RAPID MORTALITY SURVEILLANCE REPORT 2016

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BURDEN OF DISEASE RESEARCH UNIT
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A copy of this report is available on the Internet at: www.mrc.ac.za/bod/bod.htm

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ACRONYMS AND ABBREVIATIONS

q_0	-	probability of a live birth dying before age 1
$_5q_0$	-	probability of a live birth dying before age 5
$_{45}q_{15}$	-	conditional probability of a 15-year-old person dying before age 60
AIDS	-	acquired immune deficiency syndrome
ASSA	-	Actuarial Society of South Africa
HIV	-	human immunodeficiency virus
DHA	-	Department of Home Affairs
DHIS	-	District Health Information System
DNF	-	death notification form
e_0	-	life expectancy at birth
e_{60}	-	life expectancy at age 60
HDACC	-	Health Data Advisory and Coordinating Committee
ICD	-	International Statistical Classification of Diseases and Related Health Problems
ID	-	identity document
IGME	-	UN Interagency Group for Child Mortality Estimation
IMR	-	infant mortality rate
MMIEG	-	Maternal Mortality Interagency Estimation Group
MMR	-	maternal mortality ratio
NMR	-	neonatal mortality rate
NPR	-	National Population Register
NSDA	-	Negotiated Service Delivery Agreement
PRMR	-	pregnancy-related mortality ratio
RMS	-	Rapid Mortality Surveillance
SAMRC	-	South African Medical Research Council
Stats SA	-	Statistics South Africa
U5MR	-	under-5 mortality rate
VR	-	vital registration
WPP	-	World Population Prospects (2012 revision)

EXECUTIVE SUMMARY

This is the sixth report based on the Rapid Mortality Surveillance (RMS) system that provides timely empirical estimates of the mortality-based high-level indicators for Outputs 1 and 2 of the health-related targets of the Negotiated Service Delivery Agreement (NSDA) and progress towards the targets of the Medium Term Strategic Framework (MTSF) up to 2016. Estimates of the neonatal mortality rate (NMR) and the maternal mortality ratio (MMR) cannot, however, be obtained from this source. The NMR up to 2016 is based on adjusted data from the District Health Information System (DHIS) and the MMR on adjusted data from cause-of-death data from Stats SA up to 2015.

This report shows that the ***average life expectancy in South Africa now nearly 64 years***, having increased by more than 10 years since the low in 2005. The increase in life expectancy is due particularly to a drop in the levels of child mortality as well as young adult mortality. While the increase appears to be on track to meet the MTSF target for 2019, compared to earlier years, the increase in life expectancy has slowed down.

The level of infant and under-five mortality rates have continued to decline and are now 25 and 34 per 1 000 live births in 2016, respectively, and are on track to meet the 2019 targets, while the neonatal mortality continues to show no improvement remaining at 12 per 1 000 live births. The maternal mortality ratio peaked in 2009 and has declined to 152 per 100 000 live births in 2015, a slight decrease from 2014. ***Effort to reduce maternal and neonatal mortality further will be needed if the MTSF targets are to be met by 2019.***

The increase in the ratio of the number of deaths from the National Population Register (NPR) to the cause-of-death numbers (VR) captured by Stats SA suggest that deaths are being missed in the cause-of-death data, particularly in the most recent years, but this appears to have been reversed in 2015 with a noticeable increase in 2014 deaths from late registrations. Work continues on developing a methodology to provide estimates of sub-national trends for the provinces and health districts.

KEY MORTALITY INDICATORS, RMS 2012-2016

LIFE EXPECTANCY AND ADULT MORTALITY (OUTPUT 1)						
INDICATOR	**TARGET 2019[1]**	**Baseline 2012[2]**	**2013[2]**	**2014[2]**	**2015**	**2016**
Life expectancy at birth Total	64.2 (Increase of 3)	61.2	62.2	62.9	63.3	63.8
Life expectancy at birth Male	61.5 (Increase of 3)	58.5	59.4	60.0	60.3	60.8
Life expectancy at birth Female	67.0 (Increase of 3)	64.0	65.1	65.8	66.4	66.9
Adult mortality ($_{45}q_{15}$) Total	34% (10% reduction)	38%	36%	34%	34%	33%
Adult mortality ($_{45}q_{15}$) Male	40% (10% reduction)	44%	42%	40%	40%	39%
Adult mortality ($_{45}q_{15}$) Female	28% (10% reduction)	32%	30%	28%	28%	27%
MATERNAL AND CHILD MORTALITY (OUTPUT 2)						
INDICATOR	**TARGET 2019**	**Baseline 2012[2]**	**2013[2]**	**2014[2]**	**2015**	**2016**
Under-5 mortality rate (U5MR) per 1 000 live births	33* (20% reduction)	41	41	40	37	34
Infant mortality rate (IMR) per 1 000 live births	18	27	28	28	27	25
Neonatal mortality rate[3] (<28 days) per 1 000 live births	6	12	11[3]	12[3]	12[3]	12
INDICATOR	**TARGET 2014**	**Baseline 2011[5]**	**2012**	**2013**	**2014**	**2015**
Maternal mortality ratio[4] (MMR) per 100 000 live births	Downward trend below 100	200	165**	154**	164**	152

1. Target values for 2019 have been revised relative to the current 2012 estimate
2. Based on NPR data rather than VR data because of apparent significant under-recording by the VR data
3. Method changed to derive directly from the DHIS neonatal deaths and birth data
4. Stats SA data
5. Baseline for MMR set at 2011 due to lag in availability of data

* Assumed published figure of 23 is a typographical error

** Slight changes from previous report due to a change in estimate the number of births based on more recent data

INTRODUCTION

This is the sixth in the series of annual reports utilising the data from the Rapid Mortality Surveillance (RMS) database described in the first report (Bradshaw, Dorrington and Laubscher, 2012). It provides estimates of several mortality indicators after correcting for incompleteness of registration of deaths and births. These can be used to track the impact indicators identified for Output 2 of the Medium Term Strategic Framework (MTSF) - a long and healthy life for all South Africans. Targets were set from 2012 baseline values to be achieved by March 2019.

The indicators in the report include life expectancy, the adult mortality index ${}_{45}q_{15}$, under-5 mortality rate, infant mortality rate and the neonatal mortality rate. The report also includes an estimate of the maternal mortality ratio (MMR), which lags the other indices because it relies on the cause-of-death data reported by Stats SA. For this report, the RMS data series has been updated to the end of 2016 and the cause-of-death data to the end of 2014.

Estimates of the population and the number of births are essential for calculating the indicators in this report. As in the previous report, the mid-year population estimates, derived to be consistent with the 2011 Census population (Dorrington, 2013), and projected forward to 2016 using unchanging migration and slightly declining fertility since the census have been used. Every year the true numbers of births (for each calendar year) are re-estimated taking into account the most recently released data on registered births (which also include late registrations for previous years). In addition, this year the population estimates used in the past were adjusted for the change in numbers of births since the 2011 census.

As was done previously, adjustments have been made to allow for the under-registration of deaths, after first adjusting the data to account for a proportion of people who are not on the National Population Register. In addition, the same methodology as used previously, was used to estimate the MMR from the cause-of-death data.

DATA SOURCE

The Department of Home Affairs is responsible for civil registration and the maintenance of a computerised National Population Register (NPR). Registered births are added to the register and an aggregation of all births registered from 1998 to the end of the immediately preceding year is published by Stats SA (Stats SA 2017a). These data, adjusted for an estimate of under-registration are used to determine the denominator for the neonatal, infant, under-five and maternal mortality rates.

In the event of a death, a death notification form is submitted to the Department, which then issues a burial order and an abbreviated death certificate to the family of the deceased. For deaths of individuals who have a South African ID number or whose birth has been registered, the National Population Register is updated as part of the registration process.

Since 1999, the South African Medical Research Council has obtained monthly information about the deaths registered on the National Population Register and has developed a consolidated data base. Several steps in the data management process ensure that the confidentiality of the data is maintained. Ethics approval was obtained from the University of Cape Town.

These data are subject to two forms of under-reporting. The first is non-registration on the population register (because the deceased did not have a South African birth certificate or identity document). The second, in common with deaths from the vital registration system (as reported in the cause-of-death data released by Stats SA) in developing countries, is non-registration of the death.

As the NPR data only identifies cause-of-death as natural or unnatural, one needs to rely on the cause-of-death data from Stats SA to identify the maternal deaths. The latest available data are for the year 2015 (Stats SA, 2017b). In addition, too few neonatal deaths are recorded in the NPR data to produce reliable estimates, and since there is a lag in the release of the cause-of-death data, we use data from the District Health Information System 2009-16 (DHIS) to estimate the number of neonatal deaths that occur in public hospitals to produce a more recent estimate. Because of this, estimates of neonatal mortality for recent past years may need to be modified slightly to account for detailed unit record vital registration data when these are released.

POPULATION ESTIMATES

Demographic indicators require estimates of the population and births that should ideally:

- be available by single years of age to allow for more accurate estimation of the indicators
- not change frequently by substantial amounts (to avoid having to recast the indicators)
- be as consistent with the age distribution of the populations of the 2001 and 2011 Censuses as is reasonable, allowing, *inter alia*, for possible undercounting of children and age exaggeration at old age.

For the first RMS report, the estimates produced by the ASSA2008 AIDS and Demographic projection model were used to calculate the mortality-related indicators in line with the recommendations of the Health Data Advisory and Coordination

Committee of the Department of Health (HDACC, 2011). However, since then, the 2011 Census population estimates were released, and they suggested that not only has fertility been different from that assumed by ASSA model (and ALL other projection models) for the 10-15 years prior to the 2011 census, but also that immigration has turned out to be somewhat higher than assumed by projection models. Thus, for reports since then, in the absence of a suitable alternative, an alternative set of mid-year population estimates with an age distribution and size consistent with those of the 2001 and 2011 Censuses (Dorrington, 2013) has been used. Although the official mid-year estimates were constructed to match in total the size of the 2011 Census (Stats SA, 2013a) population in 2011, they were, initially, not constructed with a series of births and migration that replicates the age distribution of the population of the Census under age 30. This has been largely corrected in the release of the 2017 mid-year estimates (Stats SA 2017c).

The numbers of births were estimated by reconciling the following:

- estimates of the numbers of births (up to 2011) derived by back-projecting the numbers surviving to the 2011 Census
- estimates of the numbers of births (up to 2004) derived from the numbers of children in school in 2011 by age of child
- estimates of the number of births (up to 2015) from the registered births by year of birth corrected for estimates of the completeness of registration
- estimates of the number of births (up to 2016) derived from the number reported by the DHIS corrected for an estimate of the births that took place outside a public health facility (Dorrington and Moultrie 2015)[1]
- estimates of the number of births (up to 2017) projected by the CARe 3.2 population projection model, and
- the consistency and plausibility of the implied level of completeness of registration by number of years of registration since year of birth.

These estimates are presented and compared to the numbers of births captured by the District Health Information System (DHIS) and vital registration (VR) in Figure 1 below. Because it manifests in the estimates of some indicators it should be noted that it appears as if the total number of births declined in 2015 and 2016.

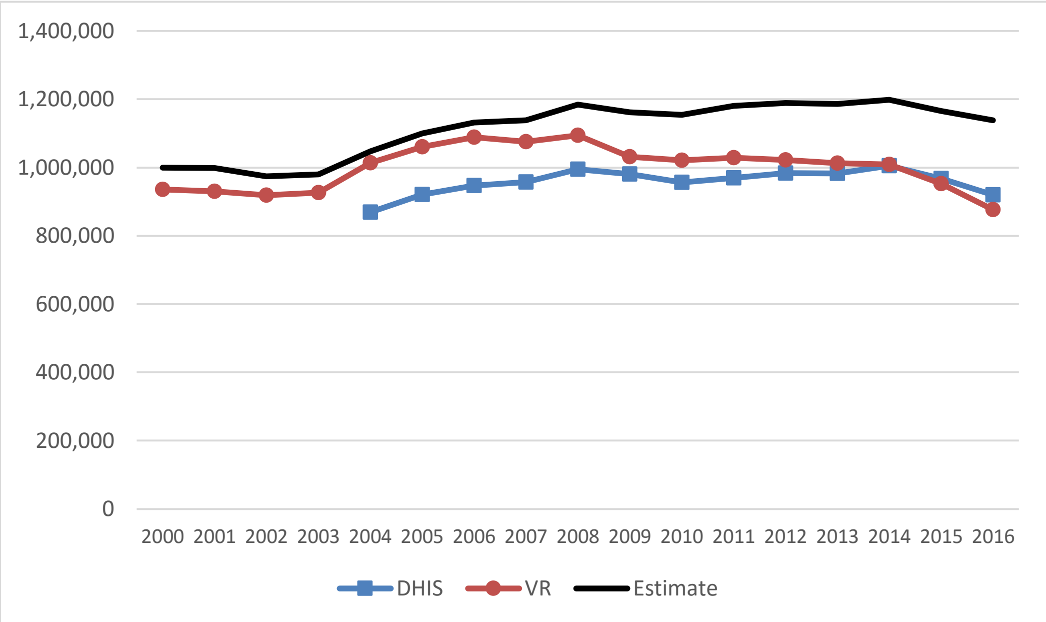


Figure 1: Estimates of the number of births compared to the numbers from the DHIS and VR, 2000-2015

ADJUSTMENTS

Evaluation of the NPR data with that of Stats SA shows that there has been a steady improvement in birth and ID registration, and a consequent reduction in the under-recording of deaths on the population register relative to those captured by Stats SA's cause-of-death processing. From Figure 2 it can be seen that more than 95% of the death notifications of people aged 25 and over, and close to or over 90% of all other ages except those in the first year of life, are on the NPR. The low proportion of death notifications under the age of one being registered on the population register is mainly because many deaths in this

[1] Estimate of the number of births outside public health facilities is based on the numbers under one who were covered by medical aid or private health insurance, plus the number of births which occur 'at home'.

age group occur before the birth is registered, and so the birth and death are not registered on the NPR even if a death notification form was completed.

