United Nations Statistics Division

Data Evaluation with Consecutive Censuses: Adult Mortality and Census Coverage

United Nations Statistics Division

Outline

1. The Population Balancing Equation
2. Adult Mortality (Death Distribution Methods)
3. Intercensal Cohort Survival Rates
4. Cohort Component Method

Population Balancing Equation

Census coverage

Population balancing equation

If a country has:

- A relatively complete system of vital registration
- A fairly reliable estimate of the degree of under-registration

- Information on the number of intercensal births, deaths and net international migrants can be used in conjunction with the results of a previous census to evaluate the coverage of a subsequent or current census.

Population balancing equation

$$P_1 = P_0 + B - D + M$$

Where:

P_1=the population enumerated in the census being evaluated

P_0= The population enumerated in a previous census

B = the number of births in the period between the two censuses

D= the number of deaths in the period between two censuses

M= the number of net international migrants in the period

$$M = I \text{ (Immigrants)} - E \text{ (Emigrants)}$$

Population balancing equation

- The population balancing equation is the most fundamental equation in demographic analysis and is also used to estimate population growth.
- It is based on the logic that:

  The population of a country can increase or decrease between any two points in time only as a result of births, deaths and movement of population across national boundaries

  - Births and immigration add to the population
  - Deaths and emigration reduce the population

Population balancing equation

- For census evaluation purposes, there is a residual (*e*) needed to make the equation balance exactly
- "*e*" in the equation is referred to as the "error of closure" and represents the balance of errors in the data on births, deaths, net migration, and the coverage of the two censuses:

$$P_1 = P_0 + B - D + M + e$$

  - *If a negative residual quantity e,* P_1 *is under-enumerated relative to* P_0
  - *If a positive residual is required to balance the equation,* P_1 *is over-enumerated relative to* P_0

Population balancing equation – Data required

- The population enumerated in two consecutive censuses
  - P_1: the census under evaluation
  - P_0: previous census

- The number of births, deaths and net international migration (immigrants-emigrants) during the intercensal period, adjusted for under-registration (to the extent possible)

Population balancing equation – Computational Procedure

1. Compile registered numbers of intercensal births, deaths and migrants

- Vital registration system
- Immigration record system (residence permit, border records, etc.)
  - Adjustment based on under-coverage of these systems including indirect estimates

2. Calculation of the "expected" census population (E(P1))

$$E(P1) = P0 + B - D + M$$

3. Calculation of the residual error or error of closure

$$e = P_1 - E(P_1)$$

Population balancing equation – Interpretation of "e"

- If P_0 has been adjusted for net coverage error, the estimated residual error (*e*) will represent an estimate of net coverage error in P_1
  - If "*e*" is positive, P_1 is overenumerated
  - If "*e*" is negative, P_1 is underenumerated

- If P_0 is not adjusted, "e" will represent an estimate of the relative level of net coverage error in P_1 in comparison with P_0

Population balancing equation – Example
Sri Lanka, 1971 and 1981 Censuses (1)

For an unadjusted census:

$E(P_1) = P_0$ (unadjusted) $+ B_{adj} - D_{adj} + M_{adj}$

$= 12{,}689{,}897 + 3{,}716{,}878 - 1{,}002{,}108 + (-446{,}911)$

$= 14{,}957{,}756$

$e = P_1 - E(P_1)$

$=14{,}848{,}364 - 14{,}957{,}756$

$=-109{,}392$ *0.7% of $E(P_1)$*

P_1 is under-enumerated relative to P_0

Source: U.S. Census Bureau (1985)

Population balancing equation – Example Sri Lanka, 1971 and 1981 Censuses (2)

For an adjusted census count:

$E(P_1)$ = P0 (adjusted) $+B_{adj} - D_{adj} + M_{adj}$

= 12,849,796 + 3,716,878 – 1,002,108 + (-446,911)

= 15,117,655

$e = P_1 - E(P_1)$ = 14,848,364 – 15,117,655

= -269,291 *1.8% of $E(P_1)$*

P_1 is underenumerated

Source: U.S. Census Bureau (1985)

Population balancing equation – Limitations

- Incomplete and defective data on the components of population change are very common
  - Applicability of the method is limited to countries with good vital registration coverage and migration data
- It is generally not useful for obtaining estimates of net census coverage error for sub-national populations (for example regions, provinces).
  - In addition to the components of population change considered, internal migration has to be considered.
  - For most practical purposes, the use of the population balancing equation is limited to analysis of net coverage error at the national level.

Death Distribution Methods

Completeness of reporting of adult mortality

Death distribution methods

- "Death distribution methods" apply the logic of the population balancing equation to different age groups in the population
  - E.g. for the age group 40 – 50, the only way to enter the age group in a country is through aging or immigration, the only way to exit is through death or emigration
  - By comparing our expectation for the size of an age group at the time of the census to its actual enumerated size, we can get a sense of whether we have "missing" or "extra" people in the enumeration

Death Distribution Methods - Advantages

- Can provide timely estimates of age-specific period mortality rates – here we will use the method to check estimates of completeness of death reporting
- Data requirements:
  - Population by sex and 5-year age groups
  - Deaths by sex and 5-year age groups
  - Can be computed with data from two consecutive censuses with an estimate of the number of deaths between the two censuses

Source: Moultrie et al. (2013)

Death Distribution Methods – Assumptions and Violations (1)

- Completeness of deaths reporting is the same across ages
  - Generally does not hold for the oldest and youngest age groups
  - To avoid, usually truncate analysis to middle age ranges
- *(Two-census variant)* Coverage of both censuses is the same for all age groups
  - Census coverage evaluation will be discussed later in this session
- Age reporting (by 5-year age groups) is accurate
  - Can be checked through age-sex distribution techniques discussed in previous sessions

Source: *IUSSP Tools for Demographic Estimation* http://demographicestimation.iussp.org/

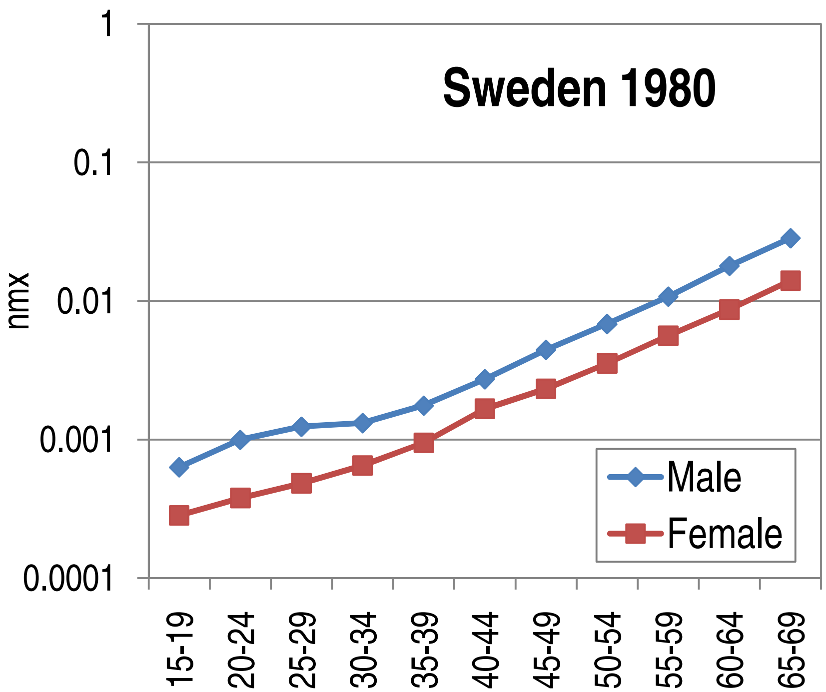
Death Distribution Methods – Assumptions and Violations (2)

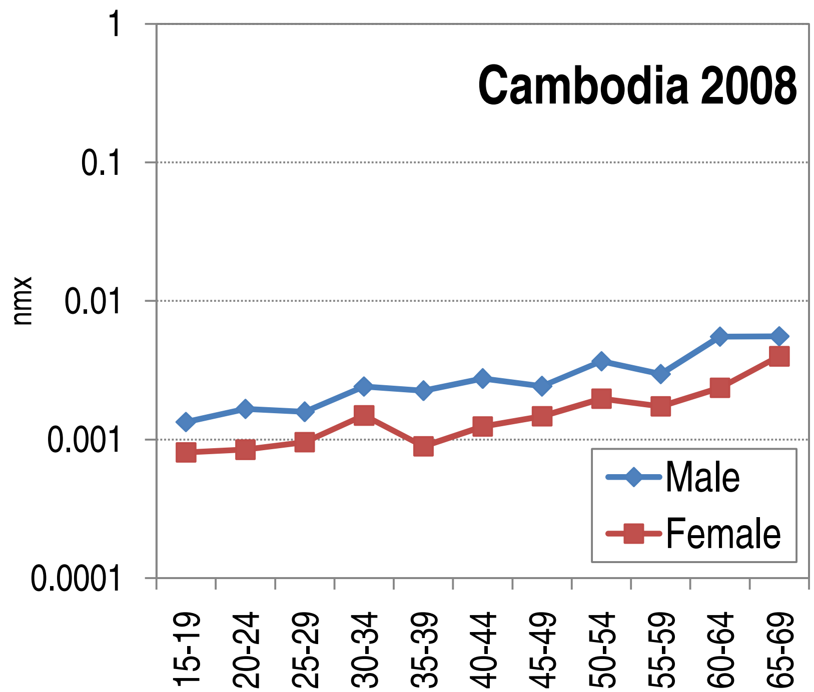
- Net in-migration is limited
  - Will depend on country context
- *(One-census variant)* population is stable (constant growth rate over past several decades)
  - Will depend on country context – in contexts with recent fertility decline, will not hold

Data quality issues

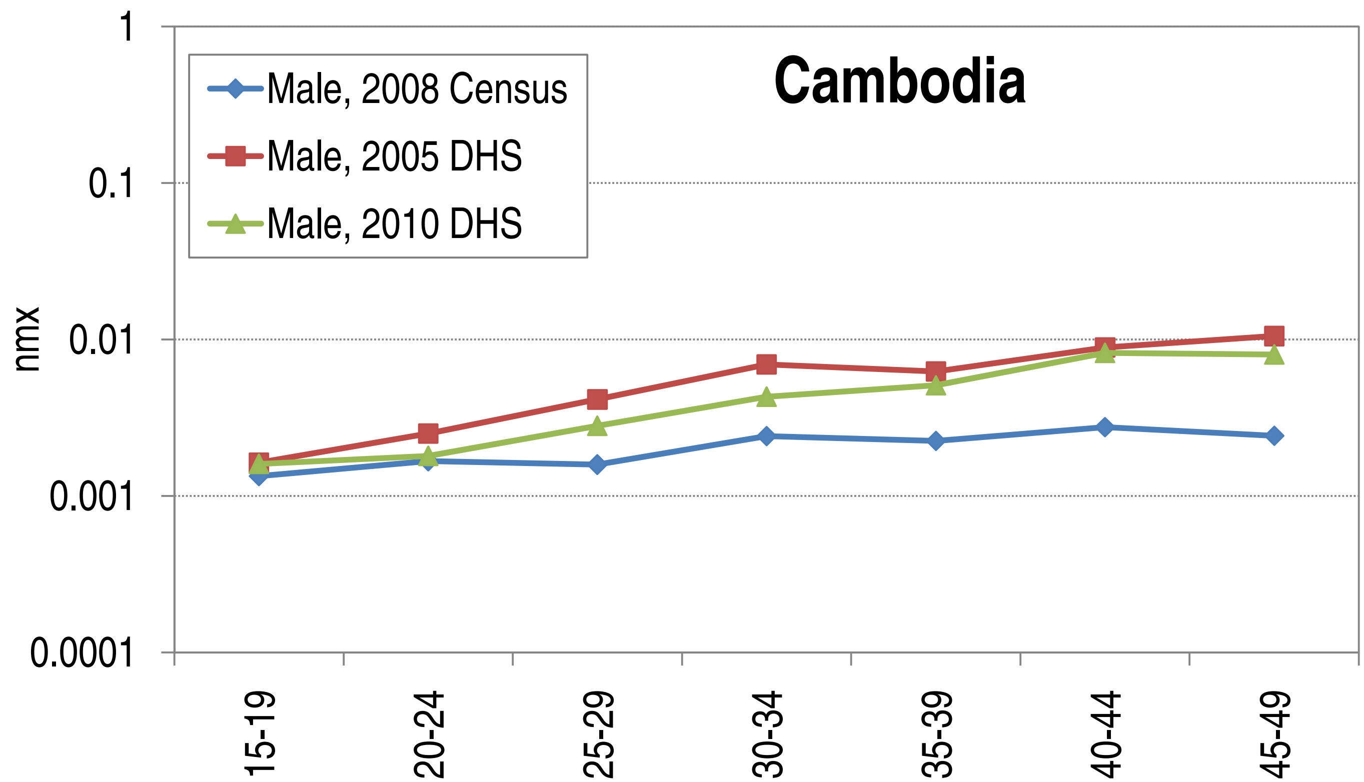
- Common errors in data on recent deaths by age
  - Under-reporting, especially for child deaths and older age deaths
  - Reference period errors in reporting of deaths (i.e. reporting deaths that occurred prior to the usual 12-month reference period)
  - Death question omitted by interviewers
  - Household breaking up due to the death of a senior household member
    - In this case, any deaths in household will not be captured
  - Age-heaping and age exaggeration
- In addition to age-sex distribution checks discussed in previous sessions, the age and sex structure of reported deaths should be examined prior to conducting any analysis

