RAPID MORTALITY SURVEILLANCE REPORT 2019 & 2020

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BURDEN OF DISEASE RESEARCH UNIT
SOUTH AFRICAN MEDICAL RESEARCH COUNCIL

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ACRONYMS AND ABBREVIATIONS

e_0	-	life expectancy at birth
e_{60}	-	life expectancy at age 60
q_0	-	probability of a live birth dying before age 1 (infant)
$_5q_0$	-	probability of a live birth dying before age 5 (under-5)
$_{10}q_5$	-	conditional probability of a 5-year-old child dying before age 15 (older children and young adolescents)
$_{10}q_{15}$	-	conditional probability of a 15-year-old child dying before age 25 (older adolescents and young adult)
$_{45}q_{15}$	-	conditional probability of a 15-year-old person dying before age 60 (adult)
NCD $_{40}q_{30}$	-	conditional probability of a 30-year-old person dying before age 70 from non-communicable disease (NCD)
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
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
NCD	-	non-communicable disease
NMR	-	neonatal mortality rate
NPC	-	National Planning Commission
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 (2019 revision)

EXECUTIVE SUMMARY

The Rapid Mortality Surveillance (RMS) Report has been providing empirical estimates of the mortality-based high-level indicators for monitoring health and the performance of the Department of Health since 2012. It provides information to track the National Development Plan (NDP) health goal to increase life expectancy at birth and selected outcomes outlined in the NDP and the Department of Health's Strategic Plan for 2020/21 – 2024/25. Deaths registered on the National Population Register by the Department of Home Affairs are the main data source for the most recent estimates while less up-to-date estimates of the MMR and non-communicable disease premature mortality rates are based on adjusted cause-of-death data from Stats SA up to 2017 (being the most recent year for which vital registration data have been released). The Neonatal Mortality Rate is based on adjusted data from the District Health Information System (DHIS) up to 2020. Efforts to improve the completeness of death registration are still required and the delay in the release of cause-of-death statistics is a major concern in the context of the substantial increase in deaths in 2020.

This report shows that in 2020***, the average life expectancy in South Africa was 64.7 years***, a slight decline from the 65.3 years experienced in 2019 after having increased by more than 10 years since the low of 53.7 in 2005. The increase in life expectancy prior to 2019 is due to both the decrease in child mortality as well as the decrease in young adult mortality while the decrease in life expectancy in 2020 resulted from SARS-CoV-2. ***The average life expectancy dropped by 0.6 years between 2019 and 2020***, a lower decline than has been measured in other countries, mostly developed countries, where this has been measured (Aburto *et al*. 2021). Furthermore, in contrast to the experience in these countries, the impact on life expectancy has been greater for females (drop of 1 year) than for males who experienced a decrease of 0.2 years. The muted impact of COVID-19 is mainly due to the impact of the severe lockdown (restricting social interaction and travel) and non-pharmaceutical interventions (NPIs) on non-COVID mortality. In the case of males, the marked reduction in the number of deaths from unnatural causes during periods of stringent lockdowns including alcohol restrictions has contributed to the lower decrease in their life expectancy.

Life expectancy at age 60 had shown little change between 2000 and 2019. However, associated with COVID-19, life expectancy at age 60 dropped from 19.6 to 18.9 years for females, and from 16.1 to 14.8 years for males, resulting in an overall decrease of 1.5 years.

Infant and under-five mortality rates reached lows of 21 and 28 per 1 000 live births, respectively, in 2020 having increased to 27 and 37 per 1 000 livebirths in 2019, respectively. The lack of seasonal increases in the numbers of registered deaths suggest that the winter increases in respiratory syncytial virus (RSV) and other pneumonias as well as seasonal outbreaks of diarrhoea were absent in 2020. In contrast the neonatal mortality rate continues to show little change at 12 per 1 000 live births. In keeping with childhood mortality, there was also a noticeable decline in the level of mortality of older children and young adolescents aged 5-14 years ($_{10}q_5$) in 2020, again due to effects of lockdown on both natural and unnatural deaths. Mortality among older adolescents and youth (the probability of a 15-year-olds dying before the age of 25 years) has dropped from 25.5 to 22.7 per 1 000 in 2020 for males and from 15.5 to 14.8 per 1000 for females. The decrease in deaths from unnatural causes likely contributed to this decline.

There was a significant decline in maternal mortality from 2016 to 2017 after the previous decline to 2016. However, inspection of the VR data suggest a concerning deterioration in the quality of the cause-of-death data (failing to identify pregnancy as a factor in all maternal deaths) resulting in the RMS estimate of the MMR for 2017 being lower than the institutional MMR. The SDG target of 70 per 100 000 births is still to be reached.

The rates of premature mortality from preventable non-communicable diseases (NCDs) also declined from 2016 to 2017, mainly due to a decline in deaths due to cardiovascular disease, and in males also cancer. The impact of COVID-19 cannot be assessed until more recent cause of death data become available.

KEY MORTALITY INDICATORS, RMS 2015 - 2020

INDICATOR		2015	2016	2017	2018	2019	2020
Life expectancy at birth	Total	63.3	63.9	64.6	64.8	65.3	64.7
	Male	60.1	60.9	61.6	61.8	62.4	62.2
	Female	66.6	66.9	67.6	67.9	68.2	67.2
Adult mortality ($_{45}q_{15}$)	Total	34%	33%	32%	31%	29%	31%
	Male	40%	39%	38%	37%	35%	36%
	Female	28%	27%	26%	25%	24%	26%

