Evaluation of Fertility Data Collected from Population Censuses

United Nations Statistics Division

Outline

1. Fertility measures (some definitions)
2. Evaluation of fertility data
    1. Data collection errors, coverage, completeness
    2. Methods for deriving fertility estimates
    3. Comparing estimates from multiple independent sources
3. Fertility data collected in the 2014 census

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

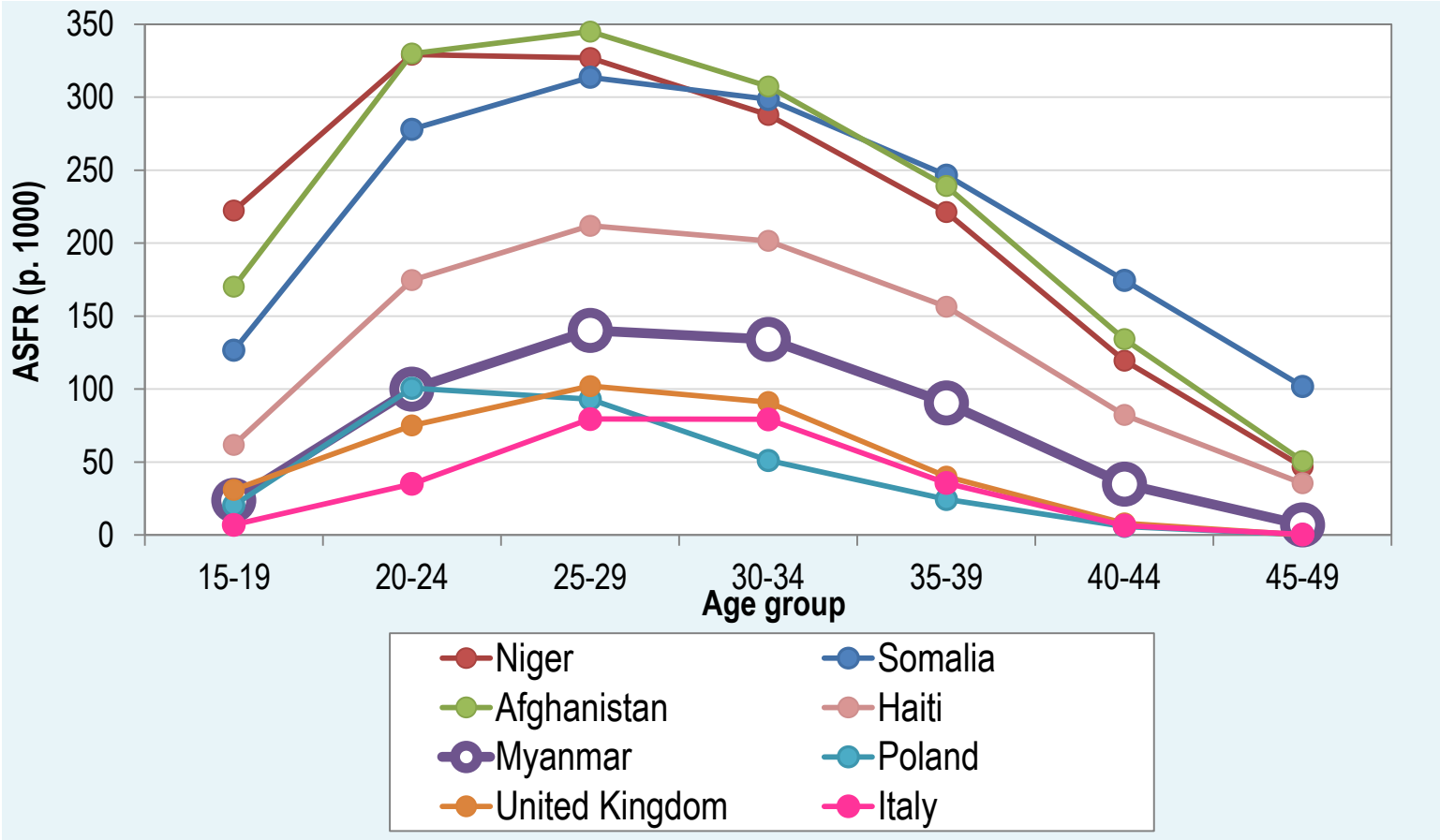
$$ASFR_{x,x+n} = {}_nF_x = \frac{Births\ to\ women\ aged\ x, x+n\ in\ a\ stated\ period}{Number\ of\ women\ aged\ x, x+n\ in\ the\ same\ period}$$

- 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*)

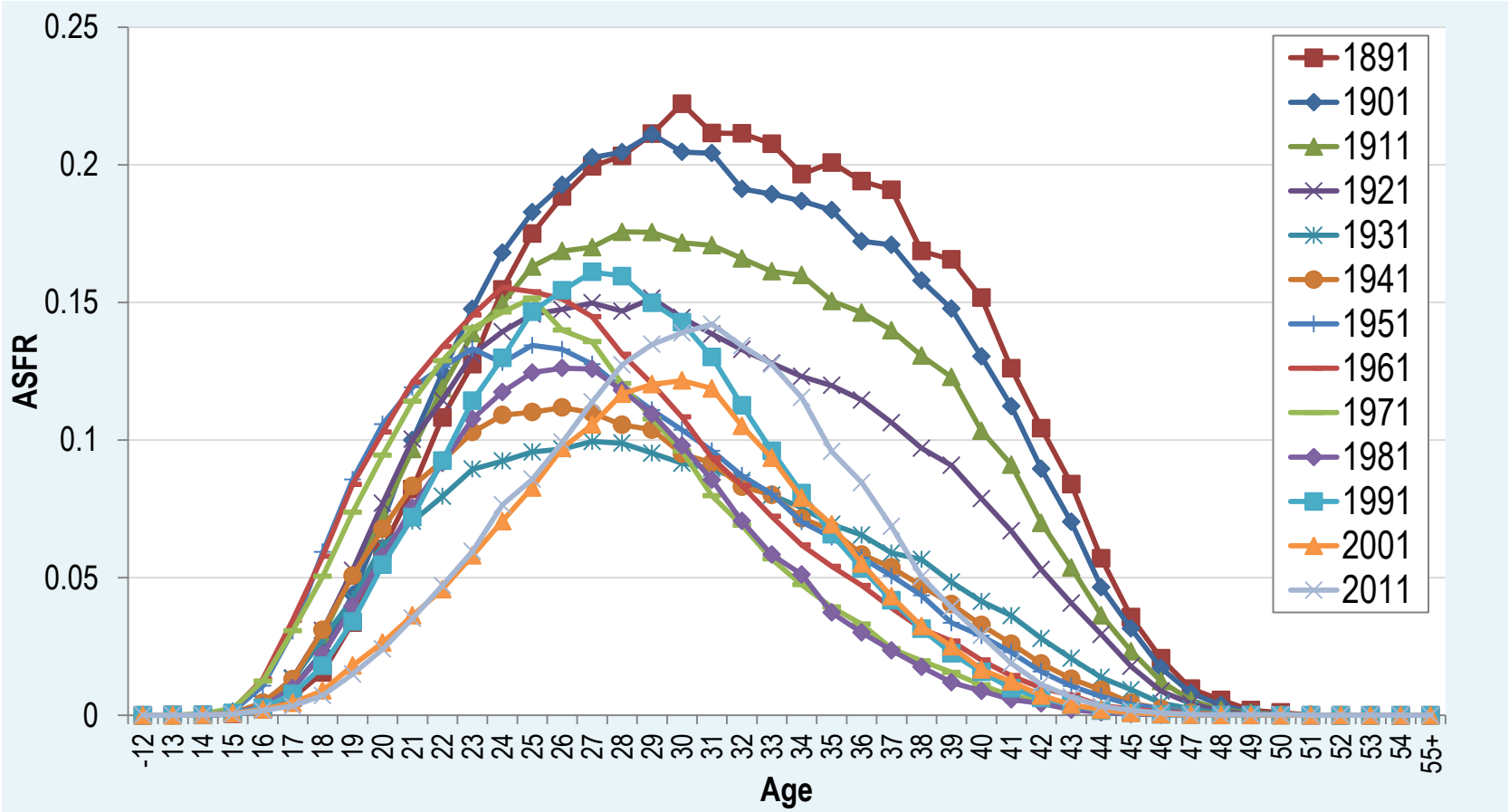
- Age pattern is important in demography
- If we know the **pattern** (*i.e.* the shape) of the phenomenon and recognize the distinct ways in which it changes under certain circumstances, but also recognize the stable features, then we can:
  a) check if data appears to be of good quality;
  b) attempt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

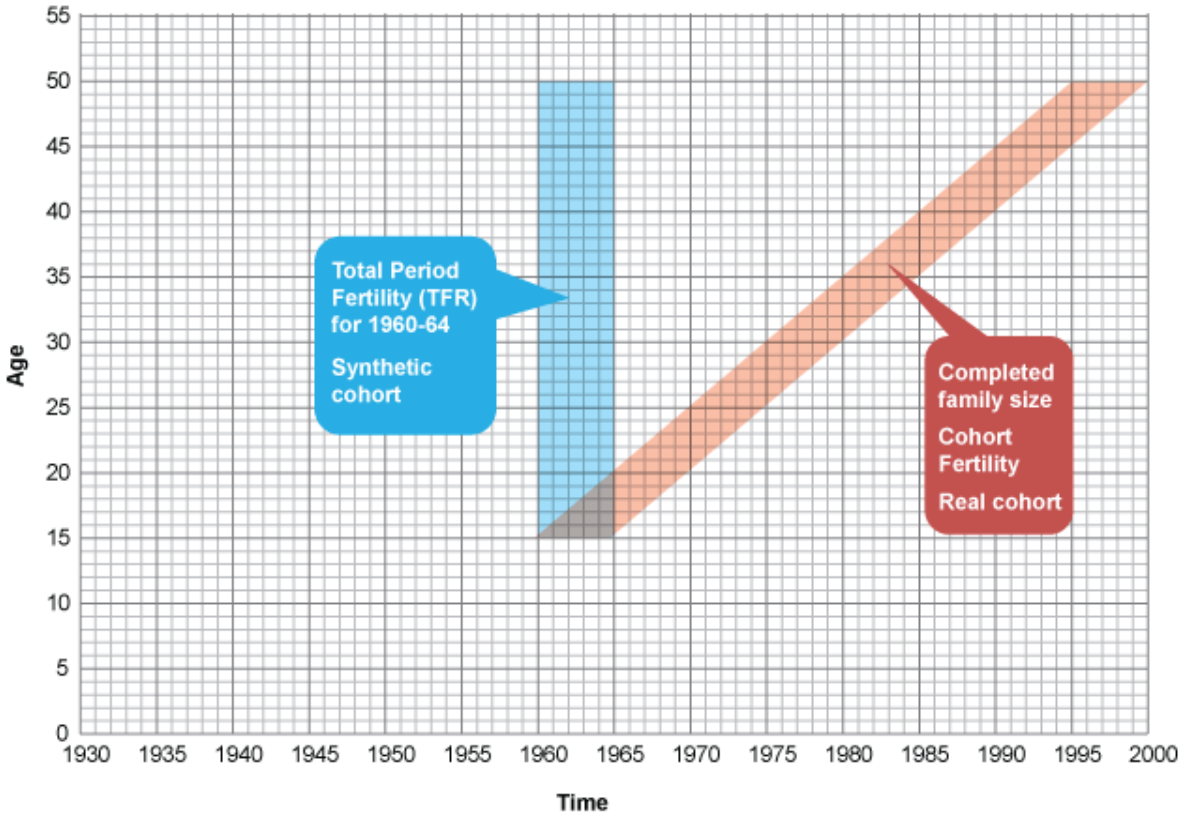
$$TFR = \sum_{x=15-19}^{45-49} ASFR \cdot 5$$

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.

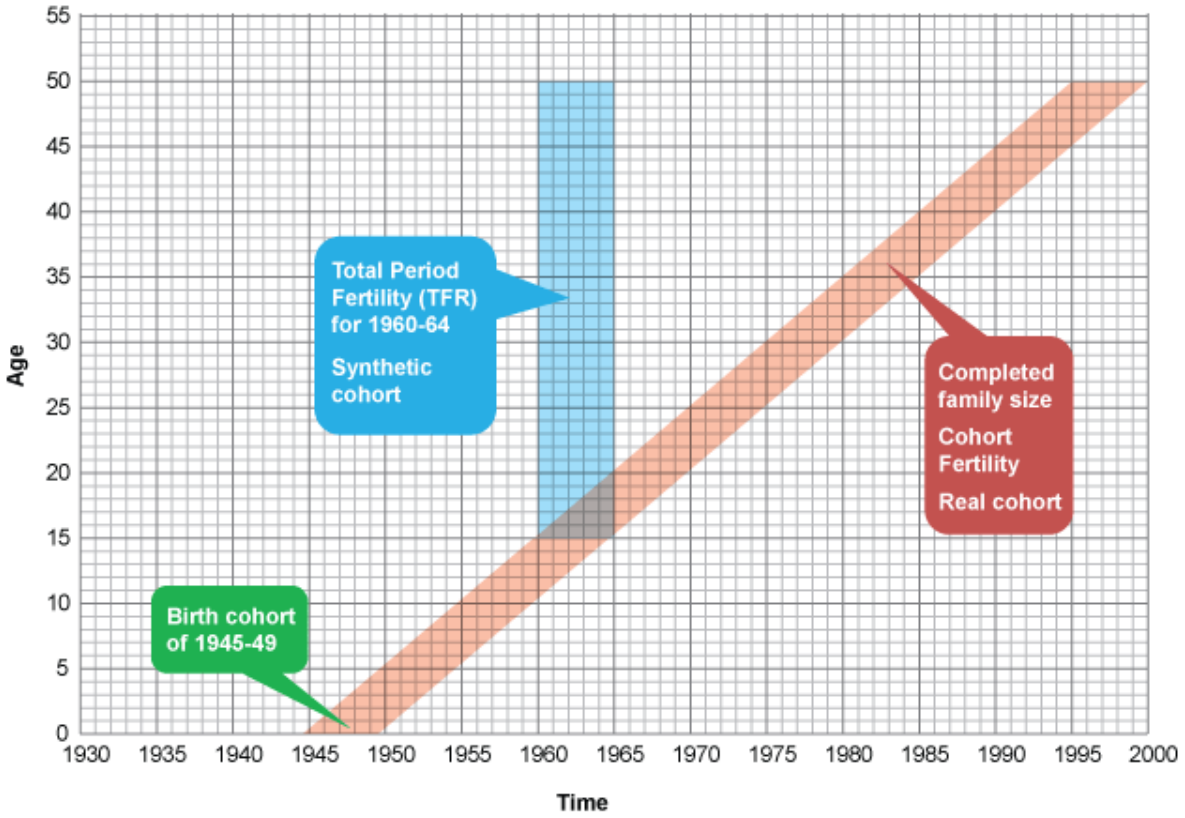
> It is an example of a synthetic cohort

Period Fertility vs. Cohort Fertility



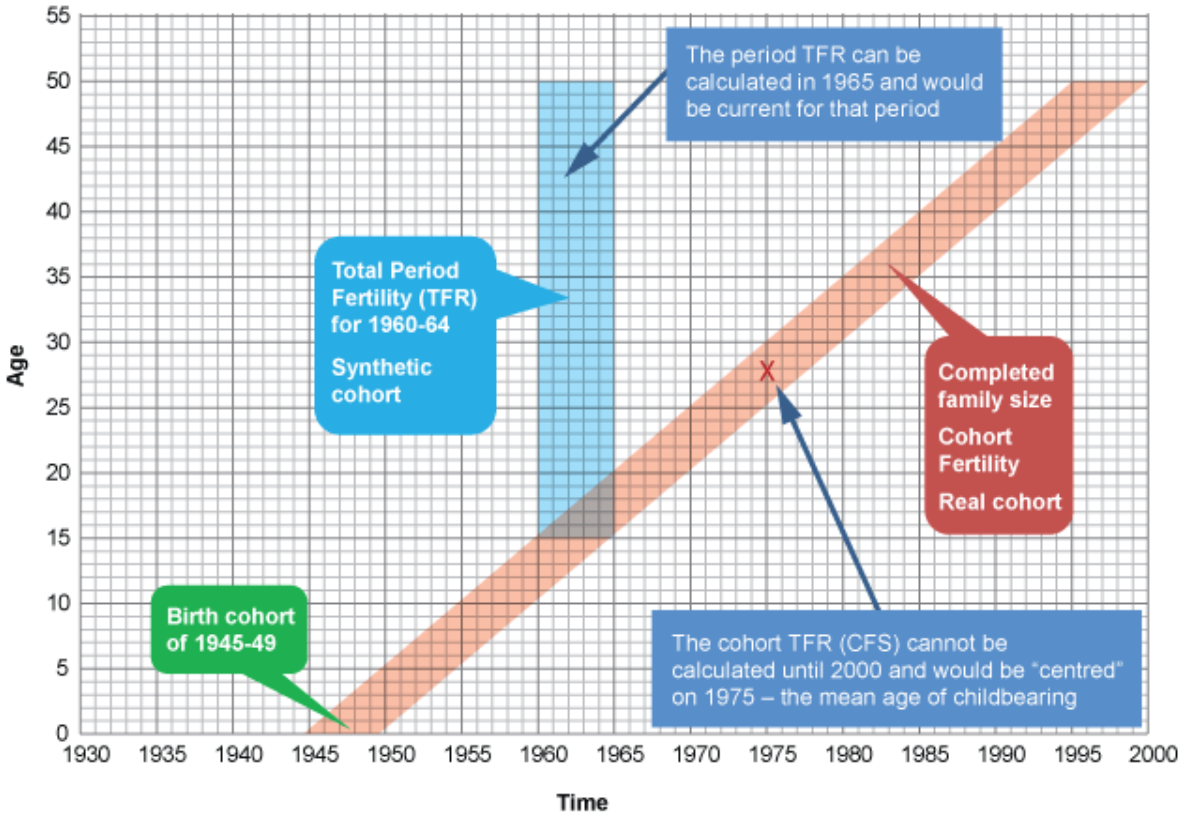
Source: IUSSP & UNFPA (n.d.)

