ACTUARIAL SOCIETY OF SOUTH AFRICA

A methodology for producing SALT

Rob Dorrington

Centre for Actuarial Research, University of Cape Town

2012 CONVENTION 16 – 17 OCTOBER

The problem

- No official life tables since 1984-86 and those covered only three population groups
- No official full life table including the African population
- Is it possible to produce reasonably reliable estimates of the mortality experience in South Africa?
- 2006-2008 case study in preparation for 2010-2012

History

- National statistics office established in 1914
- Uniformity in collection of vital statistics (on Whites) after 1924
- Coloureds and Indian/Asians included from 1937 and 1938
- 1963 legislation to facilitate vital registration of Africans, but registration remained optional in rural areas
- Separate report on deaths of Africans from 1968 in selected magisterial districts
- Expanded from 1978 to whole country (excl. TBVC) – but most died in rural areas and hence were not registered

History

- Computerised population registration (IDs) from 1972 (excluding Africans)
- Africans (excl. TBVC ‘countries’) added to population register in 1986
- Race removed from vital statistics and the population register in 1991
- TBVC reincorporated into (new) provinces in 1993
- Population group again included on the death notification form in 1998
- SALT for Whites centred on 1921, 1936, 1951, 1960, 1970, 1980, 1985 censuses, Coloureds since 1936 and Indians/Asians since 1951
- No official reason for stopping but several (under-registration, delay in processing, missing population group)

Since then

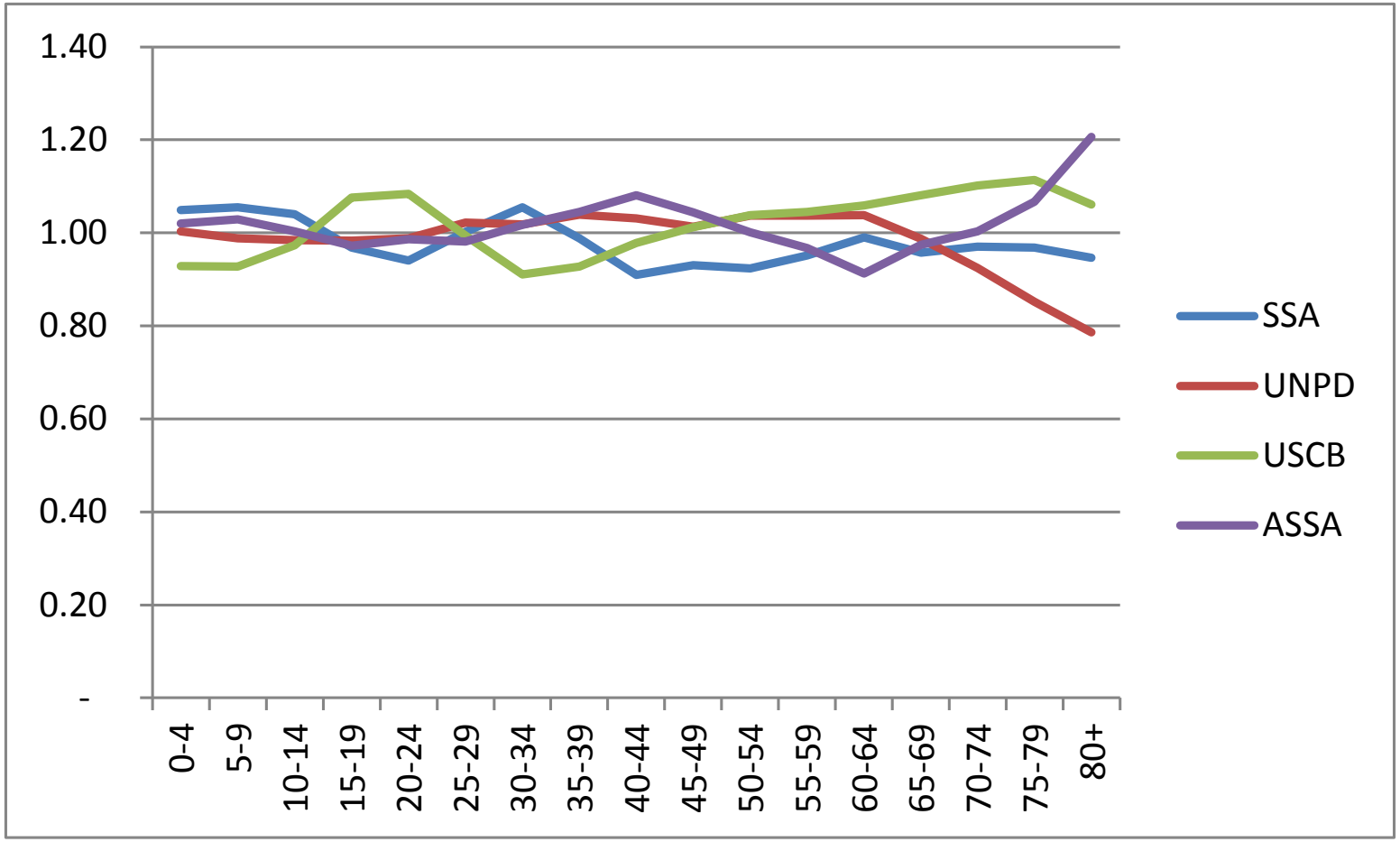
- Full life tables for Africans (1984-86 and 1990-92) by Dorrington, Bradshaw and Wegner (1999)
- Abridged life tables by Statistics (2000) *South African Life Tables, 1985-1994 and 1996* – methodologically problematic
- Completeness of registration has increased significantly (since the mid-1990s for adults and 2002 for children)
- Work by students: Szymon Marszalek, Lance Posthumus, Mayuri Reddy and Simon Marandu
- ASSA model
- RMS/HDACC

Death data 2006-2008

	Registered deaths	
	Sex	No sex
Age	99.63%	0.17%
No age	0.18%	0.02%

	Relative to expected (ASSA)		
	Male	Female	Total
<5	91%	89%	90%
5-14	41%	40%	41%
15-59	82%	87%	85%
60+	88%	97%	93%
Total	83%	89%	86%

Population estimates
(relative to the average)



Imputation

- Problem – 25% deaths missing population group
- Various methods (e.g. multiple imputation, hot decking, etc)
- All assume ‘missing at random’
- Better if have some idea of the probability that the missing record is from a specific population group
- Probability derived from comparison of registered deaths by population group with numbers expected by sex and age

Completeness of registration – adults

- Generalized Growth Balance

$$ {}_{\infty}N_x(t_2) = {}_{\infty}N_x(t_1) - B_x - {}_{\infty}D_x $$

- Divide through by the person-years lived between t_1 and t_2

$$ r(x+) = b(x+) - d(x+) $$

- If $ {}_{\infty}N_x^r(t_1) / {}_{\infty}N_x(t_1) = k_1 \,,\; {}_{\infty}N_x^r(t_2) / {}_{\infty}N_x(t_2) = k_2 \text{ and } {}_{\infty}D_x^r / {}_{\infty}D_x = c $
- then

$$ r^r(x+) + \frac{\ln\left(k_1 / k_2\right)}{t_2 - t_1} = b^r(x+) - d^r(x+)\frac{k_1 k_2}{c} $$