Data quality checks:
Schedules of death rates by age and sex





Data quality checks: Comparison with other surveys



Source: Graph produced based on IPUMS-International and DHS country report

General Growth Balance Method (GGB)

Basis: The Balancing Equation of Population Change

$$P_2 = P_1 + B - D + G$$

Assumptions:

a) population is closed to migration, G=0;

b) completeness of first census, k_1, is independent of age;

c) completeness of second census, k_2, is independent of age;

d) completeness of intercensal deaths, c, is independent both of age and year;

GGB regression: $b(x+) - r(x+) = \beta_0 + \beta_1 d(x+)$

Relative completeness of censuses

$$\frac{k_1}{k_2} = \exp(t\hat{\beta}_0)$$

Completeness of death registration

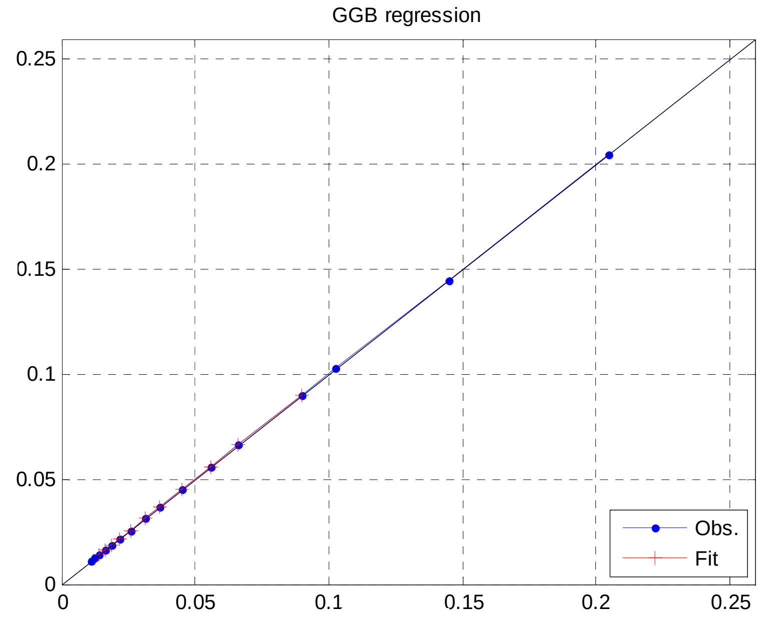
$$c = \frac{(k_1 k_2)^{\frac{1}{2}}}{\hat{\beta}_1}$$

Adjusting observed death rates

$$m = \hat{\beta}_1 m^*$$

r(x+) – population growth rate above age x
b(x+) – entry rate at age x+, "birth rate"
d(x+) – open age death rates
*m** – observed death rates
m – adjusted death rates

Ideal case:



Intercept = 0
Slope = 1

GGB regression with migration:

$$b(x+) - r(x+) + \underline{g(x+)} = \beta_0 + \beta_1 d(x+)$$

$g(x+)$ = net migration rate, age x+

A common case >> significant emigration
If migration is not accounted for (g(x)=0), estimate of the slope will be less than one, the regression line will be increasing less steep and the completeness of deaths will be overestimated (as emigration reduces the population)

United Nations Statistics Division

GGB Method – Application

GGB_2census_males.xlsx

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
1	Country:		South Africa						Age range over which line to be fitted								
2	Midpoint of the deaths:		2004.45		Mid-point of censuses:		13/06/2004		Lower age=			5					
3	Sex		Males		Intercensal period =		5.3479863		Upper age =			84	<-- must be less than		85		
4																	
5	Dates of censuses =		10/10/2001	15/02/2007											x	y	
6	Age	x	${}_5N_x(t_1)$	${}_5N_x(t_2)$	${}_5D_x$	${}_5NM_x$	P1(x+)	P2(x+)	D(x+)	NM(x+)	PYL(x+)	N(x)	n(x+)	r(x+)-i(x+)	d(x+)	=n(x+)-r(x	a+b
7	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
8	0-4	0	2,223,006	2,505,744	197,912	7,110	21434045	23348679	1568404	27153	119639203			#N/A	0.00000		
9	5-9	5	2,425,066	2,560,642	15,566	1,042	19211039	20842935	1370492	20043	107015123	2551908	0.02385	0.01506	0.01281	0.00878	
10	10-14	10	2,518,985	2,452,339	11,207	893	16785973	18282293	1354926	19001	93686904	2608389	0.02784	0.01577	0.01446	0.01207	
11	15-19	15	2,453,156	2,553,293	25,473	12,800	14266988	15829955	1343719	18108	80370426	2712585	0.03375	0.01922	0.01672	0.01453	
12	20-24	20	2,099,417	2,362,519	54,960	21,982	11813832	13276662	1318246	5308	66977684	2574960	0.03845	0.02176	0.01968	0.01668	
13	25-29	25	1,899,275	2,033,165	102,802	-12,172	9714415	10914143	1263286	-16674	55067255	2209815	0.04013	0.02209	0.02294	0.01804	
14	30-34	30	1,594,624	1,875,483	145,588	7,303	7815140	8880977	1160484	-4502	44554241	2018695	0.04531	0.02402	0.02605	0.02129	
15	35-39	35	1,441,657	1,548,185	145,900	253	6220516	7005495	1014896	-11805	35303918	1680587	0.04760	0.02257	0.02875	0.02503	
16	40-44	40	1,233,813	1,306,900	135,936	-4,373	4778859	5457310	868996	-12058	27311257	1468157	0.05376	0.02528	0.03182	0.02847	
17	45-49	45	967,744	1,104,294	121,010	-7,883	3545046	4150410	733060	-7685	20513828	1248496	0.06086	0.02988	0.03573	0.03098	
18	50-54	50	769,627	888,042	111,157	-5,958	2577302	3046116	612050	198	14984635	991556	0.06617	0.03127	0.04085	0.03490	
19	55-59	55	552,402	708,812	96,854	-2,407	1807675	2158074	500893	6156	10562911	789998	0.07479	0.03259	0.04742	0.04220	
20	60-64	60	444,592	491,871	89,930	52	1255273	1449261	404039	8563	7213279	557537	0.07729	0.02571	0.05601	0.05159	
21	65-69	65	304,835	394,305	82,843	1,897	810681	957391	314108	8511	4711508	447834	0.09505	0.02933	0.06667	0.06572	
22	70-74	70	232,604	241,976	73,036	2,717	505846	563086	231266	6614	2854216	290495	0.10178	0.01774	0.08103	0.08404	
23	75-79	75	136,466	163,112	63,871	1,688	273242	321110	158229	3897	1584130	208340	0.13152	0.02776	0.09988	0.10376	
24	80-84	80	90,856	87,698	48,163	1,801	136776	157998	94359	2209	786177	117011	0.14884	0.02418	0.12002	0.12465	
25	85+		45,920	70,299	46,196	408	45920	70299	46196	408	303855						
26																	
27	Total		21,434,045	23,348,679	1,568,404	27,153										a =	-0.0
28																k1/k2 =	0.9
29																k1 =	0.9
30																k2 =	
31																k1*k2 =	0.9
32																c =	
33																b =	1.0

Introduction | Method | Graphs

Source: Moultrie et al. (2013)

GGB Method – Estimating intercensal deaths

If accurate data for intercensal deaths is not available, they can be estimated if deaths for two other well-defined periods are available – e.g., deaths in the year prior to two different censuses

Worksheet will compute growth rates and deaths for the intercensal period

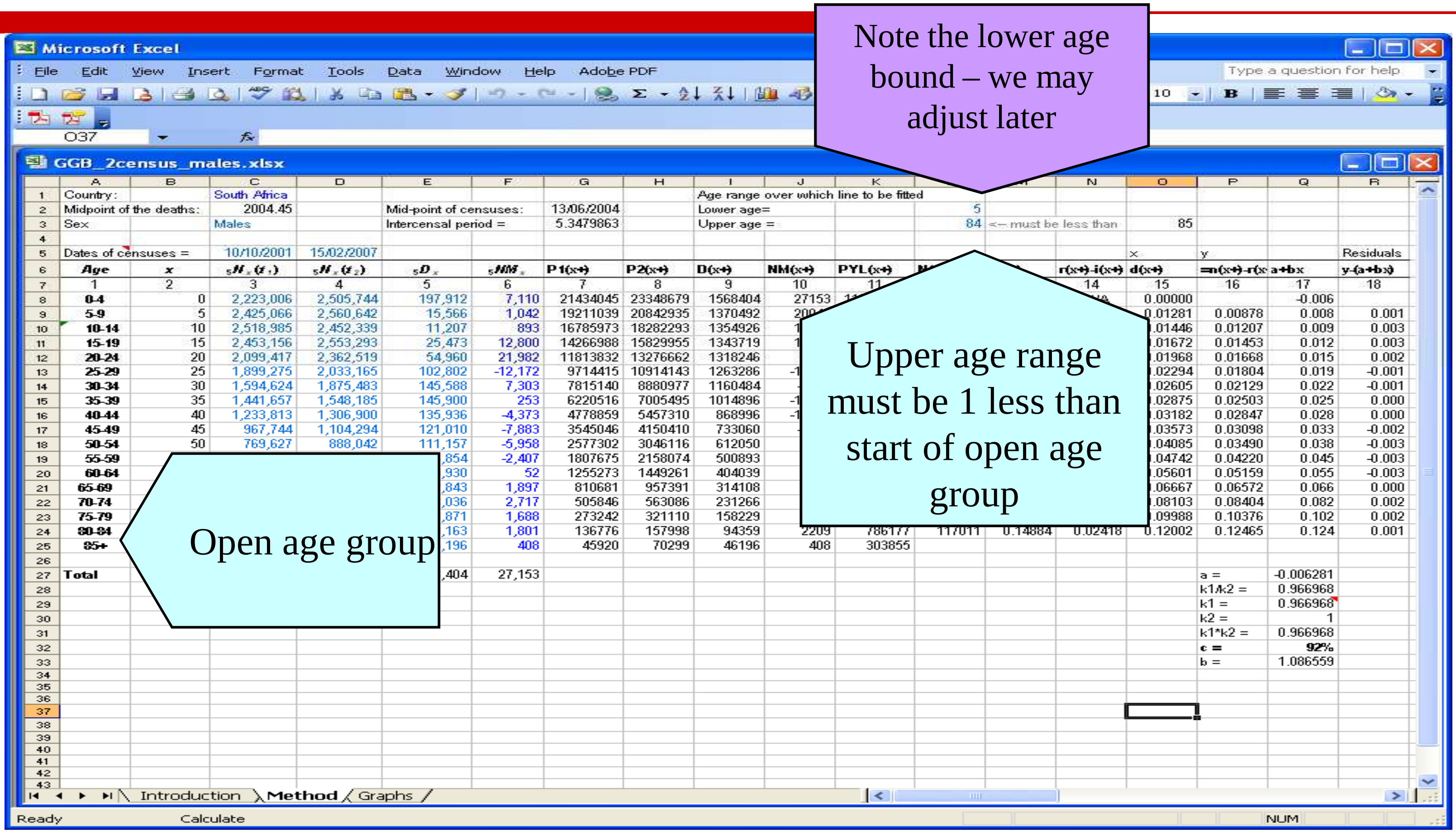
Microsoft Excel — GGB_estimating_btwncensus_deaths.XLSX

	A	B	C	D	E	F
1						
2	First period of deaths					
3	Start date	18/08/1991				
4	End date	18/08/1992	mid-point	17/02/1992		
5						
6	Second period of deaths					
7	Start date	18/08/2001				
8	End date	18/08/2002	mid-point	16/02/2002		
9						
10	Period for which deaths to be estimated					
11	Start date	18/08/1992				
12	End date	18/08/2002				
13						
14		1st period	2nd period		Estimated	
15		deaths	deaths	r	deaths for period	
16	0-4	18720	21575	0.014	202552	
17	5-9	1548	2793	0.059	21727	
18	10-14	1119	1946	0.055	15364	
19	15-19	1227	1802	0.038	15250	
20	20-24	1843	3440	0.062	26399	
21	25-29	2591	6930	0.098	46326	
22	30-34	2868	10286	0.128	61911	
23	35-39	2531	10176	0.139	58903	
24	40-44	2210	8608	0.136	50365	
25	45-49	2053	6907	0.121	42510	
26	50-54	2045	5029	0.090	34687	
27	55-59	1789	3857	0.077	27972	
28	60-64	2361	3649	0.044	30233	
29	65-69	1900	2682	0.034	23078	
30	70-74	2436	2810	0.014	26371	
31	75-79	5053	6066	0.018	55945	
32	80-84			#DIV/0!	#DIV/0!	
33	85+			#DIV/0!	#DIV/0!	
34						