Period Fertility vs. Cohort Fertility



Source: IUSSP & UNFPA (n.d.)

Period Fertility vs. Cohort Fertility



Source: IUSSP & UNFPA (n.d.)

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)

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 – 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**

Source: Hinde (1998)

Same CF, but different distribution of births

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

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

Disadvantage

Based on census data, *PPR* 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

1. Fertility measures (some definitions)
2. Evaluation of fertility data
    1. Data collection errors, coverage, completeness
    2. Methods for deriving fertility estimates
    3. Comparing estimates from multiple independent sources
3. Fertility data collected in the 2014 census

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)

- 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*

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: enumerator's error

1. **Enumerators' failure to reach individuals**
   a) The not-at-home error: information provided by neighbors
   b) Coverage error: omit 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 (ASFRs)

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

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 & Dorrington (2004), *Estimation of fertility from the 2001 South Africa census data*

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

Mongolia, 1989 Census (Source: IPUMS)

Parity	15-19	20-24	25-29	30-34	35-39	40-44	45-49
0	105,548	43,676	9,824	2,711	987	865	726
1	4,827	30,834	15,350	5,432	2,185	1,302	1,488
2	896	17,309	23,960	10,659	4,479	2,217	2,053
3	834	5,382	19,279	11,159	4,923	2,663	1,950
4	199	1,828	11,831	11,922	6,974	3,525	2,658
5	68	477	5,730	11,189	7,426	4,933	3,379
6	0	53	2,161	7,568	6,348	4,442	3,619
7	0	25	707	3,737	4,551	3,638	2,977
8	15	33	263	2,355	3,879	3,986	3,706
9	61	0	119	746	2,190	2,747	3,059
10	0	0	0	419	1,300	2,433	3,253
11	0	0	0	147	743	1,183	1,667
12	22	38	11	53	262	845	1,299
13	0	0	0	19	161	403	898
14	0	0	0	20	82	242	392
15+	0	0	0	0	72	235	629
Unknown	218	0	65	58	35	35	20

Parities obviously wrong

Unknown separated from parity '0'

CEB – quality assessment

Mongolia, 1989 Census (Source: IPUMS)

Parity	15-19	20-24	25-29	30-34	35-39	40-44	45-49
0	105,548	43,676	9,824	2,711	987	865	726
1	4,827	30,834	15,350	5,432	2,185	1,302	1,488
2	896	17,309	23,960	10,659	4,479	2,217	2,053
3	834	5,382	19,279	11,159	4,923	2,663	1,950
4	199	1,828	11,831	11,922	6,974	3,525	2,658
5	68	477	5,730	11,189	7,426	4,933	3,379
6	0	53	2,161	7,568	6,348	4,442	3,619
7	0	25	707	3,737	4,551	3,638	2,977
8	0	23	263	2,355	3,879	3,986	3,706
9	0	9	119	746	2,190	2,747	3,059
10	0	0	0	419	1,300	2,433	3,253
11	0	0	0	147	743	1,183	1,667
12	0	0	11	53	262	845	1,299
13	0	0	0	19	161	403	898
14		0	0	20	82	242	392
15+		0	0	0	72	235	629
Unknown		38	65	58	35	35	20
Total women			**89,300**	**68,194**	**46,597**	**35,694**	**33,773**
Total children			**218,303**	**267,951**	**240,263**	**220,854**	**231,755**
Proportion unknown			**0.0007**	**0.0009**	**0.0008**	**0.0010**	**0.0006**
Proportion childless	**0.9366**	**0.4383**	**0.1100**	**0.0398**	**0.0212**	**0.0242**	**0.0215**
Average parity	**0.0910**	**0.9237**	**2.4446**	**3.9292**	**5.1562**	**6.1874**	**6.8621**

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

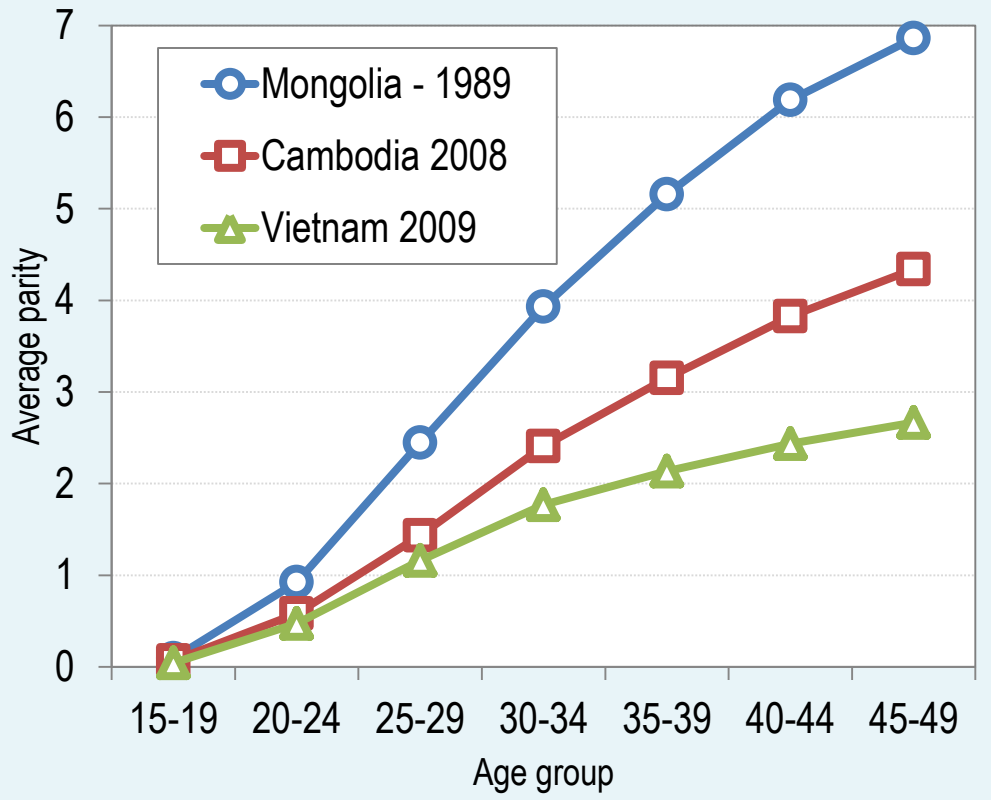
Average parity at age x:

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

where

B_x = number of births by age x

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

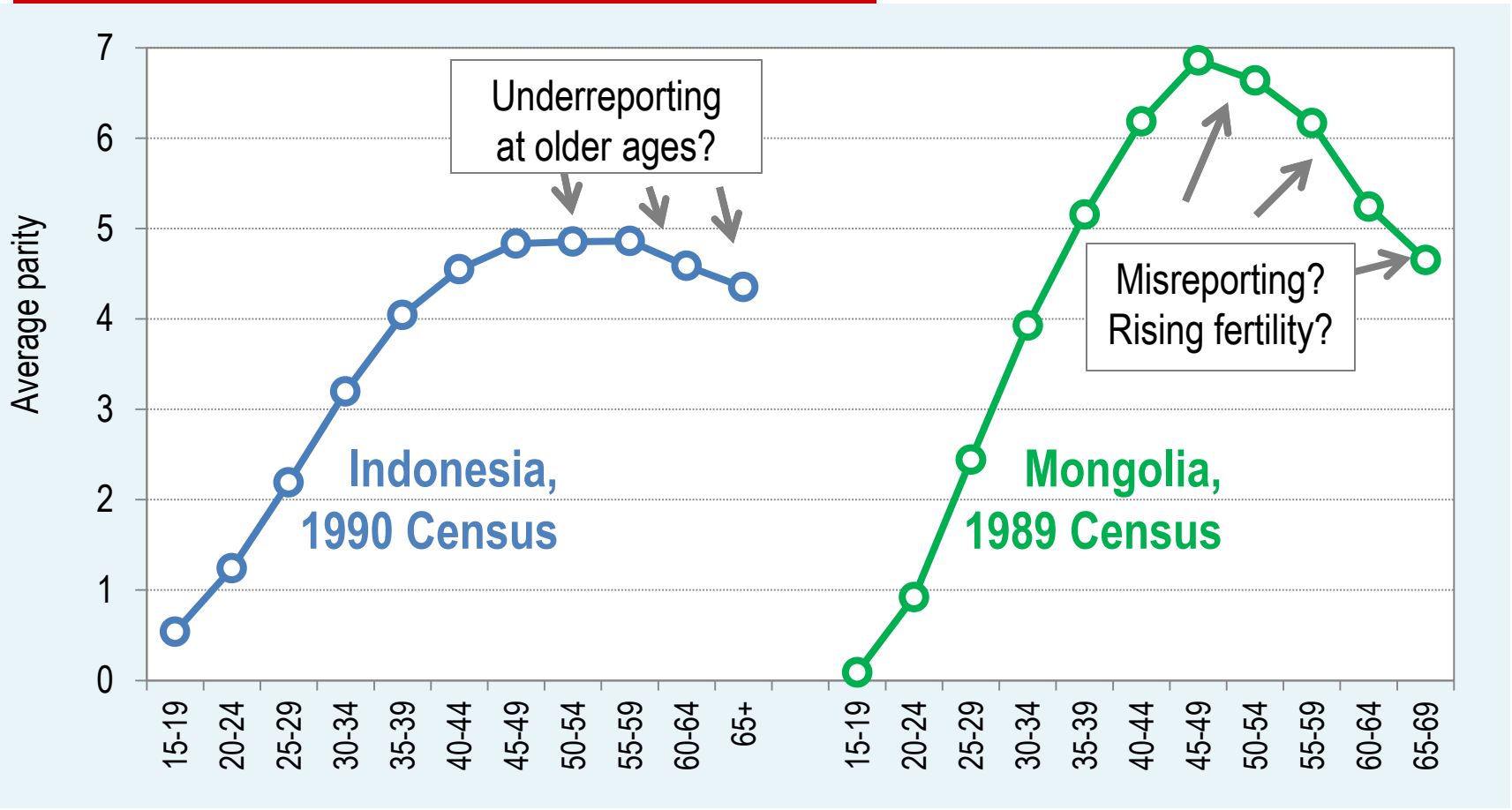


CEB – quality assessment

Mongolia, 1989 Census (Source: IPUMS)

Parity	15-19	20-24	25-29	30-34	35-39	40-44	45-49
0	105,548	43,676	9,824	2,711	987	865	726
1	4,827	30,834	15,350	5,432	2,185	1,302	1,488
2	896	17,309	23,960	10,659	4,479	2,217	2,053
3	834	5,382	19,279	11,159	4,923	2,663	1,950
4	199	1,828	11,831	11,922	6,974	3,525	2,658
5	68	477	5,730	11,189	7,426	4,933	3,379
6	0	53	2,161	7,568	6,348	4,442	3,619
7	0	25	707	3,737	4,551	3,638	2,977
8	0	23	263	2,355	3,879	3,986	3,706
9	0	9	119	746	2,190	2,747	3,059
10	0	0	0	419	1,300	2,433	3,253
11	0	0	0	147	743	1,183	1,667
12	0	0	11	53	262	845	1,299
13	0	0	0	19	161	403	898
14	0	0	0	20	82	242	392
15+	0	0	0	0	72	235	629
Unknown	316	38	65	58	35	35	20
Total women	**112,688**	**99,654**	**89,300**	**68,194**	**46,597**	**35,694**	**33,773**
Total children	**10,257**	**92,053**	**218,303**	**267,951**	**240,263**	**220,854**	**231,755**
Proportion unknown	**0.0028**	**0.0004**	**0.0007**	**0.0009**	**0.0008**	**0.0010**	**0.0006**
Proportion childless	**0.9366**	**0.4383**	**0.1100**	**0.0398**	**0.0212**	**0.0242**	**0.0215**
Average parity	**0.0910**	**0.9237**	**2.4446**	**3.9292**	**5.1562**	**6.1874**	**6.8621**

CEB – quality assessment

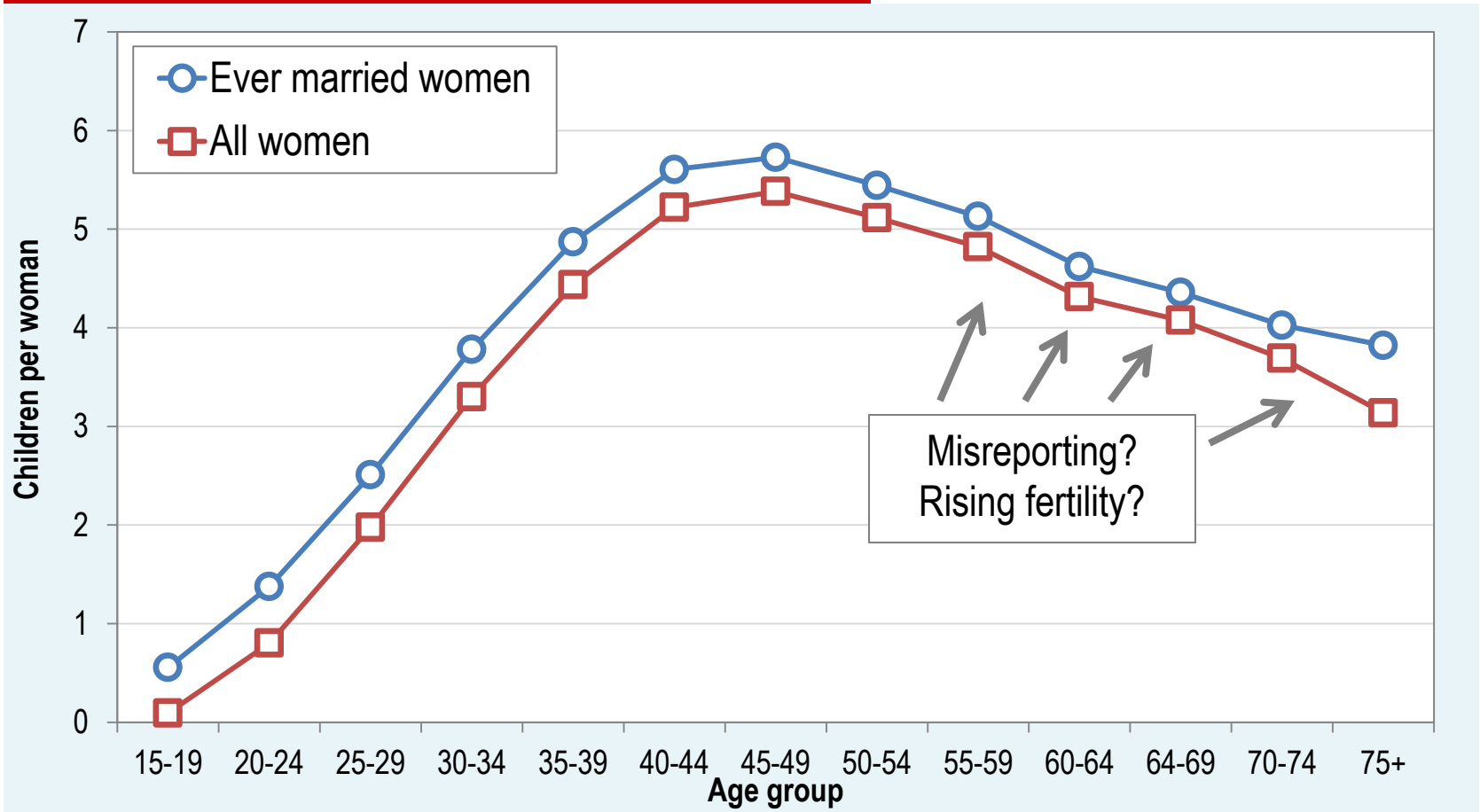


CEB – quality assessment

Myanmar, 1983 Census, CEB, *ever married* women

Parity	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
0	179,907	242,607	131,927	66,668	40,766	37,087	38,956	47,165	45,901	57,101
1	111,092	338,140	186,070	80,801	43,278	36,281	35,804	39,984	34,975	34,128
2	23,996	245,651	25,4869	125,206	62,439	47,346	45,018	47,389	38,637	35,146
3	4,166	106,115	242,278	161,685	90,093	64,501	58,706	58,210	45,847	39,698
4	1,180	31,988	162,701	169,543	101,444	76,453	67,270	62,905	47,699	39,716
5	311	8,779	80,297	146,024	113,628	88,718	77,915	69,717	52,070	42,119
6	0	2,569	29,756	98,642	102,075	85,340	77,235	64,548	46,751	36,715
7	0	741	10,092	55,855	84,709	80,226	73,276	62,411	44,896	34,191
8	0	378	2,998	25,906	57,037	67,792	62,480	52,606	36,782	26,849
9	0	135	1,037	10,378	32,454	48,987	48,746	40,687	28,544	19,735
10	0	53	785	7,089	30,918	77,815	89,134	79,189	53,149	37,494
Total ever married women	320,652	977,156	1,102,810	947,797	758,841	710,546	674,540	624,811	475,251	402,892
Total children	177,857	1,345,004	2,765,278	3,578,937	3,675,326	3,908,869	3,766,849	3,312,683	2,378,356	1,819,947
Proportion childless	0.56	0.25	0.12	0.07	0.05	0.05	0.06	0.08	0.10	0.14
Average parity	0.55	1.38	2.51	3.78	4.84	5.50	5.58	5.30	5.00	4.52