- i.e. fit $ b^r(x+) - r^r(x+) = a + bd^r(x+) $ and solve for c

Completeness of registration – adults

- Synthetic Extinct Generations

$$N(a,t) = \int_0^\infty D(a+s,t+s)ds$$

- If population stable then

$$N(a,t) = \int_0^\infty D(a+s,t+s)ds = \int_0^\infty D(a+s,t)e^{r \cdot s}ds$$

- Generalises to the following if not stable

$$N(a,t) = \int_0^\infty D(a+s,t+s)ds = \int_0^\infty D(a+s,t)e^{\int_0^s r(a+s-z,t)dz}ds$$

- Ratio of this estimate to that of the census = *c*

Completeness of registration – adults

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- Median (5,15, 35 to 69, 74, 79 & 84)

Adult completeness (2001-2007)					
Males			Females		
SEG (migr)	93.5		SEG (migr)		91.5
SEG (no migr from age 35)	95		SEG (no migr from ag		93
GGB (migr)	92		GGB (migr)		89
GGB (no migr from age 35)	93		GGB (no migr from a		85
Estimate	93		Estimate		90
1996-2001					
Males	86		Females		92

- i.e. males rose slightly while females roughly level
- Use 93% for males and 90% for females 15+
- Assumed incompleteness in the rural areas (hence African)

Completeness of registration – children

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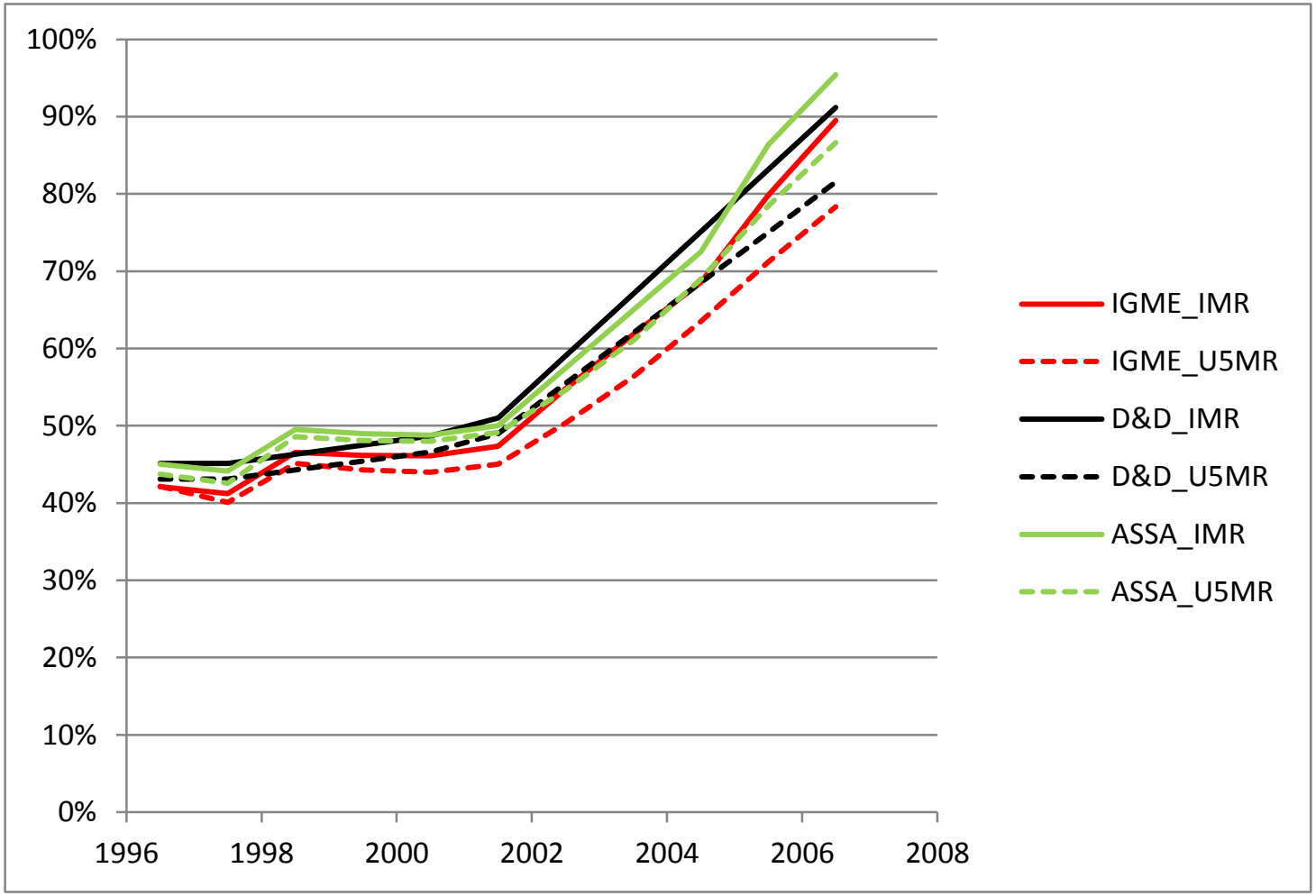
- Problem – completeness of registration appears to have improved rapidly, no indirect method of determining
- Darikwa and Dorrington (2011)
  - Estimate IMR & U5MR using (CEB/CS, h/h deaths and PBT from 2007 Community Survey, and h/h deaths from 2001 Census)
  - CEB/CS adjusted for impact of AIDS on the method using an adaptation of Ward and Zaba (2008) method
  - Compared to VR deaths/births from ASSA to estimate completeness
  - Derived rates on assumption that completeness increased monotonically over the period
  - Rates too flat, but more or less correct circa 2006-2008

Implied completeness



Completeness – children and adolescents

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- Fitted logistic curve to Darikwa and Dorrington estimated completeness <1 and <5 and averaged the three years 2006-2008
- Completeness <1: 91%
- Completeness 1-4:
  - derived from the above assuming ${}_5q_0/q_0=1.45$
- Completeness at individual ages 1-14:
  - Assumed that it increased linearly from 1 to 14, set intercept and slope such that it matched completeness in 1-4 as group and at age 15

Graduation - requirements

- Need parametric curve to fit – to smooth out ‘kinks’ in the data
- Need to extrapolate rates at old ages (data on age of deceased appears to be quite poor and quite scanty)
- Statistical test are problematic – need to allow for additional uncertainty due to estimation of completeness of death registration and imputation of population group

Graduation

- Theile and Wittstein in late 19th century, Carrier (1992)
- Heligman and Pollard (1980) (ages 1 to 80)

$$\frac{q_x}{1-q_x} = A^{(x+B)^C} + De^{-E(lnx - lnF)^2} + GH^x$$

- Levenberg-Marquardt algorithm using Data Master software (tweaked in Excel)
- Coale-Kisker for ages above 85