While it appeared that by 2010 the proportion of registered deaths for adults (15+) on the population register had reached a plateau, the proportions increased unexpectedly in 2011, to the point where there appear to be more deaths aged 25+ on the NPR than are being recorded by the VR cause-of-death data, which shouldn't be. This trend continued in 2012 and although it appeared to have worsened significantly in 2013 and 2014, this has deterioration has been reduced by the inclusion of late registrations, particularly in 2014. As it should not be possible for a death to be recorded on the population register without there being a death certificate the increase in proportion must indicate that for some reason not all deaths on the population register are being processed by Stats SA, yet this is again the case for 2015. Although some of the discrepancy appears to be due to efforts to accelerate the release of the cause-of-death reports[2], and the later close off of the 2015 registrations (Stats SA, 2017d) seems to bear that out, it seems unlikely that this can account for all the deaths missing from the VR cause-of-death data. Until this matter is investigated thoroughly, one needs to allow for the lower completeness in the 2011-2013 VR data when producing estimates from cause-of-death data. In addition, extrapolation of past trends of the relative completeness of the NPR data are no longer as reliable as they were, undermining, to some extent, confidence in the estimates produced using the NPR data.

As was done in the previous reports, the NPR data are adjusted in two steps. The first step is to account for the fact that the population register does not include the total population. The second step is to account for under-notification of deaths. The first adjustment is made by single ages up to the age of 24 years and then in three broad age groups: 25-59, 60-89 and 90+ years for each sex, to approximate Stats SA vital registration (VR) data for each year from 2006 up to 2011. The same factors are then used to produce estimates for 2012 to 2016, for which cause-of-death data are either unreliable or have yet to be processed. After this adjustment, the estimated numbers of deaths are adjusted for general under-notification (i.e. deaths with no death certificates). The levels of completeness of the VR data assumed are as follows:

> age 0: rising from around 63% in 2000 to around 81% in 2005, then 85% to 2011, then 82% for 2012 and 80% thereafter
>
> age 1: rising from around 42% in 2000 to around 56% in 2005 and then between 59-61% thereafter
>
> ages 2–14: linear trend by age between the figure for age 1 and figure for age 15+
>
> ages 15+: rising from 86% in 2000 to 92% in 2006, then 93.0% until 2010, after that it drops to 92% for 2011-2013. After 2013 it is 93% for ages up to 39 but drops below that to as low as 86% for females and 87% for males to reflect the drop in VR relative to NPR that has been observed (and is assumed to reflect a drop in completeness of VR data).

A brief description of the approach used to estimate the completeness of registration of deaths is given in the appendix.

Aside from adjusting the VR cause-of-death data for under-notification of deaths and the high proportion of ill-defined causes, according to the practice of the UN advisory group on Maternal Mortality (MMIEG), the number of maternal deaths is increased by 50% to allow for the general under-notification of maternal causes. This practice is based on the experience of some 22 studies estimating the extent in under-notification in countries with good VR data (WHO, 2010).

[2] The publication of the Statistical Release on "Mortality and causes of death in South Africa, 2012" suggest that about half of these missing deaths were captured as late registrations in the report on deaths in the following year. However, the same report on deaths registered in 2013 shows only limited further late registrations.

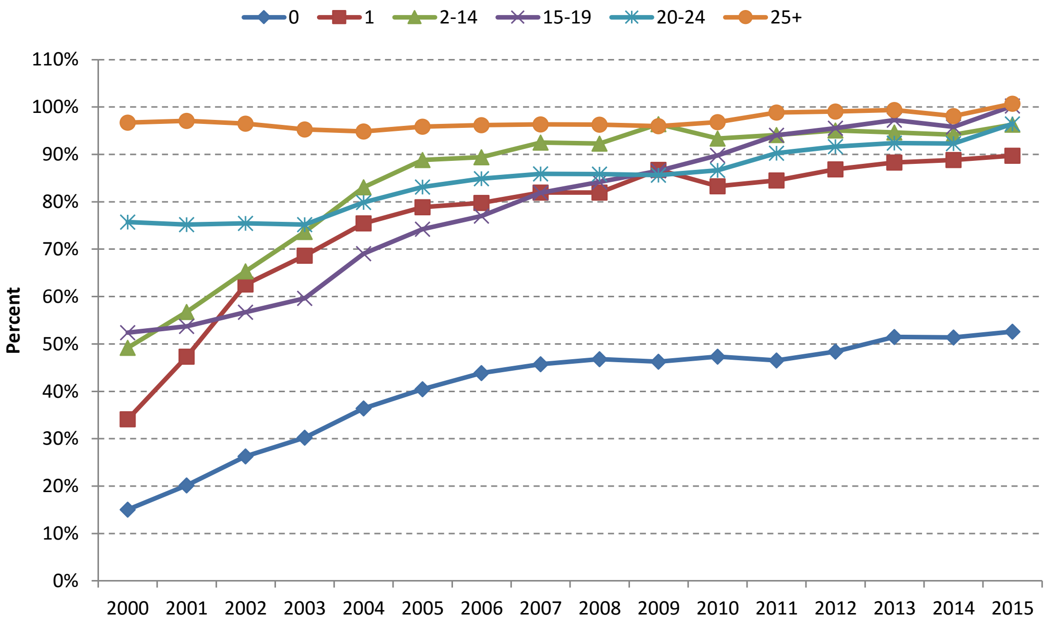


Figure 2: NPR deaths as a proportion of Stats SA deaths by age group, 2000-2015

The NPR data cannot be used to estimate neonatal deaths, because too few of these deaths are captured on the NPR (by 2011 less than 10% of the registered deaths in this age group are captured on the NPR), possibly because the birth was not registered before the death. Furthermore, this proportion appears to have been increasing (possibly with improving birth registration) over time, which makes extrapolation difficult. Comparison of the number of neonatal deaths recorded in the DHIS with those in the VR data suggests that an increasing proportion of the VR deaths are being captured by the DHIS[3]. In the past, in order to track neonatal mortality in parallel with the infant and under-5 mortality, the number of neonatal deaths that occurred in facilities and were captured by the DHIS is scaled up to estimate the number expected to be captured by the VR data. This result was then corrected for the same level of under-registration as is applied to infant deaths, in much the same way as the infant and under-5 deaths are estimated. For the years for which VR data are not yet available, the completeness of the neonatal deaths in the DHIS was estimated as the completeness for the previous year plus any increase in the ratio of neonatal deaths to stillbirths over the previous year. The rationale for this was that one would expect the ratio of neonatal deaths to stillbirths to remain fairly constant over time, so any increase in this ratio over time is probably due to an increase in completeness of coverage.

However, as the number of neonatal deaths recorded by the DHIS has exceeded those recorded by the VR since 2012 (significantly so for 2014 and 2015) it seems more appropriate to assume that part, if not all, the decline in VR neonatal deaths is due to a decline in completeness of registration commented on in previous reports and not to a decline in neonatal mortality. Thus, as was the case for the previous year's report, we estimate the neonatal mortality from 2013 onwards directly from the DHIS record of neonatal deaths (instead of VR neonatal deaths) and live births delivered at district health facilities or before arrival. (While this excludes births not in the public sector clinics, which probably have a lower NMR, it is also possible that not all neonatal deaths of public sector births are captured by the DHIS data, so the estimates are similar to the previous estimates in 2011 and 2012.)

TRENDS IN RMS DATA

The numbers of deaths (excluding late registrations) from the National Population Register are shown in Table 1 for 2000-2016 alongside the number of deaths for the latest year from the Stats SA cause-of-death reports for 2000-2015. The total numbers (T) are broken down into natural deaths (N) and unnatural deaths (U). It can be seen that the total number of deaths in both series increased to a peak in 2006. The Stats SA numbers increased from 416 420 in 2000 to a peak of 613 108 in 2006 and declined to 459 014 by 2015. The NPR numbers increased from 359 470 in 2000 to a peak of 555 081 in 2006 and declined to 445 445 by 2016. It should be noted that the changes in the numbers of deaths cannot be interpreted without taking into account the general improvement in death registration (which appears to have stalled in the most recent years), and in the case of the NPR data, improved birth registration, over the period.

The rapid decline in the number of deaths from the peak in 2006 to 2014 makes it important to investigate whether there are any indications of system failure. Although subtle changes in completeness of recording are quite difficult to detect, preliminary investigations suggest that the completeness of reporting of the VR deaths may have declined by between 1%

[3] To the point that since 2013 the DHIS captures more neonatal deaths than are recorded by the VR cause-of-death data.

and 1.5% from 2011-2013. In addition, investigations have identified evidence of some failures in the vital registration in 2014 and 2015, which will probably be corrected by late registrations in the following years. This will need to be monitored going forward.

Table 1: Number of natural (N), unnatural (U) and total (T) deaths in NPR compared with Stats SA data by year

	NATIONAL POPULATION REGISTER			STATS SA CAUSE-OF-DEATH DATA		
YEAR	Natural (N)	Unnatural (U)	Total (T)	Natural (N)	Unnatural (U)	Total (T)
2000	319 228	40 242	359 470	366 633	49 787	416 420
2001	360 348	39 835	400 183	404 775	50 351	455 126
2002	401 098	41 563	442 661	450 851	51 486	502 337
2003	446 580	42 204	488 784	504 148	52 850	556 998
2004	467 889	41 928	509 817	523 676	53 366	577 042
2005	492 688	43 645	536 333	544 344	53 977	598 321
2006	509 636	45 445	555 081	559 873	53 235	613 108
2007	505 367	46 606	551 973	549 875	54 496	604 371
2008	498 699	46 771	545 470	542 274	53 350	595 624
2009	488 305	44 860	533 165	529 428	50 283	579 711
2010	465 363	43 597	508 960	495 479	48 377	543 856
2011	442 291	42 732	485 023	459 813	45 990	505 803
2012	423 129	43 524	466 653	442 569	48 531	491 100
2013	408 397	44 801	453 198	411 714	47 219	458 933
2014	402 969	44 763	447 732	404 864	47 327	452 191
2015	399 953	47 291	447 244	408 217	50 797	459 014
2016	398 414	47 031	445 445			

The trends in the number of natural and unnatural deaths from the NPR are presented in Figure 3 which shows a continuation of the marked decline since 2006 in natural causes in the young adult age group, albeit slowing down in the most recent years. This decline is mirrored for children <15 years with a levelling off over a few more years.

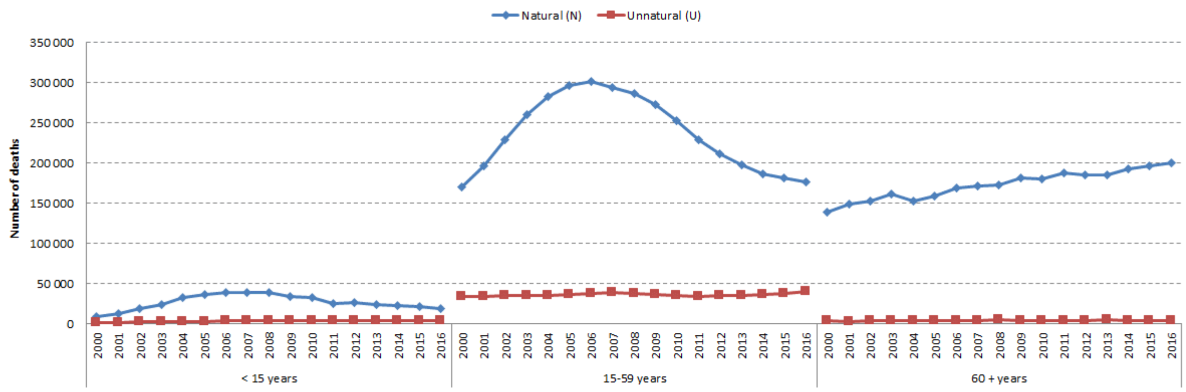


Figure 3: Trend in the number of natural (N), unnatural (U) by broad age group, NPR 2000-2016

The proportion of the VR deaths captured by the NPR increased from 86.3% in 2000 to 99% in 2014 then falling to 97.4% in 2015 (Figure 4). The proportion of unnatural deaths captured by the NPR was at a constant level of approximately 80% until 2004, after which it increased gradually to above 90% for 2011 and then fell back to around 90% in 2012 before increasing further to nearly 95% in 2013 and 2014, and then dropping to 93% in 2015.