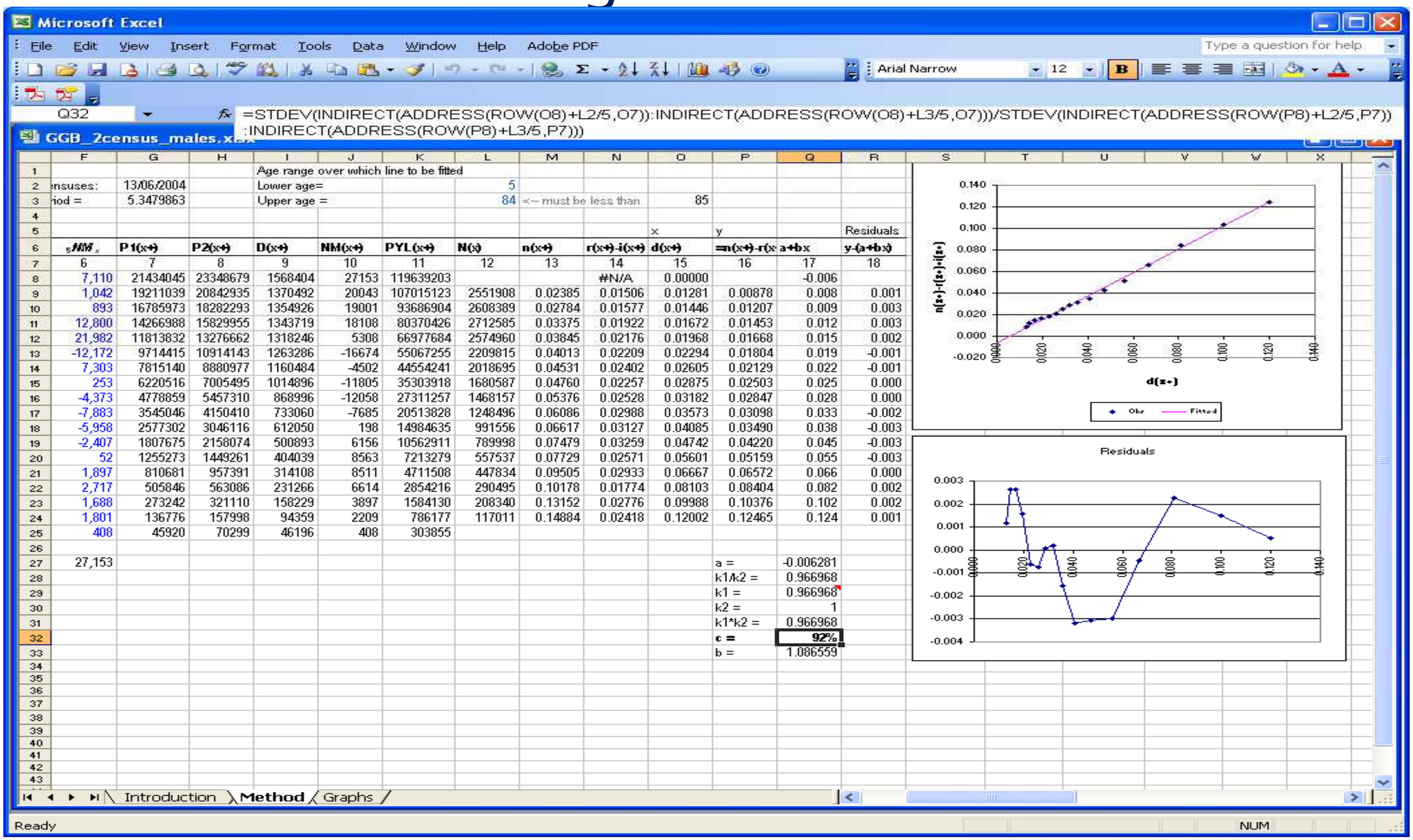
Sheet1 / Sheet2 / Sheet3

Ready NUM

GGB Method –Setting the age range

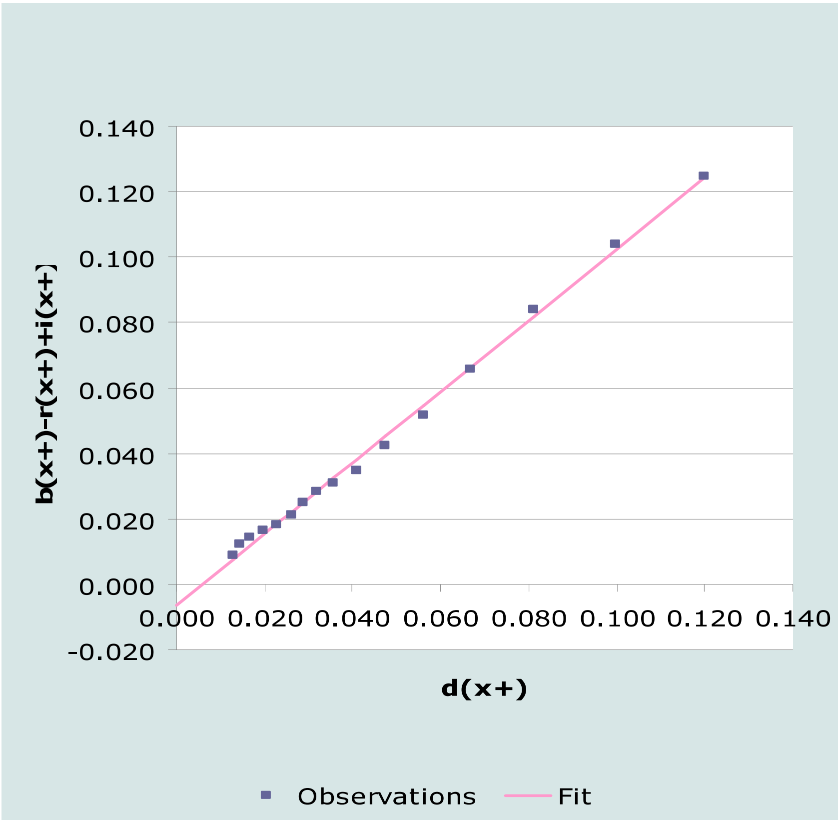


GGB Method - Diagnostics



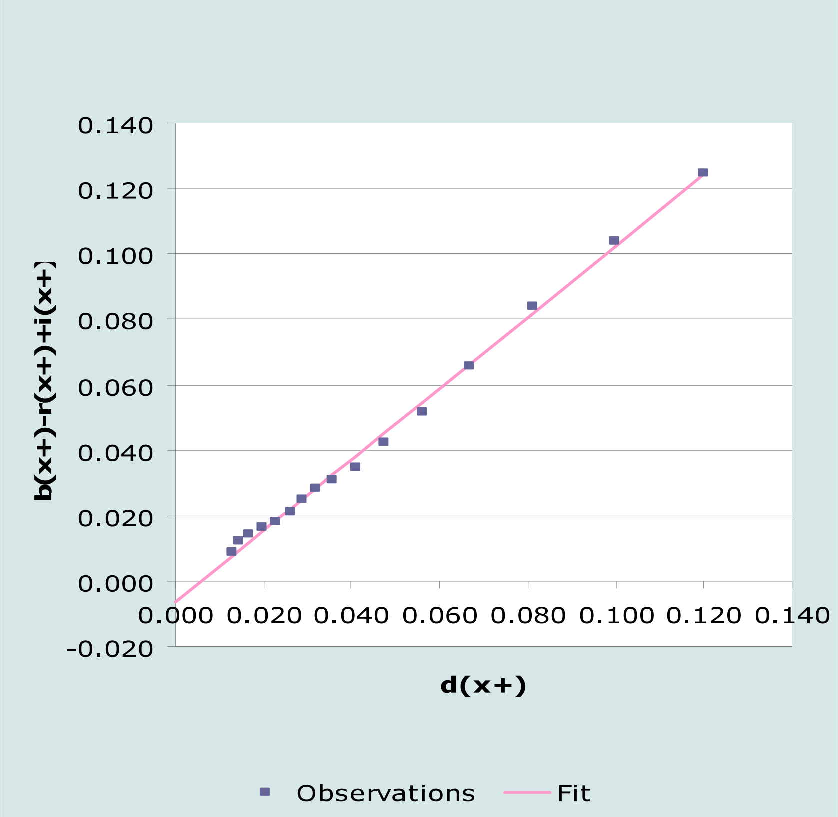
	F	G	H	I	J	K	L	M	N	O	P	Q	R
1				Age range over which line to be fitted									
2	nsuses:	13/06/2004		Lower age=			5						
3	iod =	5.3479863		Upper age =			84	<-- must be less than		85			
4													
5										x	y		Residuals
6	$_5NM_x$	P1(x+)	P2(x+)	D(x+)	NM(x+)	PYL(x+)	N(x)	n(x+)	r(x+)-i(x+)	d(x+)	=n(x+)-r(x	a+bx	y-(a+bx)
7	6	7	8	9	10	11	12	13	14	15	16	17	18
8	7,110	21434045	23348679	1568404	27153	119639203			#N/A	0.00000		-0.006	
9	1,042	19211039	20842935	1370492	20043	107015123	2551908	0.02385	0.01506	0.01281	0.00878	0.008	0.001
10	893	16785973	18282293	1354926	19001	93686904	2608389	0.02784	0.01577	0.01446	0.01207	0.009	0.003
11	12,800	14266988	15829955	1343719	18108	80370426	2712585	0.03375	0.01922	0.01672	0.01453	0.012	0.003
12	21,982	11813832	13276662	1318246	5308	66977684	2574960	0.03845	0.02176	0.01968	0.01668	0.015	0.002
13	-12,172	9714415	10914143	1263286	-16674	55067255	2209815	0.04013	0.02209	0.02294	0.01804	0.019	-0.001
14	7,303	7815140	8880977	1160484	-4502	44554241	2018695	0.04531	0.02402	0.02605	0.02129	0.022	-0.001
15	253	6220516	7005495	1014896	-11805	35303918	1680587	0.04760	0.02257	0.02875	0.02503	0.025	0.000
16	-4,373	4778859	5457310	868996	-12058	27311257	1468157	0.05376	0.02528	0.03182	0.02847	0.028	0.000
17	-7,883	3545046	4150410	733060	-7685	20513828	1248496	0.06086	0.02988	0.03573	0.03098	0.033	-0.002
18	-5,958	2577302	3046116	612050	198	14984635	991556	0.06617	0.03127	0.04085	0.03490	0.038	-0.003
19	-2,407	1807675	2158074	500893	6156	10562911	789998	0.07479	0.03259	0.04742	0.04220	0.045	-0.003
20	52	1255273	1449261	404039	8563	7213279	557537	0.07729	0.02571	0.05601	0.05159	0.055	-0.003
21	1,897	810681	957391	314108	8511	4711508	447834	0.09505	0.02933	0.06667	0.06572	0.066	0.000
22	2,717	505846	563086	231266	6614	2854216	290495	0.10178	0.01774	0.08103	0.08404	0.082	0.002
23	1,688	273242	321110	158229	3897	1584130	208340	0.13152	0.02776	0.09988	0.10376	0.102	0.002
24	1,801	136776	157998	94359	2209	786177	117011	0.14884	0.02418	0.12002	0.12465	0.124	0.001
25	408	45920	70299	46196	408	303855							
26													
27	27,153										a =	-0.006281	
28											k1/k2 =	0.966968	
29											k1 =	0.966968	
30											k2 =	1	
31											k1*k2 =	0.966968	
32											c =	92%	
33											b =	1.086559	

GGB Method - Diagnostics



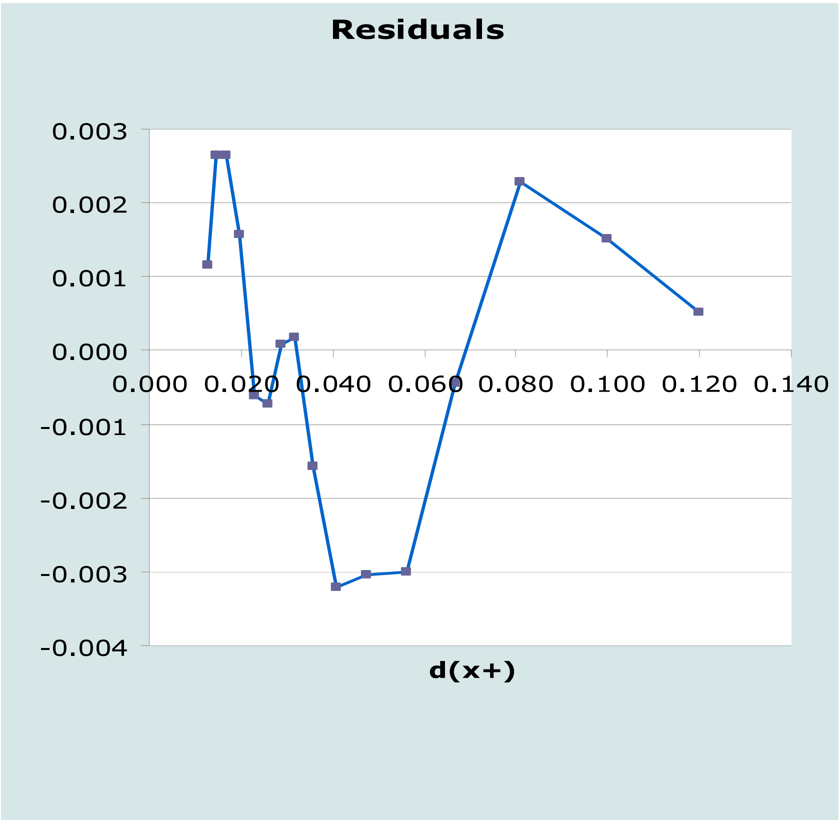
1) Ideally we want all points to fall on the line.
2) If, right-hand points (for older age groups) are falling below the line → age exaggeration. >We must then lower the upper age limit so to exclude these points. Should do this progressively, by 5-year age groups, until all points are on line.
3) Recommended not to select a last age group ending in '0'