Coale-Kisker

m_{110} = 1 for males and 0.8 for females

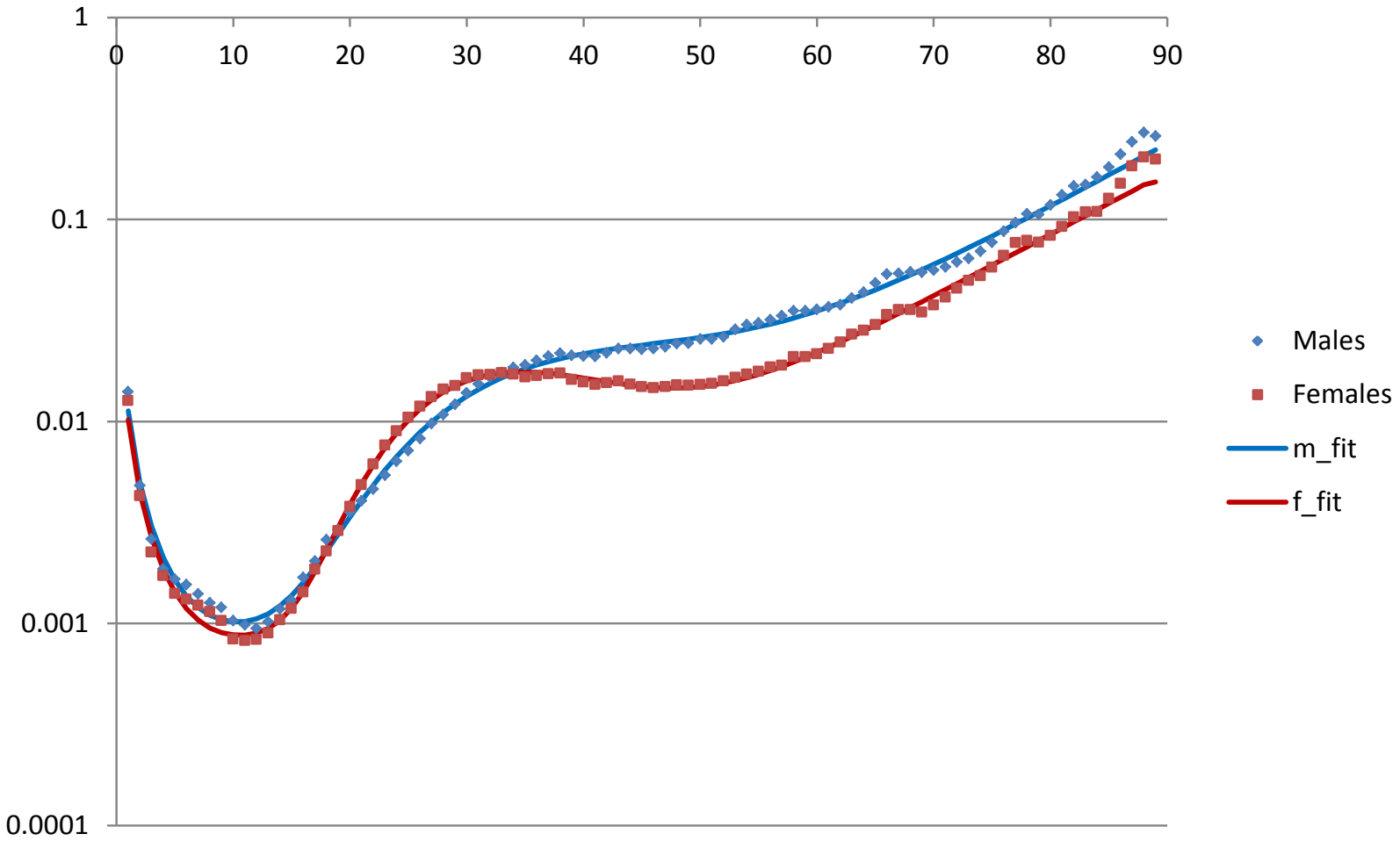
$$m_x = m_{84} \exp\left[\sum_{y=85}^{x} \left(k_{85} + (y-85)s\right)\right] \text{ for } x > 84$$

$$\text{i.e. } m_x = m_{84} \exp\left[(x-84)k_{85} + (x-85)(x-84)s\right] \text{ for } x > 84$$

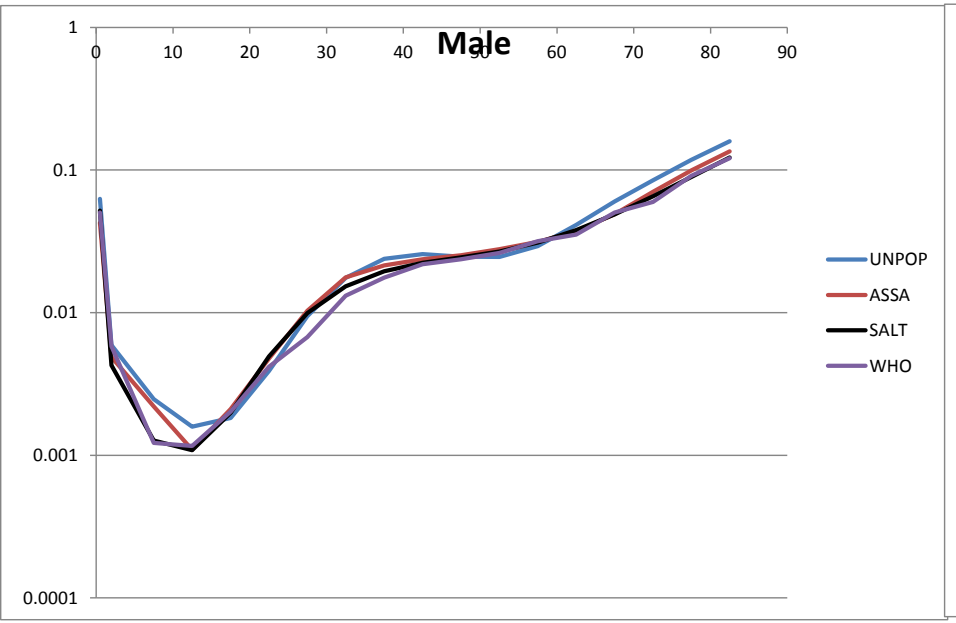
$$\text{where } k_{85} = \ln\left(\frac{m_{85}}{m_{84}}\right) \approx \frac{1}{7}\left[\ln\left(\frac{m_{88}}{m_{81}}\right)\right]$$

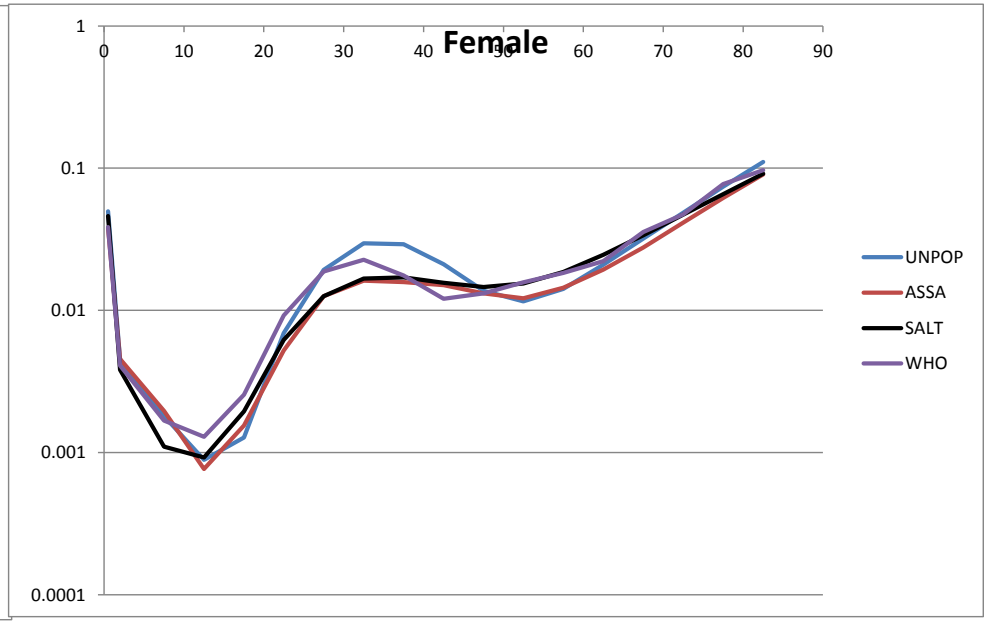
$$s = \frac{1}{325}\left[\ln\left(\frac{m_{84}}{m_{110}}\right) + 26k_{85}\right]$$

