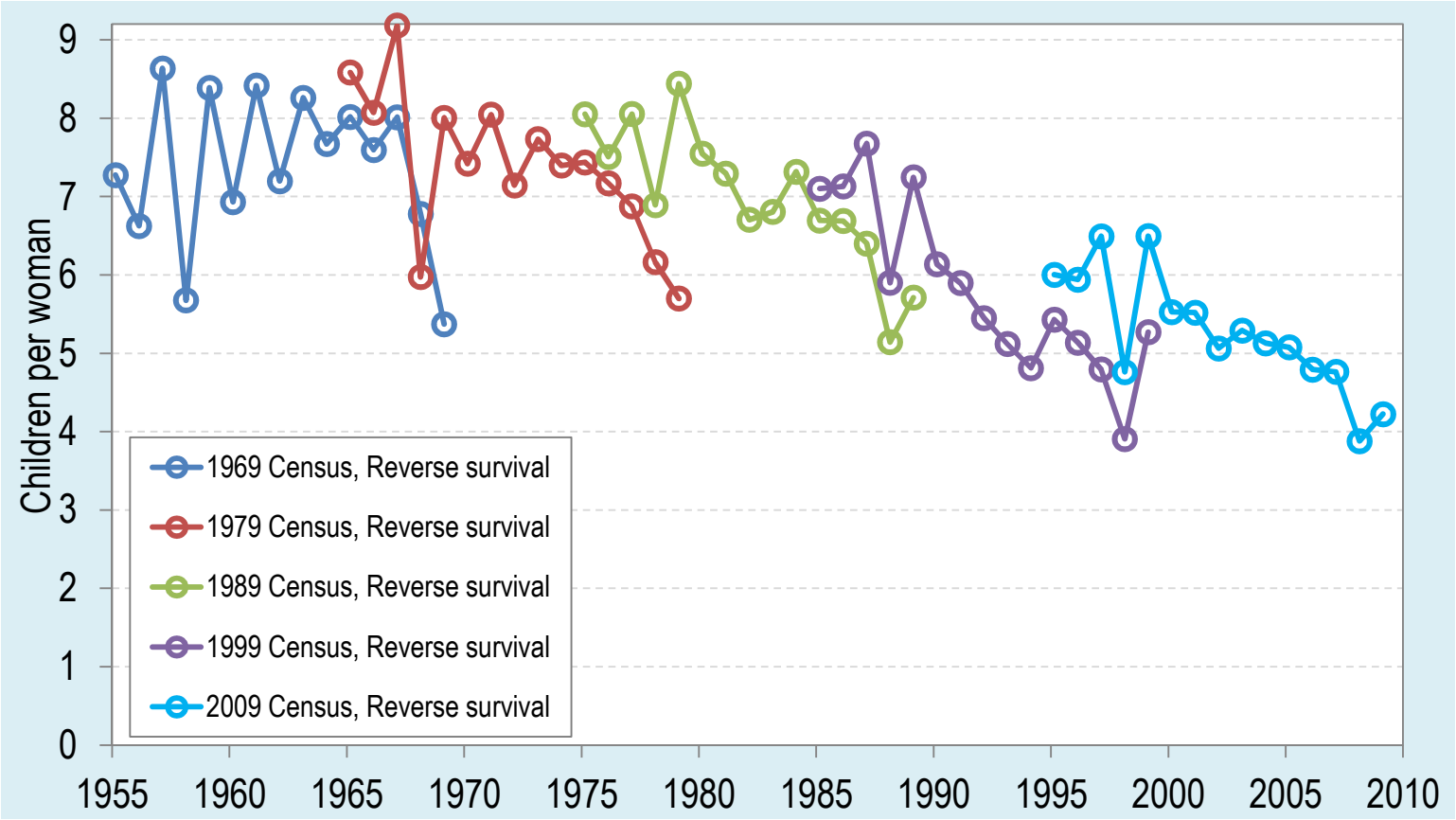
  >> New revised spreadsheet (24 September 2015) allows to use country mortality and age-specific fertility estimates from the *World Population Prospects: The 2015 Revision* as inputs

Reverse survival fertility estimates, Japan



Source: Spoorenberg (2014)