CEB – quality assessment, Myanmar 1983 Census



The el-Badry Correction

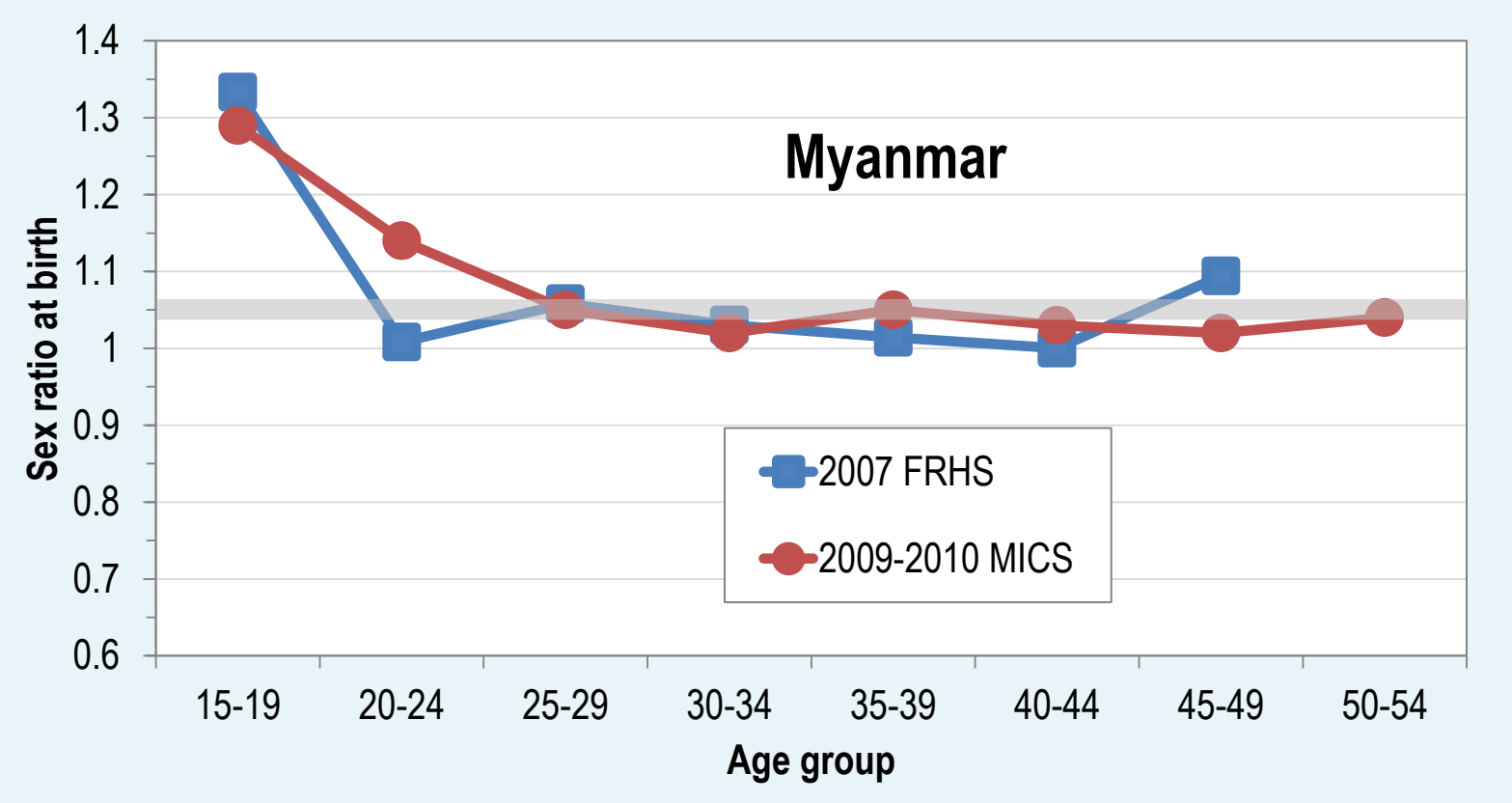
- to adjust reported data on children ever born
- A common problem with CEB data is that enumerators may incorrectly code women of zero parity as “parity unknown” or “parity not stated”
- The el-Badry method corrects for this
  - If parity unknown is less than 2% of each age group >> safe to assume that 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 at birth



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

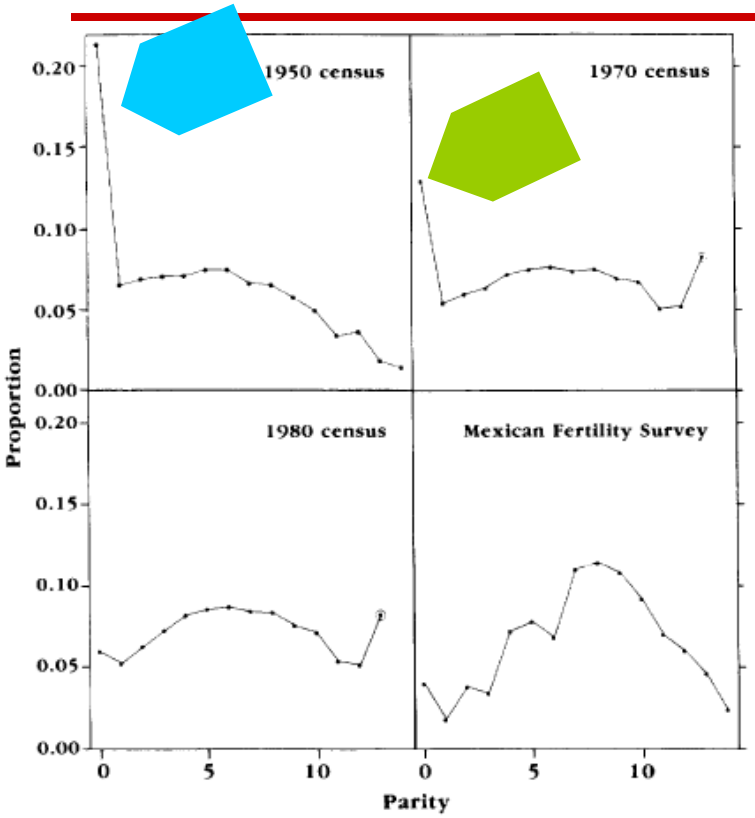
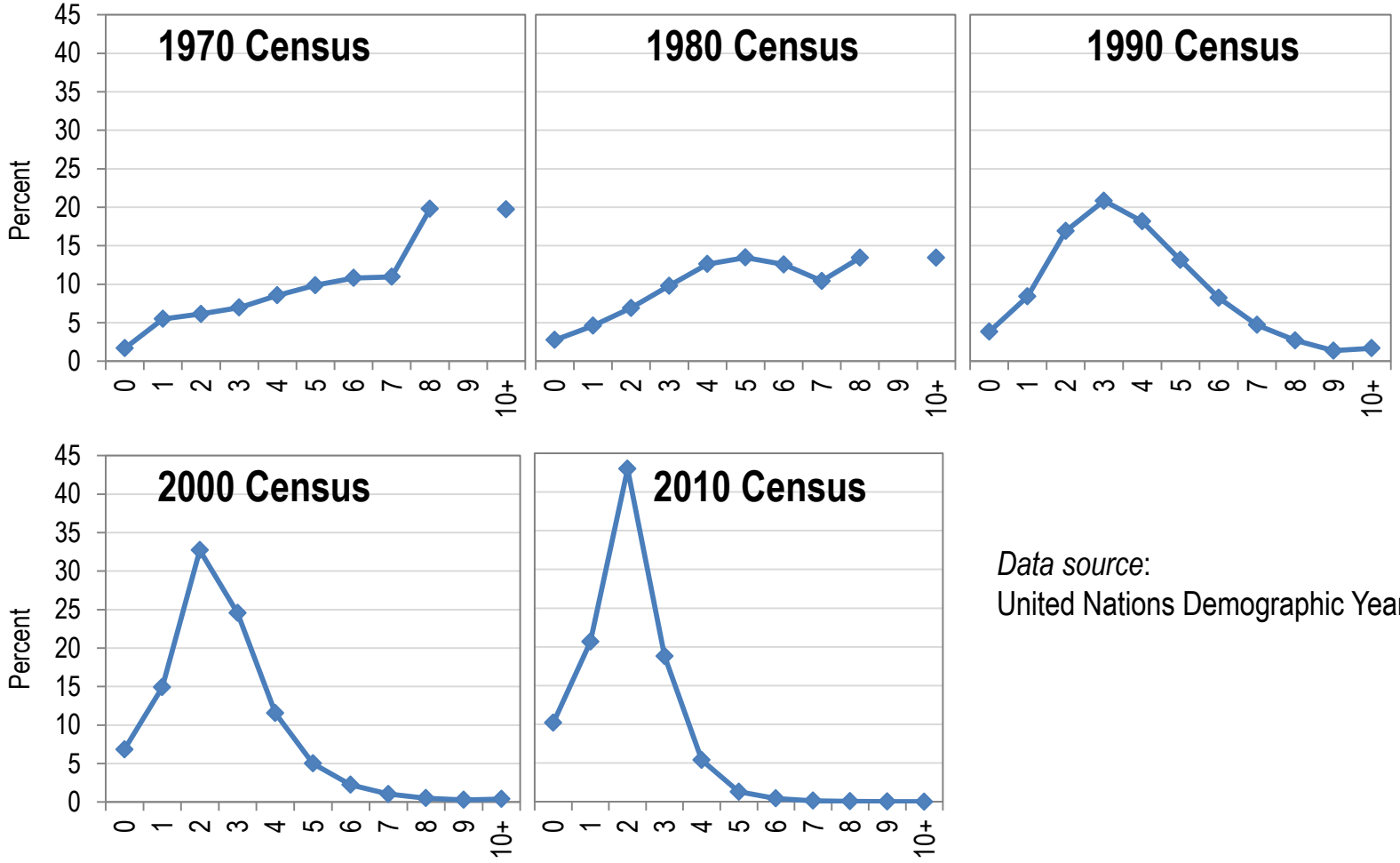


Figure 3. **Completed parity distributions for Mexico, from the censuses of 1950, 1970, and 1980 and from the Mexican Fertility Survey**

- 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)

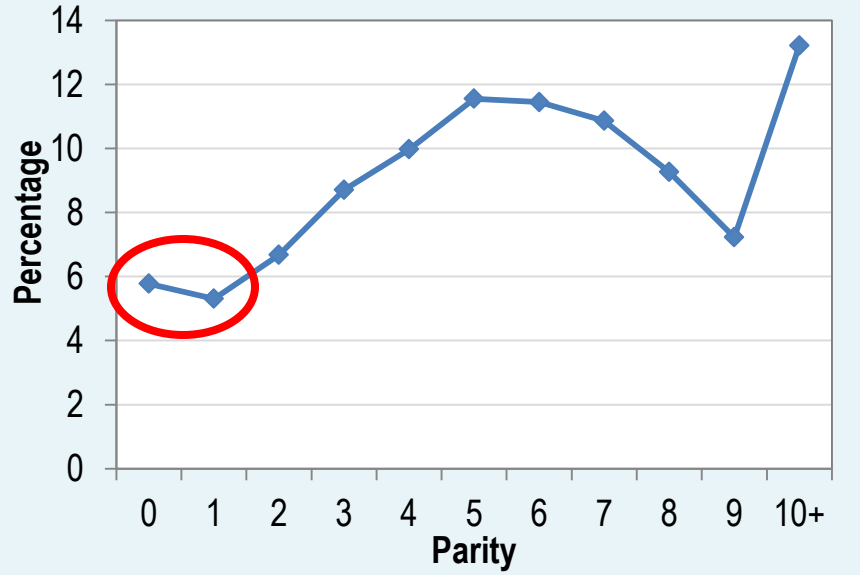
Source: Feeney (1991)

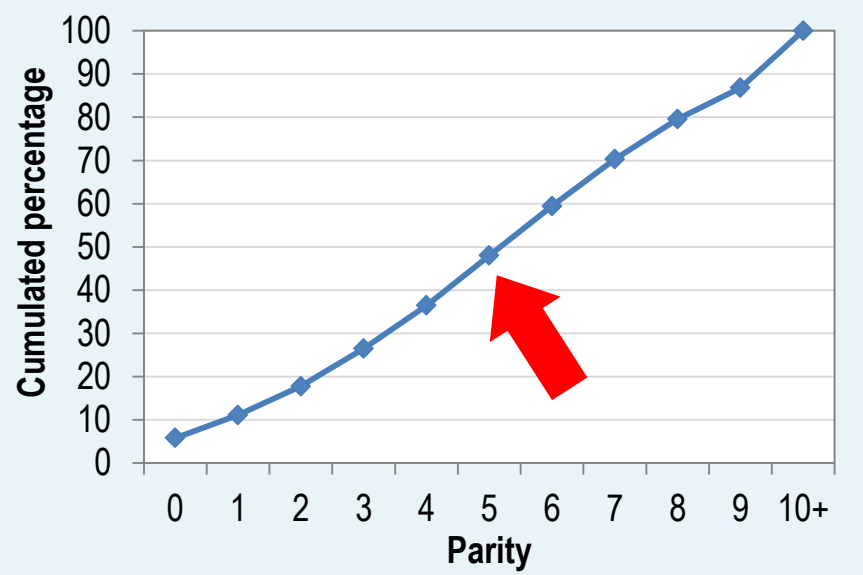
CEB Checks, Parity distribution of women age 45-49, Thailand, 1970-2010 censuses



Data source:
United Nations Demographic Yearbook

CEB Checks, Parity distribution of women age 45-49 Myanmar, 1983 census

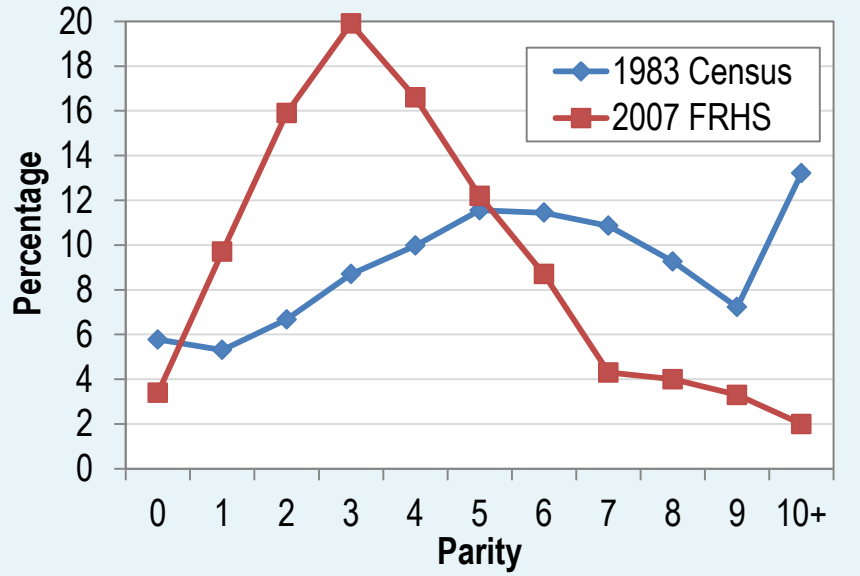


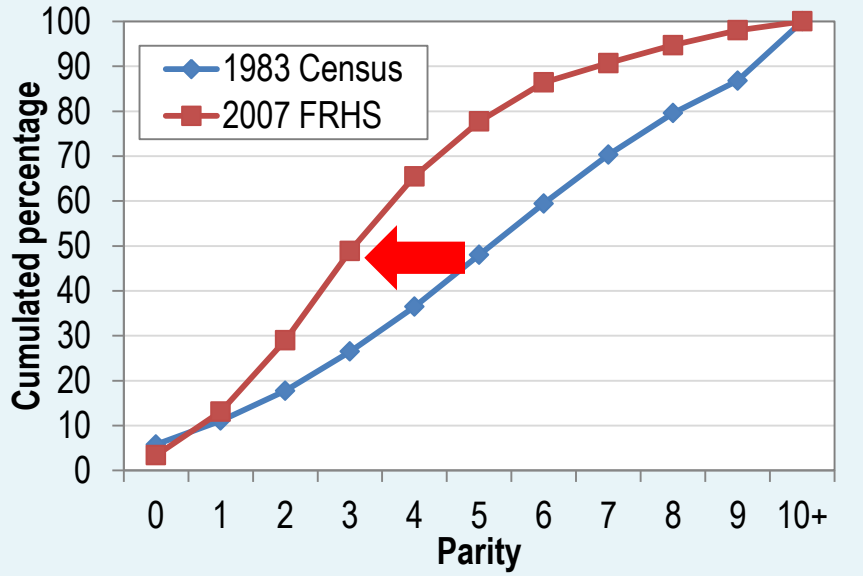


Women with non-stated parity included in 0 parity?