Graduation – national



Comparison – national





Comparison – national

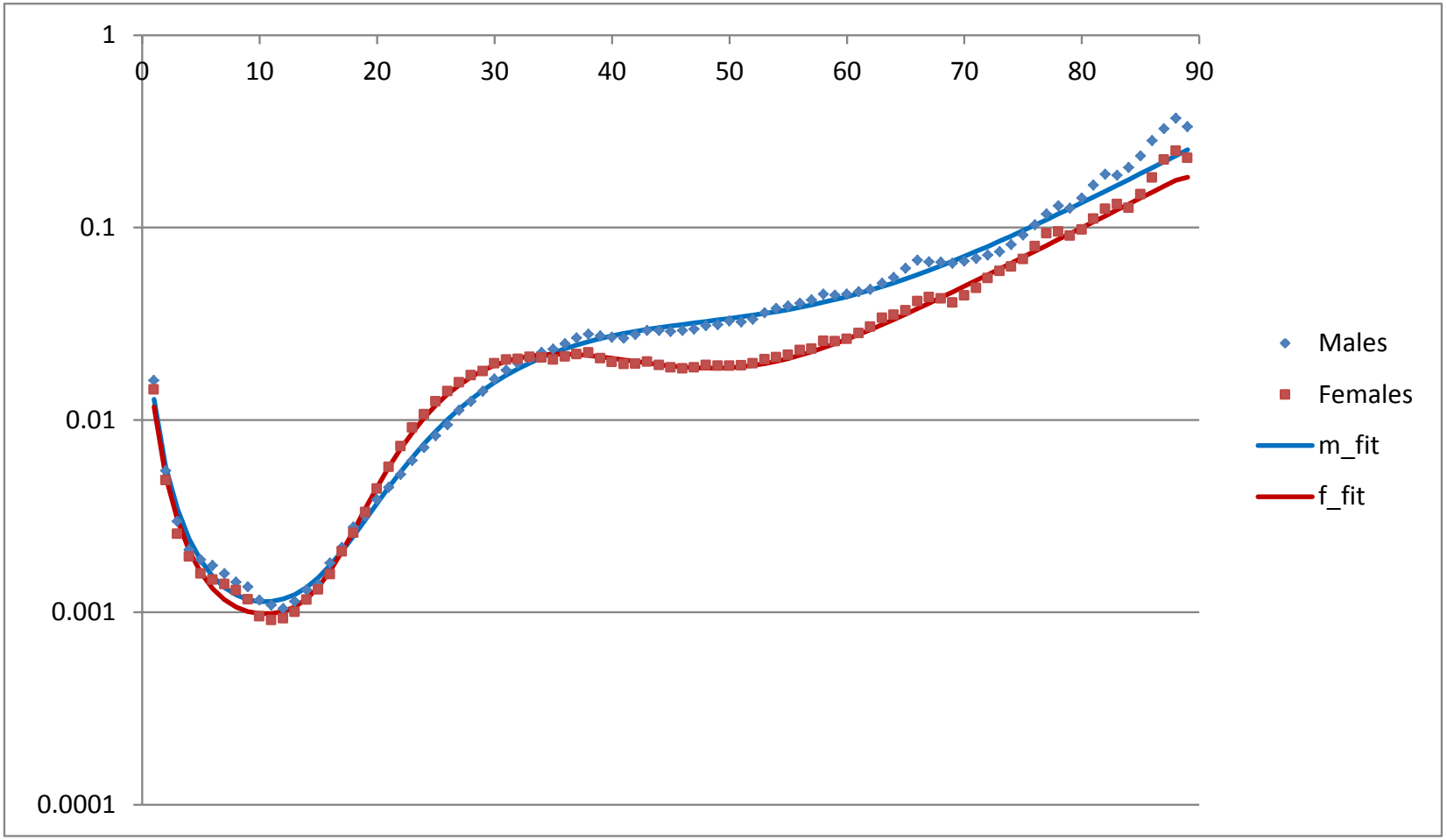
	SALT		UNPD		ASSA		Stats SA	
	Males	Females	Males	Females	Males	Females	Males	Females
e0	51.6	55.6	50.1	52.8	51.9	58.3	50.9	54.9
q0	0.051	0.045	0.061	0.048	0.041	0.037	0.045	combined
5q0	0.071	0.063	0.088	0.070	0.064	0.058	0.068	combined
45q15	0.542	0.448	0.553	0.552	0.562	0.417		
e60	14.5	17.9	10.6	14.4	13.7	18.7		

Data by population group

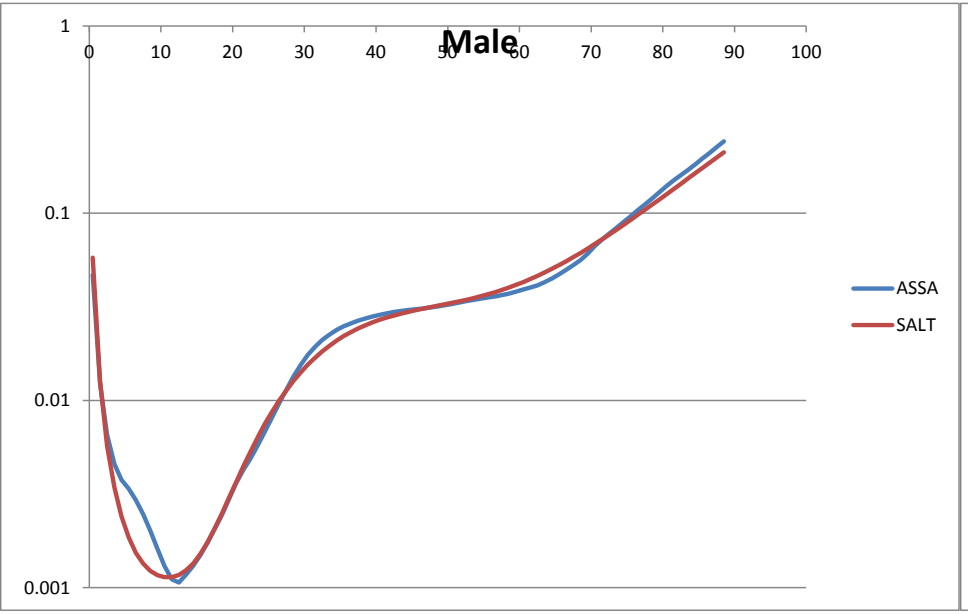
	VR	ASSA
Black	84.4%	84.4%
White	7.9%	7.9%
Indian	1.7%	1.6%
Coloured	5.8%	6.1%
Other	0.2%	