INDICATOR		2015	2016	2017	2018	2019	2020
Under-5 mortality rate (U5MR) per 1 000 live births		39	36	33	35	36	28
Infant mortality rate (IMR) per 1 000 live births		28	26	23	26	27	21
Neonatal mortality rate (<28 days) per 1 000 live births		12	12	12	11	12	12
INDICATOR[1]		**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Maternal mortality ratio (MMR) per 100 000 live births		164	153	166	153	137	109
INDICATOR		**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Older children & young adolescents ($_{10}q_5$ per 1 000)	Total	7.0	6.5	6.0	6.2	5.9	5.3
	Male	7.8	7.4	7.0	7.0	6.7	6.1
	Female	6.2	5.6	5.1	5.3	5.0	4.5
INDICATOR		**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Older adolescents & youth ($_{10}q_{15}$ per 1 000)	Total	22.3	21.7	21.4	20.8	20.5	18.7
	Male	26.3	25.8	26.0	25.2	25.5	22.7
	Female	18.4	17.5	16.9	16.4	15.5	14.8
INDICATOR		**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Life expectancy at age 60 (e_{60})	Total	17.6	17.7	17.8	17.9	18.0	16.5
	Male	15.5	15.6	15.7	15.9	16.1	14.8
	Female	19.3	19.3	19.5	19.6	19.6	18.0
INDICATOR[1]		**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
NCD $_{40}q_{30}$	Total	29%	29%	30%	30%	29%	27%
	Male	34%	34%	35%	35%	34%	32%
	Female	24%	24%	24%	24%	24%	23%
INDICATOR[1]		**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Cardiov. disease $_{40}q_{30}$	Total	14%	14%	14%	14%	14%	13%
	Male	18%	17%	18%	18%	17%	16%
	Female	12%	11%	11%	11%	11%	10%
Cancer $_{40}q_{30}$	Total	9%	9%	9%	9%	9%	9%
	Male	10%	11%	11%	11%	10%	10%
	Female	7%	7%	8%	8%	8%	7%
Diabetes $_{40}q_{30}$	Total	5%	5%	5%	5%	5%	5%
	Male	5%	5%	6%	6%	5%	5%
	Female	5%	5%	5%	5%	5%	5%
Chronic resp. disease $_{40}q_{30}$	Total	4%	4%	4%	4%	4%	4%
	Male	6%	6%	6%	6%	6%	5%
	Female	3%	2%	2%	2%	2%	2%

1. Data available till 2017

INTRODUCTION

This is the ninth in the series of annual reports, spanning 11 years, utilising the data from the Rapid Mortality Surveillance (RMS) database held by the SAMRC which consolidates basic demographic information about deaths registered onto the National Population Register (NPR) as described in the first report (Bradshaw, Dorrington and Laubscher, 2012). Although work was underway to expand this report to include provincial estimates and trends this work was interrupted by the SARS-CoV-2 pandemic, which necessitated finding a way to accelerate monitoring of mortality on a weekly basis. Since March 2020, the Department of Home Affairs (DHA) has provided the SAMRC with weekly updates and together with UCT Centre for Actuarial Research a near real-time weekly report on the estimated numbers of deaths that have occurred in different regions of the country has been published (Bradshaw et al, 2020), providing invaluable insights into the impact of the COVID-19 pandemic and quantifying excess mortality. This report provides estimates of several mortality indicators for 2019 and 2020 after correcting for incompleteness of registration of deaths and births, as has been done in previous RMS reports.

These empirical based estimates can be used to track the impact indicators identified in the National Development Plan (NPC, 2011) for the health objective, a long and healthy life for all South Africans (DPM&E, 2014). In addition, the report provides estimates for several outcome indicators identified in the Department of Health's Strategic Plan 2020/21 – 2024/25 (NDOH, 2021). This report includes life expectancy at birth, the adult mortality index ${}_{45}q_{15}$, under-5 mortality rate, infant mortality rate and the neonatal mortality rate, and young adolescents aged 5-14 years (${}_{10}q_{5}$) as well as older adolescents and young adults aged 15-24 years (${}_{10}q_{15}$). 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 NPR data series has been updated to the end of 2020, but the cause-of-death data has only been updated to include 2017 as no further data has been released to date. Thus, indicators requiring cause-of-death data, namely the MMR, the various non-communicable disease (NCD) indicators and comparisons of cause-of-death data to those from the NPR end in 2017.

Estimates of the population and the numbers of births are essential for calculating the indicators in this report. In previous reports, the mid-year population estimates, derived from the ASSA2008 model to be consistent with the 2011 Census population (Dorrington, 2013), projected forward to 2017 using unchanging migration, slightly declining fertility and mortality rates were used. Since we are currently estimating the true numbers of births and deaths as part of the RMS exercise, demographic consistency has been maintained by using these estimates of births and deaths together with the migration assumptions from the Thembisa/CARe models to project the population on a year-by-year basis from 2012 onwards.

DATA SOURCE

The Department of Home Affairs (DHA) 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, 2020a). These data on births, adjusted for an estimate of under- or late-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 updates of the deaths registered on the National Population Register, which has been used to develop a consolidated database. 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, and more recently from the SAMRC.

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 is the non-registration of the death, a common challenge experienced in developing countries.

As the NPR data only identify 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 2017 (Stats SA, 2020b)[1]. In addition, too few of the 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[2], we use data from the District Health Information System 2017-20 (DHIS) to estimate the number of neonatal deaths that occur in public hospitals to produce a more recent estimate.

[1] Stats SA has experienced extreme staff shortages for several years and the delay in reporting has extended from two to over three years.

[2] In addition, it appears that completeness of the VR data relative to the DHIS has been declining in recent years.

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 in those censuses.

For the first RMS report, the population estimates produced by the ASSA2008 AIDS and Demographic projection model (ASSA, 2011) 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 the trend in fertility been different from that assumed by ASSA model (and ALL other projection models) for 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 from covering the years 2012 to 2018, in the absence of new, suitable, empirical data, an alternative set of mid-year population estimates with an age distribution and population size consistent with those of the 2001 and 2011 Censuses (Dorrington, 2013) has been used. Because this series ends with 2017, it was decided to replace the estimates of the population from 2012 onwards with estimates based on a different and internally more consistent methodology that makes use of the series of estimates of the true numbers of births and deaths used to determine the indicators in this report, and the net numbers of migrants by sex and age assumed in the Thembisa and CARe models.

The official, annual, series of mid-year population estimates produced by Stats SA were considered for use as an alternative source of estimates. However, even though they were constructed to reproduce the total population size of the 2011 Census (Stats SA, 2013a), they, initially at least, were 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 subsequently been largely corrected in the releases of mid-year estimates from 2017 onwards (Stats SA 2017a). Unfortunately, these estimates are not available by single ages or for ages above age 80, and are based on estimates of births and deaths which are not, necessarily consistent with those used in this report.

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 2020) from the registered births by year of birth corrected for estimates of the completeness of registration
- estimates of the number of births (up to 2020) 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)[3]
- estimates of the number of births derived by applying fertility rates estimated from census and Community Survey data to the numbers of women aged 15-49 from the CARe 4.3 population projection model
- estimates of the number of births (up to 2020) projected by the CARe 4.3 population projection model, and
- the consistency and plausibility of the implied level of completeness of registration by number of years of registration since the 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 before increasing slightly between 2017 and 2020[4].

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

[4] This is difficult to interpret – it could signal a decline in registration or an increase in births in public facilities (due, for example, to a decline in medical scheme membership).