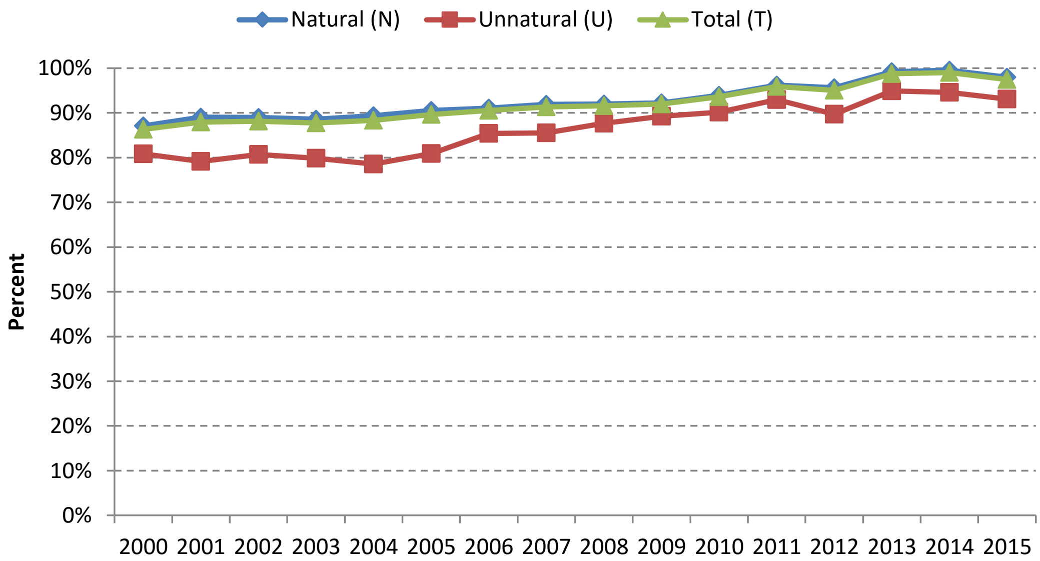
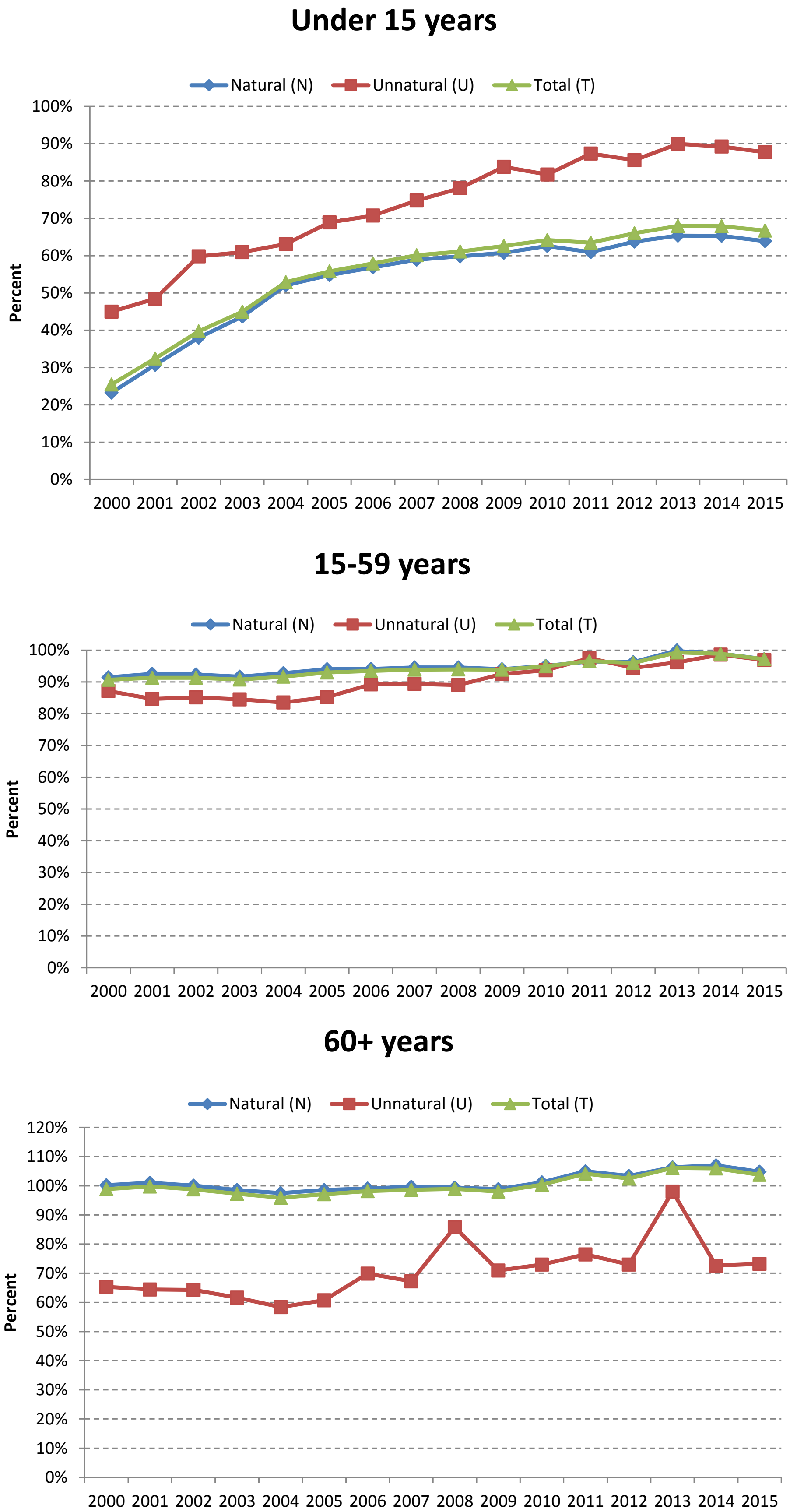


Figure 4: Ratio of NPR to Stats SA data (%) by natural (N), unnatural (U) and total (T) category, 2000-2015

Table 2 shows the numbers of deaths (excluding late registrations) in broad age groups, and the proportion of these VR deaths captured by the NPR is shown in Figure 5 for each age group. There has been a considerable increase in this proportion for children <15 years which then seemed to have been levelling off at about 60% prior to the uptick in 2012 to 2015. In this age group, the proportion of unnatural VR deaths captured by the NPR is higher than the proportion of naturals because in this age group most natural deaths occur at young ages often before the birth is registered whereas the unnatural deaths tend to occur at older ages. While the proportions for the 15-59 year age group remained fairly level, there has been a noticeable increase for 2011 increasing it to over 96% and by 2013 and 2014 it was close to 99% before dropping off slightly for 2015. This trend is also apparent in the proportions in the 60+ year age group, where the proportion has been (inexplicably) over 100% for the natural and total from 2011 onwards. In the case of unnatural deaths in the 60+ year age group, although the proportion has increased since 2005 and reaching 75% in 2011 and hovering around 70% after that, it is unclear why it is so low given the near complete match for natural deaths. This and the blips in the number of unnatural deaths in 2008 and 2013 (shown in red in the table) suggest problems with classification of deaths in the NPR data which require further investigation.

Table 2: Number of natural (N), unnatural (U) and total (T) deaths in NPR in broad age groups compared with Stats SA data by year

	NATIONAL POPULATION REGISTER			STATS SA CAUSE-OF-DEATH DATA		
YEAR	Natural (N)	Unnatural	Total (T)	Natural (N)	Unnatural	Total (T)
	<15 years					
2000	9 682	2 075	11 757	41 548	4 615	46 163
2001	13 378	2 283	15 661	43 534	4 712	48 246
2002	18 995	2 617	21 612	50 006	4 376	54 382
2003	24 439	2 873	27 312	55 995	4 715	60 710
2004	32 401	3 232	35 633	62 263	5 120	67 383
2005	37 031	3 498	40 529	67 593	5 078	72 671
2006	39 168	3 815	42 983	68 856	5 394	74 250
2007	38 859	3 973	42 832	65 924	5 316	71 240
2008	39 058	3 875	42 933	65 288	4 964	70 252
2009	33 833	4 022	37 855	55 679	4 800	60 479
2010	32 341	3 904	36 245	51 669	4 777	56 446
2011	25 374	3 853	29 227	41 633	4 412	46 045
2012	26 687	4 103	30 790	41 829	4 794	46 623
2013	24 412	3 959	28 371	37 337	4 400	41 737
2014	23 540	3 973	27 513	36 044	4 453	40 497
2015	21 440	4 020	25 460			
	15-59 years					
2000	170 044	34 532	204 576	185 872	39 611	225 483
2001	197 284	34 089	231 373	213 129	40 262	253 391
2002	228 815	35 302	264 117	247 697	41 442	289 139
2003	260 984	35 652	296 636	284 618	42 164	326 782
2004	282 753	34 944	317 697	304 713	41 816	346 529
2005	296 196	36 393	332 589	314 932	42 720	357 652
2006	301 284	37 811	339 095	320 223	42 376	362 599
2007	294 608	38 615	333 223	311 530	43 206	354 736
2008	287 152	37 832	324 984	303 474	42 481	345 955
2009	272 906	36 724	309 630	290 139	39 684	329 823
2010	252 244	35 615	287 859	265 233	38 011	303 244
2011	228 128	34 743	262 871	236 509	35 617	272 126
2012	211 243	35 272	246 515	219 489	37 342	256 831
2013	198 414	35 158	233 572	198 577	36 546	235 123
2014	187 034	36 598	223 632	189 093	37 099	226 192
2015	181 597	38 583	220 180			
	60+ years					
2000	139 502	3 635	143 137	139 213	5 561	144 774
2001	149 686	3 463	153 149	148 112	5 377	153 489
2002	153 288	3 644	156 932	153 148	5 668	158 816
2003	161 157	3 679	164 836	163 535	5 971	169 506
2004	152 735	3 752	156 487	156 700	6 430	163 130
2005	159 461	3 754	163 215	161 819	6 179	167 998
2006	169 184	3 819	173 003	170 794	5 465	176 259
2007	171 900	4 018	175 918	172 421	5 974	178 395
2008	172 489	5 064	177 553	173 512	5 905	179 417
2009	181 566	4 114	185 680	183 610	5 799	189 409
2010	180 778	4 078	184 856	178 577	5 589	184 166
2011	188 789	4 136	192 925	179 821	5 410	185 231
2012	185 199	4 149	189 348	179 108	5 684	184 792
2013	185 571	5 684	191 255	174 491	5 799	180 290
2014	192 395	4 192	196 587	179 727	5 775	185 502
2015	196 916	4 688	201 604			



* The disruptions in 2008 and 2013 appear to be the result of errors in the NPR data, highlighted in Table 2.

Figure 5: Ratio of NPR to Stats SA data (%) in broad age groups by natural (N), unnatural (U) and total (T) category, 2000-2015

CORRECTING FOR INCOMPLETENESS

Figures 6 to 11 compare the numbers of deaths, in total and for various age ranges, as reported by Stats SA (VR), from the National Population Register (NPR), together with the VR adjusted for incompleteness of registration (Adj VR), the NPR adjusted for registered deaths of people not on the National Population Register (Est VR) and this number further adjusted for incompleteness of registration of deaths (Est Adj VR). They all tell a similar story, namely, that, allowing for late registrations, there was a great deal of consistency between the NPR and VR data until 2014, after this year the VR data appear to be under-recorded relative to the NPR data, sometimes to the point where what should be a subset of VR deaths on the PR is bigger than the total number of VR deaths!

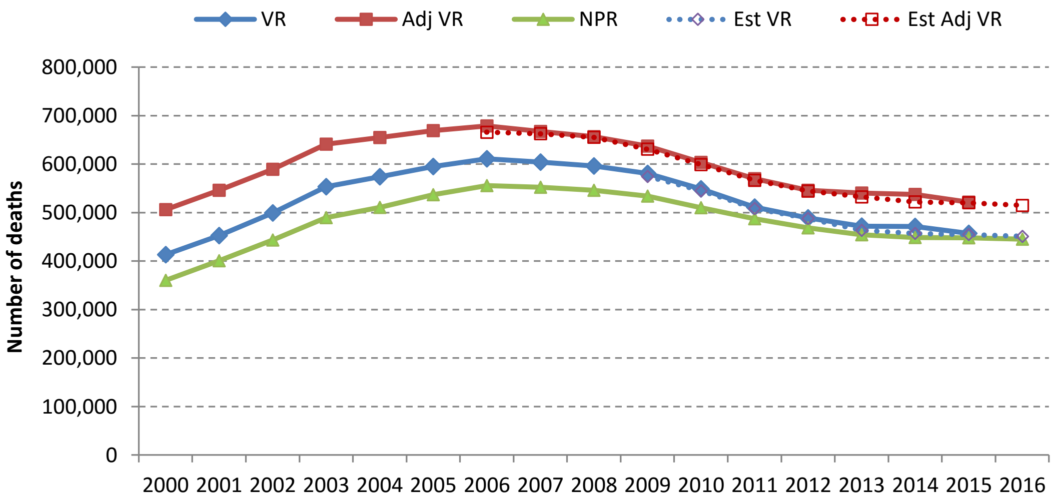


Figure 6: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Total deaths

While there were slight differences for the period 2006-2008 in the other age ranges, in total (Figure 6) and for ages 15-59 (Figure 10), the adjustments to the NPR data appear to work very well up to 2012. However, there is a clear difference in the number 60+ from 2013. Once again, for some, yet to be investigated reason, the numbers of VR death in these age groups is lower than expected on the basis of the NPR data. Since the only ways for the VR data to be lower than estimated from the NPR data are for there to have been an increase in the proportion of births being registered, which does not seem likely, particularly for adults, or for some deaths recorded on the NPR not being processed by Stats SA, this difference is puzzling. This issue is in need of further investigation.

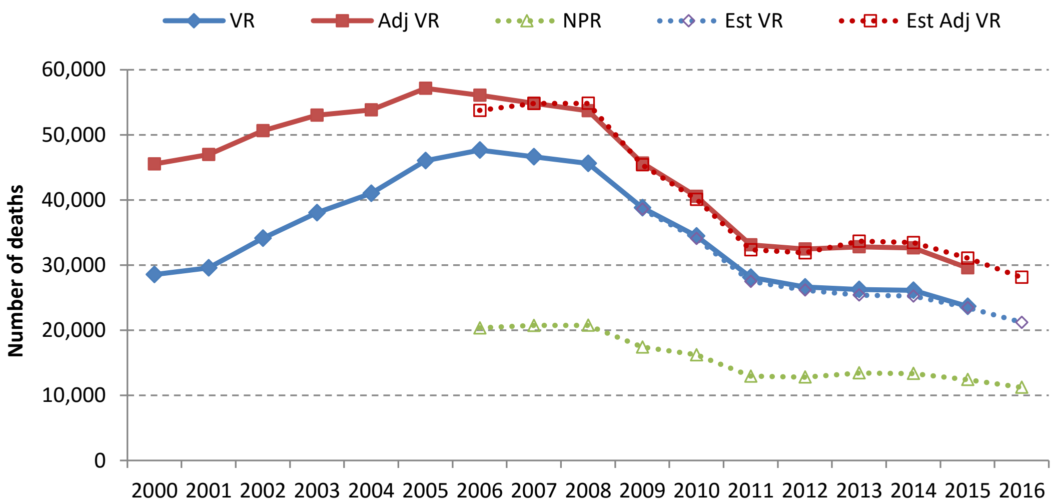


Figure 7: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Deaths < 1

The comparison of the number of deaths under the age of 1 year (Figure 7) indicate the large (but declining over time) adjustment required for deaths of babies not on the NPR. However, despite the uncertainty introduced by having to make such a large adjustment, the estimates produced from the NPR data appear quite reasonable at least until 2013 (when there appears to have been a slight drop in completeness of registration). Thus according to the NPR data the number of deaths under age 1 year (and ages 1-4 years (Figure 8)) appear to be continuing to decline after a slowdown in 2012-2014.