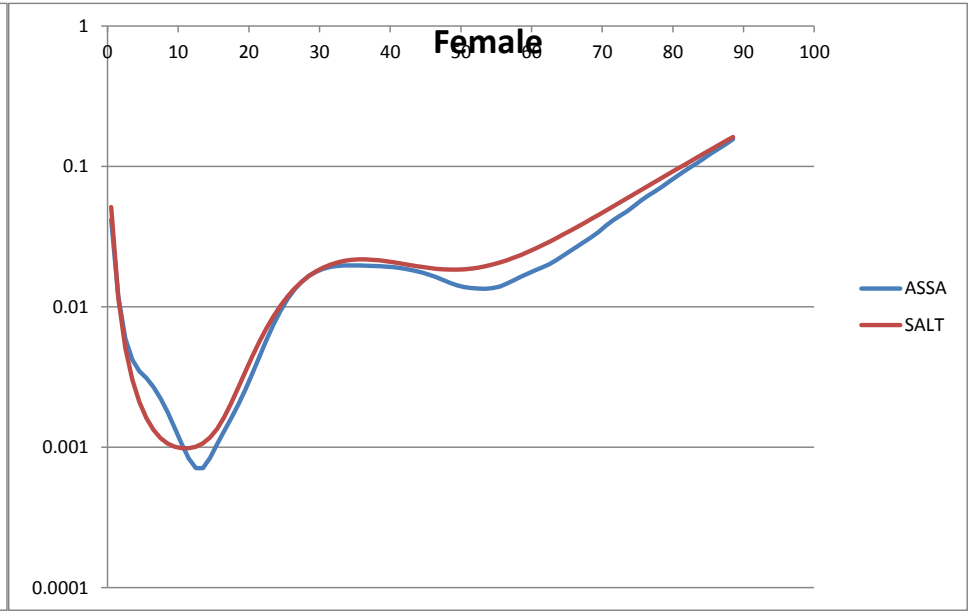
VR	Black	White	Indian	Coloured
<5	11%	1%	3%	8%
5-14	2%	0%	1%	1%
15-59	63%	24%	**41%**	**52%**
60+	24%	75%	**55%**	39%
ASSA	Black	White	Indian	Coloured
<5	12%	1%	2%	7%
5-14	3%	0%	1%	1%
15-59	63%	25%	**47%**	**55%**
60+	23%	74%	**50%**	37%