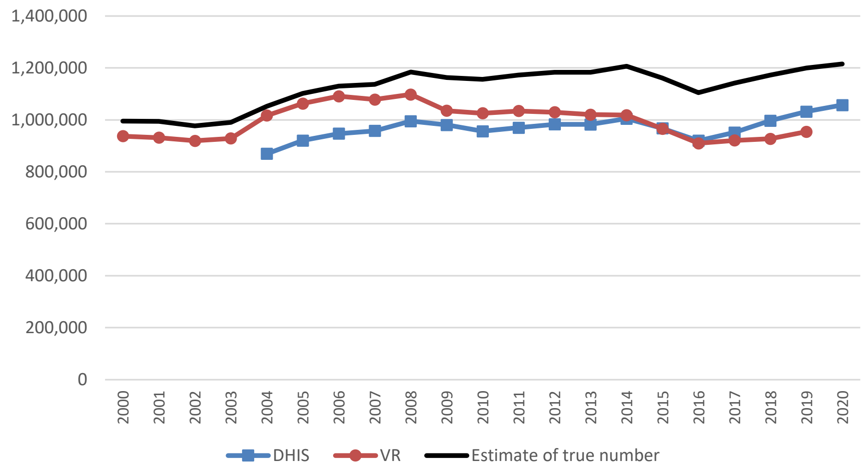


Figure 1: Estimates of the number of births compared to the numbers from the DHIS and VR, 2000-2020

ADJUSTMENTS

As was done in the previous reports, the NPR death 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 (i.e., not everybody has a national ID number). This is done by comparing the number of deaths from the NPR with the number of deaths reported by Stats SA up to the point of the most recent release, as all registered deaths should be included in the vital registration data regardless of whether the deceased had an ID number or not. This is done in 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. From 2012 to 2018 the adjustment was set as the maximum of that for the same age and the age below in the previous year, except for 2015, where it was set as the maximum of these values and the ratio of NPR to VR for the age in 2015. After this adjustment, the estimated numbers of deaths are adjusted for general under-notification (i.e., deaths with no death certificates). The second step is to account for under-notification of deaths to the Department of Home Affairs. A brief description of the approach used to estimate the completeness of registration of deaths is given in Appendix 1.

The total number of deaths from the NPR and from VR are shown in Figure 2 compared to the estimated true number of deaths after adjusting for completeness of registration. It is estimated that the number of deaths increased by nearly 53 000 from 2019 to 2020. Most of this increase in deaths (65%) were female. Although to a large extent this reflects the impact of COVID-19 and the fact that there are many more women than men aged 60 and older, the proportion is also distorted by a much greater drop in unnatural deaths in males than females due to the implementation of the State of Disaster regulation, in particular the very strict lockdown in the early months of the epidemic.

The gradual narrowing of the gap between the NPR data and the VR data shows that there has been a steady improvement in birth and ID registration. However, the very narrow gap observed in 2017 reflects late processing of documents in the system and can be expected to be widened if the late transfers of documents to Stats SA has been resolved by the time the data up to 2018 are released.

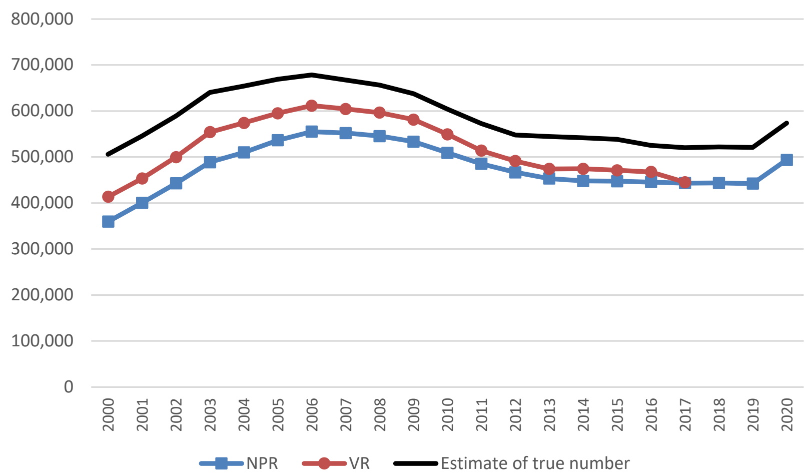


Figure 2: Estimates of the number of deaths compared to the numbers from the NPR and VR, 2000-2020

The comparison of the total number of deaths recorded by Stats SA (Stats SA, 2020b) and the NPR to the numbers estimated after correcting for under registration is shown in Figure 3. It can be seen that just over 100% of the death notifications of people aged 25 and over, and between approximately 90% and 95% 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 age group occur before the birth is registered, with the result that neither the birth nor the death are registered on the NPR even if a death notification form was completed.

While the uptick in the ratio of the number of NPR deaths to VR deaths (Stats SA) in all age groups from 2016 to 2017 is due to the absence of 2017 deaths registered after the cut-off date for the report (i.e. late registrations), the higher-than-average ratios for deaths aged 25+ in 2011, 2012 and 2013, and deaths aged under 1 for 2012 to 2017, indicate what is probably a slight drop in completeness of recording of deaths by Stats SA in these age groups in these years. This is allowed for in the estimation of the estimates of mortality in this report.

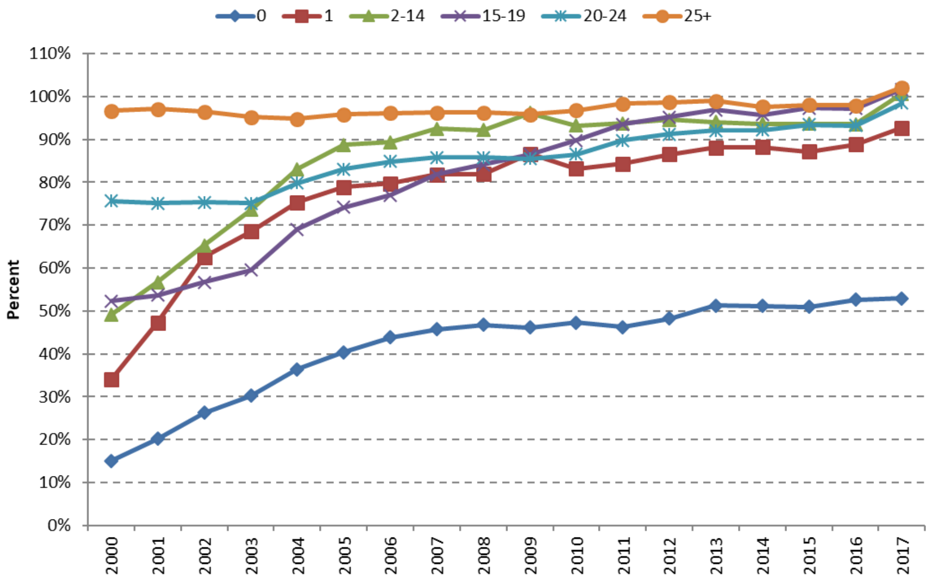


Figure 3: NPR deaths as a proportion of Stats SA deaths by age group, 2000-2017

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 deaths are not recorded on the NPR if the birth has not been recorded. Furthermore, this proportion is not stable over time (it 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[5,6]. As the number of neonatal deaths recorded by the DHIS has exceeded those recorded by the VR since 2012 (significantly so after 2014) it seemed more appropriate to assume that part, if not all, the decline in VR neonatal deaths is due to a decline in completeness of registration 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 consistent with estimates in earlier years).