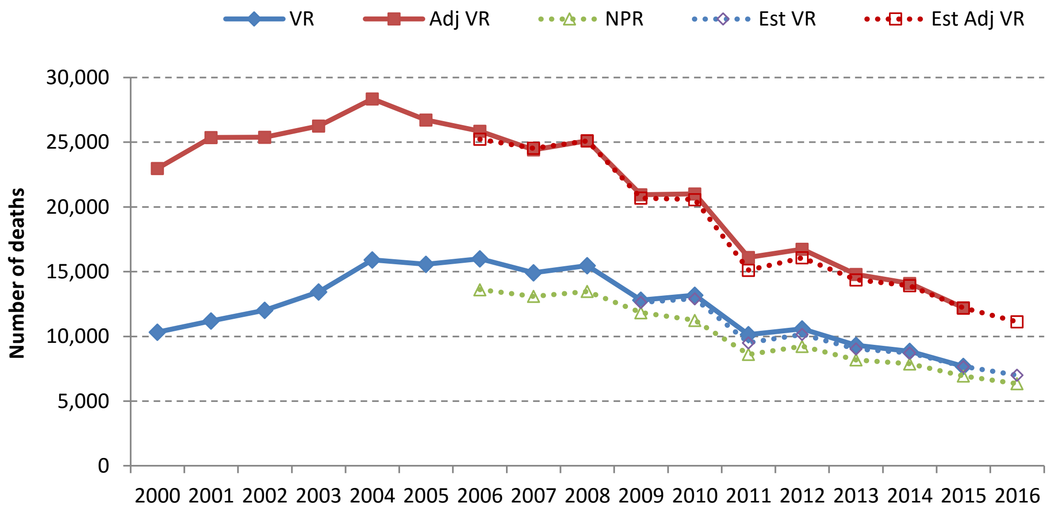


Figure 8: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Deaths 1-4

The adjustment required to account for deaths of children under the age of 15, particularly those under the age of one, produces estimates that are slightly out for the years 2006-2008 (Figures 8 to 9). However, after this period, the estimates appear to be very consistent, with only a slight difference in the Adj VR for ages 1-4 years in 2001-2012.

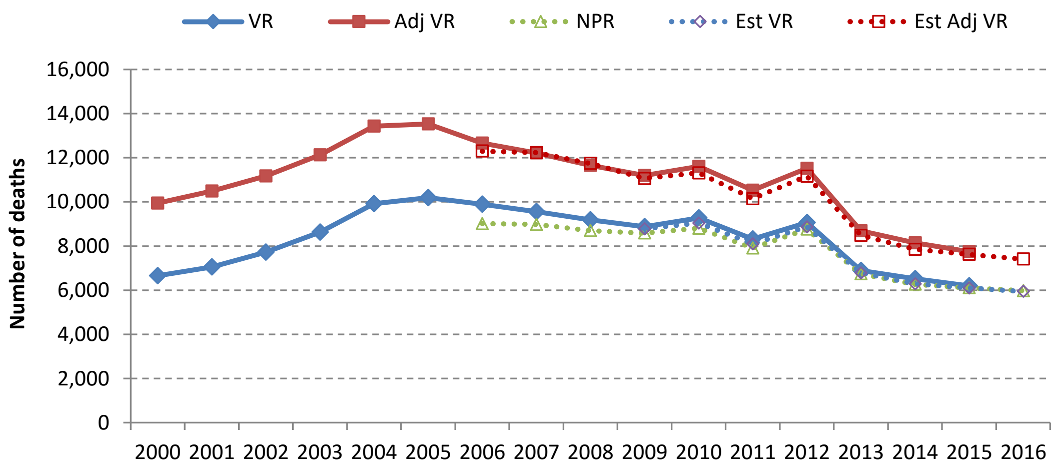


Figure 9: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Deaths 5-14

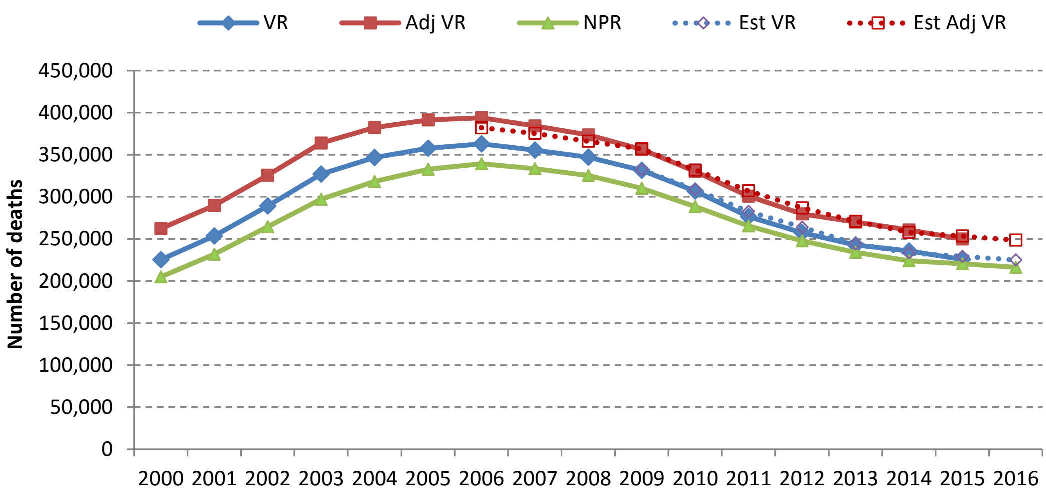


Figure 10: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Deaths 15-59

As shown in Figure 11, it appeared as if up until 2010 the number of deaths captured on the NPR was virtually the same as those ultimately reported by Stats SA, suggesting that virtually everyone aged 60 and above is on the NPR. However, once again, something appears to have changed since 2013, with the NPR capturing significantly more deaths than are reported by Stats SA.

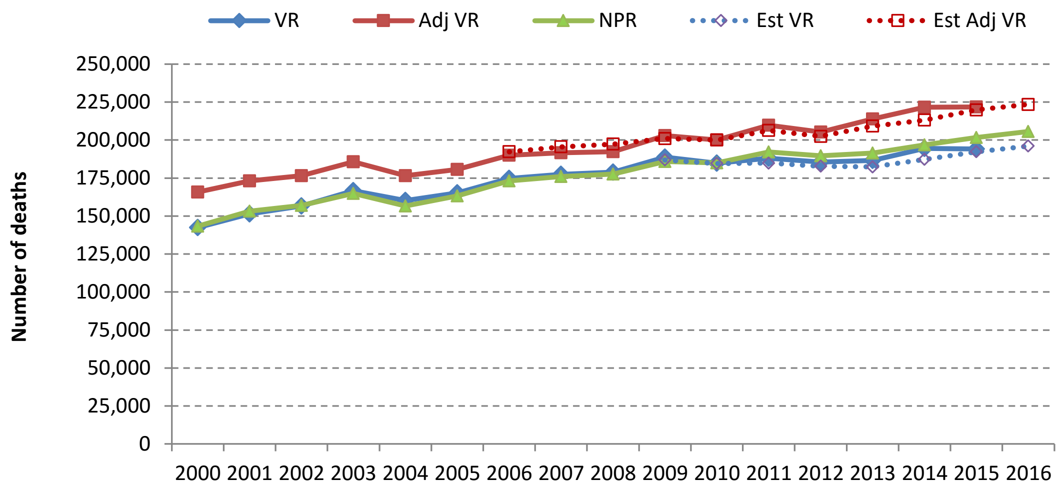


Figure 11: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Deaths 60+

LIFE EXPECTANCY AND ADULT MORTALITY

The life expectancy at birth as well as the adult mortality index, ${}_{45}q_{15}$, representing the probability of a 15-year-old person dying prematurely before the age of 60 years, are shown in Table 3 for the period 2012-2015. The trends in these indicators since 2000 are shown in Figures 12 and 13. It can be seen that life-expectancy have increased since 2005 with particularly rapid progress between 2010 and 2011. This is mainly due to a significant decline in the mortality of those under the age of 1, but is also due to a decline in adult mortality, probably as a result of the extensive roll-out of ARVs.

The estimate of ${}_{45}q_{15}$ in 2015 derived using the VR data is lower, and those of e_{60} after 2012 higher, than estimates based on NPR data, which probably reflects deaths missing from the VR dataset, and thus it is assumed that in these cases the estimates from the NPR data are the more accurate. These show a definite levelling off in trend in recent years.

Table 3: Estimated life expectancy and adult mortality (${}_{45}q_{15}$), RMS 2012-2016

INDICATOR	2012	2013	2014	2015	2016
Life expectancy at birth Total	61.2	62.2	62.9	63.4	63.8
Life expectancy at birth Male	58.5	59.4	60.0	60.3	60.8
Life expectancy at birth Female	64.0	65.1	65.8	66.4	66.9
Adult mortality (${}_{45}q_{15}$) Total	38%	36%	34%	34%	33%
Adult mortality (${}_{45}q_{15}$) Male	44%	42%	40%	40%	39%
Adult mortality (${}_{45}q_{15}$) Female	32%	30%	28%	28%	27%

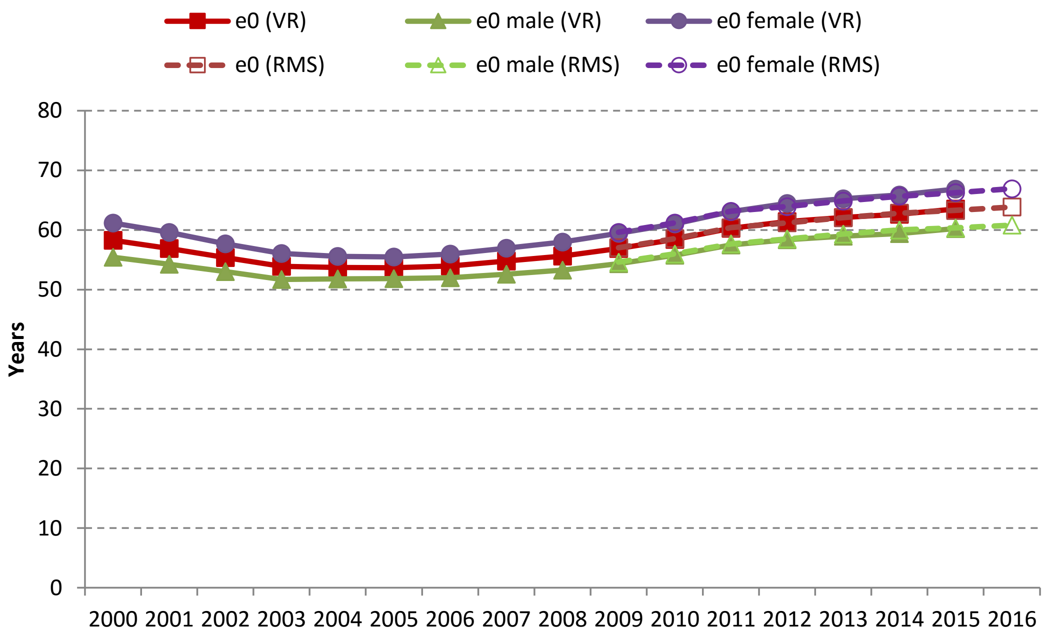


Figure 12: Life expectancy (e_0) from VR and RMS, 2000-2016 (after adjusting for incompleteness)

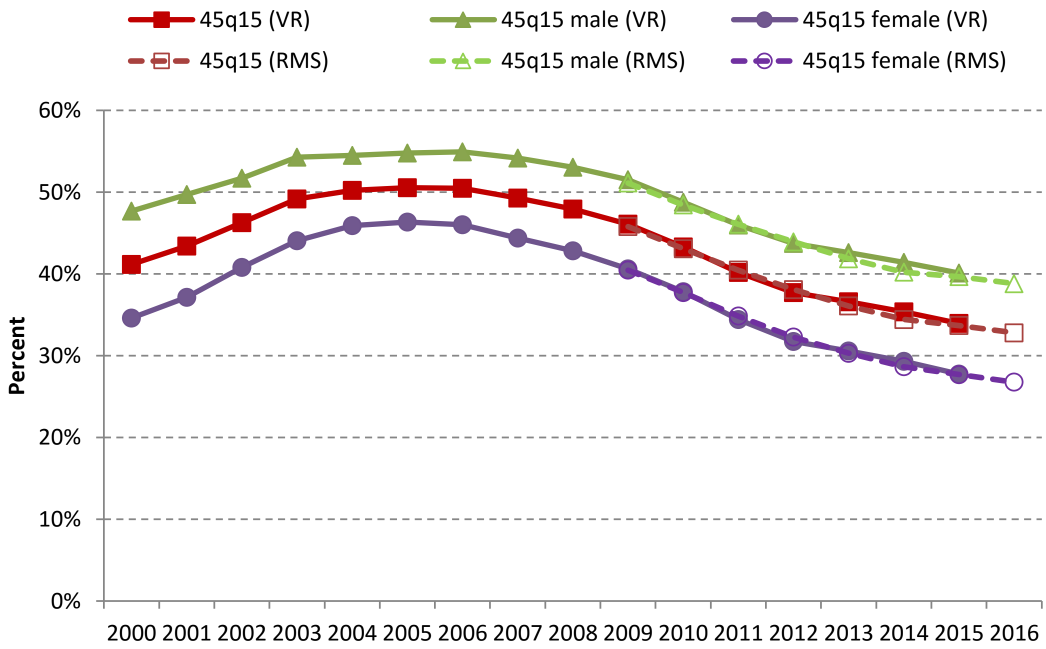


Figure 13: Adult mortality ($_{45}q_{15}$) from VR and RMS, 2000-2016 (after adjusting for incompleteness)

The trend in older-age mortality is tracked using the index e_{60} (the average life expectancy of people who have survived to age 60), and is shown in Figure 14. As can be seen from this figure, the mortality of older adults appears not to have changed much since 2001. The average life expectancy at the age of 60 remains about 15 years for men and 19 years for women.

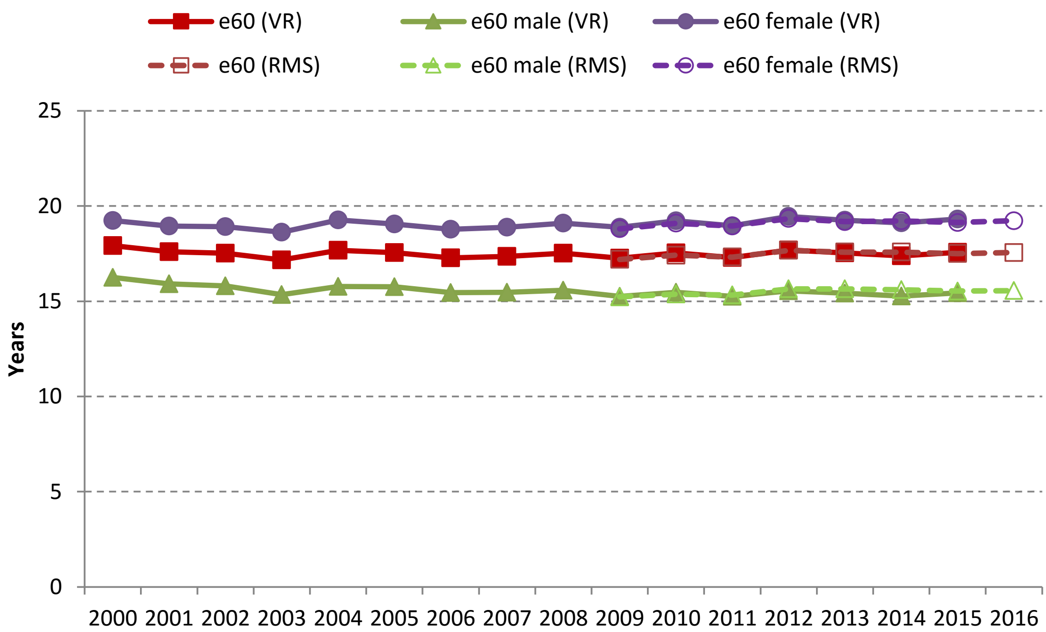


Figure 14: Life expectancy at the age of 60 (e_{60}) from VR and RMS, 2000-2016 (after adjusting for incompleteness)

CHILD MORTALITY (U5MR, IMR, NMR)

The annual number of deaths under 5 years of age on the NPR has declined from 34 006 in 2006 to 17 575 in 2016. The number of deaths by month, compared with the number of deaths reported by Stats SA for 2011-2015, is shown in Figure 15. It can be seen that there is a high degree of correspondence between the two series, with the marked seasonal effect all but disappearing as the numbers decline. However, the number of deaths are still increased over the winter months from May-August, particularly for 2015 and 2016.