Results – Black Africans

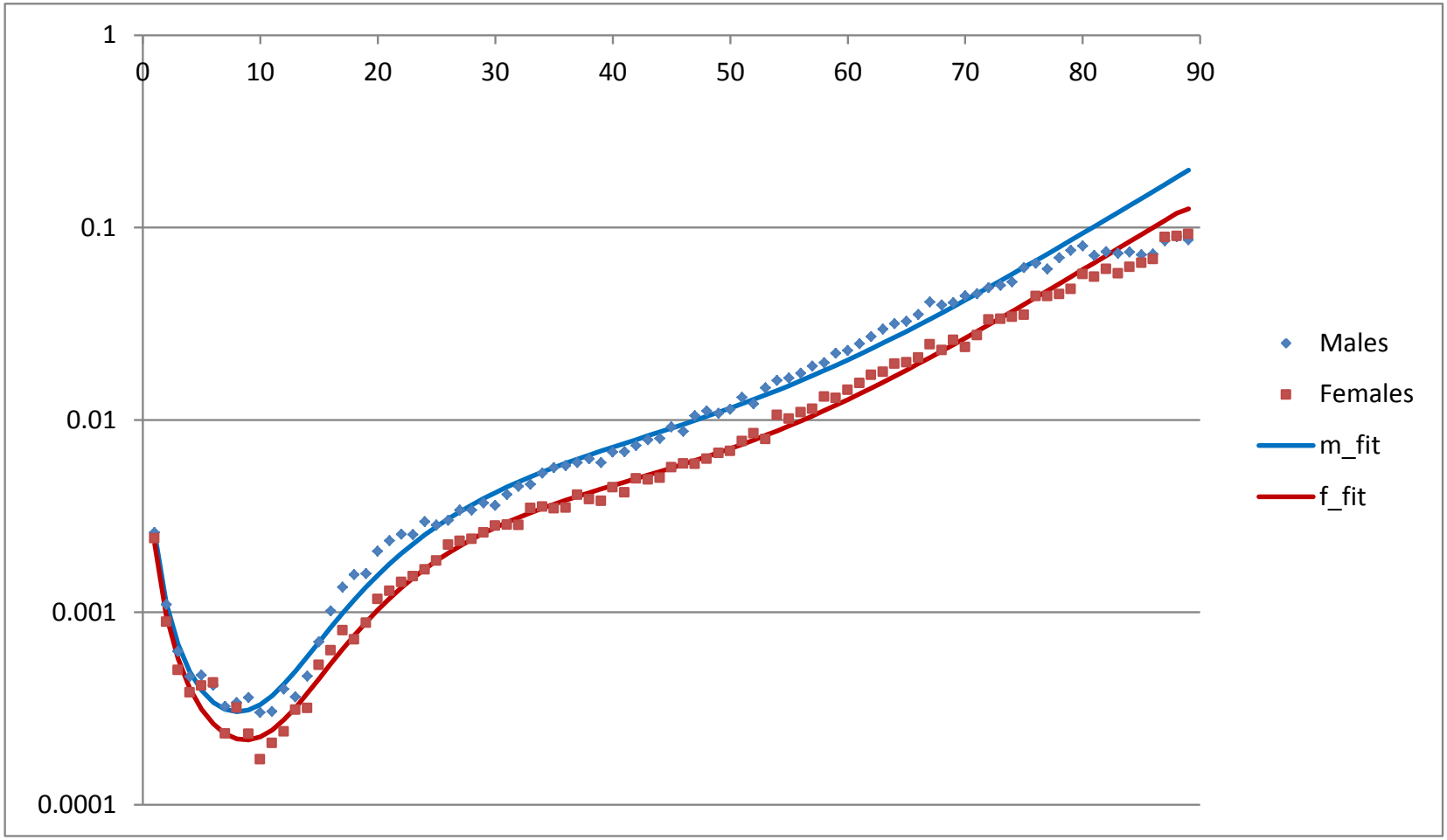


Comparison – Black Africans

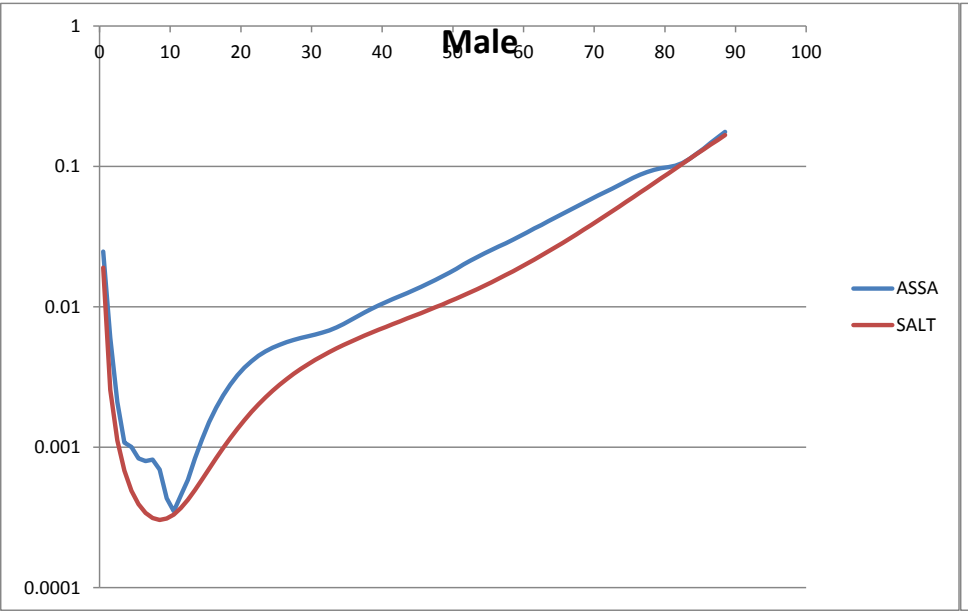


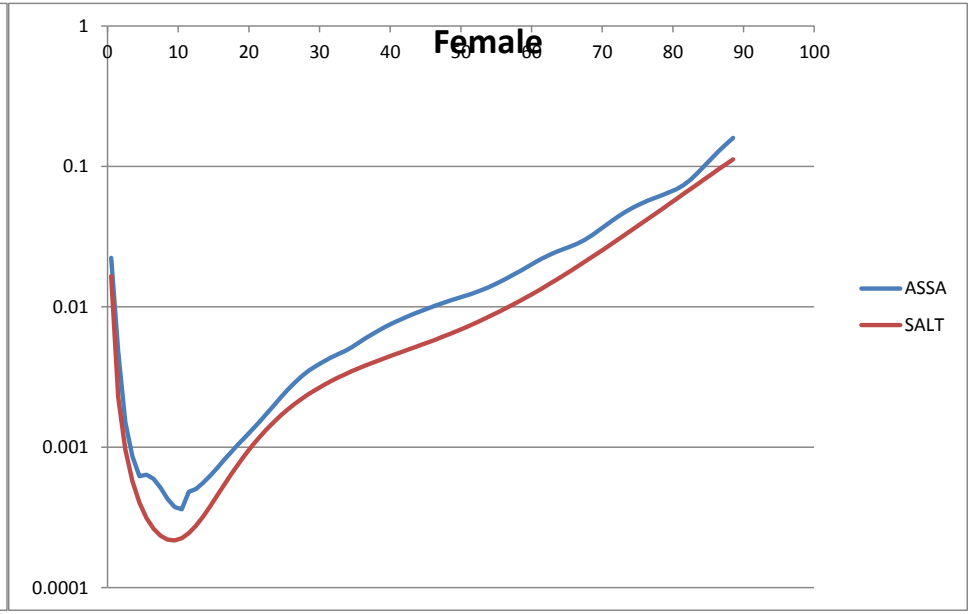


Graduation – Coloureds

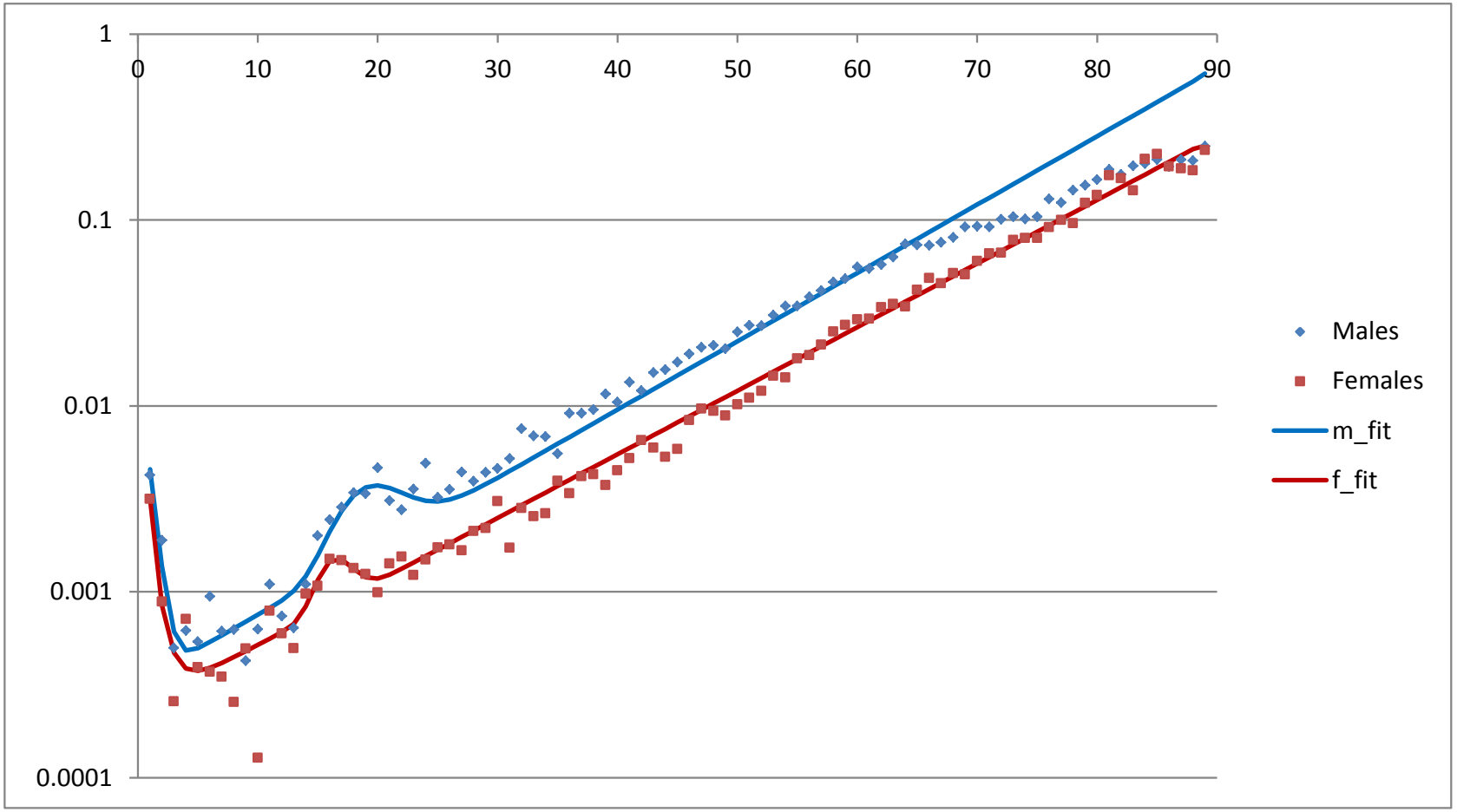


Comparison – Coloureds

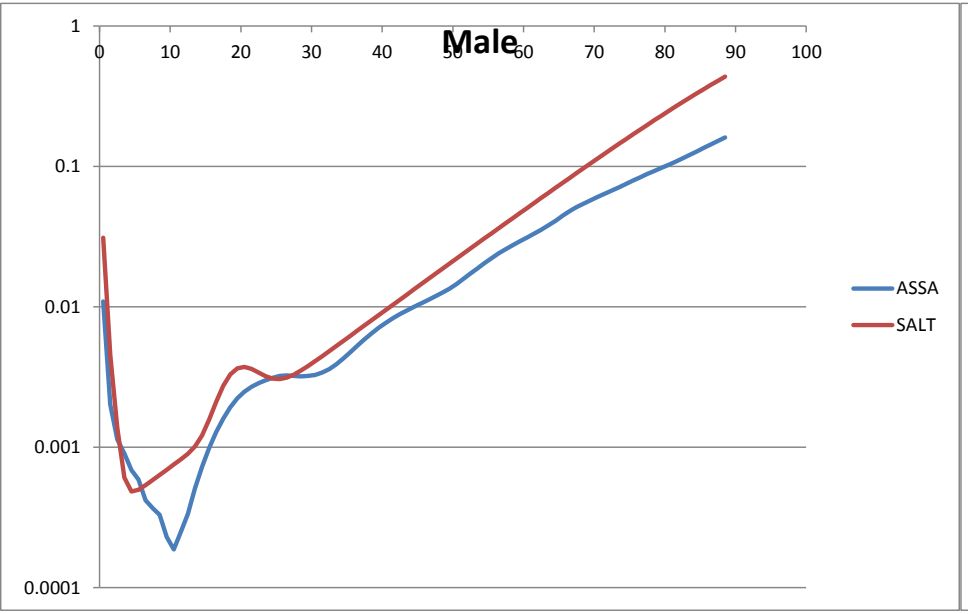


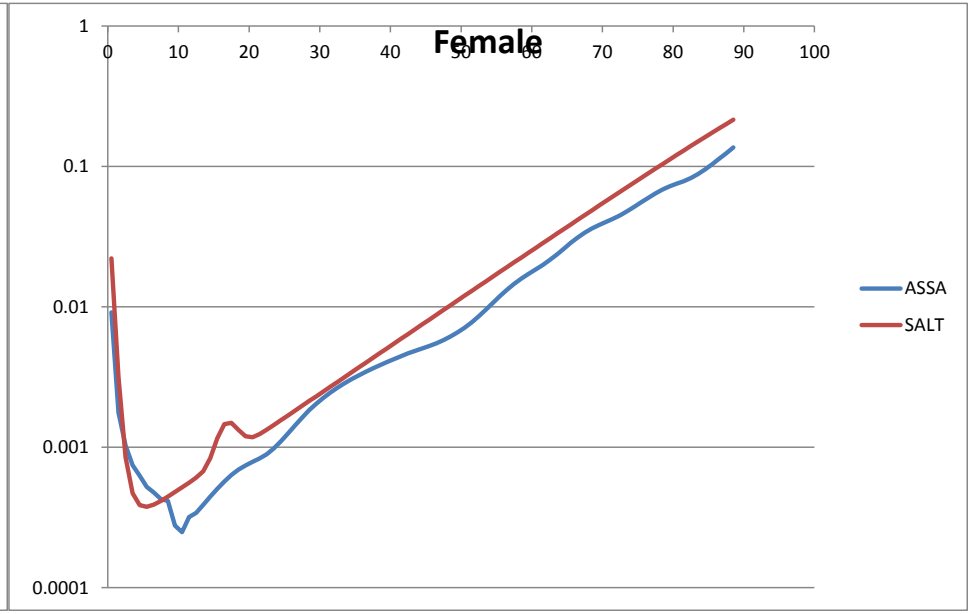


Graduation – Indian/Asians

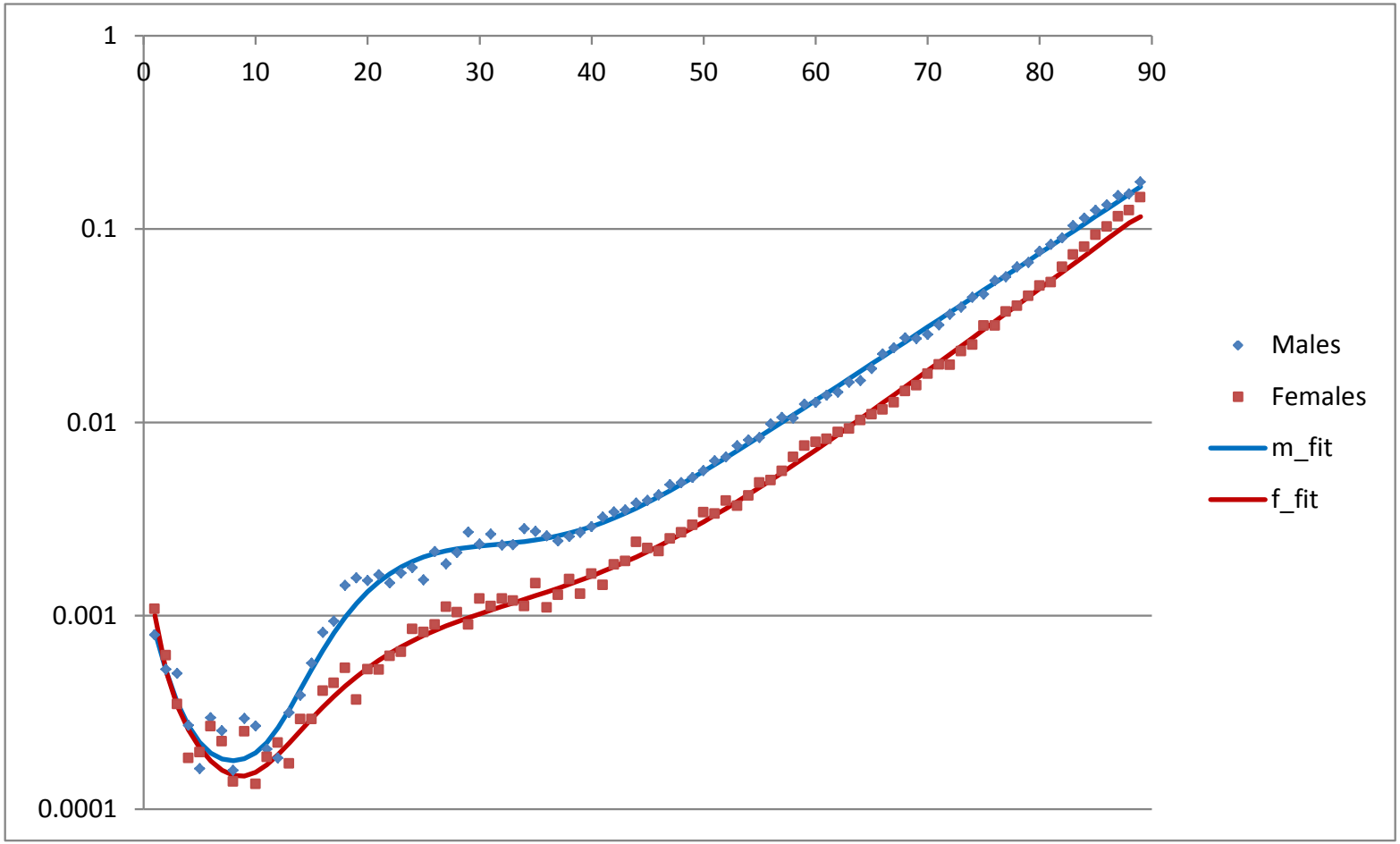


Comparison – Indians/Asians

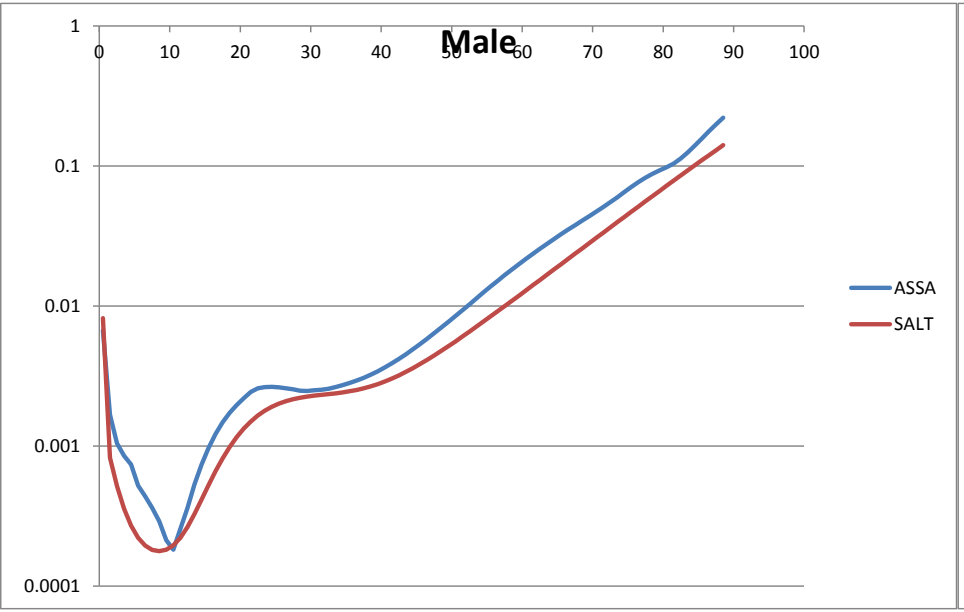


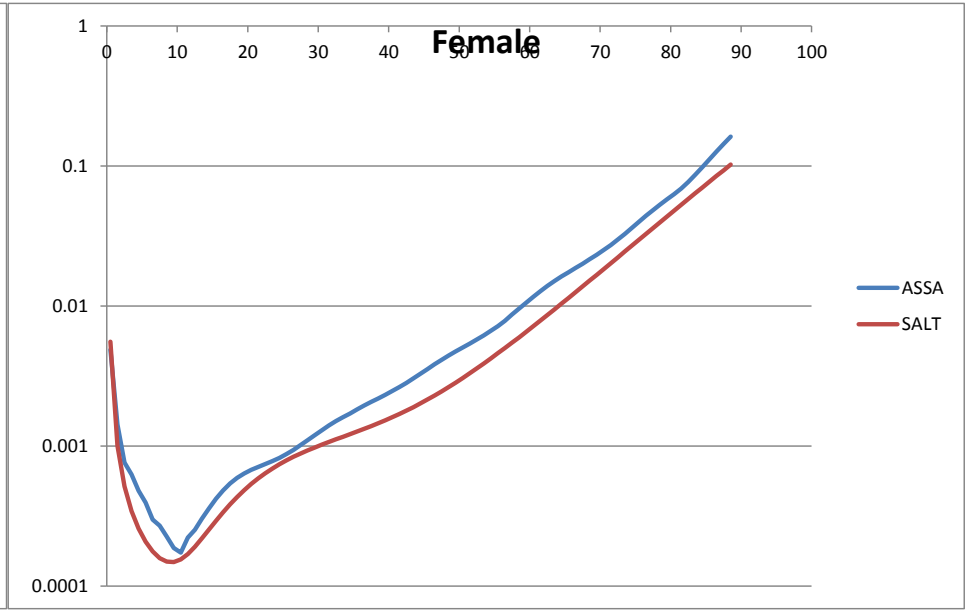