About half of the women age 45-49 have had fewer than 5 children

CEB Checks, Parity distribution of women age 45-49 Myanmar, 1983 census & 2007 FRHS





In 2007, the distribution has shifted to the left (lower parities)

In 2007, about half of the women age 45-49 have had 3 children or less

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 all childbearing at age 28 or any other age
- Reference date = Census date – (age of women – 28)

>> Census date should be in decimal format

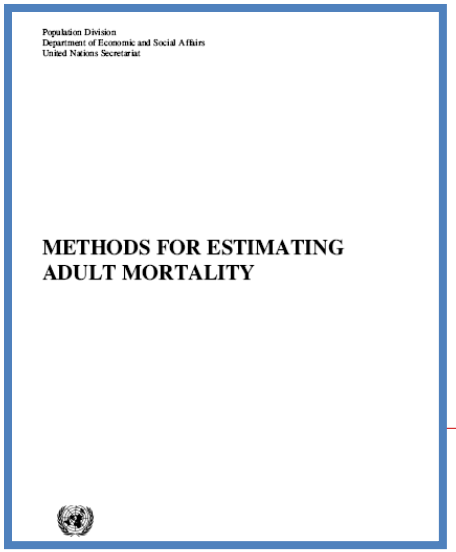
Census date in decimal format

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											
4	0											
5	0											
6	0											
7	0											
8	0											
9	0											
10	0											
11	0											
12	0											
13	0.036	0.121	0.197	0.282	0.364	0.449	0.532	0.616	0.701	0.784	0.868	0.951
14	0.038	0.123	0.200	0.285	0.367	0.452	0.534	0.619	0.704	0.786	0.871	0.953
15	0.041	0.126	0.203	0.288	0.370	0.455	0.537	0.622	0.707	0.789	0.874	0.956
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	0.712	0.795	0.879	0.962
18	0.049	0.134	0.211	0.296	0.378	0.463	0.545	0.630	0.715	0.797	0.882	0.964
19	0.052	0.137	0.214	0.299	0.381	0.466	0.548	0.633	0.718	0.800	0.885	0.967
20	0.055	0.140	0.216	0.301	0.384	0.468	0.551	0.636	0.721	0.803	0.888	0.970
21	0.058	0.142	0.219	0.304	0.386	0.471	0.553	0.638	0.723	0.805	0.890	0.973
22	0.060	0.145	0.222	0.307	0.389	0.474	0.556	0.641	0.726	0.808	0.893	0.975
23	0.063	0.148	0.225	0.310	0.392	0.477	0.559	0.644	0.729	0.811	0.896	0.978
24	0.066	0.151	0.227	0.312	0.395	0.479	0.562	0.647	0.732	0.814	0.899	0.981
25	0.068	0.153	0.230	0.315	0.397	0.482	0.564	0.649	0.734	0.816	0.901	0.984
26	0.071	0.156	0.233	0.318	0.400	0.485	0.567	0.652	0.737	0.819	0.904	0.986
27	0.074	0.159	0.236	0.321	0.403	0.488	0.570	0.655	0.740	0.822	0.907	0.989
28	0.077	0.162	0.238	0.323	0.405	0.490	0.573	0.658	0.742	0.825	0.910	0.992
29	0.079	NA	0.241	0.326	0.408	0.493	0.575	0.660	0.745	0.827	0.912	0.995
30	0.082	NA	0.244	0.329	0.411	0.496	0.578	0.663	0.748	0.830	0.915	0.997
31	0.085	NA	0.247	NA	0.414	NA	0.581	0.666	NA	0.833	NA	1.000
Day/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

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



Census date in decimal format

Examples

1983 Census of Myanmar was conducted 1-5 April 1983 with a reference date of 1 April 1983

1 April in decimal date = 0.249

1 April 1983 in decimal date = 1983+0.249 = **1983.249**

Reference date of the 2014 Census of Myanmar in decimal = **???**

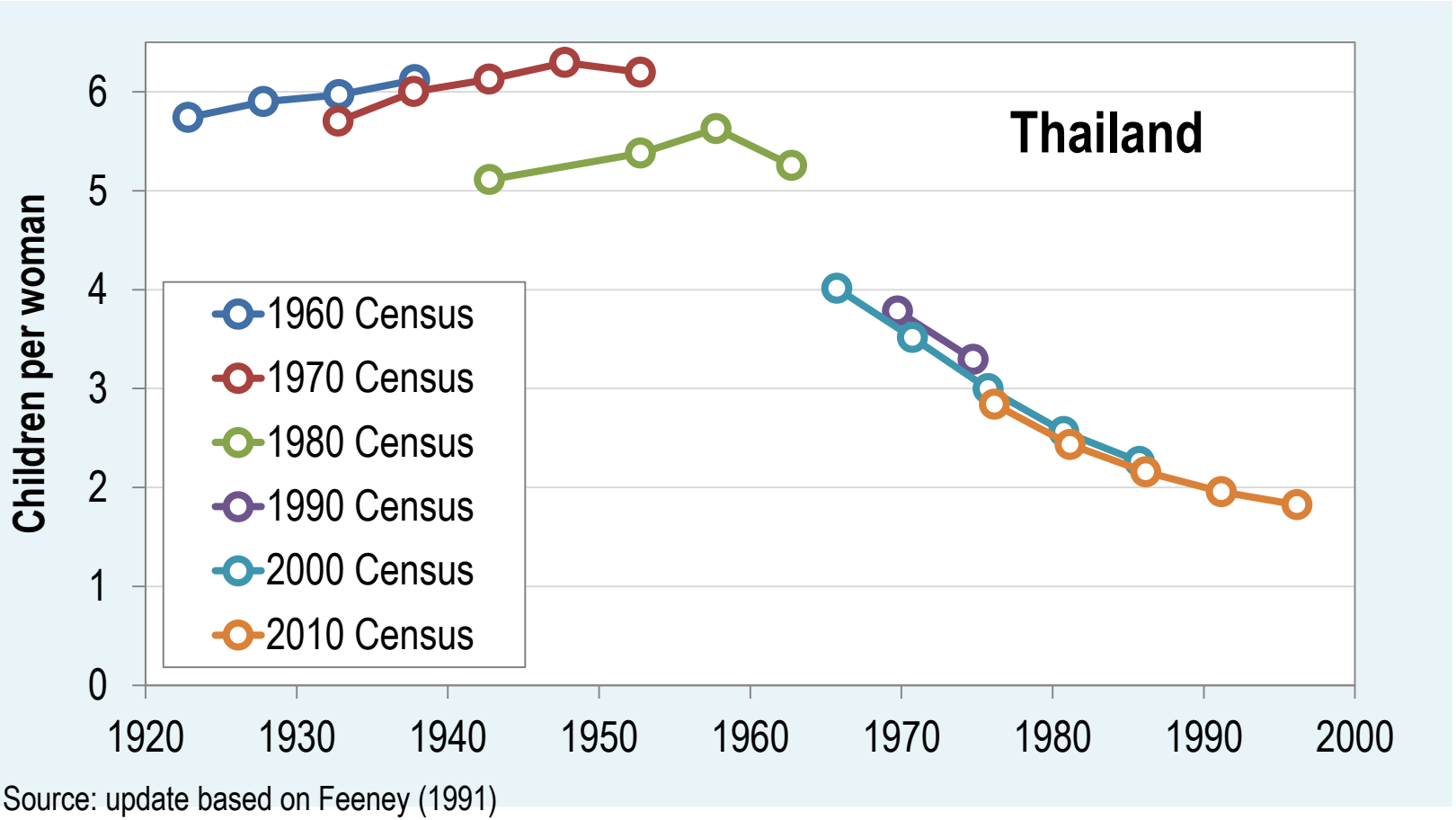
CEB - Additional Checks
Cohort analysis of mean CEB

Example of Thailand: 1970 census

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

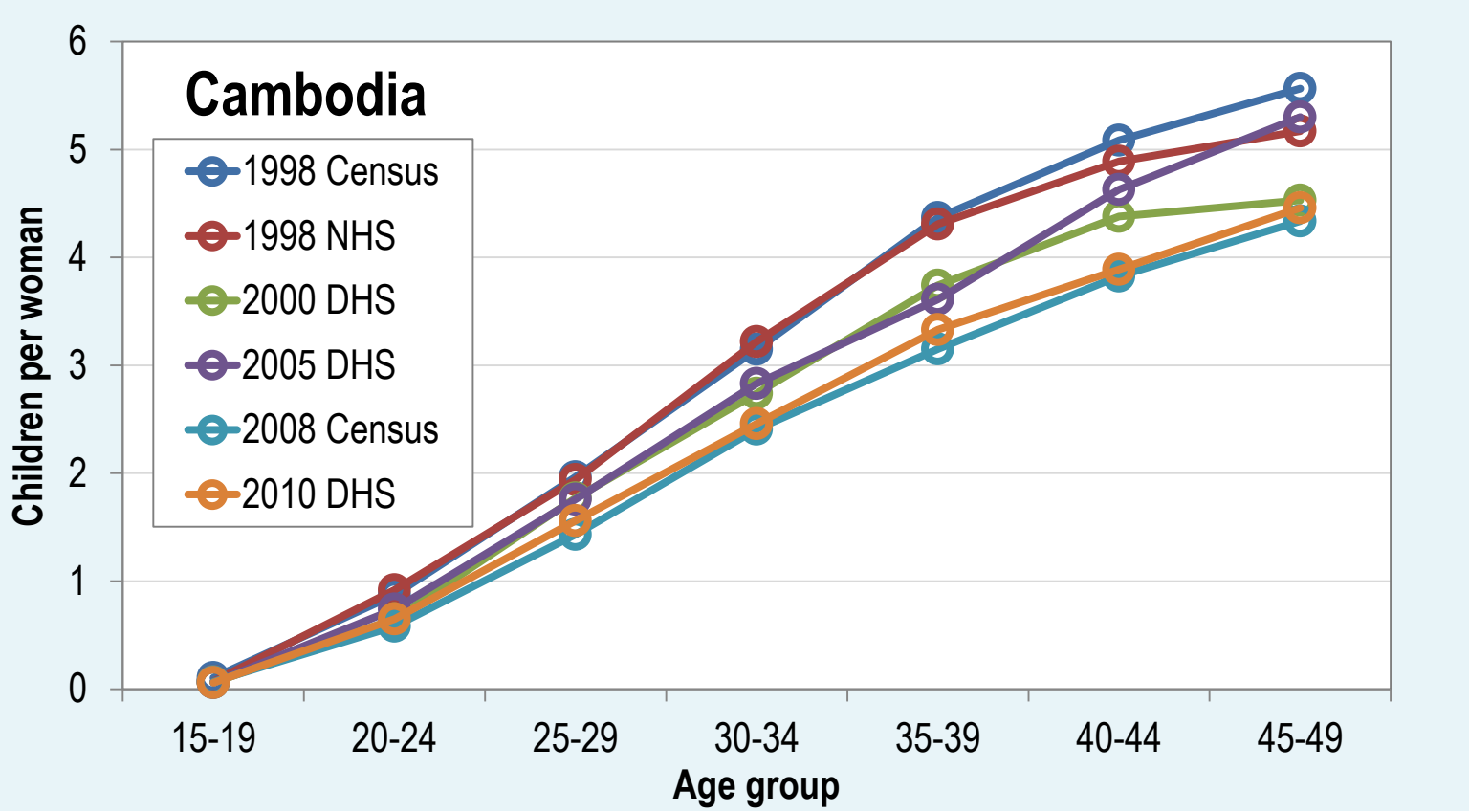
Age group	Total women	Total CEB	Average CEB	Mid-group age	Mean age at childbearing	Number of preceding years for which average CEB refers	Reference date of census	Reference date of average CEB
	(1)	(2)	(3) = (2)/(1)	(4)	(5)	(6) = (4) - (5)	(7)	(8) = (7) - (6)
40-44	712,916	4,417,277	**6.196**	42.5	28	14.5	1970.249	**1955.749**
45-49	558,293	3,513,567	**6.293**	47.5	28	19.5	1970.249	**1950.749**
50-54	457,606	2,803,846	**6.127**	52.5	28	24.5	1970.249	**1945.749**
55-59	374,274	2,246,517	**6.002**	57.5	28	29.5	1970.249	**1940.749**
60-64	830,483	4,734,988	**5.701**	62.5	28	34.5	1970.249	**1935.749**

CEB - Additional Checks
Cohort analysis of mean CEB



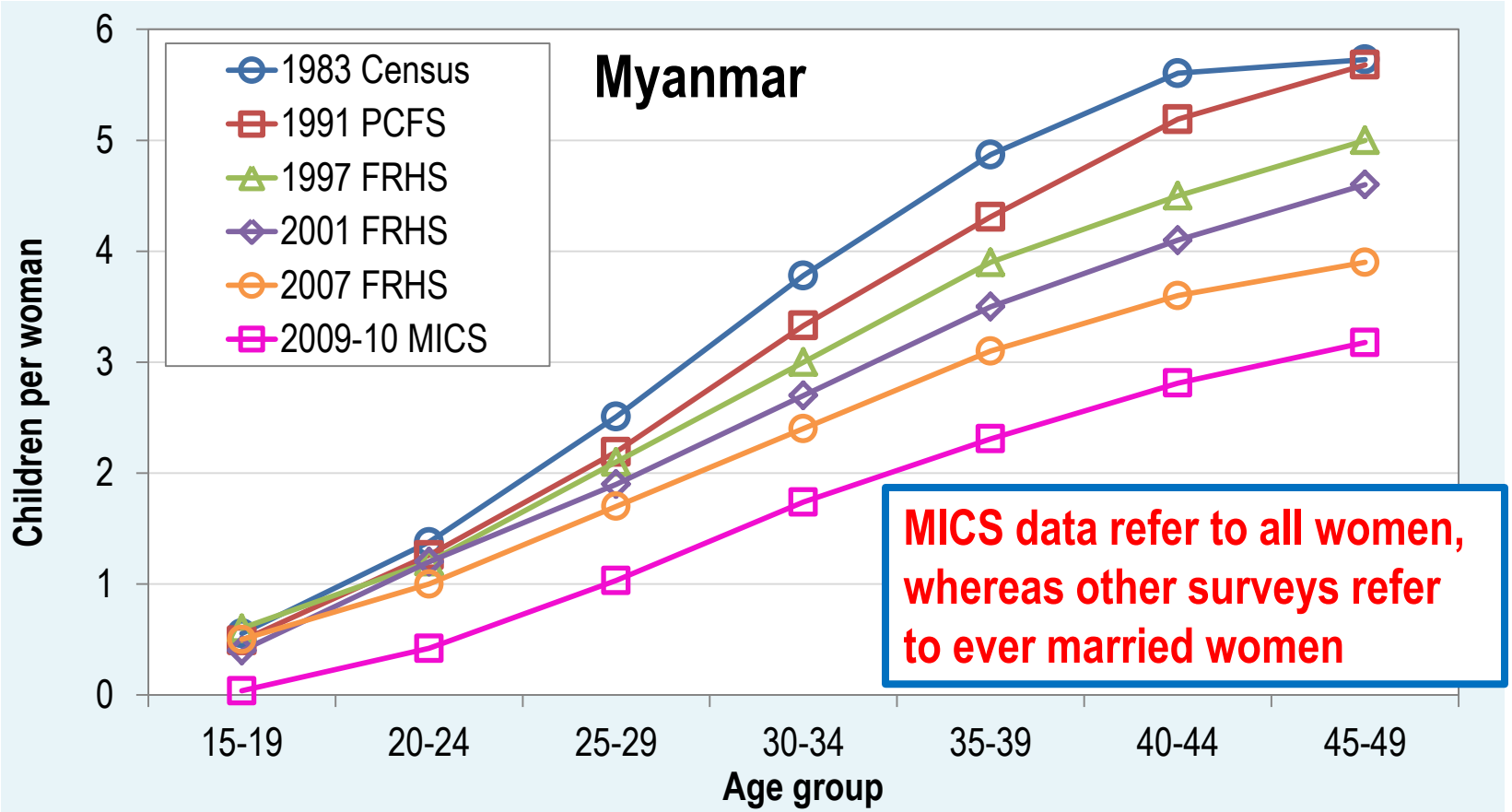
Source: update based on Feeney (1991)