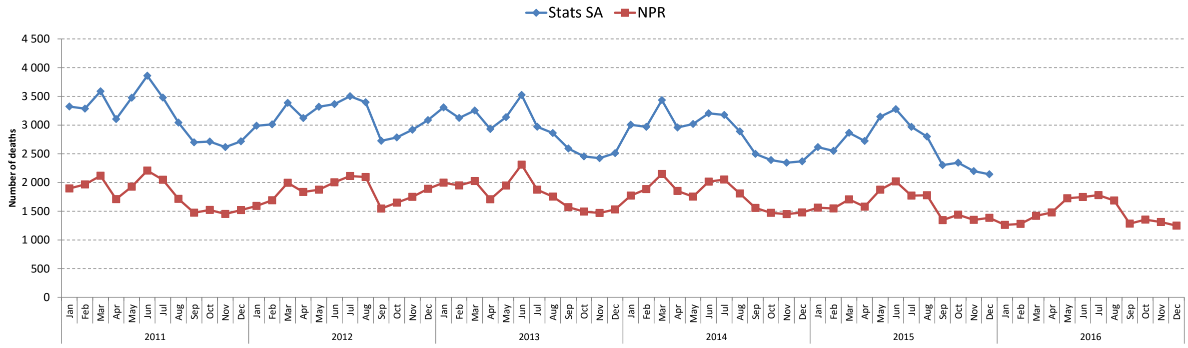


Figure 15: Monthly number of child deaths under 5 years from Stats SA and NPR, 2011-2016

The trends in selected causes in the Stats SA data for 2010-2015 are shown in Figure 16. Although the peaks are lower in the more recent years, both diarrhoeal deaths (ICD code A09) and pneumonia deaths (ICD code J18) show characteristic seasonal patterns. In 2011, the diarrhoeal deaths peaked in Feb-March and the pneumonia deaths in June. The overall effect was a unimodal peak from March-June. The deaths from causes originating in the perinatal period (ICD codes P00-P99) do not follow any seasonal trend, while the deaths without any cause (ICD code R99) tend to follow the pneumonia pattern with a winter peak. The HIV deaths (ICD codes B20-B24), including pseudonyms (ICD codes B33 and D84), are much lower than expected, reflecting the tendency of not disclosing HIV on death notifications. The trend in the HIV deaths indicates a very mild seasonal effect. Deaths from diarrhoeal diseases showed a considerable decline between 2008 and 2009, with a substantial drop in the summer peak and a smaller drop in the May peak. It remains a challenge to know what contribution the reductions in HIV infection, the introduction of new vaccines, and improved access to water and sanitation have made to the decrease. However, generally, as the U5MR decreases, deaths due to perinatal conditions, which have remained quite stable, contribute a higher proportion of the deaths.

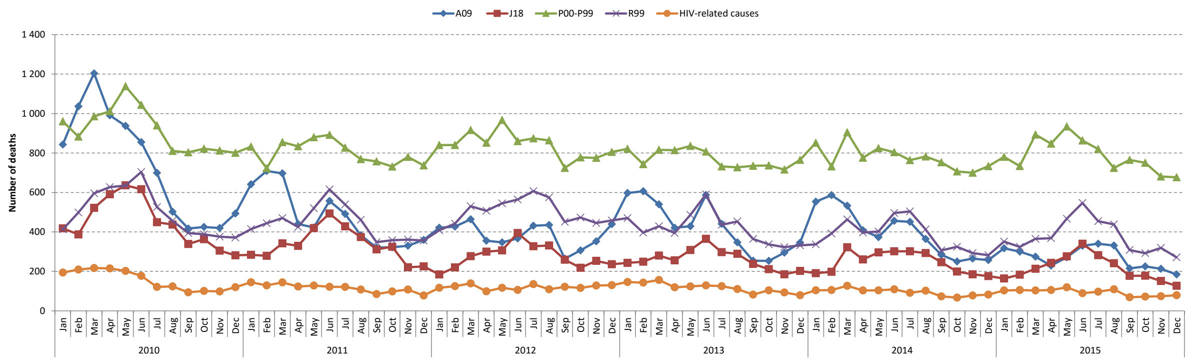


Figure 16: Number of child deaths under 5 years of age by selected cause-of-death, Stats SA 2010-2015

Figure 17 shows the monthly number of deaths from the NPR by year (with the lines becoming darker as the years progress to 2015), indicating the decline in the number of deaths under 5 years accompanied by an attenuation of the seasonal effect particularly between 2010 and 2011. From 2011 there is no clear pattern of deaths by months (with the possible exception of a high point in May to August and low points in September to April) with little change in the overall level.

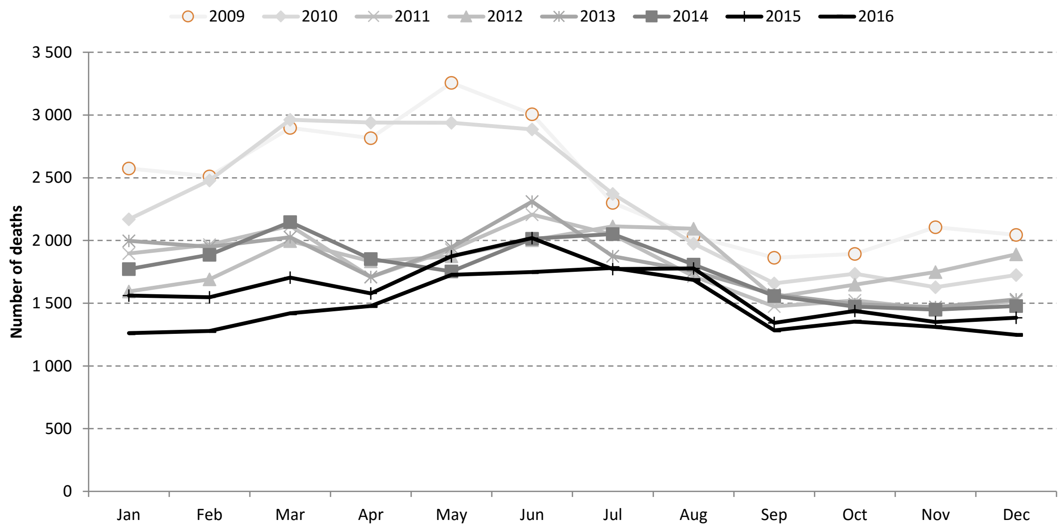


Figure 17: Number of child deaths under 5 years by month, NPR 2009-2016

When compared with the vital registration data from Stats SA, it is found that neonatal deaths on the NPR account for only a small proportion of the registered deaths. In addition, this proportion is not stable over time. For these reasons, it is necessary to consider an alternative data source to monitor the level of NMR. Figure 18 shows the number of neonatal deaths and stillbirths from the DHIS compared to the number of neonatal deaths from the cause-of-death data from vital registration (VR). It can be seen that the neonatal deaths from the VR data were fairly steady from 2006-2009 but declined over the next four years after which they appear to have levelled off. The number of neonatal deaths in the DHIS, on the other hand, has increased steadily from 2008-2014 and then declining, overtaking the VR deaths in 2012. While at the same time the VR data of registered stillbirths shows little change over the period at a level of about 15 000, whereas the stillbirths captured by the DHIS has declined steadily over the whole period, particularly from 2015 to 2016.

The VR system misses neonatal deaths that have not been registered, while the DHIS misses the deaths that occur in the private sector or at home. In 2008, the DHIS captured 72% of the VR neonatal deaths, 75% in 2009, and 86% in 2010. However, in 2011, the number of neonatal deaths in the DHIS matched the number of the VR neonatal deaths and since then has risen above the numbers of VR deaths in recent years.

Since both the proportion of VR neonatal deaths that are captured by the DHIS and the number of neonatal deaths relative to the number of stillbirths captured by the DHIS increased over this period, it is probable that, certainly up to 2012, the increase in number of neonatal deaths from the DHIS was mainly due to an increase in coverage. To allow for this increase in coverage, the completeness of the DHIS relative to the VR neonatal deaths for 2010-2012 was estimated as the completeness for the previous year plus any increase in the ratio of neonatal deaths to stillbirths over the previous year from the DHIS data. As a check of the reasonableness of the method, the estimate of DHIS as a proportion of VR data for 2009 is 73% vs the true estimate of 72%, while that for 2010 was 76% vs the true estimate of 86%. Although the difference in 2010 is unsatisfactory, the resulting error in the estimate of NMR is less than 10%. As the proportion of VR that are captured by the DHIS increases the difference between the estimates of the proportion reduces. However, since the number of neonatal deaths recorded by the DHIS has exceeded those recorded by the VR since 2012 (significantly so for 2014 and 2015) it seems more appropriate to assume that part, if not all, the decline in VR neonatal deaths is due to a decline in completeness of registration commented on in previous reports. Thus for this report we have decided to estimate the neonatal mortality directly from the DHIS record of neonatal deaths (instead of VR neonatal deaths) and live-births recorded by the DHIS.

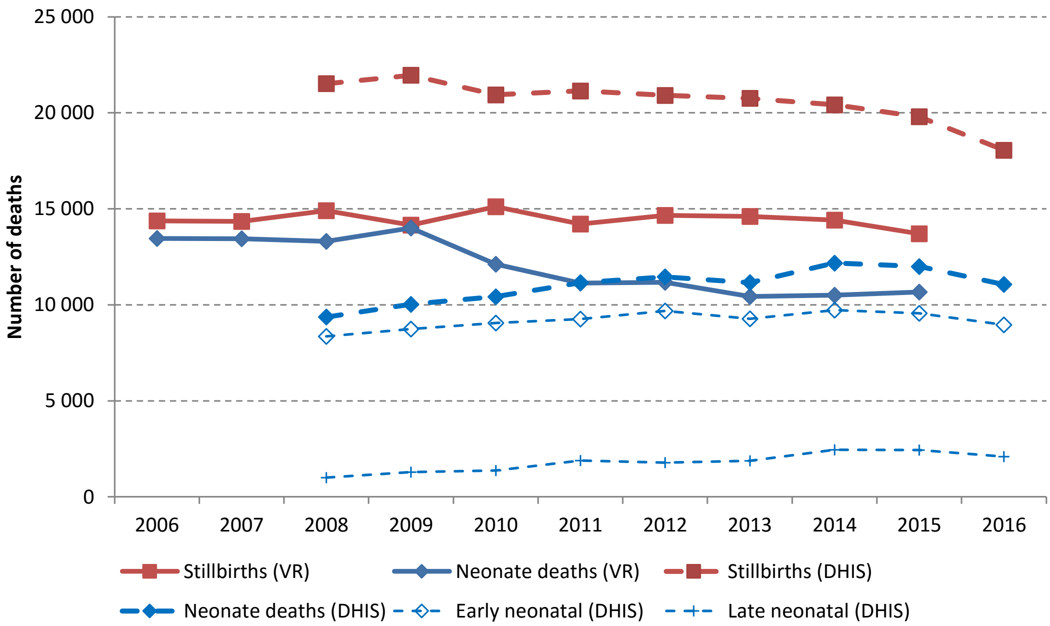


Figure 18: Stillbirths and neonatal deaths from VR and DHIS

Estimates of the key indicators of mortality for children are shown in Table 4 for the period 2009-2015, together with the reworked targets recommended by HDACC. Figure 19 shows the U5MR, IMR and NMR. The U5MR and IMR are calculated from VR data for the period 2006-2015 and from the NPR data for the period 2009-2016, once the data have been adjusted for under-registration. The NMR is estimated from the registered deaths (adjusted for under-registration) for the period 2006-2015 and the DHIS (adjusted for under-coverage, relative to the registered deaths, and the incompleteness of the vital registration) for the period 2011-2016. From Figure 18, we can see that the estimates of the NMR derived from the DHIS are reasonably consistent with those derived later from the VR data, and that the NMR has declined gradually from 14 per 1 000 live births to 11 per 1 000 live births (below the HDACC target) for the period 2009-2013 then increased slightly to 12 per 1 000 in 2014 and 2015. The IMR and the U5MR declined rapidly since 2008, and by 2011 are well below the targets recommended by HDACC. However, the rates remained unchanged for 2012-2014 before again falling in 2015.

Also included on the figure are estimates of IMR and NMR estimated directly from VR data (i.e. registered deaths without adjustment for incompleteness and the number of births registered up to the end of the registration year after the year of birth, also not corrected for incompleteness), as well as the direct estimation (without correction for incompleteness) of the NMR using the neonatal deaths from the DHIS. These estimates confirm that it is to produce as accurate estimates of the NMR and IMR from the recorded data directly. From this year the NMR is being estimated from the DHIS deaths and births directly.