Graduation – Whites

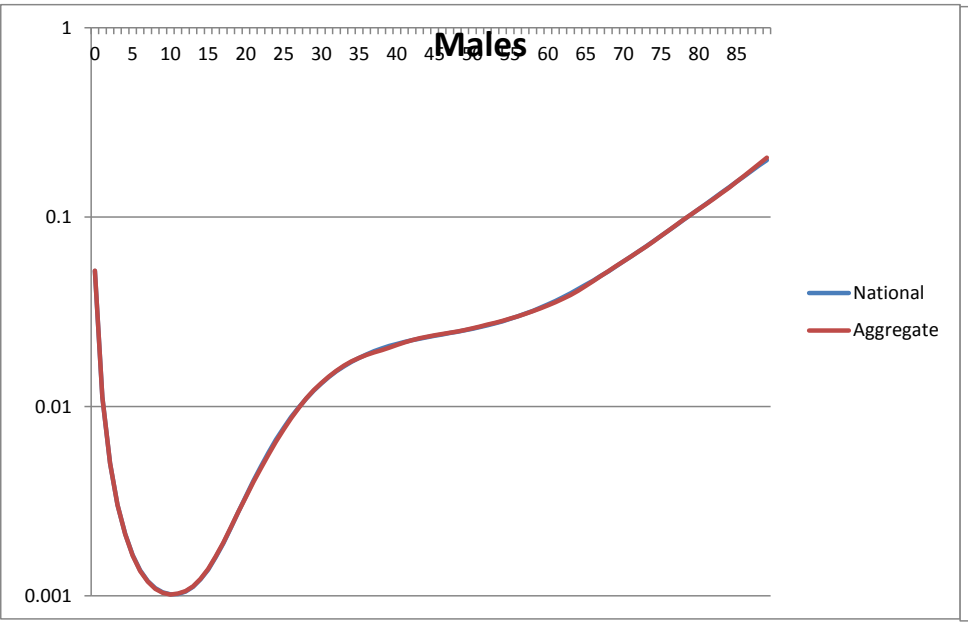


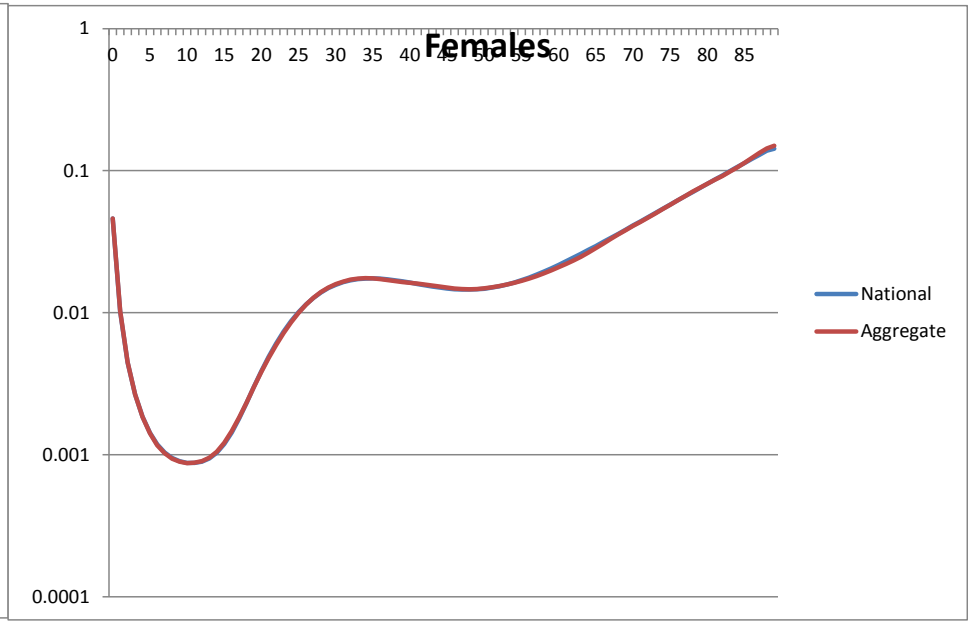
Comparison – Whites





National vs aggregate rates





Key indicators by population group

	National		Black African		Coloured		Indian/Asian		White	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
e0	51.6	55.6	48.1	51.8	65.8	72.3	56.3	64.6	72.8	79.2
q0	0.051	0.045	0.056	0.050	0.019	0.016	0.031	0.022	0.008	0.006
5q0	0.071	0.063	0.079	0.071	0.024	0.021	0.037	0.027	0.010	0.008
45q15	0.54	0.45	0.62	0.52	0.28	0.18	0.44	0.27	0.16	0.09
e60	14.5	17.9	13.1	16.3	17.6	21.7	10.0	15.1	20.1	24.2

Discussion

- Limitations of data
  - Kinks, missing population group, Indian males
- Limitations of H-P parametric equation
  - Over-parameterized, ‘hump’ not specific to AIDS
- Limitations on fitting complex non-linear function
- Limitation of estimating uncertainty
- Problem with optimising by minimizing Chi-squared statistic
- Differences for non-Black African groups not due to imputation

Conclusion

- Should this method be used to produce official South African Life tables in future?