CEB – Additional checks
Multiple sources of data



Data source: United Nations *Demographic Yearbook* and DHS STATcompiler http://www.statcompiler.com/

CEB – Additional checks
Multiple sources of data



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

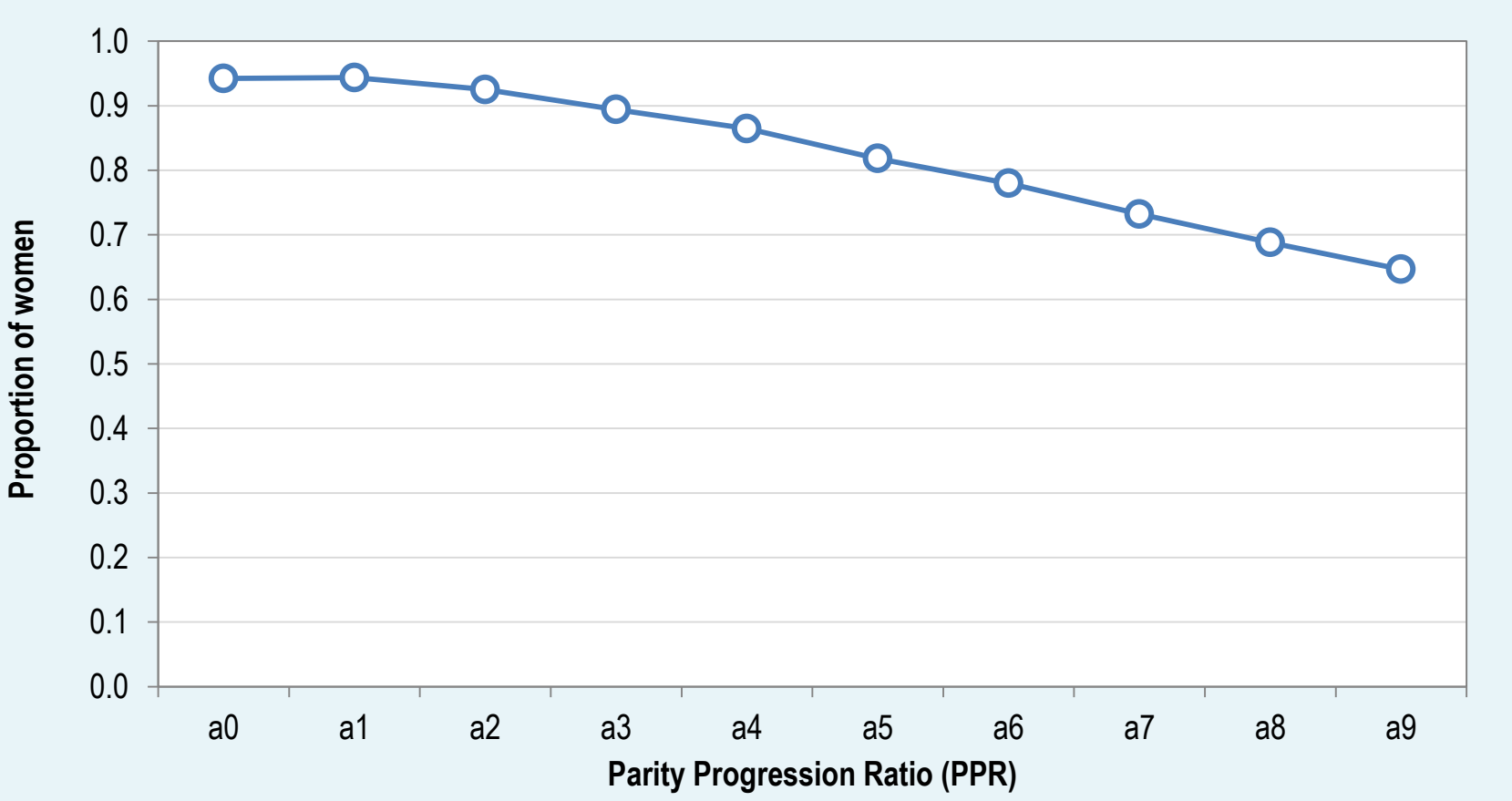
>> useful to understand the **distribution** of cohort fertility (i.e. proportion of women in a cohort who end up with exactly no children, exactly one, exactly two,…, at the end of the childbearing years).

CEB - Parity progressions ratios, Myanmar 1983 Census

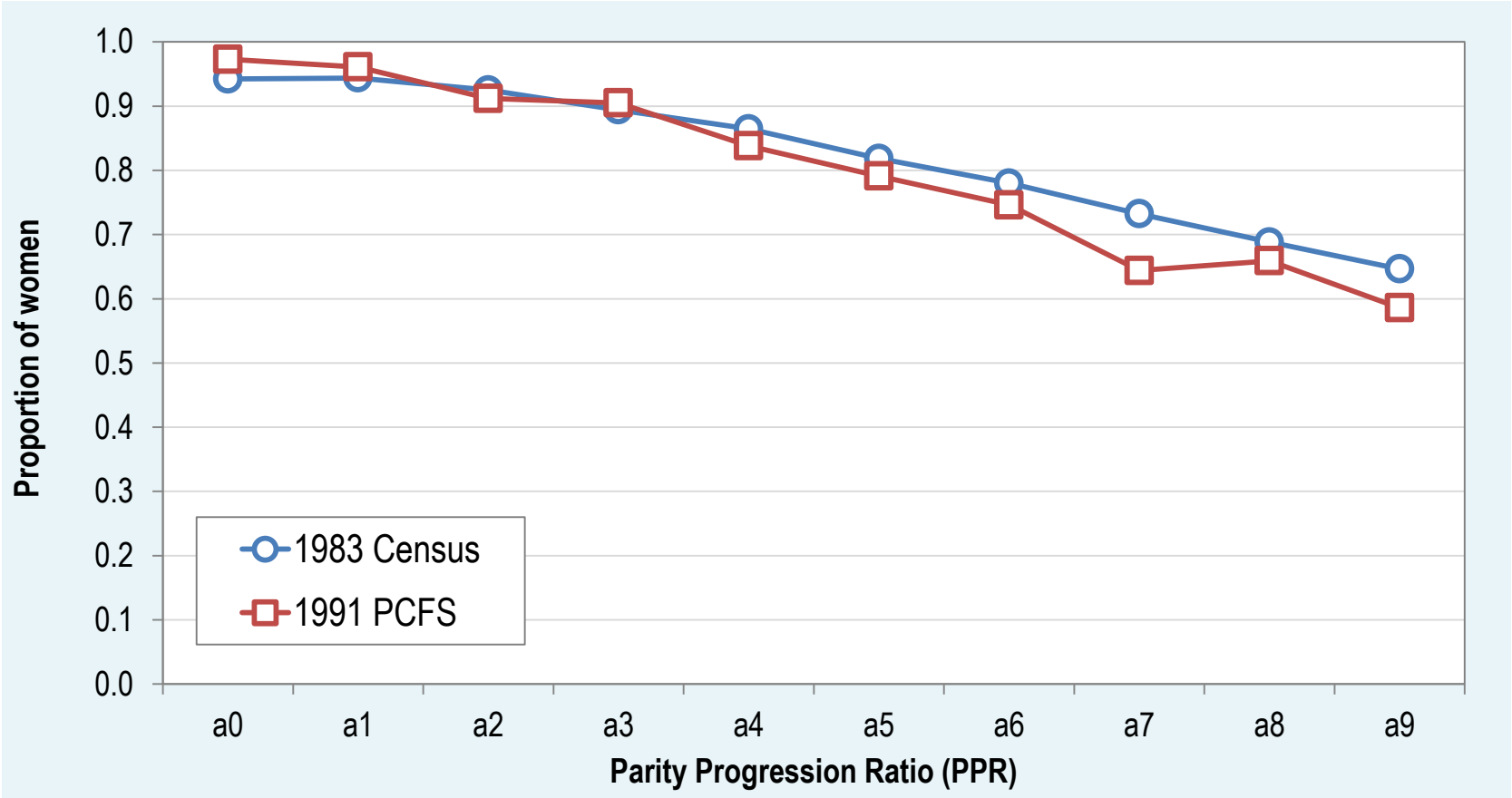
Children ever born N	Number of women age 45-49	Women 45-49 with at least N children	Parity progression ratio (PPR)	Symbol
0	38956	674540	0.942	a0
1	35804	635584	0.944	a1
2	45018	599780	0.925	a2
3	58706	554762	0.894	a3
4	67270	496056	0.864	a4
5	77915	428786	0.818	a5
6	77235	350871	0.780	a6
7	73276	273636	0.732	a7
8	62480	200360	0.688	a8
9	48746	137880	0.646	a9
10+	89134	89134		

Cumulate

PPRs – Myanmar, 1983 Census



PPRs – Myanmar, 1983 Census & 1991 PCFS



Cohort analysis of mean number of *CEB* – *PPRs*

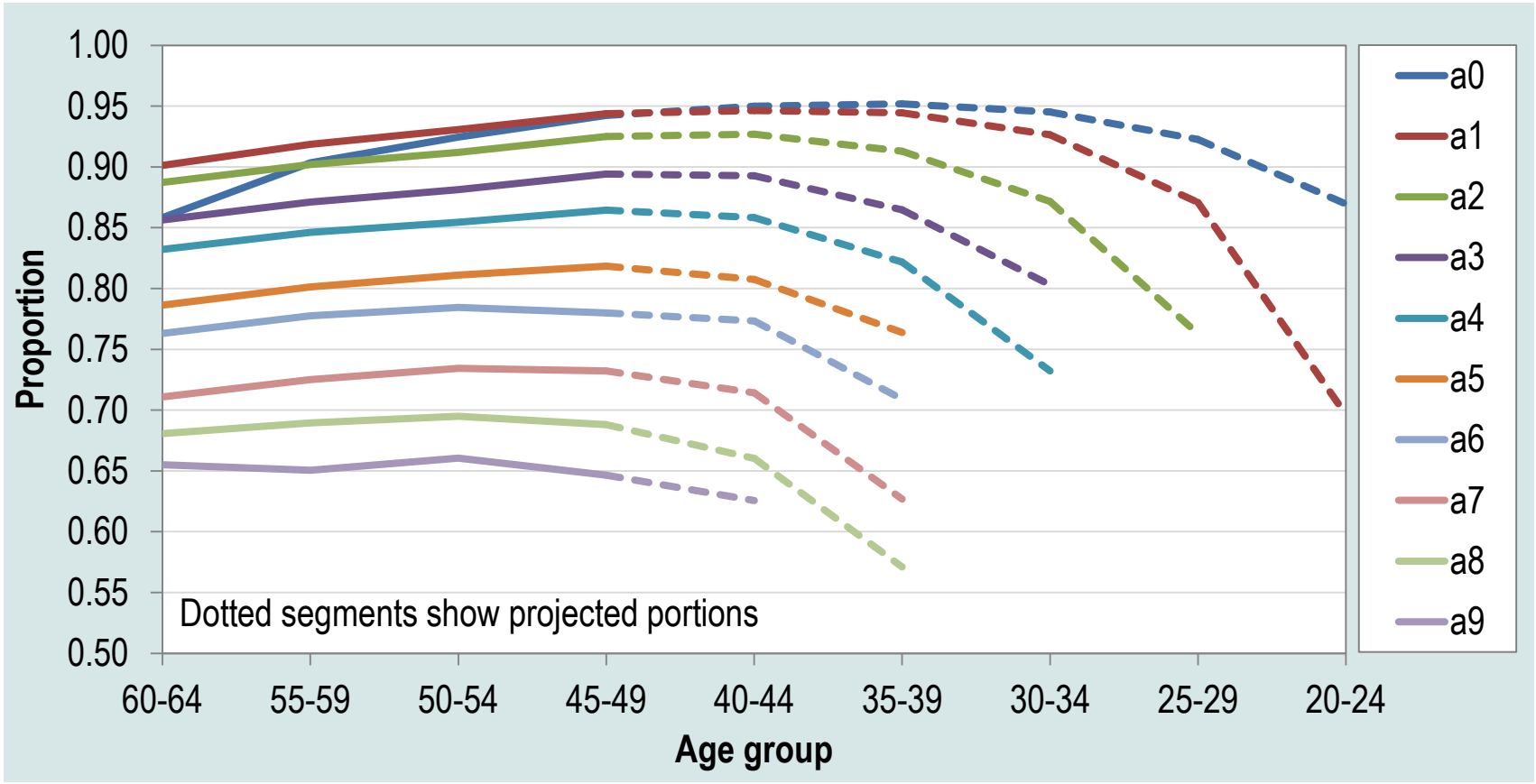
PPR = proportion of women who progress from one parity to the next

Comparison of successive cohorts **>>** trends in fertility (but more reliable conclusions if PPRs for the same cohorts can be compared across more than one census)

For younger women, who provide information on more recent fertility trends, most of their childbearing experience is missing **>>** need to estimate based on experiences of older women (assuming that younger women will behave like older ones)

- Software: Excel Sheet "**FE_PPR.xlsx**" in Moultrie & Zaba (2013), available online at: http://demographicestimation.iussp.org/content/parity-progression-ratios

(Projected) PPRs – Myanmar, 1983 Census



Recent births – quality assessment

Initial assessment

Any missing values in data? (month/date/year of birth)

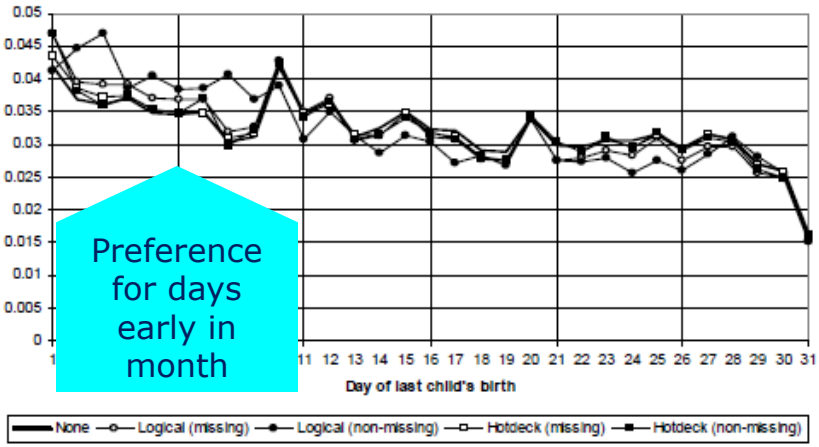
- Missing data for any relevant variables? (age of mother, sex of child, survival status of the child)

Is distribution of reported birth dates reasonable?