Table 4: Estimated U5MR, IMR and NMR, RMS 2012-2015 and DHIS 2012-2016

INDICATOR	TARGET 2019	BASELINE 2012	2013	2014	2015	2016
Under-5 mortality rate (U5MR)	33* (20% reduction)	41 per 1 000 live births	41 per 1 000 live births	40 per 1 000 live births	37 per 1 000 live births	34 per 1 000 live births
Infant mortality rate (IMR)	18	27 per 1 000 live births	28 per 1 000 live births	28 per 1 000 live births	27 per 1 000 live births	25 per 1 000 live births
Neonatal mortality rate (<28 days) (NMR)	6	12 per 1 000 live births	11 per 1 000 live births**	12 per 1 000 live births**	12 per 1 000 live births**	12 per 1 000 live births**

* Assumed published figure of 23 was typographical error
** Changed method to derive directly from DHIS neonatal deaths and live births rather than VR deaths and births from 2013

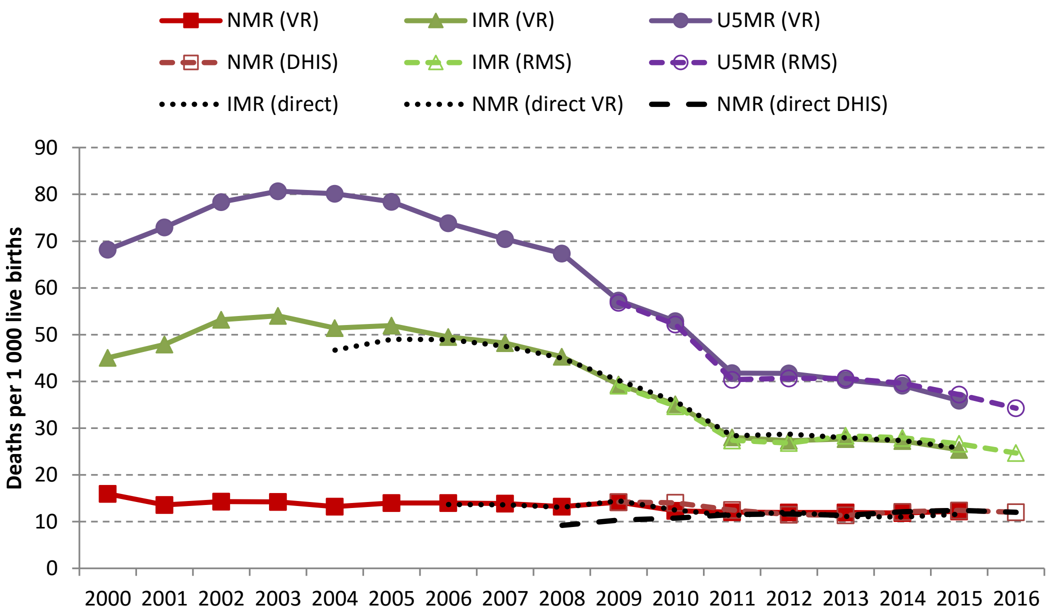


Figure 19: Under-5 mortality rate (U5MR) and infant mortality rate (IMR) from VR/RMS and neonatal mortality rate (NMR) from VR/DHIS, 2000-2016 (after adjusting for incompleteness)

MATERNAL DEATH

The uncertainty about the level of maternal mortality is well recognised (HDACC, 2011; Bradshaw and Dorrington, 2012; Stats SA, 2013c; Dorrington and Bradshaw, 2015). The estimated MMR rose from 287 per 100 000 live births in 2008 to peak at 307 per 100 000 live births in 2009 before dropping substantially to 154 per 100 000 live births in 2014 (Table 5).

Table 5: Estimated MMR, Stats SA 2011-2015

INDICATOR	TARGET 2019	2011*	2012	2013	2014	2015
Maternal mortality ratio (MMR)	Downward trend below 100	200 per 100 000 live births	165** per 100 000 live births	154** per 100 000 live births	164** per 100 000 live births	152 per 100 000 live births

* Baseline for MMR set at 2011 due to lag in availability of data

** Slight changes from previous years due to a change in the method used to estimate the numbers of births

Figure 20 shows the estimates of the maternal mortality ratios (MMRs) and pregnancy-related mortality ratios (PRMRs) produced from different data sources. (By definition, the MMR includes direct and indirect maternal causes of death, while the PRMR also includes incidental deaths during the pregnancy risk period.) The values from vital registration and the confidential enquiry increase to a peak at the same time and appear to match up to 2008 after which the confidential enquiry estimates are about 30% higher than those estimated from VR data. After the peak they both decline, and provide values that are much lower than the RMS/MDG estimates until recent years when they are very similar. It is somewhat surprising that the RMS estimates should be so close to that of the confidential enquiry. This would suggest that maternal deaths that occur outside state facilities at about the same rate as those that occur within these facilities which seems a little implausible. It raises concerns about the VR data for 2013-14. Although late registrations of deaths may increase the estimates slightly, judging by the change in estimate for 2013 from last year due to late registrations, the impact is limited.

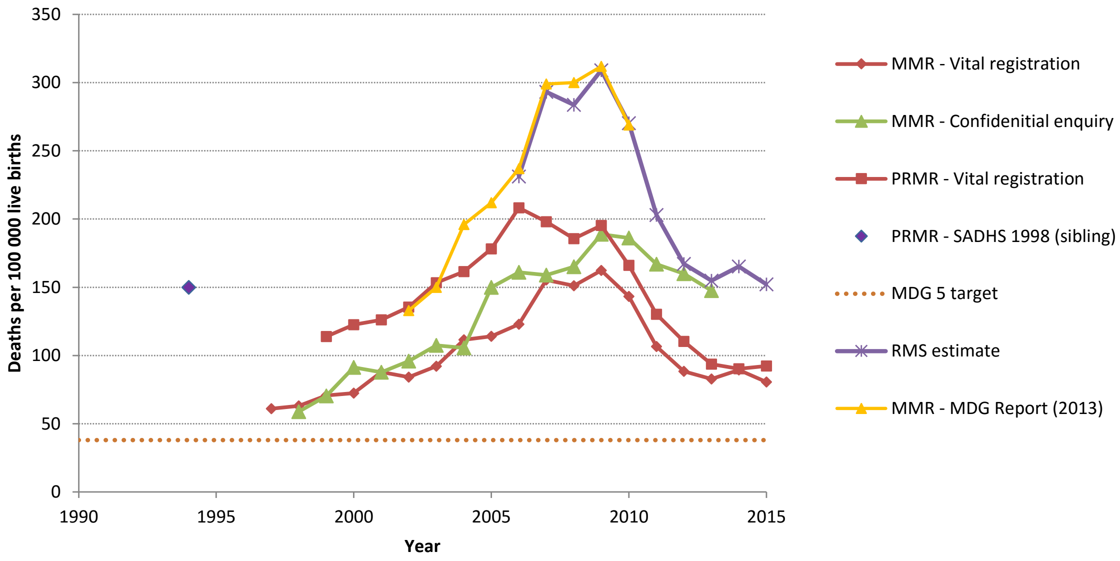


Figure 20: Estimate of MMR from various sources, 1995-2015
Source: Adapted and updated from Bradshaw and Dorrington, 2012

Nonetheless, the RMS estimates, as well as those reported in the 2013 MDG Country Report (Stats SA, 2013c), and the institutional MMR reported by the National Committee for Confidential Enquiry into Maternal Deaths (Pattinson, Fawcus and Moodley, 2013), indicate that maternal mortality may have peaked in 2009. The decline may primarily be the result of extensive provision of ARVs to pregnant women and the change in the ARV guideline to initiate HAART at a CD4 count of 350 cells/mm^3 (announced on 1 December 2009), as well as the move to use efavirenz instead of nevirapine when initiating women on HAART after the first trimester. Interestingly although the maternal mortality ratio from VR also peaks in 2009, the ratio based on pregnancy-related deaths as reported in the VR data peaks three years earlier.

The numbers of registered deaths from maternal causes shown in Figure 21 indicate a marked increase in the number of indirect maternal deaths since 2003. As noted by Bradshaw and Dorrington (2012), the timing of the increase in indirect maternal deaths is possibly surprising given that the rapid increase in the mortality of women aged 15-49 due to HIV started some 7-8 years ago and peaked some 2-3 years before 2008. Longer exposures to HIV infection, adverse effects of antiretroviral therapy or changed death certification practice are possible reasons for the delayed increase, but deciding which would require further investigation. However, what is of interest from Figure 20 is the fact that there appears to have been a drop in the number of deaths from every cause since 2009, with a sizeable decline in “Complications from other conditions” from 2011 to 2012, followed by a further decline over the next year. To what extent the declines in the most recent years are connected to the apparent under-reporting is still unclear. However, it is also of interest to note that there were no decline in “Complications from other conditions” for 2012-2014 and yet deaths from these causes are three times the level they were in 2003. The decline in numbers due to other causes appear also to have ceased since 2013 with the exception of “Complications from other conditions”, which dropped sharply from 2014 to 2015, but is still two and half times higher than in 2003.

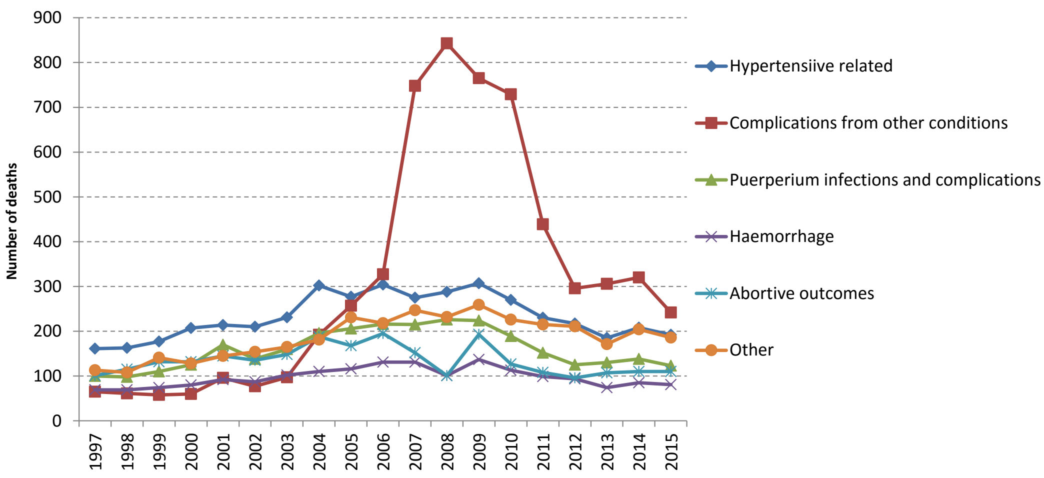


Figure 21: Trend in the number of maternal deaths by cause, Stats SA 1997-2015

COMPARISON WITH ESTIMATES FROM OTHER SOURCES

A natural question to consider is how the estimates derived in this report compare with those presented elsewhere. Where appropriate, the VR/NPR estimates are compared with those from Stats SA (from the MDG country report[4], the official mid-year population estimates, the SDG and other ad hoc reports), UN agencies (WHO and UN Population Division), their advisory groups including the UN Inter-agency Group for Child Mortality Estimation (IGME) and the Maternal Mortality Estimation Interagency Group (MMEIG) and the Gates funded Institute for Health Metrics and Evaluation (IHME) based at Washington State University (in particular the estimates from the 2013 and 2015 Global Burden of Disease (GBD) reports (not shown), and the 2016 GBD report). In addition, this year we have included comparison of under-five and neonatal mortality with estimates from the 2016 South African Demographic and Health Survey (NDoH, StatsSA, SAMRC & ICF, 2017).

Figure 22 compares the estimates of under-five mortality. There is broad agreement between the RMS estimates and those of IGME (United Nations Interagency Group on Child Mortality Estimation 2017) over most of the period, those of the World Population Prospects (WPP), 2017 revision, (UN Population Division 2017) in the first half of the period, and the MDG from 2007-2010 and the SDG (2017d) estimates for 2010 and 2011. While the estimates from the official mid-year population projection are quite a bit higher from 2010 and even a little different from those in the WPP (which underlie the Spectrum model used by Stats SA to produce the mid-year estimates), the 2013 GBD (Wang et al 2014) are higher than any of the other estimates for years prior to 2010. Previously, we (Dorrington et al 2015), suggested that these rates were too high, which may be the reason for the reduction in the more recent GBD estimates (IHME, 2016 & Naghavi et al., 2017). However, these more recent estimates are now somewhat higher than all other estimates from 2006-2010 and remain significantly higher than ours from 2006 onwards (with a decidedly odd trend over time). There is good agreement with estimates from the MDG report from 2007 onwards, although prior to this the MDG estimates are implausible. On the other hand the SDG estimates after 2011 are lower than all other estimates suggesting that these probably underestimate under-five mortality. Although the UN IGME now take the RMS estimates into account when producing their estimates, it is unable to incorporate into their modelling the apparent stagnation in rates from 2011. The estimates from the official mid-year estimates (Stats SA 2017) are lower than estimates of all the other models at the peak and as high if not higher than other estimates from 2011 onwards, which suggests that they underestimate the peak (around 2003) and overestimate under-five mortality in recent years. On the other hand their estimates using the 2011 Census data (Stats SA 2015c) are lower that all other estimates, which suggests that these underestimate mortality. The estimate are not consistent with those from the SADHS 2002-2006, which is undoubtedly due to the bias in the SADHS estimates due to fact that women infected with HIV have died and thus there is no record of the mortality of their children. Other than that the estimates are largely consistent with those from the SADHS for the past 10 years, suggesting that the recent estimates from other sources are probably on the high side.

The picture is similar for IMR (not presented), with the exception that relative to the U5MR, the 2016 GBD assume higher IMR (over 73% of U5MR) than do the other sources (averages 68%) when the U5MRs are around 80, which results in the estimates of IMR being even higher relative to those of the RMS. The RMS and IGME estimates are similar for 2002-2010, after which the RMS estimate a greater decline to 2011 and then little change to 2014 after which they decline slowly, whereas the IGME rates show little decline after 2010, ending up, along with most other recent estimates about 10 per mille higher than the RMS estimates. The SADHS estimate of IMR for last five years is much higher than the RMS estimates and thus more consistent with the other recent estimates, which suggests that the RMS estimates of IMR may be too low in recent years. However, it is also substantially higher for the previous five years, and given that the SADHS estimate of neonatal mortality appears to be too high in the past 10 years, further investigation is needed to determine the true extent of the errors.

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[4] According to the MDG report (Stats SA, 2013c), the MDG estimates are from the 2013 mid-year estimates (Stats SA, 2013b), which have been derived using the Spectrum model. However, the MDG estimates do not seem to have corrected for the fact that the estimates are not for the regular calendar year but for the year starting six months earlier, while the mid-year estimates appear to have been corrected.