Reverse survival fertility estimates, Kenya

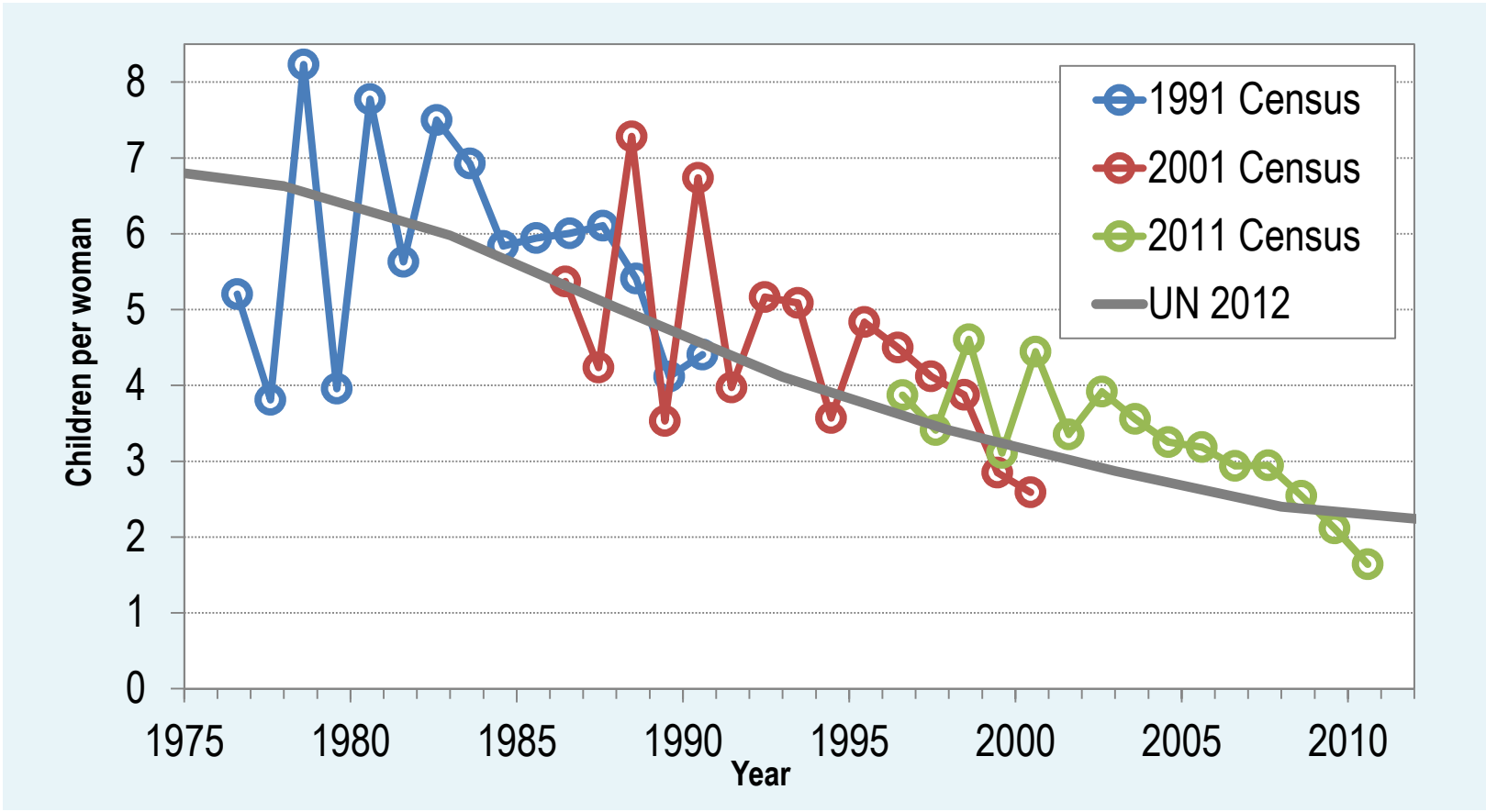


Source: Spoorenberg 2014

Own-children method of fertility estimation

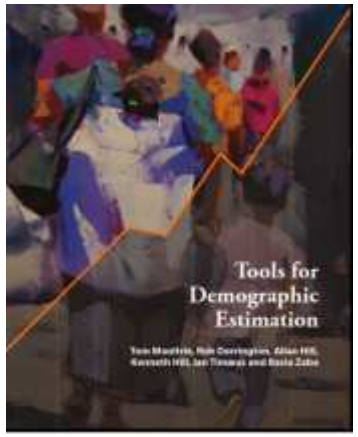
- Based on the same idea as the reverse survival method
- Produces estimates of both TFR and fertility age pattern
- Data requirements
  - Distribution of own children by age and by age of mother
  - Estimates of mortality for the period before census
- **Sotfware**: **FERT** developed by East-West Center, available online: http://www.eastwestcenter.org/research/research-program-overview/population-and-health/demographic-software-available-from-the-east-west-center
- Reference: United Nations (1983, pp. 182-195), Cho et al (1986).

Fertility Estimates by Own-Children Method, Bangladesh



Source: Using IPUMS microdata, computed using Fert.exe (East-West Center).

Main references



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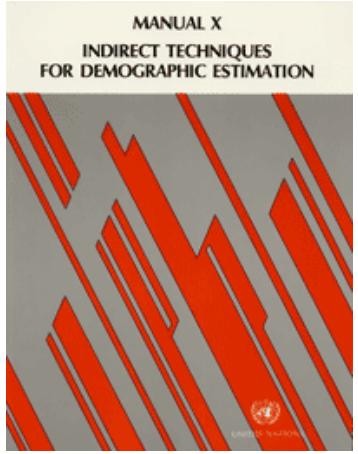
http://demographicestimation.iussp.org/

Available in PDF:
http://demographicestimation.iussp.org/content/get-pdf-book-website



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http://www.un.org/en/development/desa/population/publications/manual/estimate/demographic-estimation.shtml

Softwares

- **MORTPAK** – The United Nations software package for demographic measurement, available online:

  http://www.un.org/en/development/desa/population/publications/mortality/mortpak.shtml

- **Excel templates** provided with each chapter of Moultrie et al. (2013), available online: http://demographicestimation.iussp.org/

- **Programs for Fertility Estimation**, East-West Center available online: http://www.eastwestcenter.org/research/research-program-overview/population-and-health/demographic-software-available-from-the-east-west-center

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Thank you

Questions?

>> until 9 October:

>> After 9 October: spoorenberg@un.org