If possible, compare with civil registration data on live births

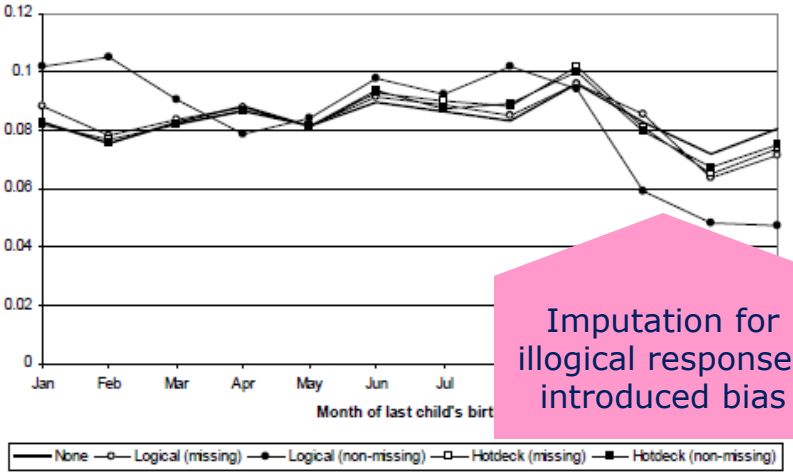
Recent births – quality assessment – missing and inconsistent data

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



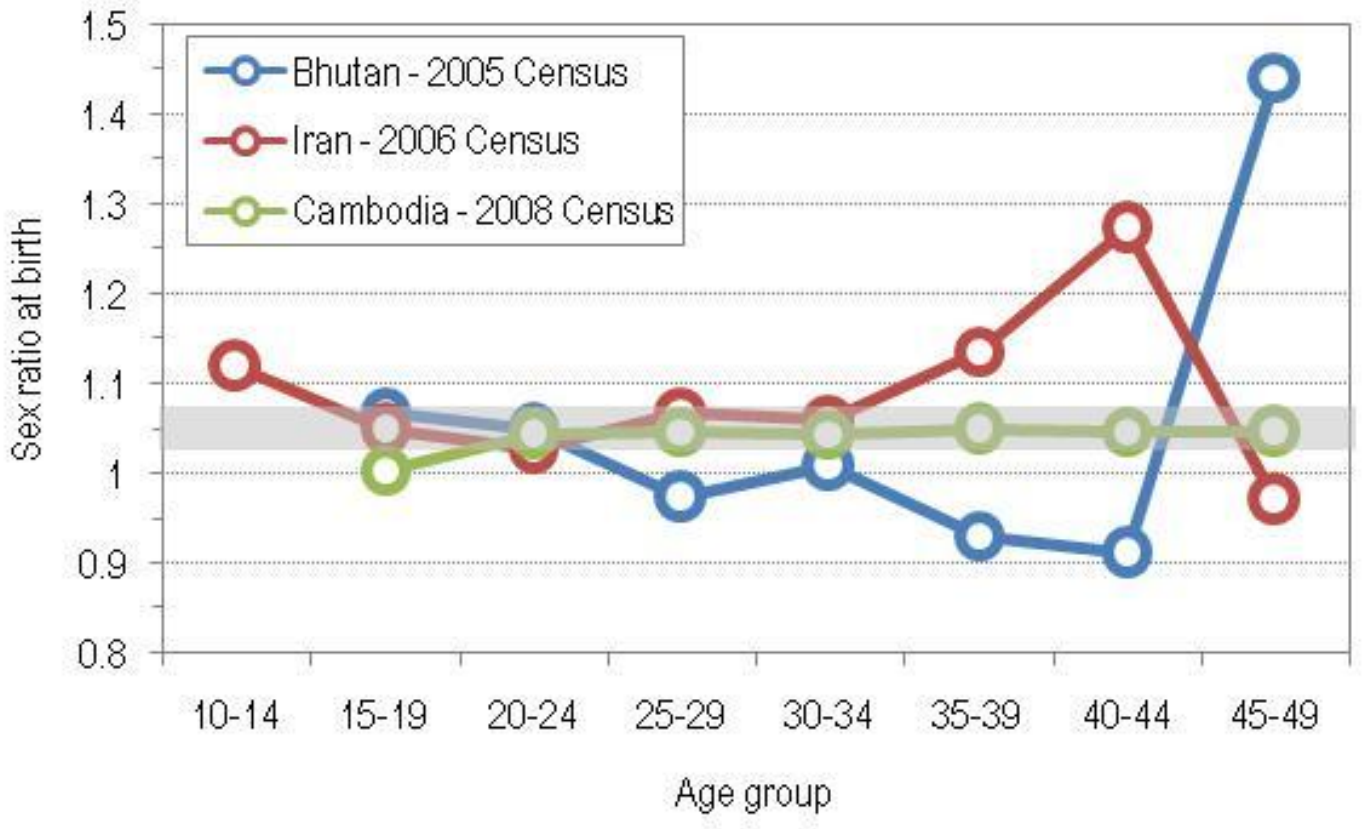
Imputation for illogical responses introduced bias

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*		*Hotdeck applied to*		*TOTAL*
		missing response	*non-missing response*	*missing response*	*non-missing response*	
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



Data source: United Nations Demographic Yearbook

Recent births quality assessment age specific fertility rates (ASFR)

Age Specific Fertility Rate (ASFR)

$$nFx = \frac{nBx}{nWx}$$

nBx =Births to women age x to x+n during period

nWx =Mid-period population of women age x to x+n

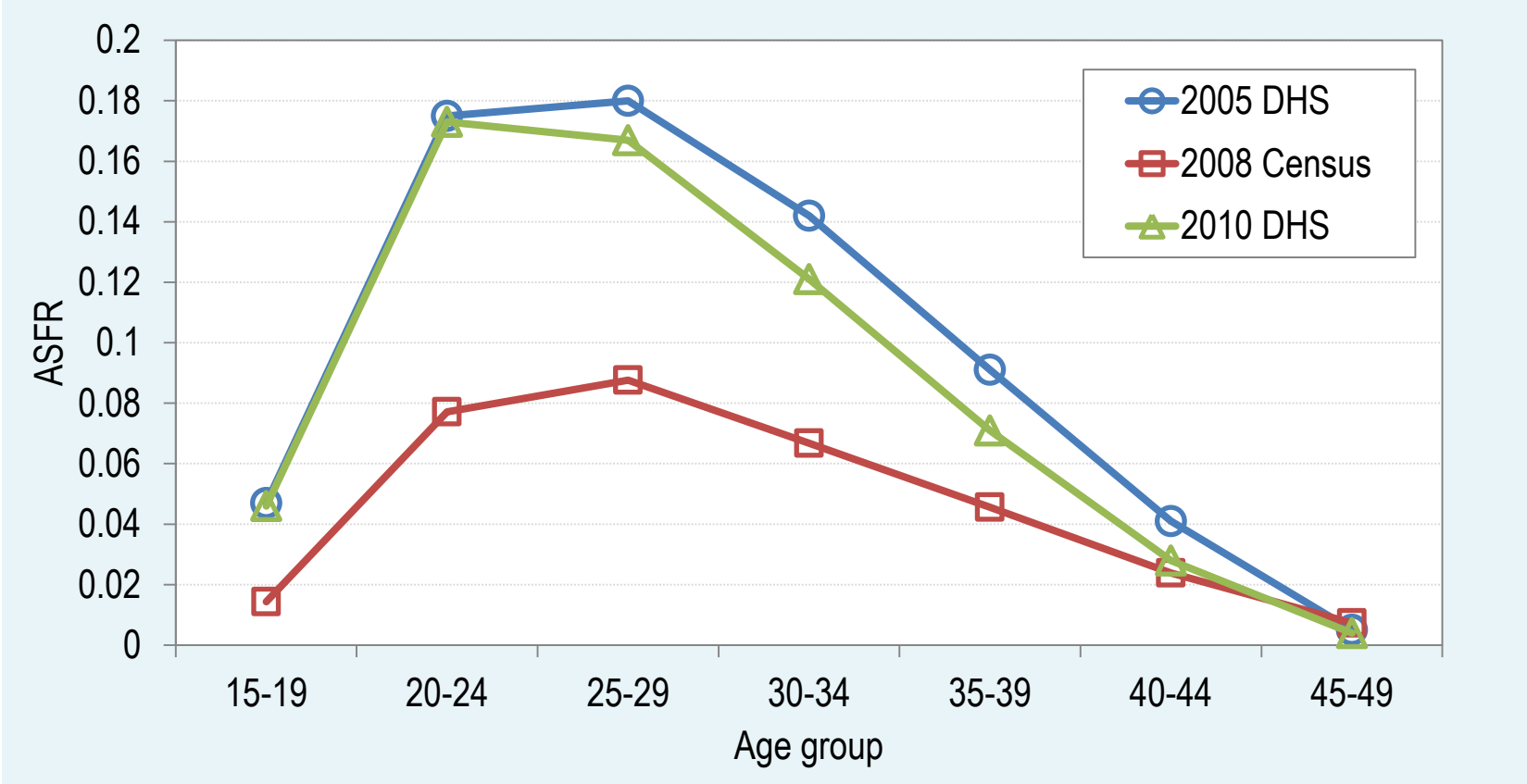
Are births classified by age of mother at birth of her child or by age of mother at the survey/census date?

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.

Cambodia, 2008 Census

Age group	Births in 12 months preceding census	Total women in age group	ASFR
14.5 – 19.5	11,160	780,320	0.0143
19.5 – 24.5	53,740	697,160	0.0771
24.5 – 29.5	54,910	626,430	0.0877
29.5 – 34.5	24,130	361,650	0.0667
34.5 – 39.5	19,880	435,880	0.0456
39.5 – 44.5	9,380	393,760	0.0238
44.5 – 49.5	2,580	352,520	0.0073

Recent births, quality assessment
Comparing *ASFR*s, Cambodia

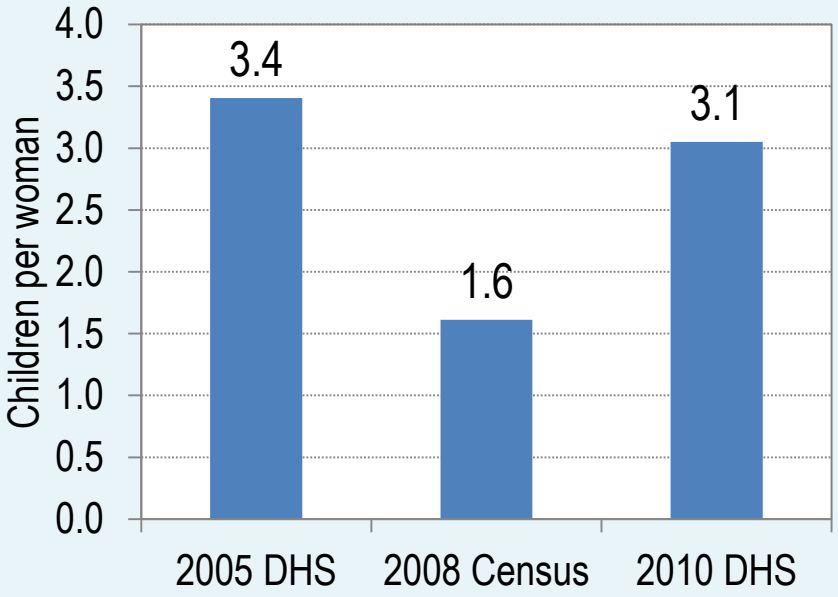


Data sources: IPUMS-International and DHS STATcompiler

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

Cambodia, TFRs comparison

Age group	2005 DHS	2008 Census	2010 DHS
15 - 19	0.047	0.014	0.046
20 - 24	0.175	0.077	0.173
25 - 29	0.180	0.088	0.167
30 - 34	0.142	0.067	0.121
35 - 39	0.091	0.046	0.071
40 - 44	0.041	0.024	0.028
45 - 49	0.005	0.007	0.004
TFR	**3.4**	**1.6**	**3.1**



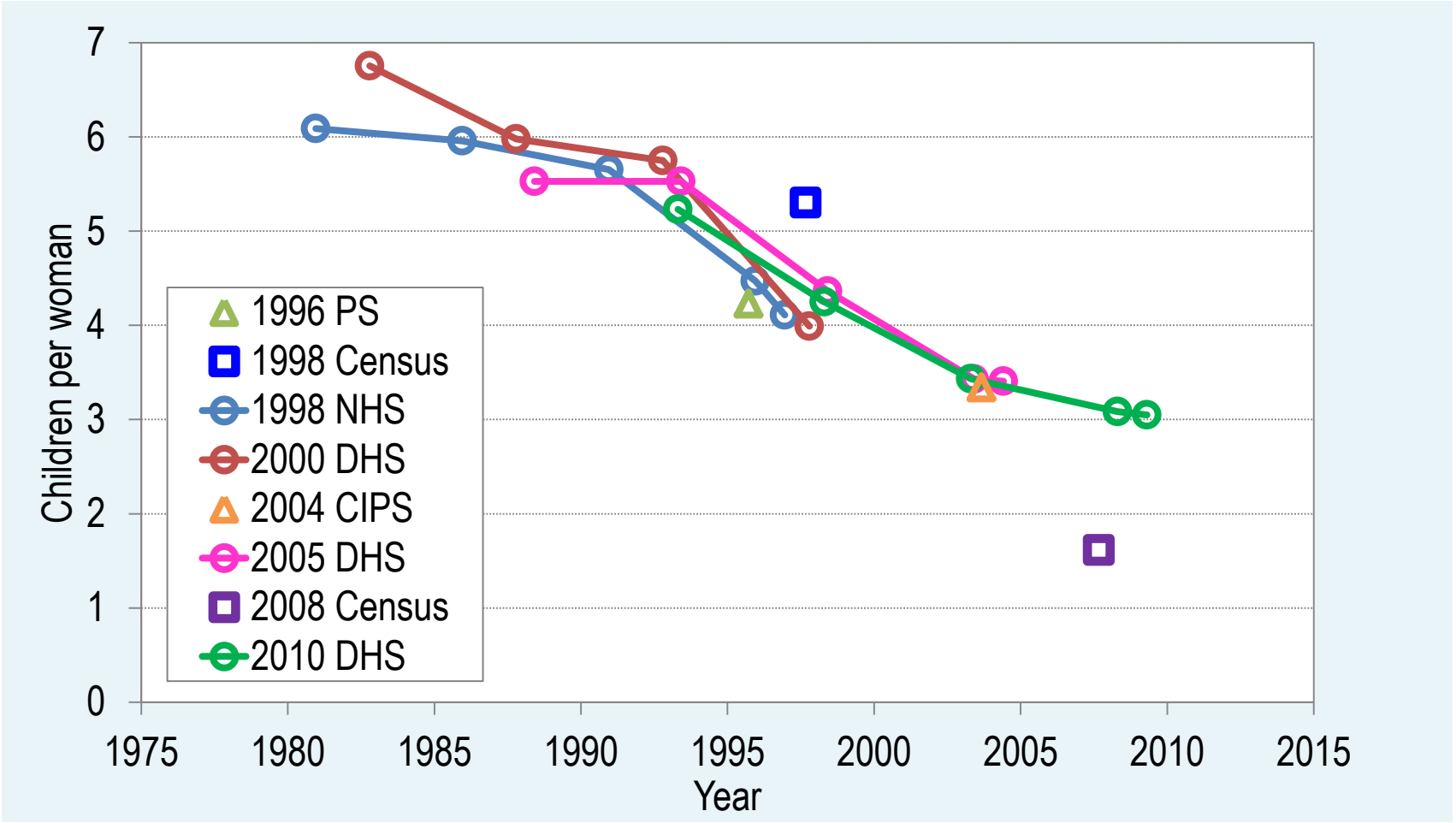
$$TFR = 5 \cdot \sum_{x=15-19}^{45-49} {}_5F_x$$

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

Cambodia, 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: Timor-Leste 2004 Census

Estimation of age-specific fertility rates from data on children ever born

TITLE: Timor-Leste, 2004 Census

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

	First Enumeration
Month	July
Year	2004
Fertility pattern is tabulated by age of woman at:	enumeration

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

In the present case the adjustment factors are declining over the age groups:
Increasing fertility or increasing mis-reporting with women's age?