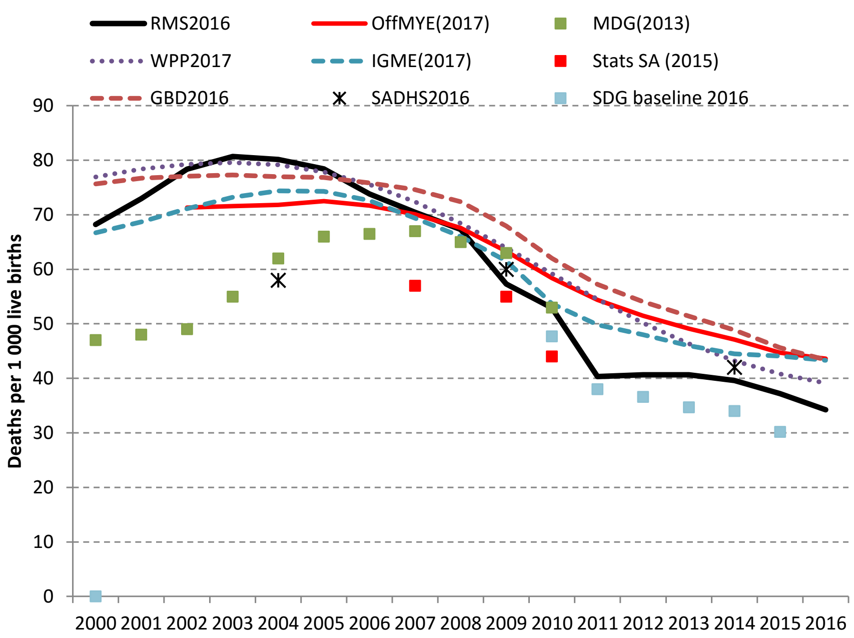

Figure 22: Comparison of estimates of the under-5 mortality rate (U5MR), 2000-2016

Figure 23 compares the life expectancy at birth with those from other sources. It shows that, while there is some consistency in the overall conclusion that life expectancy reached a minimum around 2004/2005, the estimates of the level differ, with the RMS estimates one and four years higher than the IHME estimates (Naghavi et al. 2015; IHME 2016b; IHME 2017) and two years higher than the WPP 2017 estimates. About one year of the difference in the level from the WPP life expectancies is due to higher WPP adult mortality, the rest of the difference between the RMS and other life expectancies is mainly due to differences in under-five mortality. The official mid-year estimates (Stats SA 2017c) are almost entirely consistent with the RMS estimates (despite noticeable difference in the mortality under age five).

In all cases the life expectancy of females is higher than that of males throughout the period with the difference higher in 2000 than in 2013 and beyond, and declining to a minimum in 2005 (not presented). However, while according to the RMS the difference declined from 5.7 years in 2000 to 3.6 years in 2005 before rising to 5.1 years in 2010 and 6.4 in 2015, the comparable figures for GBD2016 (IHME 2016a) were 5.9 years, 2.7 years, 3.1 years and 6.1 years, somewhat different from those for WPP, namely, 6.2 years, 4.9 years, 5.9 years and 7.1 years respectively.

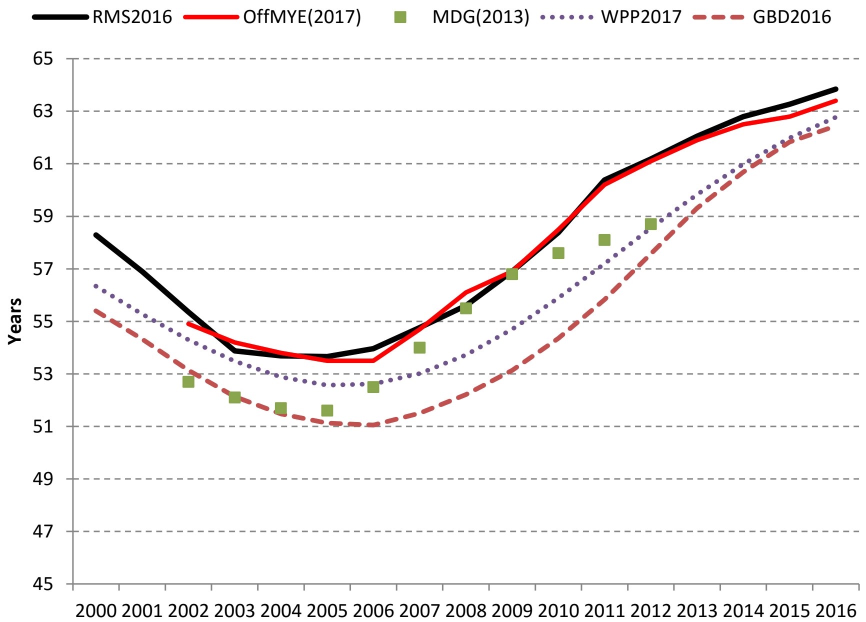

Figure 23: Comparison of estimates of life expectancy at birth (e_0), 2000-2016

Although there is consistency between the RMS, and MDG and SDG estimates of MMR (Figure 23), this is mainly because the same method and similar data were used for these estimates. In truth, as pointed out by Dorrington and Bradshaw (2015), there is a great deal of uncertainty surrounding the estimates of this indicator, and not all of it is random, as reflected by the three quite different estimates (not shown) produced by IHME[5] (Hogan et al 2010, Lozano et al 2011 and Kassebaum et al 2014) prior to the latest, and different yet again, GBD 2015 (IHME 2016a) estimate and the two quite different estimates produced by MMEIG, two years apart (WHO et al 2012 & 2014) (not shown) and the most recent estimate (MMEIG 2016). The latest, GBD2016 estimates from IHME (2017) are similar to the GBD2014 estimates, peaking higher than any other estimates and ending about 50 per 100 000 higher than GBD2015 in 2015. However, the fact that the RMS estimates lie comfortably in the cloud of uncertainty suggests that they are at least as reliable as any of the estimates shown in Figure 24. Surely, they are more sensible than estimates that suggest that HIV/AIDS had no impact on maternal mortality or estimates that suggest the ratio peaked several years before adult mortality rates peaked because of HIV/AIDS.

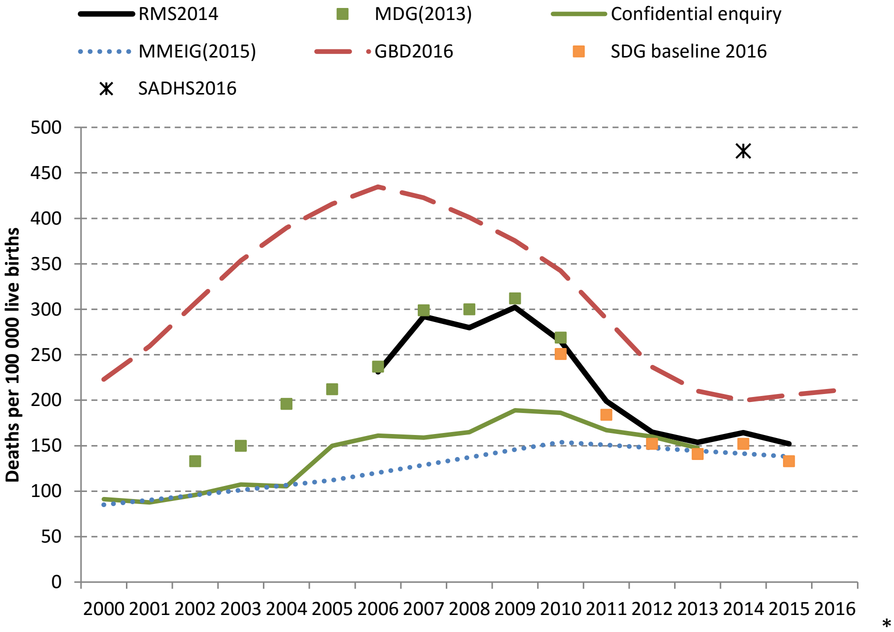

Figure 24: Comparison of estimates of maternal mortality ratio (MMR), 2000-2016

As far as adult mortality is concerned (Figure 25), the RMS estimates lie below both the WPP and IHME estimates but are very close to the WPP estimates. However, the WPP estimates do not show the slow the levelling off of rates (due to limiting impact of ARVs) found in the RMS estimates.

As indicated above, the IHME estimates of life expectancy at birth are lower that all the other estimates, which is consistent with their estimates of adult mortality being quite a bit higher than both the RMS and the WPP estimates (Figure 25).

[5] Although usually one would simply accept the most recent set of estimates from an institution, in the case of IHME, the estimates available via their website tool are still the older estimates, and for both the IHME and MMEIG, the sizeable difference between recent estimates gives a good indication of the uncertainty about the estimates.

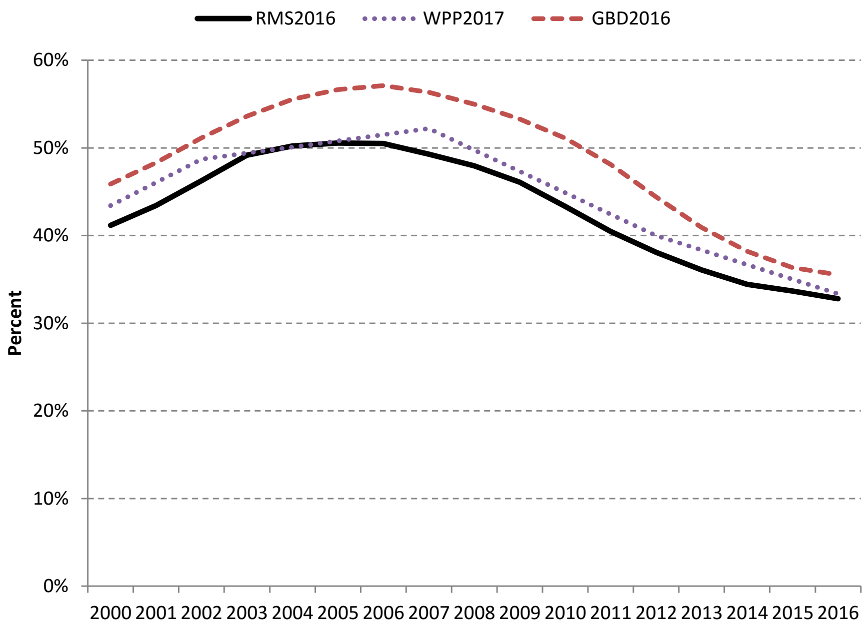

Figure 25: Comparison of estimates of adult mortality ($_{45}q_{15}$) for males and females combined, 2000-2016

Although it is difficult to assert that the neonatal mortality in South Africa is as low as that estimated by the RMS (Figure 26), it is important to point out that the IHME estimates (only the 2016 GBD shown) (IHME 2015; IHME 2016b, IHME 2017) imply implausibly high completeness of reporting of post-neonatal deaths in in some years (in the case of the GBD 2015 the post-neonatal deaths are actually lower than the registered deaths in years 2006-2008). In addition comparison of estimates of stillbirths suggest that it is possible that the GBD 2016 and SADHS underestimate by about 7 per 1,000, which might be connected to the overestimate of neonatal mortality. On the other hand the IGME rates match so closely that it is probable that they are merely a smoothed version of the RMS rates.

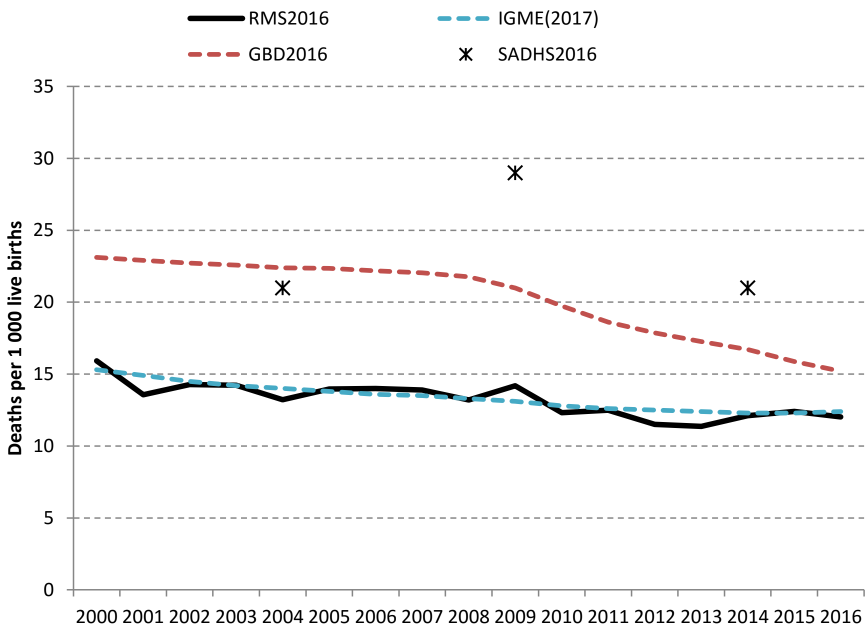

Figure 26: Comparison of estimates of neonatal mortality rates (NMR), 2000-2016

CONCLUSIONS

The estimates of mortality show that South Africa is continuing to make progress in extending life expectancy and reducing mortality albeit at a slowing pace. The empirical data indicates that life expectancy has increased by nearly ten years from 2005, reaching a level of 60.8 years for males and 66.9 years for females in 2016. This has resulted from the sustained improvements in mortality of young adults and particularly child mortality, largely due to the roll-out of ARV treatment and prevention of mother-to-child transmission of HIV. However, as pointed out by the 2nd National Burden of Disease Study (Pillay-van Wyk et al, 2016) there have been small gains in mortality from some other conditions which could be contributing to the decline in the past two years.

The MTSF has set ambitious targets for maternal and child mortality to be achieved by March 2019. If the published target for the U5MR is 23 per 1 000 live births, then there is inconsistency in the MSTF targets with 2/3rds of the reduction in IMR to arise from a fall in NMR while half of the decline in U5MR is to result from a more than 50% reduction in the mortality of children between 1 and 5. We therefore, assume that there is a typographical error and the target for the U5MR is 33 per 1 000 live births. Nonetheless, while the gains in child mortality observed in 2015 and 2016 keep it on course to meeting the targets, more effort to reduce maternal and neonatal mortality will be needed if the MTSF targets are to be met by 2019.

After a rapid decline in the childhood mortality, rates stagnated between 2011 and 2014, after which both the infant and under-5 mortality rates declined in 2015 and 2016 to a new national low of 25 and 35 per 1 000 live births respectively. In contrast, the neonatal mortality rates that had shown a modest decline up till 2014 to a level of 12 per 1 000 live births, are little changed since then. In addition, if the SADHS estimate of neonatal mortality (21 per 1,000 live-births for the five years 2012-2016) is correct then the target will not be met.