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

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

[6] 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 was 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.

continues to be 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).

TRENDS IN NPR DATA

The numbers of deaths (excluding late registrations) from the National Population Register are shown in Table 1 for 2000-2020 alongside the numbers of deaths for the latest year from the Stats SA cause-of-death reports for 2000-2017. 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 446 544 by 2017. The NPR numbers increased from 359 470 in 2000 to a peak of 555 081 in 2006 and declined to 441 996 by 2019 then increased to 493 602 in 2020. It should be noted that the changes in the number of deaths cannot be interpreted without taking into account the general improvement in the completeness of 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.

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	405 370	51 242	456 612
2017	393 659	49 540	443 199	395 380	51 164	446 544
2018	392 481	51 009	443 490			
2019	389 327	52 669	441 996			
2020	447 131	46 471	493 602			

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 registration 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% and 1.5% from 2011-2013 before recovering to previous levels. In addition, investigations have identified evidence of some failures in the vital registration in 2014-2017, which hopefully will be corrected by late registrations in subsequent years. This will need to be monitored going forward.

The trends in the number of natural and unnatural deaths from the NPR are presented in Figure 4 which shows a marked increase in adult natural deaths in 2020, particularly those over 60. For children under 15 the number of natural deaths declined in 2020. Also noticeable is a decline in the number of unnatural deaths in 2020 for adults aged 15-59. The steady increase in the number of natural deaths in 60+ age group up to 2019, exceeding those aged 15-59 from 2014, reflects the strong growth in the size of the population in this age group rather than an increase in mortality. In total, the number of deaths in the 60+ age group exceeded those in the 15-59-year age group from 2018.

The trend in the number of deaths from the NPR by 5-year age group and sex are presented in Appendix 2. Increases in the number of deaths from natural causes in 2020 are seen for males and females in the age groups 35 years and older, with marked increases for age groups 60 years and older. Striking differences in trends by gender are seen in the 15-19 and 20-24 age groups. For males, the numbers of unnatural deaths are somewhat higher than the number of natural deaths. For females, a rapid increase in the number of natural deaths is observed, reaching a high of nearly 12 000 deaths in 2006. Since then, the number of female deaths has declined steadily, falling below the number of deaths in 2000. Except for the oldest age group, the number of male unnatural deaths is higher than the number of female unnatural deaths.

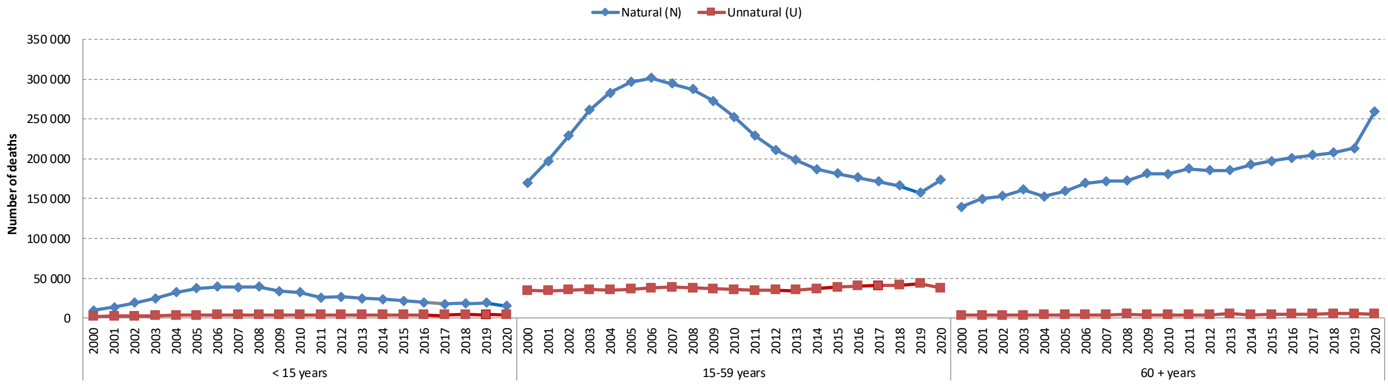


Figure 4: Trend in the number of natural (N), unnatural (U) by broad age group, NPR 2000-2020

As reported in the previous report (covering deaths through 2018) the proportion of the VR deaths captured by the NPR increased from 86.3% in 2000 to 99% in 2014 then to 99.3% in 2017 (Figure 5). 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, dropping to 92% in 2016 and recovering to 99% in 2017.