GGB Method - Diagnostics



4) If left-hand points (younger age groups), particularly ages 15–30 are deviating from the line this likely indicates that our migration data are insufficient (or, if they are missing entirely, that there is indeed significant migration that we have missed). We should then raise the lower limit to age 30 or 35

GGB Method - Diagnostics



Residuals should not exceed 0.01

GGB Method – Two census (6) Interpretation

Check the estimate of completeness of death reporting and reasonableness of the analysis

- Compare with the results for the opposite sex – unless we have reason to believe that completeness will vary significantly by sex, should be fairly close
- Compare with results of Synthetic Extinct Generations approach (worksheets also available through IUSSP)

Synthetic Extinct Generations method (Bennett & Horiuchi)

- Used for estimating completeness of death registration, with different inputs
- Population at exact age, *N*, can be computed from registered deaths, *D*, and intercensal rates of increase *r*:

$$N(a) = \int_a^{\infty} D(x) e^{\int_a^x r(u)du} dx$$

- Software:

  Ken Hill's spreadsheet, `Death_dist_method all template.xls`
  IUSSP Tools for Demographic Estimation's spreadsheet, `AM_SEG_... .xls`

Cohort Survival Ratios

Mortality and census coverage

Cohort survival ratios

This technique is based on a comparison of the size of birth cohorts enumerated in successive censuses

In the absence of census errors, the ratio of the number of persons in a cohort enumerated in the second census to the number enumerated in the first census should approximate the survival rate that would be expected on the basis of mortality conditions

- E.g. we have a cohort of males aged 40 – 44 at the time of the first census, say in 2000
- If the next census is held exactly 10 years later, in 2010, this cohort will be aged 50 – 54
- In the absence of other factors, we expect their numbers to have been reduced only by the life table quantity ${}_{10}d_x = l_x - l_{x+n}$, the number of deaths to those aged x over the subsequent 10 years

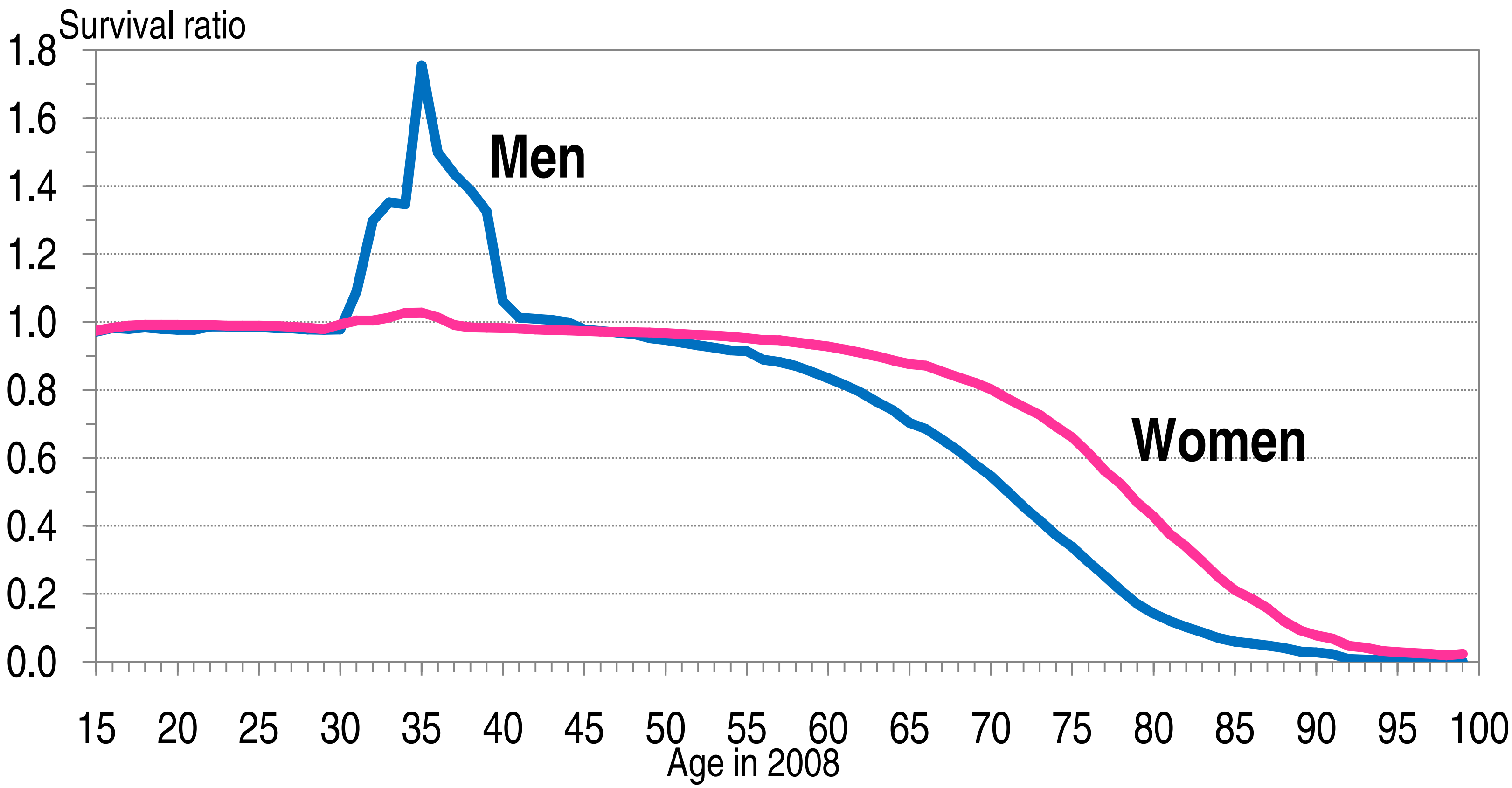
Source: U.S. Census Bureau (1985); Moultrie et al. (2013)

Cohort Survival Ratios: Caveats

The method is less useful when other factors make it difficult to determine whether deviations from the expected CSR are due to census error or something else

- Substantial net migration (unless there are accurate estimates of net migration by age)
- Changes in country borders between censuses
- Changes in the population groups included in the two censuses (e.g. active military, nomadic groups) if the size of these groups is substantial

Cohort Survival Ratios: DPR Korea



Source: Spoorenberg & Schwekendiek (2012), "Demographic changes in North Korea: 1993-2008", *Population and Development Review*, 38(1): 133-158.

Calculating CSRs (1)

Intercensal cohort survival rates are defined as:

$$ {}_nCSR_x\ (a) = \frac{{}_nP_{x+a}\ (t+a)}{{}_nP_x\ (t)} $$

Where:

- t = time of first census
- a = number of years between censuses
- ${}_nP_x$ (t) = size of the cohort at the time of the first census
- ${}_nP_{x+a}$ (t+a) = size of the cohort at the time of the second census

Calculating CSRs (2)

The ratio of the observed intercensal cohort survival rate to the corresponding life-table survival rate

$$ {}_nR_x = \frac{{}_nP_{x+a}(t+a) \,/\, {}_nP_x(t)}{{}_nL_{x+a} \,/\, {}_nL_x} $$

Where:

- ${}_nP_{x+a}(t+a)$ = size of the cohort at time of the second census
- ${}_nP_x(t)$ = size of the cohort at the time of the first census
- ${}_nL_{x+a}$ = the life table number of person-years lived in the age interval x+a to x+a+n years
- ${}_nL_x$ = the life table number of person-years lived in the age interval x to x+n years

Cohort Survival Ratio - Interpretation

In the absence of census error, the expected value of the ratio ($_nR_x$) would be 1.0

Ratio values for any particular cohort which exceed 1.0 would indicate over-enumeration of the cohort in the second census relative to the first census

Ratio values of less than 1.0 would indicate under-enumeration of the cohort in the second census relative the first census

Cohort survival ratios – Example (1)

Step 1: Adjustment for migration (if appropriate)

- In countries experiencing significant levels of net intercensal immigration, the number of net immigrants in each cohort may either added to the cohort enumerated in the first census or subtracted from the cohort enumerated in the second census
- In cohorts experiencing net intercensal emigration, the number of net intercensal emigrants can either added to the second census or subtracted from the first census
- Should be confident that migration data is reasonably accurate before making any adjustments

Cohort survival ratios – Example (2)

Step 2: Calculation of census survival rates using two consecutive censuses ${}_nP_{x+a}(t+a)$ / ${}_nP_x$ (t)

Microsoft Excel – CSR.xls

Brazil

B07 Population by age, sex and urban/rural residence

	1 Aug 2000			1 Aug 2010		Cohort Survival Ratio 2000 - 2010	
	Male	Female		Male	Female	Male	Female
0 - 4	8,326,926	8,048,802	0 - 4	7,016,987	6,779,172		
5 - 9	8,402,353	8,139,974	5 - 9	7,624,144	7,345,231		
10.14	8,777,639	8,570,428	10.14	8,725,413	8,441,348	1.0479	1.0488
15 - 19	9,019,130	8,920,685	15 - 19	8,558,868	8,432,002	1.0186	1.0359
20 - 24	8,048,218	8,093,297	20 - 24	8,630,227	8,614,963	0.9832	1.0052
25 - 29	6,814,328	7,035,337	25 - 29	8,460,995	8,643,418	0.9381	0.9689
30 - 34	6,363,983	6,664,961	30 - 34	7,717,657	8,026,855	0.9589	0.9918
35 - 39	5,955,875	6,305,654	35 - 39	6,766,665	7,121,916	0.9930	1.0123
40 - 44	5,116,439	5,430,255	40 - 44	6,320,570	6,688,797	0.9932	1.0036
45 - 49	4,216,418	4,505,123	45 - 49	5,692,013	6,141,338	0.9557	0.9739
50 - 54	3,415,678	3,646,923	50 - 54	4,834,995	5,305,407	0.9450	0.9770
55 - 59	2,585,244	2,859,471	55 - 59	3,902,344	4,373,875	0.9255	0.9709
60 - 64	2,153,209	2,447,720	60 - 64	3,041,034	3,468,085	0.8903	0.9510
65 - 69	1,639,325	1,941,781	65 - 69	2,224,065	2,616,745	0.8603	0.9151
70 - 74	1,229,329	1,512,973	70 - 74	1,667,373	2,074,264	0.7744	0.8474
75 - 79	780,571	999,016	75 - 79	1,090,518	1,472,930	0.6652	0.7585
80 - 84	428,501	607,533	80 - 84	668,623	998,349	0.5439	0.6599
85 - 89	208,088	326,783	85 - 89	310,759	508,724	0.3981	0.5092
90 - 94	65,117	115,309	90 - 94	114,964	211,595	0.2683	0.3483
95 - 99	19,221	36,977	95 - 99	31,529	66,806	0.1515	0.2044
100 +	10,423	14,153	100 +	7,247	16,989		

Sheet1 Sheet2 Sheet3

Cohort survival ratios – Example (3)

Step 3: Calculation of life table survival rates based on the expected level of mortality

$$nSx = (nLx+a / nLx)$$

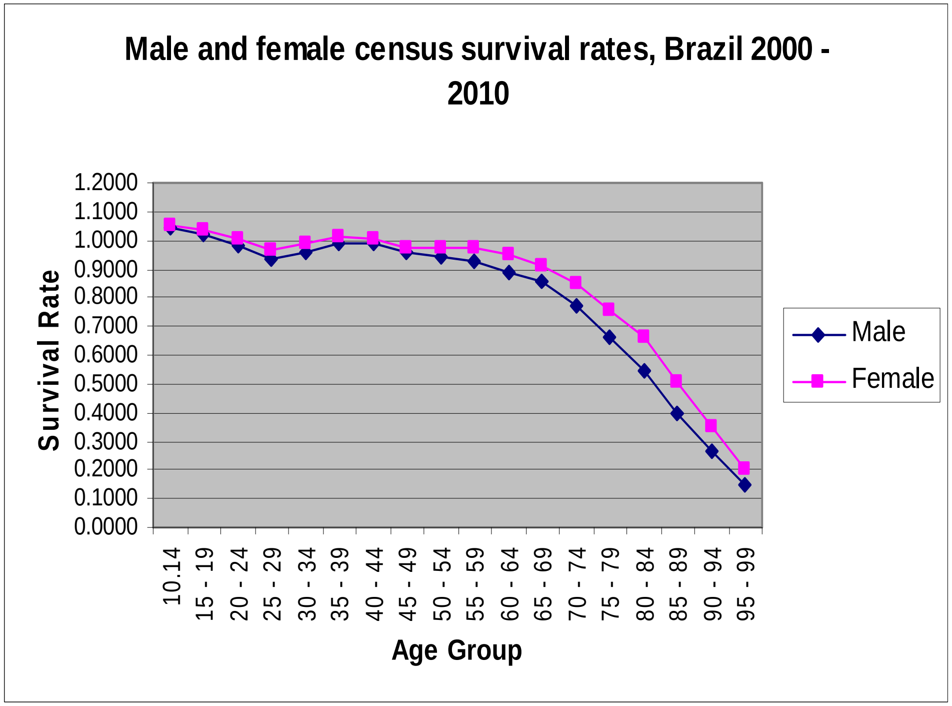
Step 4: Calculation of cohort survival ratios (nRx)