To some extent there has been an increase in the number of neonatal deaths corresponding to a decrease in the number of stillbirths, which could possibly reflect more successful resuscitation efforts reducing the number of stillbirths, only to be thwarted a few weeks later. This re-emphasises the need to improve health care services, particularly for the neonatal care. The 2nd National Burden of Disease Study highlights that further reduction in child mortality will also require efforts to eliminate the transmission of HIV from mother to child, as well as reducing the number of deaths from pneumonia and diarrhoea. Aside from strengthening primary health care including the promotion of exclusive breast feeding, environmental and social factors associated with poor infant and child health need to be addressed.

The maternal mortality ratio, which remains challenging to measure accurately, declined dramatically after 2010 but has remained between 150 and 165 deaths per 100 000 live births since then. South Africa has some way to go to reach the MDG target of 50 per 100 000 live births.

It has been noted that the reduced lag in reporting the cause-of-death data that has been achieved by Stats SA in recent years is to be commended, but resulted in a drop in the number of deaths reported for the year in question, owing to an increase in late transfers of records to Stats SA for processing, possibly leading to a decline in ultimate completeness of registration. Attempts were made to avoid this problem by extending the lag period to 14 months rather than 11 months (personal communication – Ms Mmamokete Mogoswane, Stats SA) and this appears to have led to a noticeable increase in completeness of registration of deaths in 2014, and possibly 2015.

As these estimates are based on the assumption of no further increase in the completeness of registration of deaths, there is some uncertainty and it will be important to benchmark the child mortality rates with the other data sources. In this regard our under-five mortality rates appear to be consistent with those from the 2016 SADHS but our infant mortality rates are quite a bit lower. Until it is possible to analyse the SADHS data fully it is difficult to decide which is closer to the truth. Further investigation is needed to assess why the deaths on the NPR exceed the number processed by Stats SA in an increasingly large age range. In addition, we had hoped to expand the analysis to provincial data in this report, but are trying to make sense of the estimates of completeness of registration at the provincial level.

REFERENCES

Actuarial Society of South Africa (ASSA). 2011. *ASSA2008 AIDS and Demographic Model.* Available: http://aids.actuarialsociety.org.za Accessed 31 March 2012.

Bradshaw D, Dorrington RE and Laubscher R. *Rapid mortality surveillance report 2011*. Cape Town: South African Medical Research Council, 2012. ISBN: 978-1-920618-00-1.

Bradshaw D, Dorrington RE. Maternal mortality ratio – trends in the vital registration data. *S Afr J OG* 2013; **18**(2):38-42.

Dorrington RE. 2013. *Alternative South African mid-year estimates, 2013*. Centre for Actuarial Research Monograph 13, University of Cape Town. ISBN: 978-0-7992-2501-3.

Dorrington RE and Bradshaw D. 2015. Acknowledging uncertainty about maternal mortality ratio estimates. *Bulletin of the World Health Organization* Online first Perspectives Article ID: BLT.15.155036. Available: http://www.who.int/bulletin/online_first/BLT.15.155036.pdf Accessed 3 December 2015.

Dorrington R E and Moultrie T A. *The age distribution of younger people in South Africa: What can it tell us about recent fertility trends?* Paper presented at the 7th African Population Conference, Johannesburg, 30 November – 4 December 2015.

Dorrington RE, Bradshaw D, Laubscher R and Nannan N. *Rapid mortality surveillance report 2014*. Cape Town: South African Medical Research Council, 2015. ISBN: 978-1-928340-02-7.

Health Data Advisory and Co-ordination Committee (HDACC). *Health Data Advisory and Co-ordination Committee Report November 11, 2011*. Pretoria: Department of Health, 2011.

Hogan MC, Foreman KJ, Naghavi M, Ahn SY, Wang M, Makela SM, Lopez AD, Lozano R, Murray CJ. Maternal mortality for 181 countries, 1980-2008: a systematic analysis of progress to Millennium Development Goal 5. *Lancet* 2010; **375**: 1609-23.

Institute for Health Metrics and Evaluation. *GBD Compare*, 2015. vizhub.healthdata.org/gbd-compare/. Accessed 3 November 2015.

Institute for Health Metrics and Evaluation (IHME). *Global Burden of Disease Study 2015 (GBD 2015) Results*. Seattle, United States, 2016a. Available from http://ghdx.healthdata.org/gbd-results-tool. Accessed 28 November 2016.

Institute for Health Metrics and Evaluation (IHME). *Mortality Visualization*. Seattle, WA: IHME, University of Washington, 2016b. Available from http://vizhub.healthdata.org/mortality. Accessed 28 November 2016

Institute for Health Metrics and Evaluation (IHME). Mortality Visualization. Seattle, WA: IHME, University of Washington, 2017. Available from http://vizhub.healthdata.org/mortality/. Accessed 14 February 2018.

United Nations Interagency Group on Child Mortality *Estimation. Estimates generated by the UN Inter-agency Group for Child Mortality Estimation (IGME) in 2015*, 2015. www.childmortality.org . Accessed 3 November 2015.

Kassebaum, N. and et al. Global, regional, and national levels and causes of maternal mortality during 1990—2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014: **384**(9947):980-1004.

Lozano R, Wang H, Foreman KJ, Rajaratnam JK, Naghavi M, Marcus JR, Dwyer-Lindgren L, Lofgren KT, Phillips D, Atkinson C, Lopez AD, Murray CJ. Progress towards Millennium Development Goals 4 and 5 on maternal and child mortality: an updated systematic analysis. *Lancet* 2011; **378**(9797):1139-65.

Maternal Mortality Estimation Inter-agency Group (MMEIG). Trends in maternal mortality: 1990 to 2015. Estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division. WHO 2016. http://apps.who.int/iris/bitstream/10665/194254/1/9789241565141_eng.pdf. Accessed 28 November 2016.

Naghavi M, Wang H, Lozano R, Davis A, Liang X, Zhou M, et al. Global, regional, and national age–sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2015; **385**(9963):117–71.

Naghavi, M, Abajobir A A, Abbafati C, et al. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*; **390**(10100): 1151 – 1210.

National Department of Health (NDoH), Statistics South Africa (Stats SA), South African Medical Research Council (SAMRC) and ICF. *South Africa Demographic and Health Survey 2016: Key Indicators*. Pretoria, South African and Rockville, Maryland, USA: NDoH, Stats SA, SAMRC and IDF, 2017. www.statssa.gov.za/publications/Report%2003-00-09/Report%2003-00-092016.pdf. Accessed 21 June 2016.

Pattinson, Fawcus and Moodley. *Ninth interim report on the Confidential Enquiries into Maternal Deaths in South Africa 2011*. Pretoria: National Committee for Confidential Enquiries into Maternal Deaths, Department of Health, 2013.

Pillay-Van Wyk V, Laubscher R, Msemburi W, Dorrington RE, Groenewald P, Vos T, et al. *Second South African National Burden of Disease Study: Data cleaning, validation and SANBD List*. Cape Town: Burden of Disease Research Unit, South African Medical Research Council, 2014. ISBN: 978-1-920618-17-9. Available at: http://www.mrc.ac.za/bod/reports.htm

Pillay-van Wyk V, Msemburi W, Laubscher R, Dorrington RE, Groenewald P, Glass T, Nojilana B, Joubert JD, Matzopoulos R, Prinsloo M, Nannan N, Gwebushe N, Vos T, Somdyala N, Sithole N, Neethling I, Nicol E, Rossouw A, Bradshaw D. Mortality trends and differentials in South Africa from 1997 to 2012: second National Burden of Disease Study. *Lancet Glob Health* 2016; 4(9):e642-53.

The Presidency of the Republic of South Africa (DPM&E). *Medium-term Strategic Framework 2014–2019*. Pretoria: The Presidency; 2014.

Statistics South Africa (Stats SA). *Millennium Development Goals Country Report 2010*. Pretoria: Stats SA 2010. http://www.statssa.gov.za/news_archive/Docs/MDGR_2010.pdf Accessed 3 October 2010.

Statistics South Africa (Stats SA). *Census 2011 Statistical release (Revised) – P0301.4.* Pretoria: Statistics South Africa, 2013a. http://www.statssa.gov.za/Publications/P03014/P030142011.pdf. Accessed 26 February 2013.

Statistics South Africa (Stats SA). *Mid-year population estimates, 2013*. Pretoria: Statistics South Africa, 2013b. http://www.statssa.gov.za/publications/statsdownload.asp?PPN=P0302&SCH=4203 Accessed 8 June 2013.

Statistics South Africa (Stats SA). *Millennium Development Goals Country Report 2013*. Pretoria: Statistics South Africa 2013c. http://beta2.statssa.gov.za/wp-content/uploads/2013/10/MDG_October-2013.pdf Accessed 26 October 2013.

Statistics South Africa (Stats SA). *Recorded live births 2013-2016*. Pretoria: Statistics South Africa, 2017a. http:// http://www.statssa.gov.za/publications/P0305/P03052016.pdf Accessed 28 September 2017.

Statistics South Africa (Stats SA). *Mid-year population estimates, 2017*. Pretoria: Statistics South Africa, 2017c. http://www.statssa.gov.za/publications/P0302/P03022017.pdf Accessed 31 July 2017.

Statistics South Africa (Stats SA). *SUSTAINABLE DEVELOPMENT GOALS (SDGs): Indicator Baseline Report 2017*. Pretoria: Statistics South Africa, 2017d.

Statistics South Africa (Stats SA). *Mortality and causes of death in South Africa, 2011: Findings from death notification.* Pretoria: Stats SA, 2014b. http://www.statssa.gov.za/publications/P03093/P030932011.pdf. Accessed 9 April 2014.

Statistics South Africa (Stats SA). *Mortality and causes of death in South Africa, 2013: Findings from death notification.* Pretoria: Stats SA, 2014c. http://www.statssa.gov.za/publications/P03093/P030932013.pdf. Accessed 20 December 2014.

Statistics South Africa (Stats SA). *Mortality and causes of death in South Africa, 2015: Findings from death notification.* Pretoria: Stats SA, 2017b. http://www.statssa.gov.za/publications/P03093/P030932015.pdf. Accessed 28 February 2017.

Statistics South Africa (Stats SA). *Census 2011: Estimation of mortality in South Africa* Pretoria: Stats SA, 2015c. http://www.statssa.gov.za/publications/Report-03-01-62/Report-03-01-622011.pdf. Accessed 28 December 2015.

Wang H, Liddell CA, Coates MM, Mooney MD, Levitz CE, Schumacher AE et al. Global, regional, and national levels of neonatal, infant, and under-5 mortality during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014; **384**(9947): 957-79.

World Health Organization (WHO). Trends in Maternal Mortality: 1990 to 2010: WHO, UNICEF, UNFPA and the World Bank Estimates. Geneva: WHO, 2012. http://www.who.int/reproductivehealth/publications/monitoring/9789241503631/en/ Accessed 17 November 2015.

World Health Organization (WHO). *Trends in Maternal Mortality: 1990 to 2013: Estimates Developed by WHO, UNICEF, UNFPA, the World Bank and UN Population Division. Geneva: WHO, 2014.* http://data.unicef.org/corecode/uploads/document6/uploaded_pdfs/corecode/MMR2013_117.pdf Accessed 28 October 2014.

United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision, DVD Edition. http://esa.un.org/unpd/wpp/DVD/ Accessed 22 June 2017.

United Nations Inter-agency Group for Child Mortality Estimation (UN IGME). 2017. Levels and trends in child mortality. New York: UNICEF, WHO, World Bank & United Nations. 2017. http://www.childmortality.org/2017/files_v21/download/IGME%20report%202017%20child%20mortality%20final.pdf. Accessed 21 October 2017

APPENDIX: ESTIMATION OF COMPLETENESS OF REPORTING OF DEATHS

Completeness of reporting of deaths is estimated in three processes for three different age ranges: infant and child mortality, adult (15+) mortality and finally the completeness of reporting of deaths aged 5-14. The process of estimating completeness of reporting deaths, particularly infant and child deaths was quite intricate and is described only in broad terms. A more detailed description appears in the technical report on the second South African National Burden of Disease methods (Pillay-van Wyk et al, 2014).

Infants and children under 5 years

The numbers of registered deaths, under the ages of one and five in particular, were compared to the number expected based on estimates of the rates (q_0 and ${}_5q_0$) for specific years and applied to estimates of births for the same year. The estimates of the rates (q_0 and ${}_5q_0$) were derived from several sources including the deaths reported by households (2001 and 2011 Censuses and the 2007 Community Survey) and reports of women on the survival of their children (1998 DHS, 1996, 2001 and 2011 Censuses, and the 2007 Community Survey).

The number of births by calendar year was estimated as the number required to be consistent with in the number of surviving children at each age at the time of the 2011 Census.

The completeness in individual years between the years of the point estimates of the expected number of deaths was estimated, in general,[6] by assuming that the completeness changed linearly with time between the years of the point estimates. Completeness of reporting of childhood (1-4) deaths was derived from the differences between reported and expected deaths under the ages of five and one.

Adults (15+ years)

Completeness of reporting of adult deaths was estimated by first estimating it for the following intercensal periods using death distribution methods: 1996-2001, 2001-2007 and 2001-2011. As these estimates represent averages for each period, estimates for single years were derived by fitting a logistic curve to estimates of completeness by year, derived on the assumption that it changed linearly over each period.

However, because of what appears to be a decline in completeness of the registration of adult deaths after 2010, completeness was reduced to 92% for 2011-2013. After 2013 it is returns to 93% for ages up to 39 but drops below that to as low as 86% for females and 87% for males to reflect a drop in VR relative to NPR that has been observed (and is assumed to reflect a drop in completeness of VR data).

Children 5-14 years

Completeness of reporting by single years of age for ages 5-14 were derived on the assumption that the average of completeness for ages 1-4 was equal to that estimated for the age group 1-4 in total, and that completeness changes linearly with age between ages 1 and 15.

Post-2011

Previously the assumption was that completeness remained constant post 2011. However, in 2017 the estimates were amended slightly to allow for what appears to be a decline in registration of deaths in the period 2011-2013 for adult mortality and 2012 and beyond for childhood mortality.

[6] There were one or two years where this assumption implied implausible change in rates between one year and the next, in which case the drastic change in the reported number of deaths was assumed to be due to a change in completeness rather than rate of mortality.