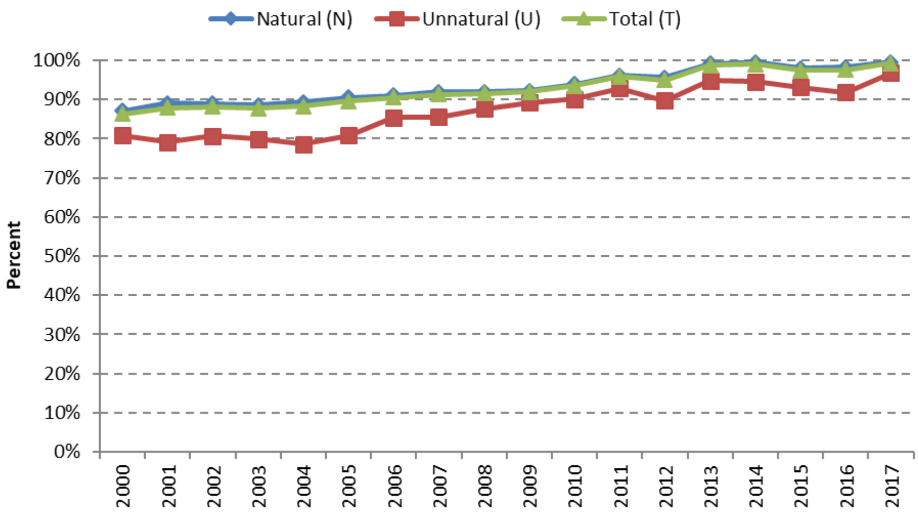


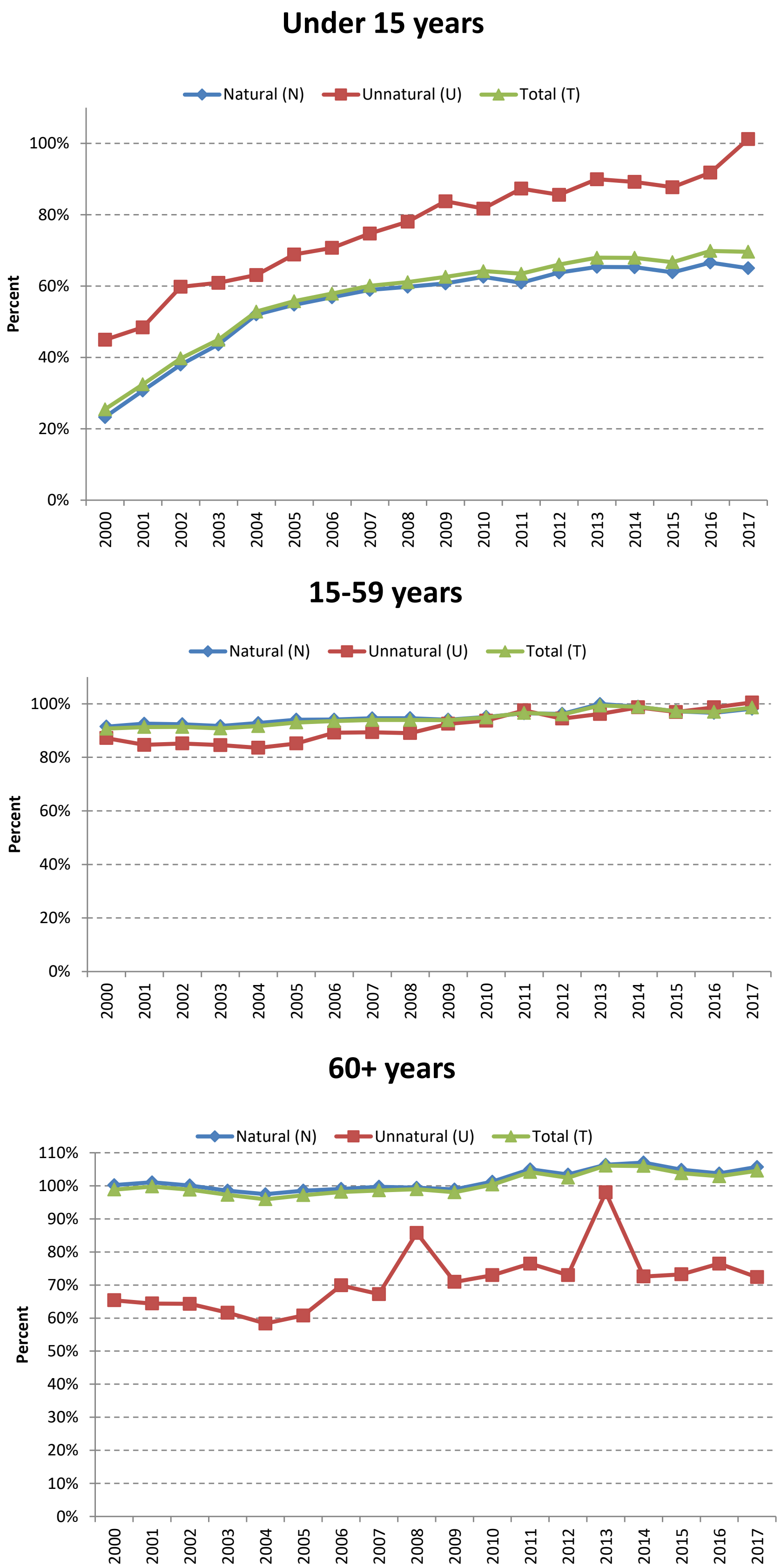
Figure 5: Ratio of NPR to Stats SA data (%) by natural (N), unnatural (U) and total (T) category, 2000-2017

Table 2 shows the numbers of deaths (excluding late registrations) in broad age groups, while the proportion of these VR deaths captured by the NPR is shown in Figure 6 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 after 2012. The proportion of unnatural VR deaths captured by the NPR is higher than the proportion of natural deaths 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 to over 96%, and by 2013 and 2014 close to 99%, before dropping off slightly after that. 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 deaths from 2011 onwards. In the case of unnatural deaths in the 60+ year age group, although the proportion has increased since 2005 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 (U)	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	25460	33 571	4 583	38 154
2016	19 527	4 021	23 548	29 326	4 379	33 705
2017	17 666	4 000	21 666	27 166	3 951	31 117
2018	18 681	4 258	22 939			
2019	19 180	4 219	23 399			
2020	15 132	3 889	19 021			
	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	186 817	39 812	226 629
2016	176 155	40 050	216 205	182 377	40 584	222 961
2017	171 486	40 664	212 150	174 705	40 475	215 180
2018	166 260	41 437	207 697			
2019	157 206	43 060	200 266			
2020	173 234	37 743	210 977			
	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	187 829	6 402	194 231
2016	200 890	4 802	205 692	193 667	6 279	199 946
2017	204 507	4 876	209 383	193 509	6 738	200 247
2018	207 540	5 314	212 854			
2019	212 941	5 390	218 331			
2020	258 765	4 839	263 604			



* The disruptions in 2008 and 2013 in 60+ appear to be the result of the anomalies in the NPR data, highlighted in Table 2.

Figure 6: Ratio of NPR to Stats SA data (%) in broad age groups by natural (N), unnatural (U) and total (T) category, 2000-2017

CORRECTING FOR INCOMPLETENESS

Figures 7 to 12 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 further adjusted for incompleteness of registration of deaths (Est Adj VR). They all tell a similar story, namely, that, adjusting for late registrations, there is a great deal of consistency between the NPR and VR data, with the exception of the shortfall in most recent VR data due to missing late registrations.