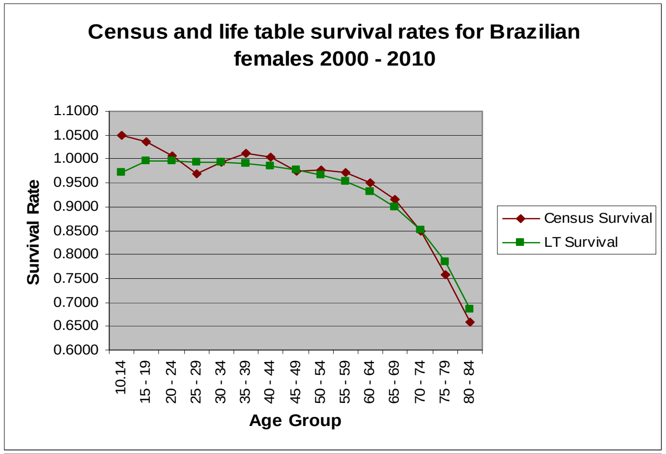
Brazil

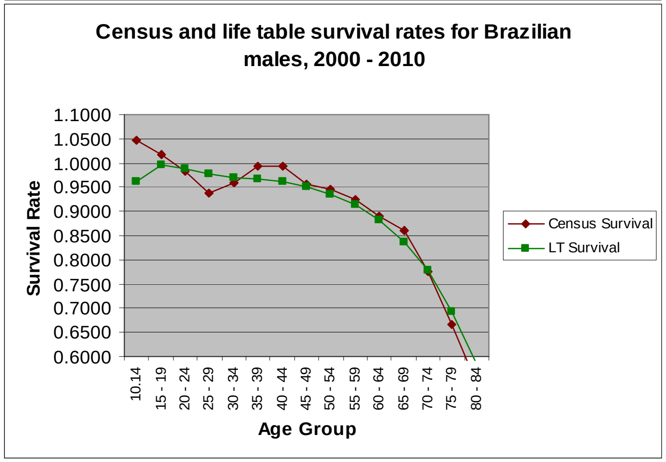
B07 Population by age, sex and urban/rural residence

	1 Aug 2000			1 Aug 2010		Cohort Survival Ratio 2000 - 2010		Life Table Survival Rate		nRx	
	Male	Female		Male	Female	Male	Female	Male	Female	Male	Female
0 - 4	8,326,926	8,048,802	0 - 4	7,016,987	6,779,172						
5 - 9	8,402,353	8,139,974	5 - 9	7,624,144	7,345,231						
10.14	8,777,639	8,570,428	10.14	8,725,413	8,441,348	1.0479	1.0488	0.9623	0.9722	1.0889	1.0788
15 - 19	9,019,130	8,920,685	15 - 19	8,558,868	8,432,002	1.0186	1.0359	0.9954	0.9970	1.0234	1.0389
20 - 24	8,048,218	8,093,297	20 - 24	8,630,227	8,614,963	0.9832	1.0052	0.9887	0.9960	0.9944	1.0092
25 - 29	6,814,328	7,035,337	25 - 29	8,460,995	8,643,418	0.9381	0.9689	0.9771	0.9940	0.9601	0.9748
30 - 34	6,363,983	6,664,961	30 - 34	7,717,657	8,026,855	0.9589	0.9918	0.9703	0.9920	0.9883	0.9998
35 - 39	5,955,875	6,305,654	35 - 39	6,766,665	7,121,916	0.9930	1.0123	0.9668	0.9892	1.0271	1.0233
40 - 44	5,116,439	5,430,255	40 - 44	6,320,570	6,688,797	0.9932	1.0036	0.9611	0.9850	1.0334	1.0188
45 - 49	4,216,418	4,505,123	45 - 49	5,692,013	6,141,338	0.9557	0.9739	0.9511	0.9780	1.0048	0.9959
50 - 54	3,415,678	3,646,923	50 - 54	4,834,995	5,305,407	0.9450	0.9770	0.9352	0.9672	1.0105	1.0102
55 - 59	2,585,244	2,859,471	55 - 59	3,902,344	4,373,875	0.9255	0.9709	0.9133	0.9521	1.0134	1.0198
60 - 64	2,153,209	2,447,720	60 - 64	3,041,034	3,468,085	0.8903	0.9510	0.8810	0.9304	1.0105	1.0221
65 - 69	1,639,325	1,941,781	65 - 69	2,224,065	2,616,745	0.8603	0.9151	0.8367	0.8982	1.0282	1.0188
70 - 74	1,229,329	1,512,973	70 - 74	1,667,373	2,074,264	0.7744	0.8474	0.7778	0.8520	0.9956	0.9947
75 - 79	780,571	999,016	75 - 79	1,090,518	1,472,930	0.6652	0.7585	0.6930	0.7835	0.9600	0.9681
80 - 84	428,501	607,533	80 - 84	668,623	998,349	0.5439	0.6599	0.5844	0.6843	0.9307	0.9643
85 - 89	208,088	326,783	85 - 89	310,759	508,724	0.3981	0.5092				
90 - 94	65,117	115,309	90 - 94	114,964	211,595	0.2683	0.3483				
95 - 99	19,221	36,977	95 - 99	31,529	66,806	0.1515	0.2044				
100 +	10,423	14,153	100 +	7,247	16,989						

Cohort survival ratios – Example (4)







Cohort Survival: Uses and limitations

It is a widely applicable approach for examining error in consecutive censuses

Method requires relatively little information

- Information on the level of fertility is not required since the method does not assess the coverage of the population born between two censuses

Method is complicated by migration etc. as discussed

When only two censuses are available, the method suffers from the limitations shared by many demographic methods, namely difficulties in separating census errors from real irregularities caused by extraordinary events

- The utility of census survival approaches increases significantly when three or more censuses are available

Cohort Component Method

Census coverage

Overview of cohort-component method

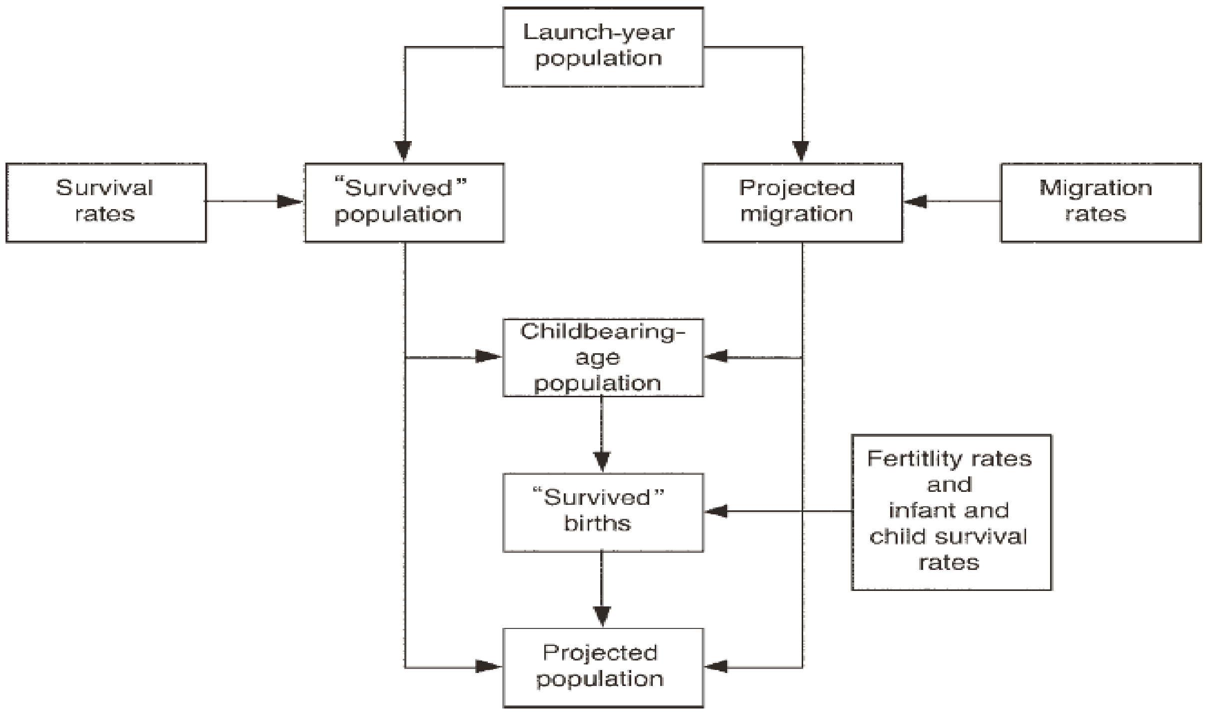


FIGURE 21.2 Overview of the cohort-component method for a projection interval.
Source: Smith *et al.* (2001, p. 47).

Smith, S., J. Tayman, and D. A. Swanson. 2001. *State and Local Population Projections: Methodology and Analysis*. New York: Kluwer Academic/Plenum Publishers.

Cohort component method

In this approach, the population enumerated in the first census is projected to the reference date of the second census based on estimated levels and age schedules of fertility, mortality and migration during the intercensal period

The expected population from the projection is then compared with the actual population enumerated in the second census

Data for intercensal births, deaths and migration are taken from estimates and/or assumptions regarding the level and age schedules of these parameters rather than directly available data based on registration systems

Cohort component method – data required

1. The population enumerated in two censuses by age and sex
2. Age specific fertility rates for women aged 15 to 49 (in 5-year age groups), assumed to represent the level and age structure of fertility during the intercensal period
3. Life table survival rates for males and females, assumed to be representative of mortality conditions during the intercensal period
4. An estimate of sex ratio at birth
5. Estimates of the level and age pattern of net international migration during the intercensal period if the level of net migration is substantial

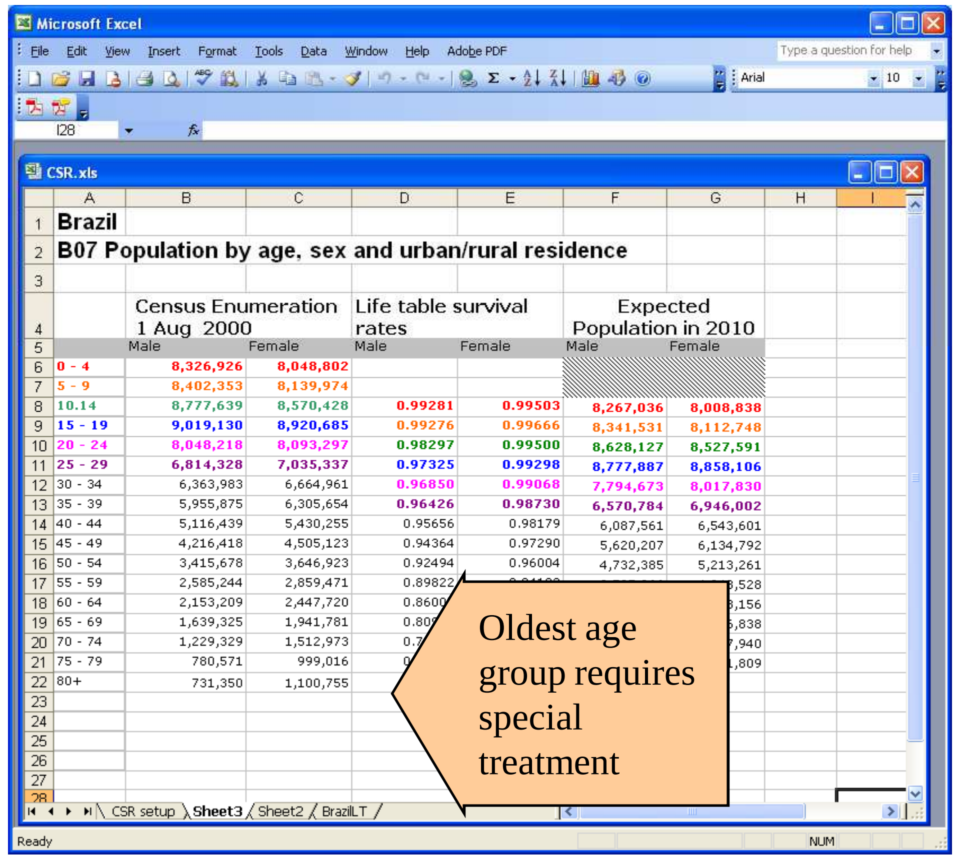
Cohort component method – overview of computational steps

1. "Survive" the age distribution at the initial census to the time of the second census
    1. Multiply each age group population by life table survival rates
    2. Open-ended interval requires special handling
2. Make any necessary adjustments for migration
3. Calculate the number of births during the period
    1. Average initial and projected population for each age group between 15 – 49 to estimate mid-period female population
    2. Apply age-specific birth rates to these populations to generate total numbers of births during time period
    3. Apply sex ratio factor to get female and male births from total births
4. Apply life table survivorship to these births to determine number that survive to time of the second census
5. Compare the estimated female population by age group with the enumerated female population