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
July 2004											
				Recorded	Calculated						
15 - 20	0.113	0.0427	0.0828	0.0427	0.0552	0.0828	0.0552	1.5007	0.0621	0.0550	0.0586
20 - 25	1.049	0.2485	0.2795	0.2485	0.2667	0.3624	0.3219	1.1257	0.3002	0.2659	0.2831
25 - 30	2.564	0.3263	0.2866	0.3263	0.3290	0.6490	0.6509	0.9971	0.3703	0.3280	0.3492
30 - 35	3.859	0.3066	0.2353	0.3066	0.3005	0.8843	0.9513	0.9295	0.3382	0.2996	0.3189
35 - 40	4.912	0.2269	0.1692	0.2269	0.2184	1.0535	1.1698	0.9006	0.2459	0.2178	0.2319
40 - 45	5.426	0.1204	0.0867	0.1204	0.1100	1.1402	1.2798	0.8909	0.1238	0.1097	0.1168
45 - 50	5.327	0.0453	0.0316	0.0453	0.0369	1.1718	1.3167	0.8900	0.0416	0.0368	0.0392
Mean Age of Childbearing:			27.9248		28.9905						
Total Fertility Rate:			5.8592		6.5836				7.4113	6.5647	6.9880

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

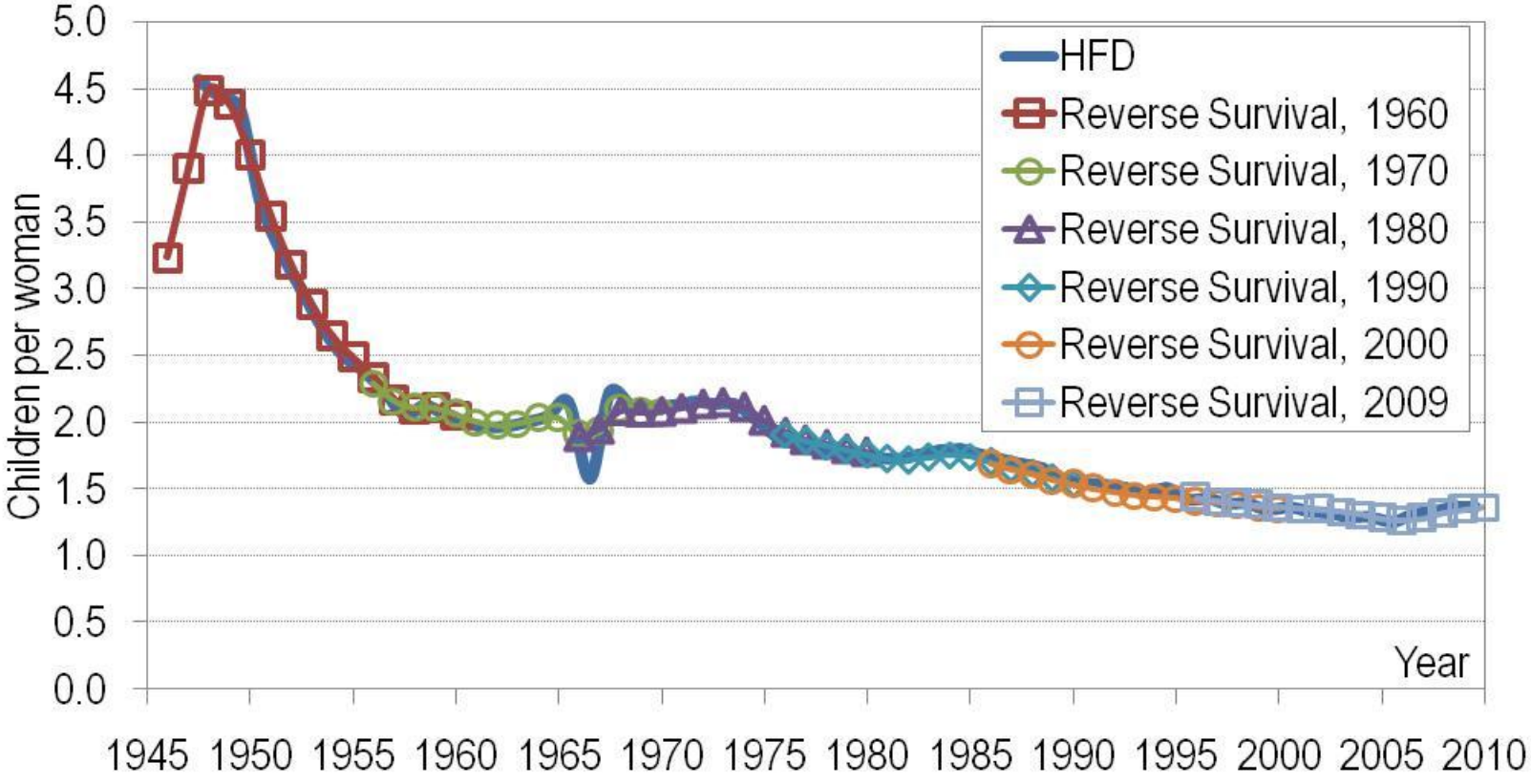
- Population by single age and sex is 15-year back projected (reverse survived)
- *TFR* for years *y0*, *y-1*, *y-2*, … *y-14* computed to match births obtained by reverse survival
- Assumptions:
  - Population by single age and sex is free of errors
  - Estimates of mortality are available for the period 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.xlsx**" in Timæus & Moultrie (2013), available online at: http://demographicestimation.iussp.org/content/reverse-survival-methods

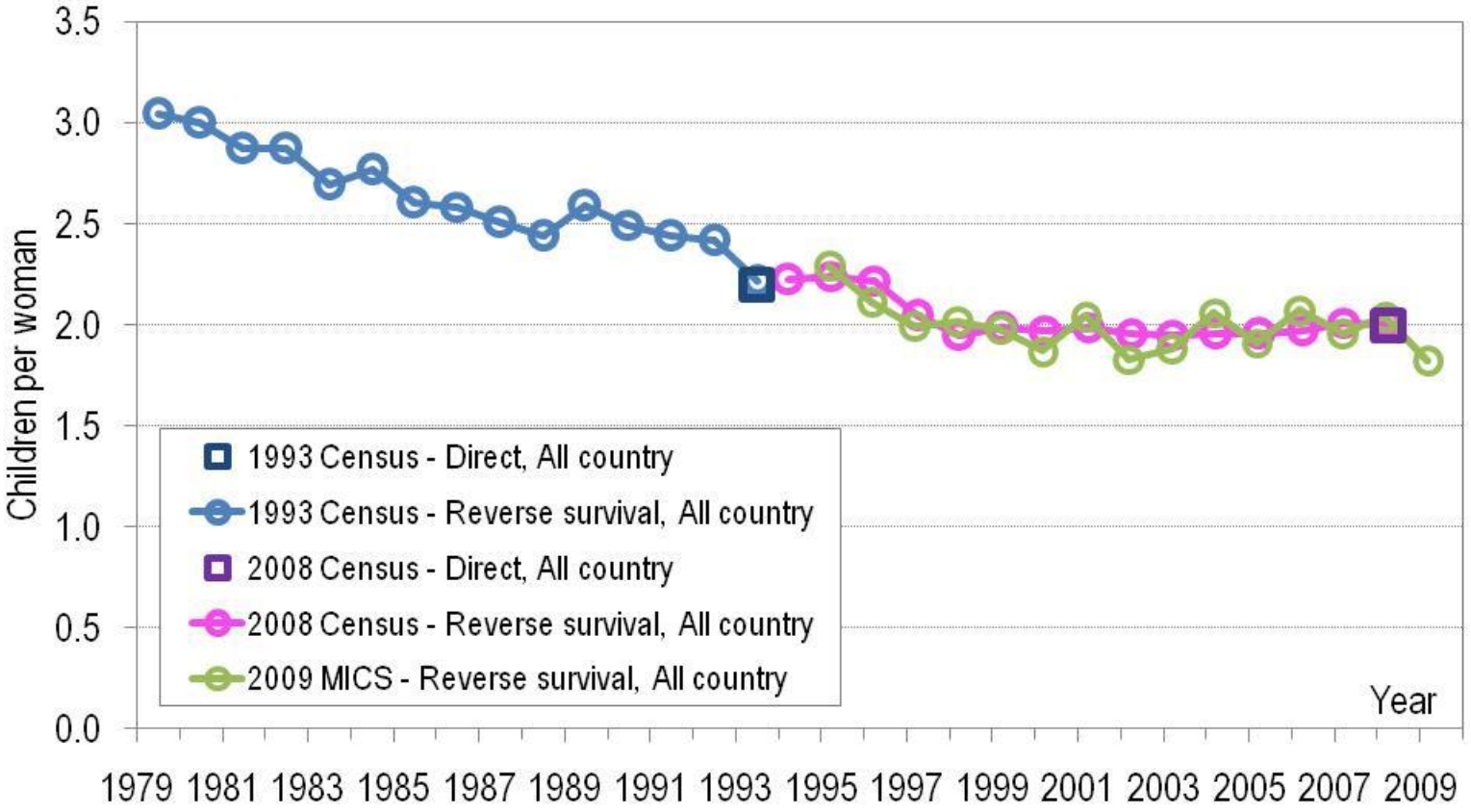
- Modified version "**FE_reverse_4_updated.xlxs**" distributed allows to use country mortality and age-specific fertility estimates as parameters

Reverse survival fertility estimates, Japan



Source: Spoorenberg (2014)

Reverse survival fertility estimates, DPR Korea



Sources: computed from 1993 and 2008 census and 2009 MICS

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).

Step 1

Obtain distribution of own children by age and by age of mother:

TABLE 161. OWN-CHILDREN DATA, WITH CHILDREN CLASSIFIED BY SINGLE YEAR OF AGE AND SINGLE YEAR AGE OF MOTHER, COLOMBIA, 1978

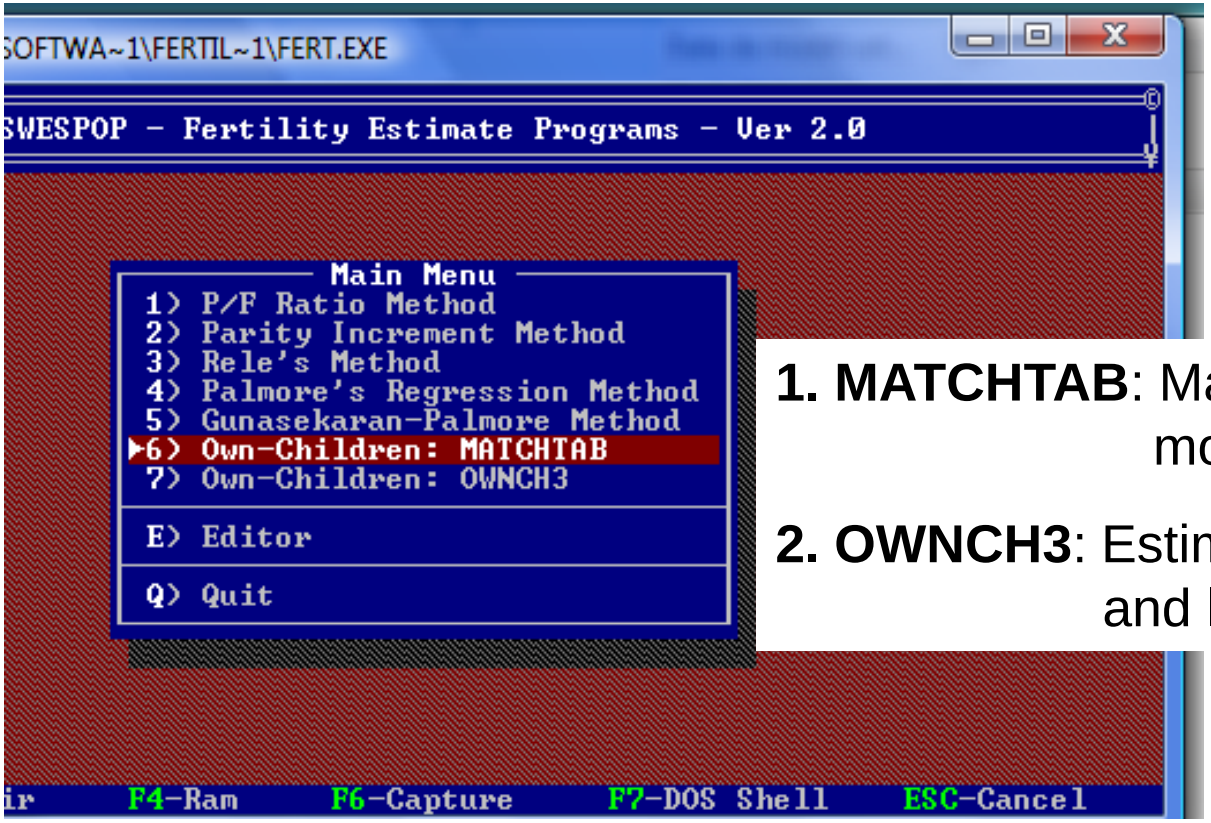
Age of mother	Number of children, by age of child																Number women
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
15	13	7	0	2	2	2	1	4	3	4	2	1	3	1	3	3	755
16	12	3	0	2	0	2	1	1	1	0	0	0	2	0	0	1	696
17	23	16	6	1	0	0	0	0	0	0	1	0	0	0	0	0	686
18	58	36	17	3	0	3	1	2	0	0	0	0	0	0	0	0	706
19	66	46	24	13	11	1	3	1	0	0	0	0	1	0	0	1	538
20	77	55	45	33	19	12	2	1	0	2	2	1	1	1	0	0	602
21	78	71	56	47	48	17	7	5	3	0	1	2	1	1	0	0	488
22	84	80	76	73	46	26	18	15	3	0	0	0	0	0	1	0	534
23	84	85	80	84	61	53	29	24	7	9	1	2	0	2	1	0	488
24	93	63	78	72	56	48	45	34	17	9	8	3	0	1	1	1	411
25	91	84	87	83	69	71	55	52	31	21	5	5	2	1	0	0	464
26	73	67	65	70	66	70	61	55	41	24	17	11	1	1	2	0	393
27	58	61	70	58	63	79	64	64	47	28	27	16	11	5	2	1	339
28	83	71	77	81	94	80	87	91	80	60	42	34	16	8	3	2	442
29	48	58	52	59	68	64	77	75	61	66	48	50	23	23	6	4	330
30	46	60	70	62	82	86	86	86	82	74	69	50	45	31	20	8	403
31	42	39	42	36	44	44	55	66	63	56	57	46	43	24	12	8	243
32	45	50	67	54	66	65	73	82	79	91	78	64	63	66	38	30	343

Usually requires tabulations of **microdata**. Algorithms for matching mothers and own children can be fairly complicated.

Step 2

Apply reverse survival techniques to the distribution obtained at the previous step to estimate shape and level of fertility in the last 15 year