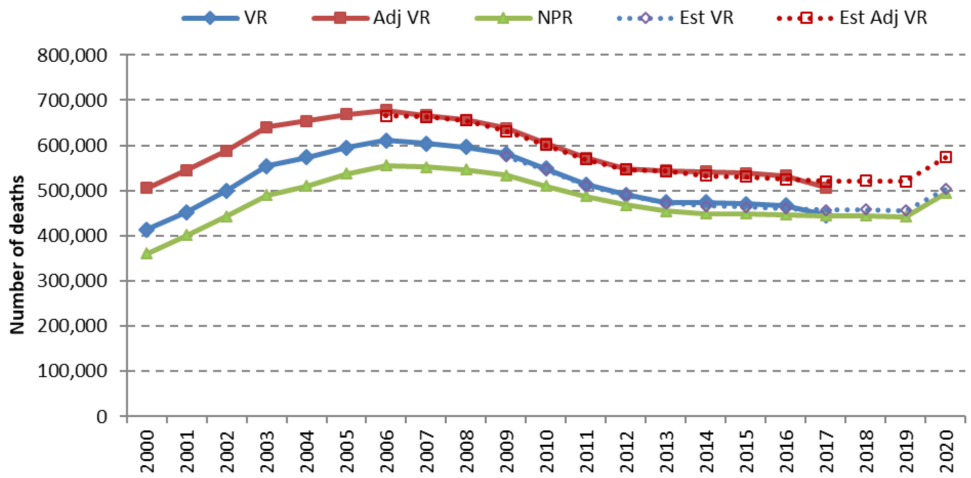


Figure 7: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Total deaths

While there were slight differences for the period 2006-2008 in the other age ranges, in total (Figure 7) and for ages 15-59 (Figure 11), the adjustments to the NPR data appear to work very well. The slight differences in the number 60+ (Figure 12) after 2013 found in previous reports are less pronounced. Once again, for some yet to be investigated reason, the numbers of VR deaths in these age groups are lower than expected, based on 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 still needs further investigation.

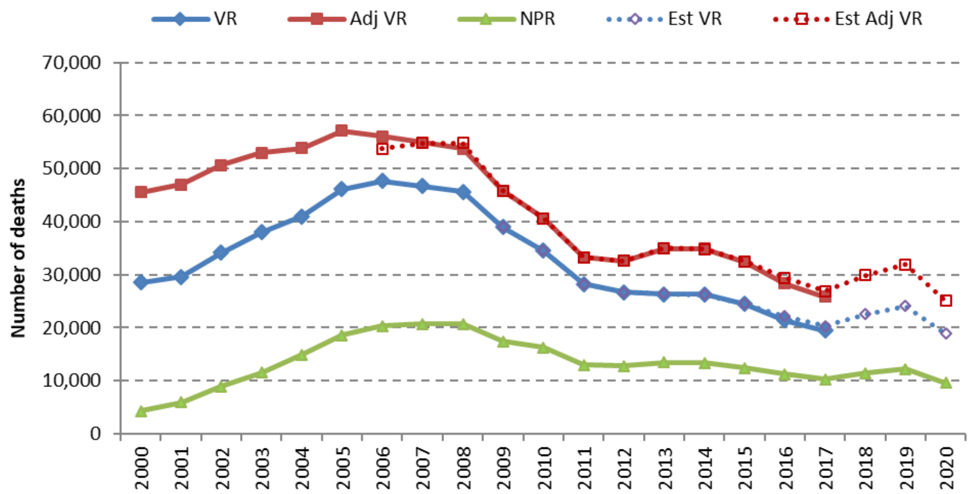


Figure 8: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Deaths < 1

The comparison of the number of deaths under the age of 1-year (Figure 8) indicate the large (but declining over time) adjustment required for deaths of infants 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 (after now adjusting for what appears to have been a slight drop in completeness of registration since 2013). Thus, according to the NPR data the number of deaths under age 1 year (but not ages 1-4 years (Figure 9)) appear to have increased since 2018 and declined in 2020.

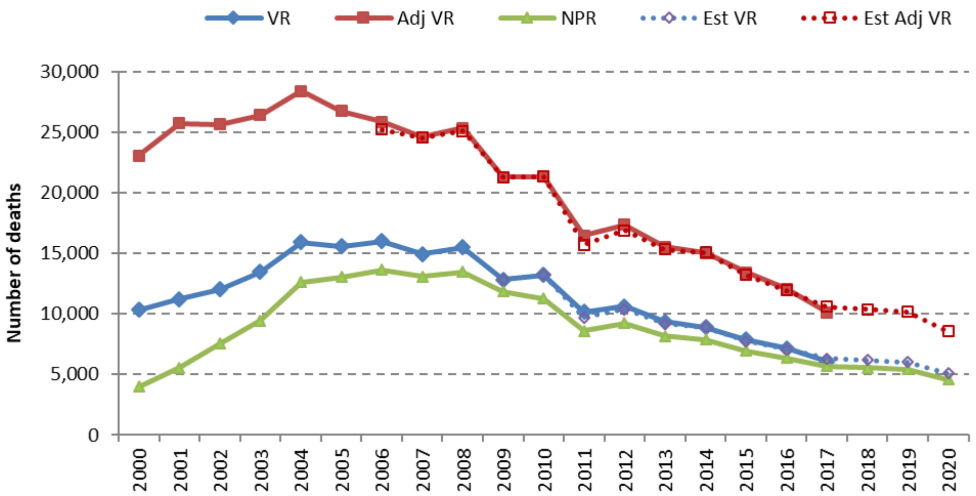


Figure 9: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Deaths 1-4

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 10). 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 2011 and 2012.