Cohort component method – Step 1 (survive initial age distribution)

1. "Survive" the age distribution at the initial census to the time of the second census

$$ {}_{n}S_{x} = \frac{{}_{n}L_{x+a}}{{}_{n}L_{x}} $$



Brazil

B07 Population by age, sex and urban/rural residence

	Census Enumeration 1 Aug 2000		Life table survival rates		Expected Population in 2010	
	Male	Female	Male	Female	Male	Female
0 - 4	8,326,926	8,048,802				
5 - 9	8,402,353	8,139,974				
10.14	8,777,639	8,570,428	0.99281	0.99503	8,267,036	8,008,838
15 - 19	9,019,130	8,920,685	0.99276	0.99666	8,341,531	8,112,748
20 - 24	8,048,218	8,093,297	0.98297	0.99500	8,628,127	8,527,591
25 - 29	6,814,328	7,035,337	0.97325	0.99298	8,777,887	8,858,106
30 - 34	6,363,983	6,664,961	0.96850	0.99068	7,794,673	8,017,830
35 - 39	5,955,875	6,305,654	0.96426	0.98730	6,570,784	6,946,002
40 - 44	5,116,439	5,430,255	0.95656	0.98179	6,087,561	6,543,601
45 - 49	4,216,418	4,505,123	0.94364	0.97290	5,620,207	6,134,792
50 - 54	3,415,678	3,646,923	0.92494	0.96004	4,732,385	5,213,261
55 - 59	2,585,244	2,859,471	0.89822	[illegible]	[illegible]	[illegible]
60 - 64	2,153,209	2,447,720	[illegible]	[illegible]	[illegible]	[illegible]
65 - 69	1,639,325	1,941,781	[illegible]	[illegible]	[illegible]	[illegible]
70 - 74	1,229,329	1,512,973	[illegible]	[illegible]	[illegible]	[illegible]
75 - 79	780,571	999,016	[illegible]	[illegible]	[illegible]	[illegible]
80+	731,350	1,100,755				

Cohort component method – Step 1 (survive initial age distribution)

2. For the oldest age category (open-ended)

$$ {}_{w}S_{x} = \frac{{}_{w}T_{x+a}}{{}_{w}T_{x}} $$

w= the oldest age attainable in the population

a= the length of the projection interval

${}_{w}S_{x}$= the life table survival ratio for the population aged x and above

${}_{w}T_{x}$= the number of life table persons lived at ages x and above

${}_{w}T_{x+a}$= the number of life table person-years lived at ages x+a and above

Brazil

B07 Population by age, sex and urban/rural reside...

	Census Enumeration 1 Aug 2000		Life table survival rates		Expected Population in 2010	
	Male	Female	Male	Female	Male	Female
0 - 4	8,326,926	8,048,802				
5 - 9	8,402,353	8,139,974				
10.14	8,777,639	8,570,428	0.99281	0.99503	8,267,036	8,008,838
15 - 19	9,019,130	8,920,685	0.99276	0.99666	8,341,531	8,112,748
20 - 24	8,048,218	8,093,297	0.98297	0.99500	8,628,127	8,527,591
25 - 29	6,814,328	7,035,337	0.97325	0.99298	8,777,887	8,858,106
30 - 34	6,363,983	6,664,961	0.96850	0.99068	7,794,673	8,017,830
35 - 39	5,955,875	6,305,654	0.96426	0.98730	6,570,784	6,946,002
40 - 44	5,116,439	5,430,255	0.95656	0.98179	6,087,561	6,543,601
45 - 49	4,216,418	4,505,123	0.94364	0.97290	5,620,207	6,134,792
50 - 54	3,415,678	3,646,923	0.92494	0.96004	4,732,385	5,213,261
55 - 59	2,585,244	2,859,471	0.89822	0.94193	3,787,266	4,243,528
60 - 64	2,153,209	2,447,720	0.86007	0.91534	2,937,715	3,338,156
65 - 69	1,639,325	1,941,781	0.80924	0.87668	2,092,085	2,506,838
70 - 74	1,229,329	1,512,973	0.73828	0.82033	1,589,662	2,007,940
75 - 79	780,571	999,016	0.64175	0.73737	1,052,036	1,431,809
80+	731,350	1,100,755	0.39246	0.43807	482,460	662,789

Still need to estimate youngest cohorts based on fertility data

Cohort component method – Step 2 (adjust for migration)

If net international migration is substantial, the "survived" cohort population must be adjusted to reflect the effects of migration

- The introduction of net migrants by age group at the mid-point of the projection period and the survival of net migrants to the end of the period:

$$ {}_n\hat{M}_{x+i} = \frac{1}{4}\,{}_nM_x\left(1+{}_nS_x\right) + \frac{1}{4}\,{}_nM_{x+i}\left(1+{}_nS_{x+i}\right) $$

Assumptions: i) An equal distribution of net migrants across years of the intercensal period, ii) Migrants have the same fertility and mortality level as the enumerated population

Cohort component method – Step 3 (calculate births)

1. Calculate the average number of women in each childbearing age group (15 – 49) during the intercensal period in order to estimate the number of births during the projection period

$$ {}_{n}\overline{P}_{x} = \frac{{}_{n}P^{0}{}_{x} + {}_{n}P^{1}{}_{x}}{2} $$

${}_{n}\overline{P}_{x}$ = average number of females aged x to x+n in the projection period

${}_{n}P^{0}{}_{x}$ = number of females aged x to x+n at the beginning of the projection period

${}_{n}P^{1}{}_{x}$ = projected number of females aged x to x+n at the end of the projection period

Cohort component method – Step 3 (calculate births)

2. Calculate total births during the period

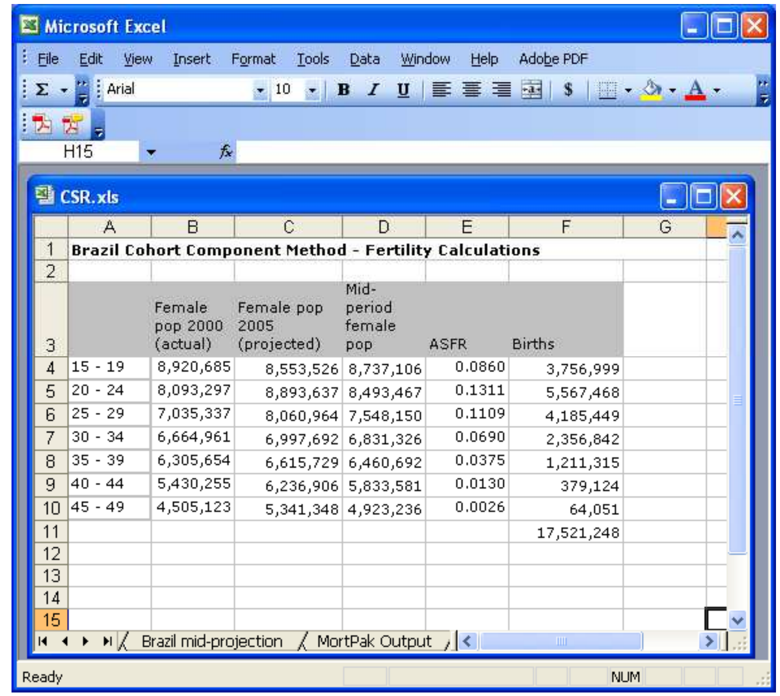
$$B = \sum_{x=15}^{49} ({}_n\bar{P}_x * {}_nf_x) \quad \text{for 1-year projection}$$

$$B = 5 * \sum_{x=15}^{49} ({}_n\bar{P}_x * {}_nf_x) \quad \text{for 5-year projection period}$$

B = the estimated number of births during the projection period

${}_n\bar{P}_x$ = the average number of women in the age group x to x+n years during the projection period

${}_nf_x$ = the age specific fertility rate (per woman) for women age x to x+n years during the projection period



Brazil Cohort Component Method - Fertility Calculations

	Female pop 2000 (actual)	Female pop 2005 (projected)	Mid-period female pop	ASFR	Births
15 - 19	8,920,685	8,553,526	8,737,106	0.0860	3,756,999
20 - 24	8,093,297	8,893,637	8,493,467	0.1311	5,567,468
25 - 29	7,035,337	8,060,964	7,548,150	0.1109	4,185,449
30 - 34	6,664,961	6,997,692	6,831,326	0.0690	2,356,842
35 - 39	6,305,654	6,615,729	6,460,692	0.0375	1,211,315
40 - 44	5,430,255	6,236,906	5,833,581	0.0130	379,124
45 - 49	4,505,123	5,341,348	4,923,236	0.0026	64,051
					17,521,248

Cohort component method – Step 3 (calculate births)

3. Calculate proportion of male and female births

$$B^f = 1 - \frac{SRB}{1 + SRB}$$

$B^f = 1 - (1.05)/(1+1.05) = .488$

$= .488 * 17{,}521{,}248 = 8{,}550{,}369$

$$B^m = \frac{SRB}{1 + SRB}$$

$B^m = (1.05)/(1+1.05) = .512$

$= .512 * 17{,}521{,}248 = 8{,}970{,}879$

Cohort component method – Step 4 (survive intercensal births)