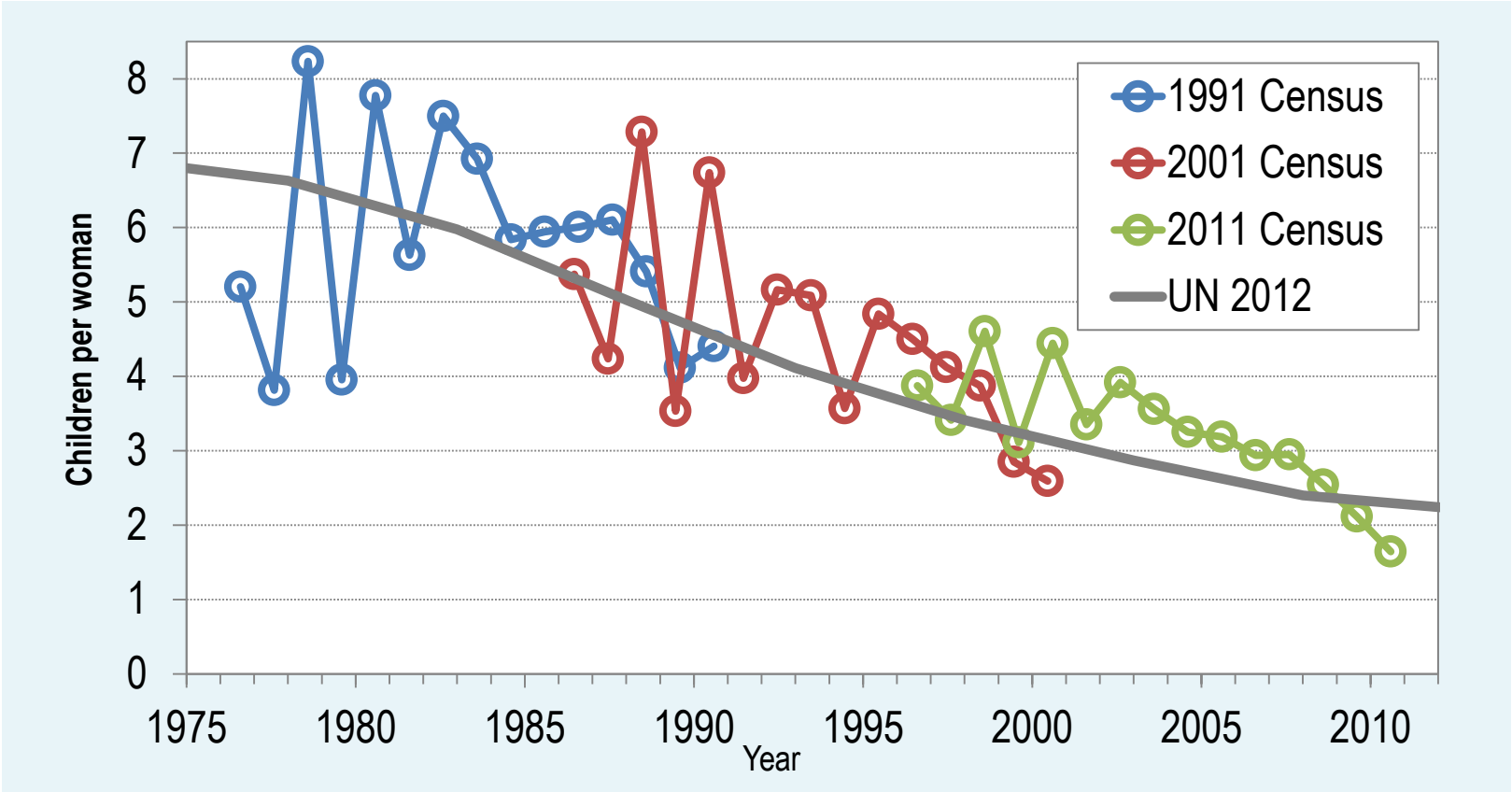
Own-children method: FERT software



1. **MATCHTAB**: Matching children with mother

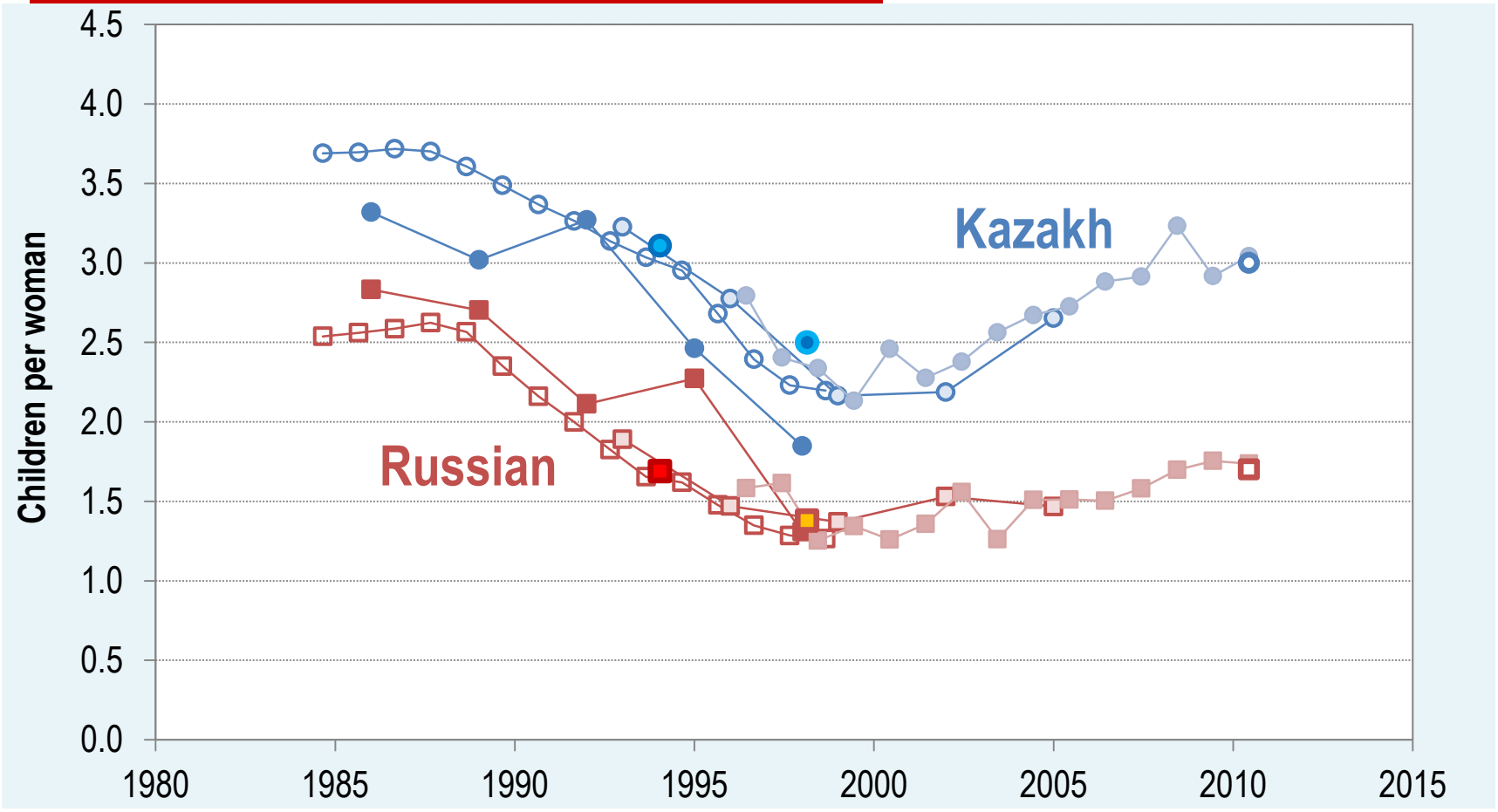
2. **OWNCH3**: Estimation of age patterns and level of fertility

Fertility Estimates by Own-Children Method, Bangladesh



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

Fertility estimates by ethnic groups, Kazakhstan



Outline

1. Fertility measures (some definitions)
2. Evaluation of fertility data
    1. Data collection errors, coverage, completeness
    2. Methods for deriving fertility estimates
    3. Comparing estimates from multiple independent sources
3. Fertility data collected in the 2014 census

Fertility data collected in the 2014 census

Direct estimates

Question 25

Number of children ever born alive (only ***ever married*** women aged 15 and above)

Question 29

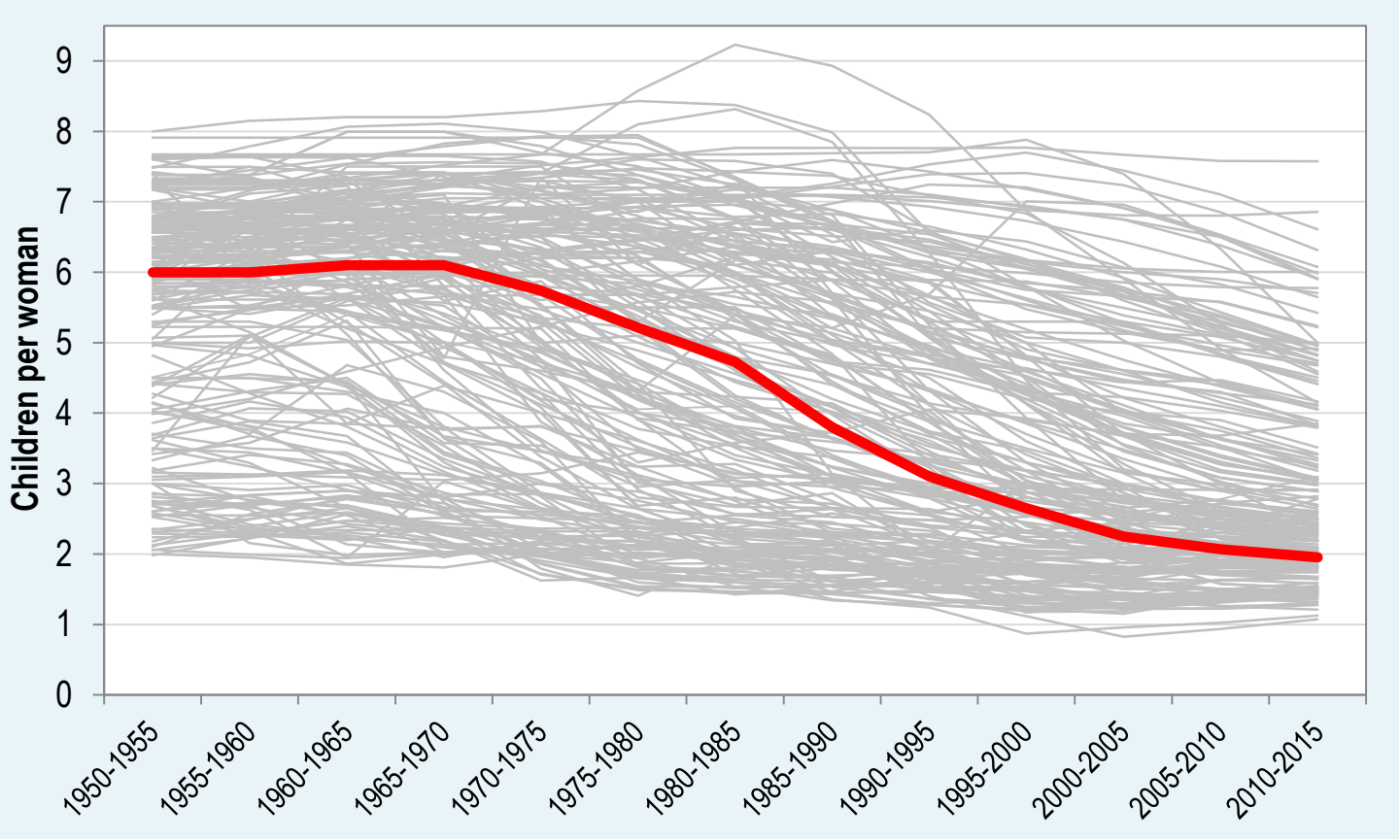
Date of last live birth

Indirect estimates

Questions 3, 4 and 5

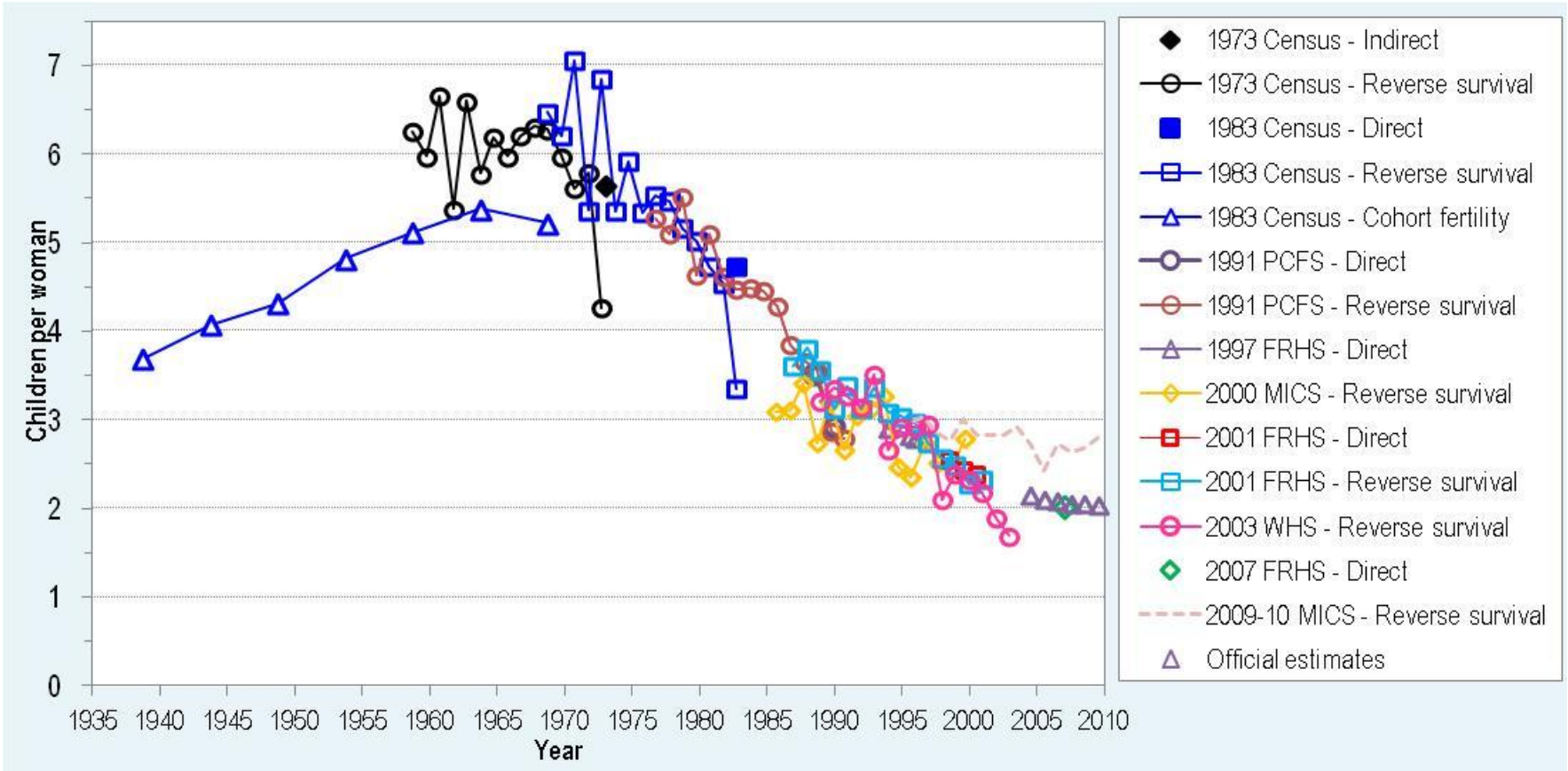
Relationship to the household, sex and age **>>** Own-children method
Sex and age **>>** Reverse survival method

Fertility transition in Myanmar (1950-2015)



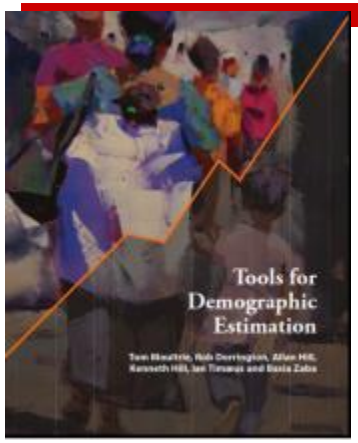
Source: World Population Prospects: 2012 Revision

Fertility estimates in Myanmar



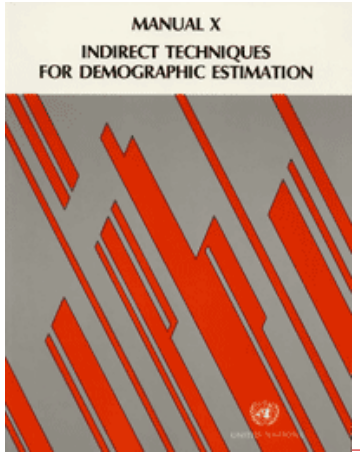
Source: updated based on Spoorenberg (2013)

Main references



Moultrie T.A., R.E. Dorrington, A.G. Hill, K. Hill, I.M. Timæus & B. Zaba (eds). 2013. *Tools for Demographic Estimation*. Paris: International Union for the Scientific Study of Population. available online at: http://demographicestimation.iussp.org/

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



United Nations (1983), *Manual X: Indirect Techniques for Demographic Estimation*, New York: United Nations, available online at:
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

Other references

Arriaga, E.E. (1983), *Estimating Fertility from Data on Children Ever Born by Age of Mother,* International Research Document No. 11. US Bureau of the Census, Washington, DC

Avery C., T. St. Clair, M. Levin & K. Hill (2013), "The 'Own Children' fertility estimation procedure: A reappraisal", *Population Studies* 67(2): 171-183.

Cho, L.-J., R.D. Retherford, & M. K. Choe (1986), *The Own-Children Method of Fertility Estimation,* Honolulu, University of Hawaii Press.

Feeney, G. (1991), "Child survivorship estimation: Methods and data analysis", *Asian and Pacific Population Forum* 5(2-3): 51-55, 76-87.

Hinde, A. (1998), *Demographic Methods*, London: Arnold.

IUSSP & UNFPA (n.d.), *Population Analysis for Policies and Programmes*, Paris: International Union for the Scientific Study of Population, available online (last accessed 25/11/2014): http://papp.iussp.org/

Moultrie, T.A. (2013), "The relational Gompertz model"., in T.A. Moultrie R.E. Dorrington, A.G. Hill, K. Hill, I.M. Timæus & B. Zaba (eds). *Tools for Demographic Estimation*. Paris: International Union for the Scientific Study of Population. Available online (last accessed 14/10/2014) http://demographicestimation.iussp.org/content/relational-gompertz-model

Moultrie T. & R. Dorrington (2004), *Estimation of Fertility from the 2001 South Africa Census Data,* Centre for Actuarial Research, University of Cape Town.

Spoorenberg, T. (2013), "Demographic changes in Myanmar since 1983: An examination of official data", *Population and Development Review* 39(2): 309-324.

Spoorenberg, T. (2014), "Reverse survival method of fertility estimation: An evaluation", *Demographic Research* 31(9): 217-246.

Timæus, I.M. & T.A. Moultrie (2013), "Estimation of fertility by reverse survival", in T.A. Moultrie, R.E. Dorrington, A.G. Hill, K. Hill, I.M. Timæus & B. Zaba (eds). *Tools for Demographic Estimation*. Paris: International Union for the Scientific Study of Population. available online (last accessed 25/11/2014): http://demographicestimation.iussp.org/content/reverse-survival-methods

Thank you

ကျေးဇူးတင်ပါတယ်။

Questions?

>> until 12 December:

>> After 12 December: **spoorenberg@un.org**