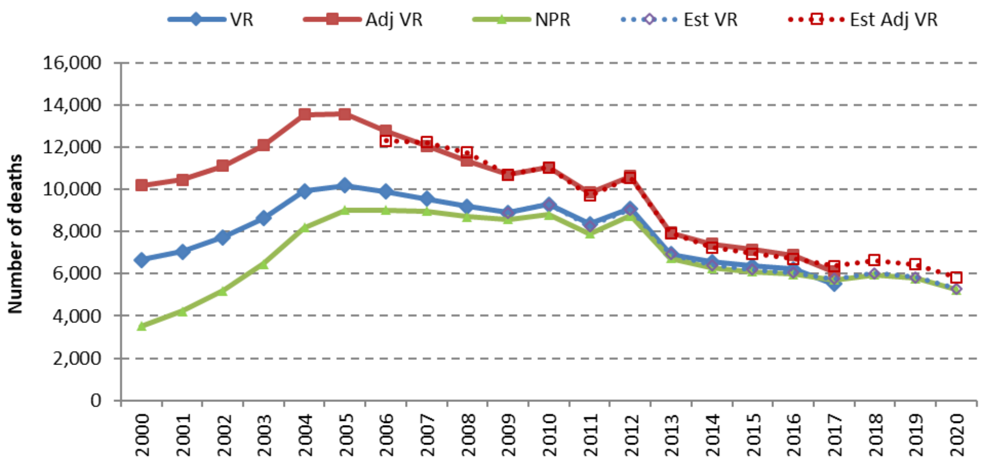


Figure 10: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Deaths 5-14

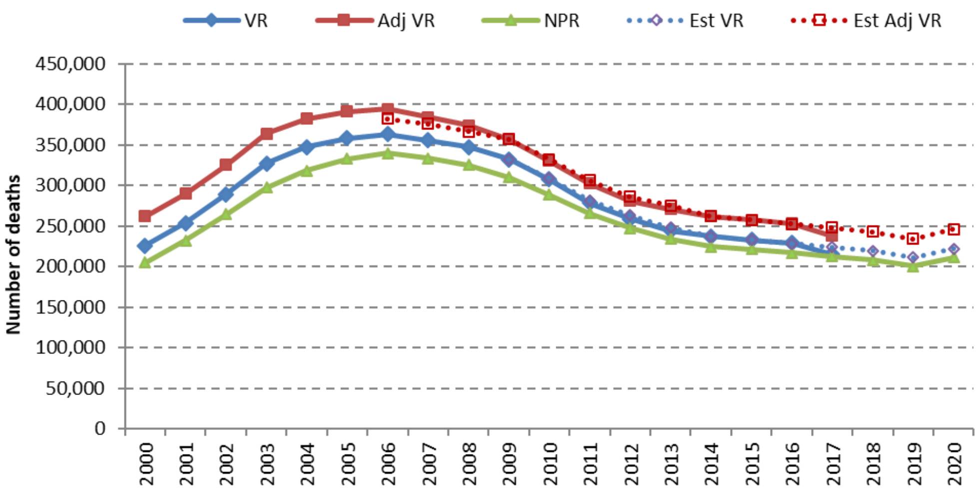


Figure 11: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Deaths 15-59

Although the increase in deaths from 2019 to 2020 for the 15-59 age group shown in Figure 11 appears to be at odds with the increase in natural deaths shown in Figure 4, this is simply because Figure 11 represents all-cause mortality and thus the decrease in unnatural deaths reduces the increase in natural deaths.

From Figure 12, 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, as mentioned above, something appears to have changed after that, with the NPR capturing noticeably more deaths than are reported by Stats SA.

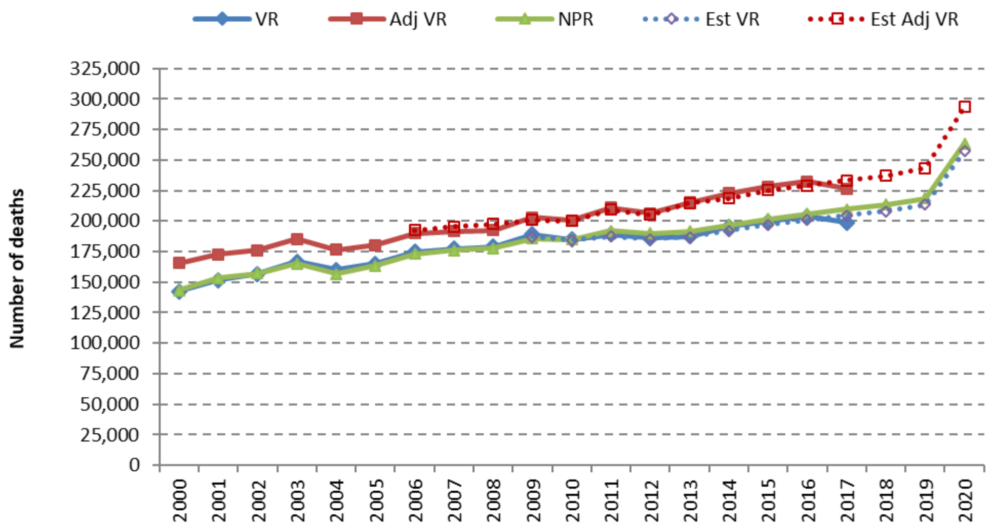


Figure 12: VR, VR adjusted for incompleteness of reporting, NPR, estimated VR, estimated adjusted VR: Deaths 60+

LIFE EXPECTANCY AND ADULT MORTALITY

The life expectancy at birth (e_0) as well as the index of adult mortality, ${}_{45}q_{15}$, representing the probability of a 15-year-old person dying before the age of 60, are shown in Table 3 for the period 2014-2020. The trends in these indicators since 2000 are shown in Figures 13 and 14. It can be seen that life expectancy increased from 2005 to 2019 with particularly rapid progress to 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, both of which are probably as a result of the extensive provision of ARVs. The improvement in e_0 is only marginal between 2017 and 2018, largely because of an increase in infant mortality recorded by the NPR, it then improved in 2019, on a fall in infant mortality, ending, surprisingly (given the increase in numbers of deaths) only a little more than 7 months lower in 2020. However, the change from 2019 to 2020 differs for males and females, with e_0 in 2020 about 2.5 months lower than that in 2019 for males and one year lower for females.

The reason for this difference by sex is due to two factors, the first being the reduction in 2020 in mortality due to the drop in deaths due to (mainly) unnatural causes (which are much more significant in males) and the second being the much higher number of deaths female population (mainly because of higher numbers surviving to old ages, which are more vulnerable to COVID-19 and related causes).

In keeping with the explanation above the estimate of ${}_{45}q_{15}$ decreased from 2014 to 2019 before increasing from 2019 to 2020 for both males and females, but more so (both relatively and absolutely).