3. Apply life table survivorship to these births to determine number that survive to time of the second census

$${}_5P^f_0 = B^f * {}_5S_0$$

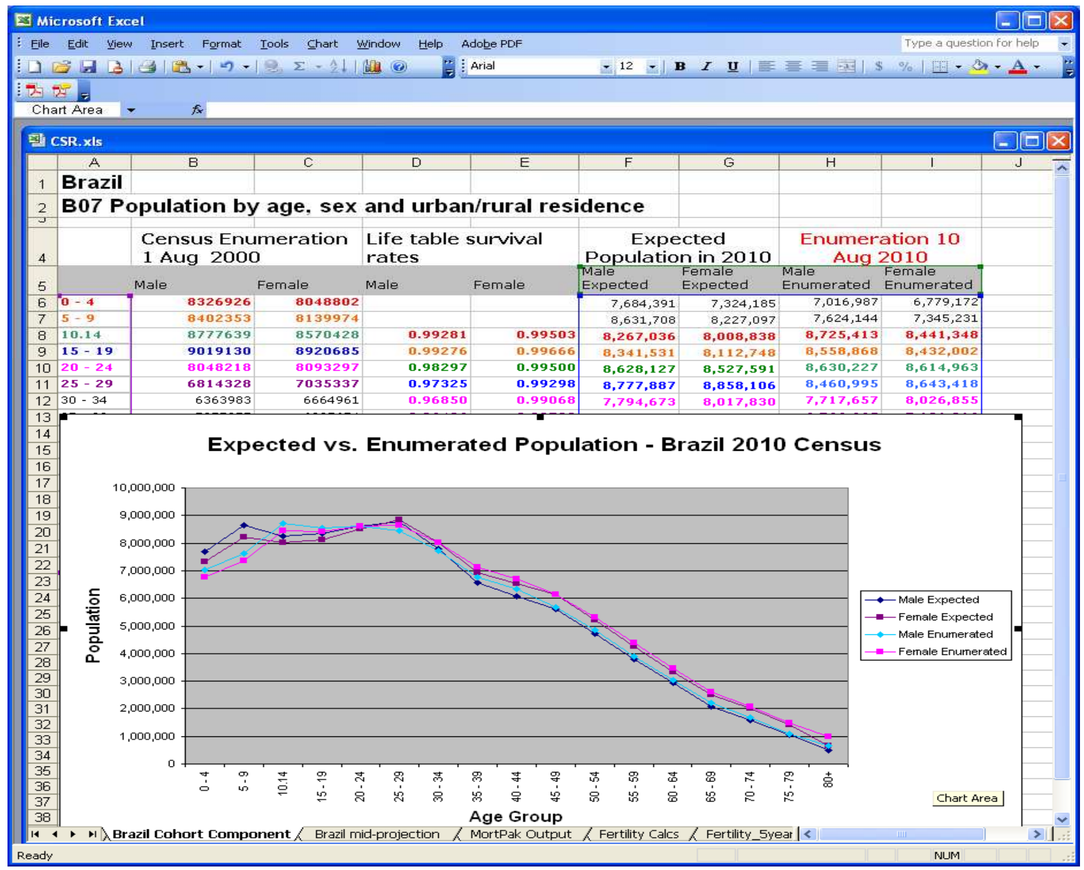
$${}_5S_0 = \frac{{}_5L_0}{5 * l_0}$$

$${}_5S_0 = 484{,}129/500{,}000 = .968$$

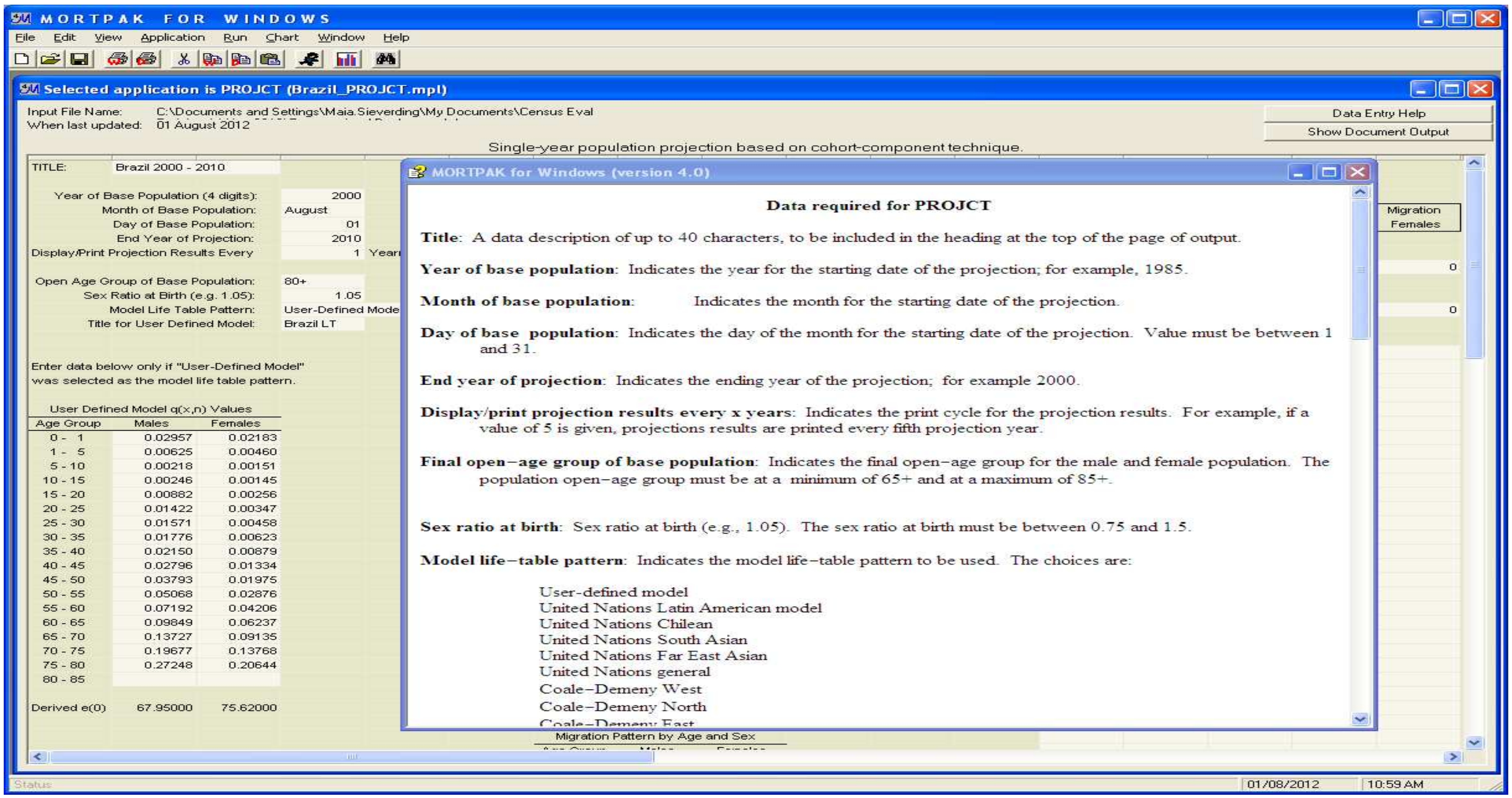
$${}_5P^f_0 = .968 * 8{,}550{,}369 = 8{,}276{,}757$$

Cohort component method – Step 5 (compare with enumerated population)

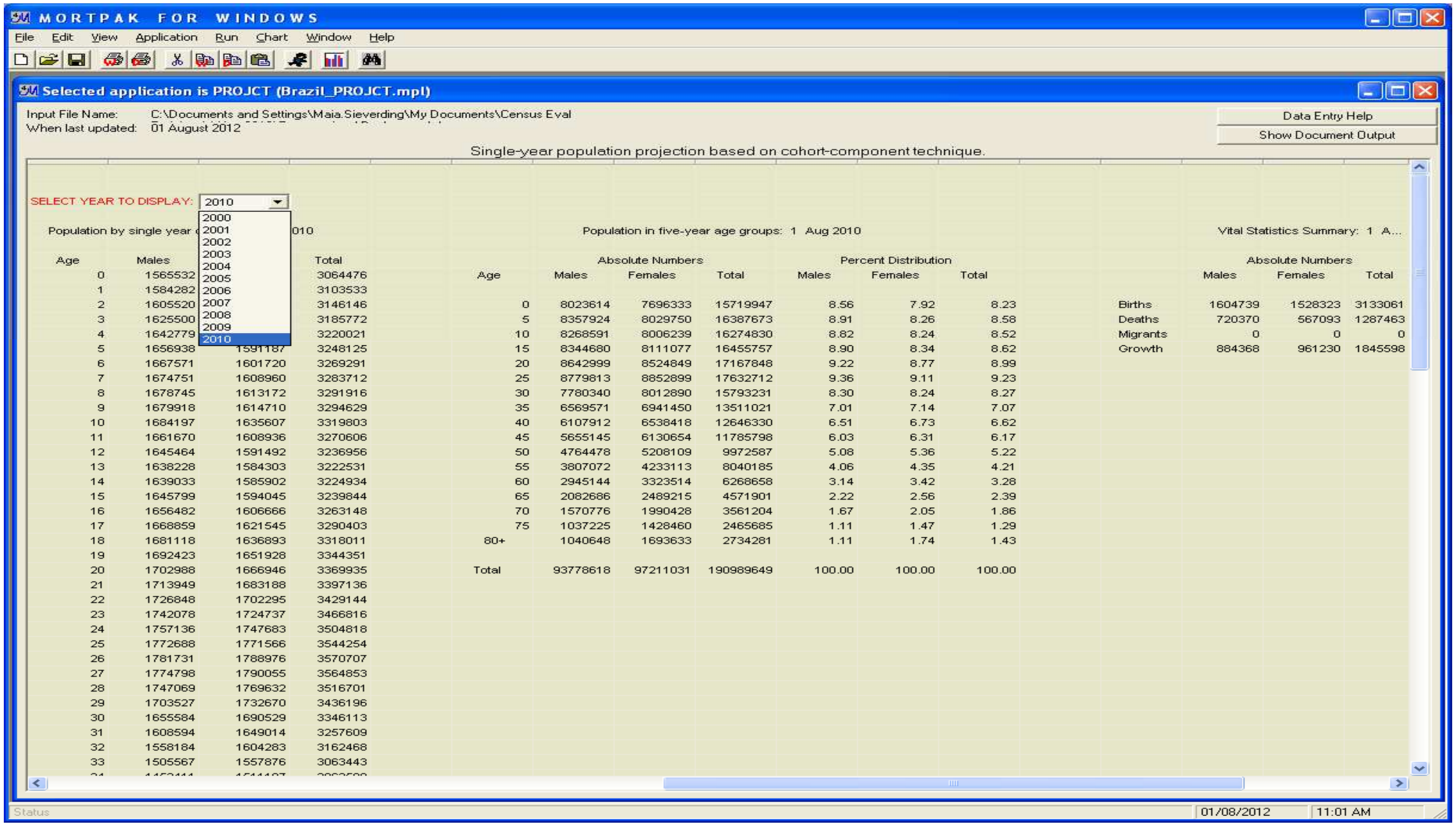
Final step in procedure is to compare the enumerated population by age and sex in the second population with the expected population



Cohort component method in MortPak (1)



Cohort component method in MortPak (2)



MORTPAK FOR WINDOWS

File Edit View Application Run Chart Window Help

Selected application is PROJCT (Brazil_PROJCT.mpl)

Input File Name: C:\Documents and Settings\Maia.Sieverding\My Documents\Census Eval

When last updated: 01 August 2012

Data Entry Help

Show Document Output

Single-year population projection based on cohort-component technique.

SELECT YEAR TO DISPLAY: 2010

2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

Population by single year [illegible] 010

Age	Males	Females	Total
0	1565532		3064476
1	1584282		3103533
2	1605520		3146146
3	1625500		3185772
4	1642779		3220021
5	1656938	1591187	3248125
6	1667571	1601720	3269291
7	1674751	1608960	3283712
8	1678745	1613172	3291916
9	1679918	1614710	3294629
10	1684197	1635607	3319803
11	1661670	1608936	3270606
12	1645464	1591492	3236956
13	1638228	1584303	3222531
14	1639033	1585902	3224934
15	1645799	1594045	3239844
16	1656482	1606666	3263148
17	1668859	1621545	3290403
18	1681118	1636893	3318011
19	1692423	1651928	3344351
20	1702988	1666946	3369935
21	1713949	1683188	3397136
22	1726848	1702295	3429144
23	1742078	1724737	3466816
24	1757136	1747683	3504818
25	1772688	1771566	3544254
26	1781731	1788976	3570707
27	1774798	1790055	3564853
28	1747069	1769632	3516701
29	1703527	1732670	3436196
30	1655584	1690529	3346113
31	1608594	1649014	3257609
32	1558184	1604283	3162468
33	1505567	1557876	3063443

Population in five-year age groups: 1 Aug 2010

Age	Absolute Numbers Males	Absolute Numbers Females	Absolute Numbers Total	Percent Distribution Males	Percent Distribution Females	Percent Distribution Total
0	8023614	7696333	15719947	8.56	7.92	8.23
5	8357924	8029750	16387673	8.91	8.26	8.58
10	8268591	8006239	16274830	8.82	8.24	8.52
15	8344680	8111077	16455757	8.90	8.34	8.62
20	8642999	8524849	17167848	9.22	8.77	8.99
25	8779813	8852899	17632712	9.36	9.11	9.23
30	7780340	8012890	15793231	8.30	8.24	8.27
35	6569571	6941450	13511021	7.01	7.14	7.07
40	6107912	6538418	12646330	6.51	6.73	6.62
45	5655145	6130654	11785798	6.03	6.31	6.17
50	4764478	5208109	9972587	5.08	5.36	5.22
55	3807072	4233113	8040185	4.06	4.35	4.21
60	2945144	3323514	6268658	3.14	3.42	3.28
65	2082686	2489215	4571901	2.22	2.56	2.39
70	1570776	1990428	3561204	1.67	2.05	1.86
75	1037225	1428460	2465685	1.11	1.47	1.29
80+	1040648	1693633	2734281	1.11	1.74	1.43
Total	93778618	97211031	190989649	100.00	100.00	100.00

Vital Statistics Summary: 1 A...

	Absolute Numbers Males	Absolute Numbers Females	Absolute Numbers Total
Births	1604739	1528323	3133061
Deaths	720370	567093	1287463
Migrants	0	0	0
Growth	884368	961230	1845598

Status 01/08/2012 11:01 AM

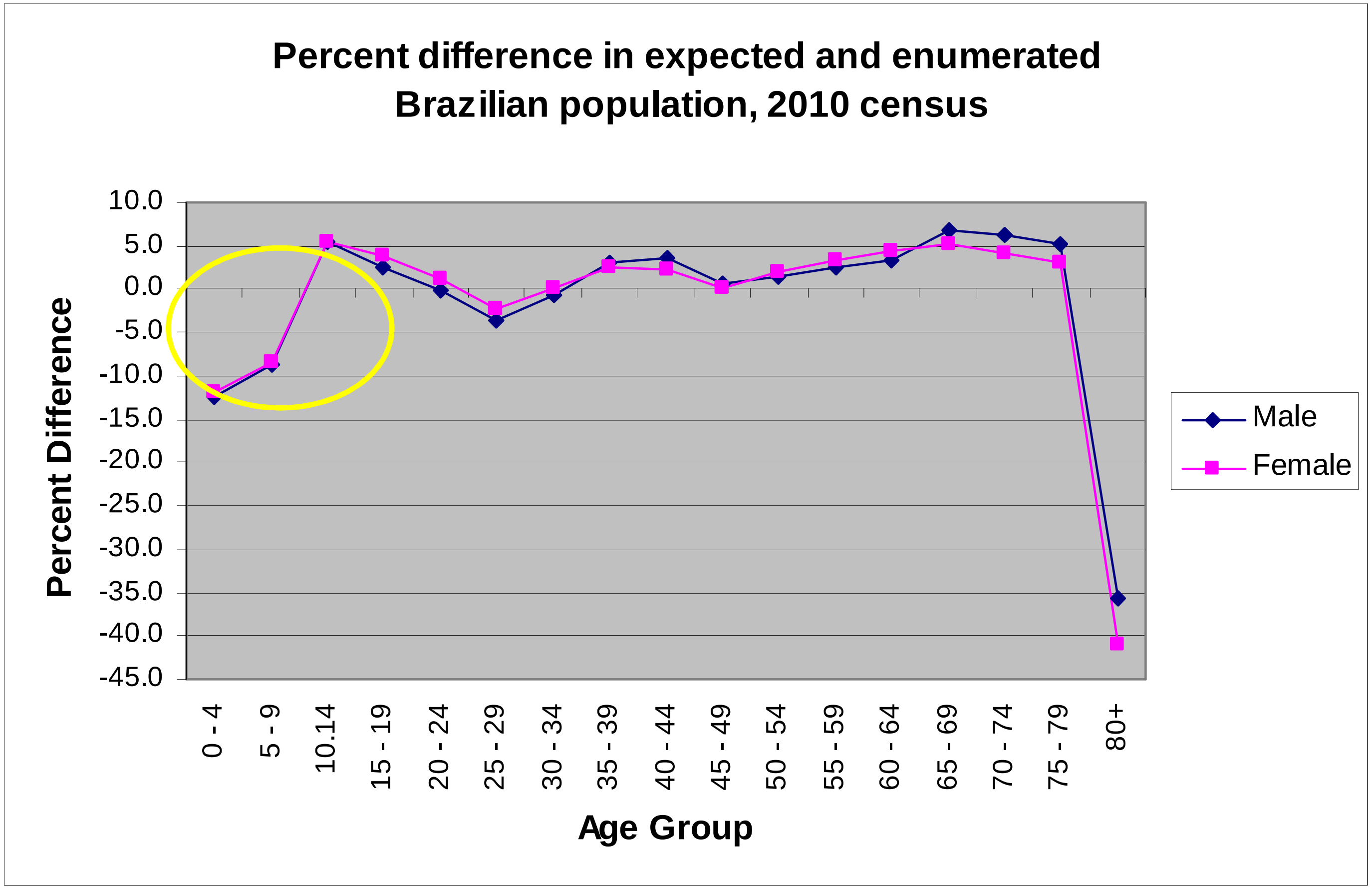
Brazil Example with MortPak - Results

Microsoft Excel — CSR.xls — I22 =(G22/E22)*100

	Acutal Enumeration 10 Aug 2010		MortPak Projections		Absolute Difference (Enumerated - Expected)		Percent Difference (Absolute Difference/Expected *100)	
Age	Male Enumerated	Female Enumerated	Male Projected	Female Projected	Male	Female	Male	Female
0 - 4	7,016,987	6,779,172	8,023,614	7,696,333	-1,006,627	-917,161	-12.5	-11.9
5 - 9	7,624,144	7,345,231	8,357,924	8,029,750	-733,780	-684,519	-8.8	-8.5
10.14	8,725,413	8,441,348	8,268,591	8,006,239	456,822	435,109	5.5	5.4
15 - 19	8,558,868	8,432,002	8,344,680	8,111,077	214,188	320,925	2.6	4.0
20 - 24	8,630,227	8,614,963	8,642,999	8,524,849	-12,772	90,114	-0.1	1.1
25 - 29	8,460,995	8,643,418	8,779,813	8,852,899	-318,818	-209,481	-3.6	-2.4
30 - 34	7,717,657	8,026,855	7,780,340	8,012,890	-62,683	13,965	-0.8	0.2
35 - 39	6,766,665	7,121,916	6,569,571	6,941,450	197,094	180,466	3.0	2.6
40 - 44	6,320,570	6,688,797	6,107,912	6,538,418	212,658	150,379	3.5	2.3
45 - 49	5,692,013	6,141,338	5,655,145	6,130,654	36,868	10,684	0.7	0.2
50 - 54	4,834,995	5,305,407	4,764,478	5,208,109	70,517	97,298	1.5	1.9
55 - 59	3,902,344	4,373,875	3,807,072	4,233,113	95,272	140,762	2.5	3.3
60 - 64	3,041,034	3,468,085	2,945,144	3,323,514	95,890	144,571	3.3	4.3
65 - 69	2,224,065	2,616,745	2,082,686	2,489,215	141,379	127,530	6.8	5.1
70 - 74	1,667,373	2,074,264	1,570,776	1,990,428	96,597	83,836	6.1	4.2
75 - 79	1,090,518	1,472,930	1,037,225	1,428,460	53,293	44,470	5.1	3.1
80+	668,623	998,349	1,040,648	1,693,633	-372,025	-695,284	-35.7	-41.1
Total	**92,942,491**	**96,544,695**	**93,778,618**	**97,211,031**	**-836,127**	**-666,336**	**-0.9**	**-0.7**
Combined Sex				**190,989,649**		**-1,502,463**		-0.8

CSR setup | Brazil Cohort Component | MortPak Output | Fertility Calcs | BrazilLT

Brazil Example with MortPak - Results



Main findings from Brazil example

Suggests underenumeration by about 1.5 million people, or 0. 8% of the population

Significant underenumeration of youngest two age groups, particularly children 0 - 4

Some overenumeration of 10 – 14 year olds – could be a result of the underenumeration of this group (as 0 – 4 year olds) in the original census in 2000

Seeing same under-enumeration of 25 – 29 year olds of both sexes as when we calculated by hand – needs to be explored

Consistent but fairly low level of overenumeration of adults age 35 – 39 to 75 – 79

- Could potentially indicate in-migration, ideally want to incorporate migration data

Significant overenumeration of older people

- Very likely that there is age exaggeration
- Also might consider that our life table is not accurate for these ages

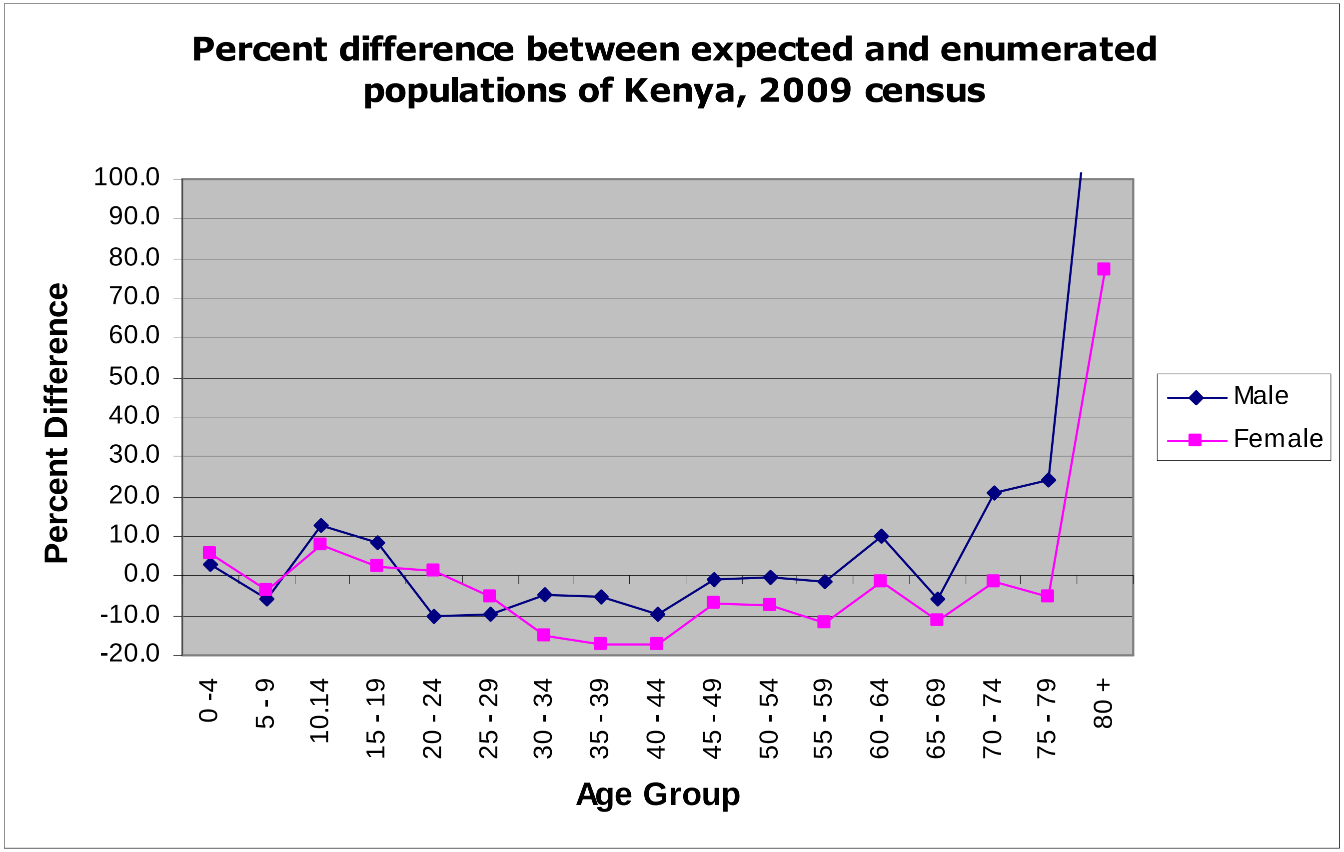
Kenya (1) – 2009 census

Kenya Cohort Component Analysis 1999 - 2009

Age Group	Enumerated Pop 1 Jul 1999 Male	Enumerated Pop 1 Jul 1999 Female	Enumerated Pop 24 Aug 2009 Male	Enumerated Pop 24 Aug 2009 Female	MortPak Projections Male	MortPak Projections Female	Absolute Difference (Enumerated - Expected) Male	Absolute Difference (Enumerated - Expected) Female	Percent Difference (Absolute Difference/Expected *100) Male	Percent Difference (Absolute Difference/Expected *100) Female
0 -4	2,342,576	2,366,559	3,617,282	3,543,961	3,516,567	3,362,901	100,715	181,060	2.9	5.4
5 - 9	1,987,900	2,028,015	2,832,669	2,765,047	3,010,305	2,863,182	-177,636	-98,135	-5.9	-3.4
10.14	1,995,510	2,034,447	2,565,313	2,469,542	2,272,991	2,287,239	292,322	182,303	12.9	8.0
15 - 19	1,740,730	1,820,619	2,123,653	2,045,890	1,956,541	2,000,494	167,112	45,396	8.5	2.3
20 - 24	1,379,948	1,560,951	1,754,105	2,020,998	1,957,961	1,997,245	-203,856	23,753	-10.4	1.2
25 - 29	1,124,732	1,280,910	1,529,116	1,672,110	1,689,959	1,763,593	-160,843	-91,483	-9.5	-5.2
30 - 34	885,768	940,088	1,257,035	1,262,471	1,320,253	1,491,082	-63,218	-228,611	-4.8	-15.3
35 - 39	703,401	728,140	1,004,361	1,004,271	1,059,470	1,212,626	-55,109	-208,355	-5.2	-17.2
40 - 44	534,186	551,737	743,594	732,575	821,909	886,654	-78,315	-154,079	-9.5	-17.4
45 - 49	418,546	431,630	635,276	637,469	642,699	685,708	-7,423	-48,239	-1.2	-7.0
50 - 54	322,763	334,748	478,346	477,860	478,976	517,700	-630	-39,840	-0.1	-7.7
55 - 59	254,342	270,412	359,466	352,487	364,886	400,689	-5,420	-48,202	-1.5	-12.0
60 - 64	199,299	227,383	295,197	298,581	268,479	303,404	26,718	-4,823	10.0	-1.6
65 - 69	155,091	180,878	183,151	207,612	194,901	233,991	-11,750	-26,379	-6.0	-11.3
70 - 74	117,522	137,336	160,301	179,000	132,320	181,158	27,981	-2,158	21.1	-1.2
75 - 79	82,970	90,346	99,833	118,675	80,356	125,127	19,477	-6,452	24.2	-5.2
80 +	96,925	126,616	159,125	224,576	61,616	126,791	97,509	97,785	158.3	77.1
Total			**19,797,823**	**20,013,125**	**19,830,190**	**20,439,582**	**-32,367**	**-426,457**	**-0.2**	**-2.1**
Combined Sex Total				**39,810,948**		**40,269,773**		**-458,825**		**-1.1**

Botswana 01-11 / Burkina 96-06 / Kenya 99 - 09 / Sheet5

Kenya (2)


Percent difference between expected and enumerated populations of Kenya, 2009 census
Percent Difference
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
0 -4
5 - 9
10.14
15 - 19
20 - 24
25 - 29
30 - 34
35 - 39
40 - 44
45 - 49
50 - 54
55 - 59
60 - 64
65 - 69
70 - 74
75 - 79
80 +
Age Group
Male
Female

Kenya (3)

Overall suggests net undercount of 1.1%, about 460,000 people

Most of undercount is coming from males aged 20-45 and females aged 25–59

- Migration may account for some of this difference
- The lifetable used (based on Kenya 1999) census may not accurately represent changing mortality conditions over the 10 year period due to the HIV/AIDS epidemic
- There may be a 'true' undercount of these age-sex groups

Cohort component method – uses and limitations

- It is applicable when registration data are not-existent or deficient to such an extent that satisfactory adjustment is not possible
- Sufficient information to derive estimates of fertility and mortality levels should be available
  - Mortality estimates can be complicated by HIV/AIDS – with a generalized epidemic, one life table is generally not sufficient to model mortality patterns over a 10 year period
- Lack of information on international migration is often a problematic issue when applying this method
- In case where sufficient information exists to derive reliable estimates of demographic parameters, the method is perhaps the most powerful among the alternative demographic approaches for the evaluation of censuses, since it provides age and sex specific estimates of net census error

Tools

- In addition to MortPak, the DemProj module of Spectrum can be used for population projections
- http://www.futuresinstitute.org/spectrum.aspx
  - DemProj is recommended for projection in contexts in which HIV/AIDS prevalence exceeds a few percent – better modeling of mortality conditions
  - Requires more data input, including prevalence and treatment estimates for HIV/AIDS
  - Data input options somewhat less flexible than MortPak

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धन्यवाद

terima kasih

Ташаккур

Рахмат!

THANK YOU …

ขอขอบคุณคุณ

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Kaadinchhey La

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