Table 3: Estimated life expectancy at birth (e_0) and adult mortality (${}_{45}q_{15}$), RMS 2014-2020

INDICATOR		2014	2015	2016	2017	2018	2019	2020
Life expectancy at birth	Total	62.7	63.3	63.9	64.6	64.8	65.3	64.7
	Males	59.5	60.1	60.9	61.6	61.8	62.4	62.2
	Females	65.9	66.6	66.9	67.6	67.9	68.2	67.2
Adult mortality (${}_{45}q_{15}$)	Total	35%	34%	33%	32%	31%	29%	31%
	Males	41%	40%	39%	38%	37%	35%	36%
	Females	29%	28%	27%	26%	25%	24%	26%

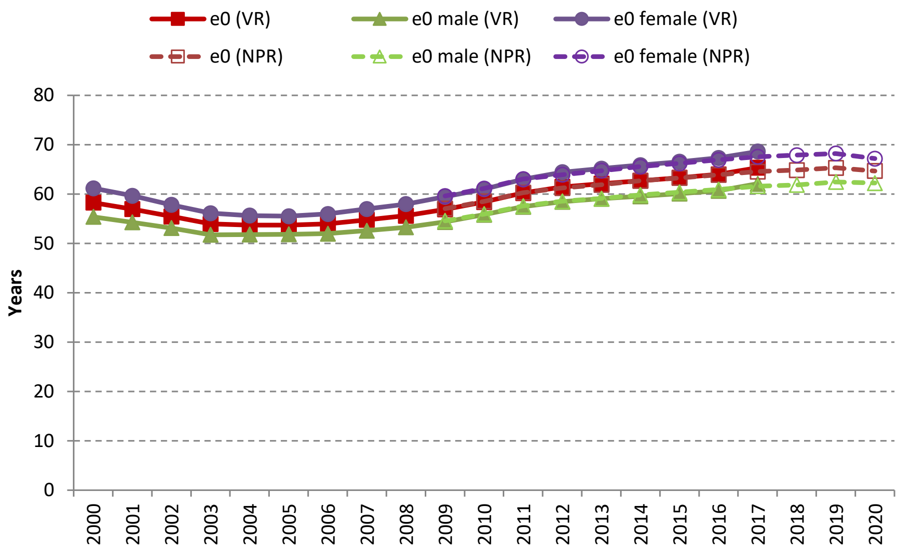


Figure 13: Life expectancy at birth (e_0) from VR and RMS, 2000-2020 (after adjusting for incompleteness)

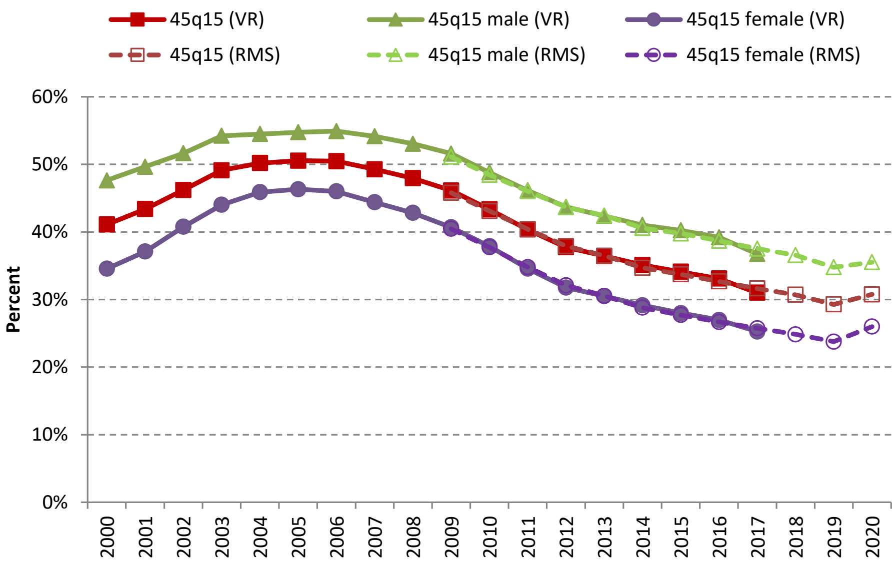


Figure 14: Adult mortality ($_{45}q_{15}$) from VR and RMS, 2000-2020 (after adjusting for incompleteness)

The trend in older-age mortality tracked using the index e_{60} (the average life expectancy of people who have survived to age 60) is shown in Figure 15. As can be seen from this figure, the mortality of older adults appears not to have changed much between 2000 and 2019, with the average life expectancy at the age of 60 rising from about 15.5 years to 16.1 in 2019 for men and around 19.3 years to 19.6 in 2019 for women. However, e_{60} declined by about 1.5 years to reach 16.5 years in 2020, and more than a year to 14.8 years for men and 1.6 years to 18 years for women.

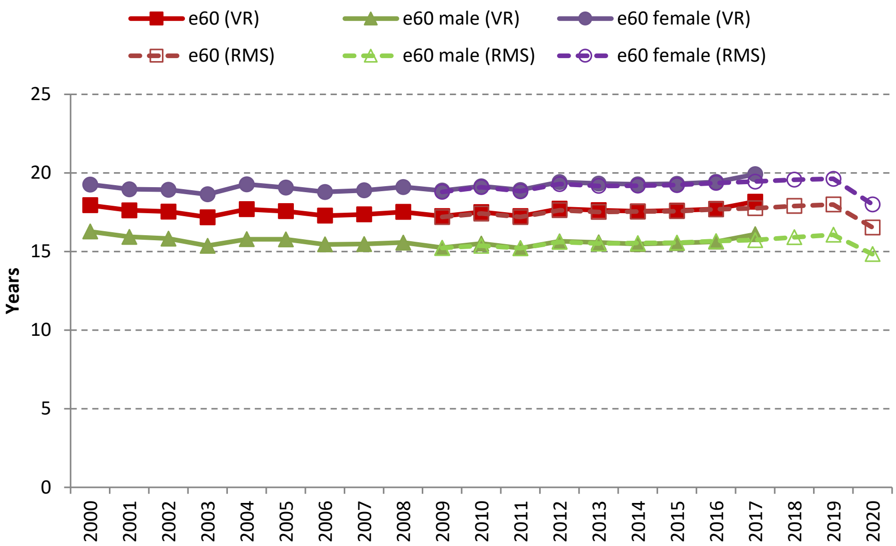


Figure 15: Life expectancy at the age of 60 (e_{60}) from VR and RMS, 2000-2020 (after adjusting for incompleteness)

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 17 622 in 2019 and decreased to 13 773 in 2020. The numbers of deaths by month, compared with the numbers of deaths reported by Stats SA for 2015-2017, is shown in Figure 16. There is a high degree of correspondence between the two series, with the marked seasonal effect all but disappearing in 2017 but returning in 2018, with deaths higher over the winter months from May-August. Late registrations for the last few months of 2017 had been captured by Stats SA by release of the data in 2018[7]. The monthly numbers of deaths in 2020 were unusually low in April and May and show no seasonal trend in the following months probably the result of impact of lockdown in the early months of COVID-19 epidemic.

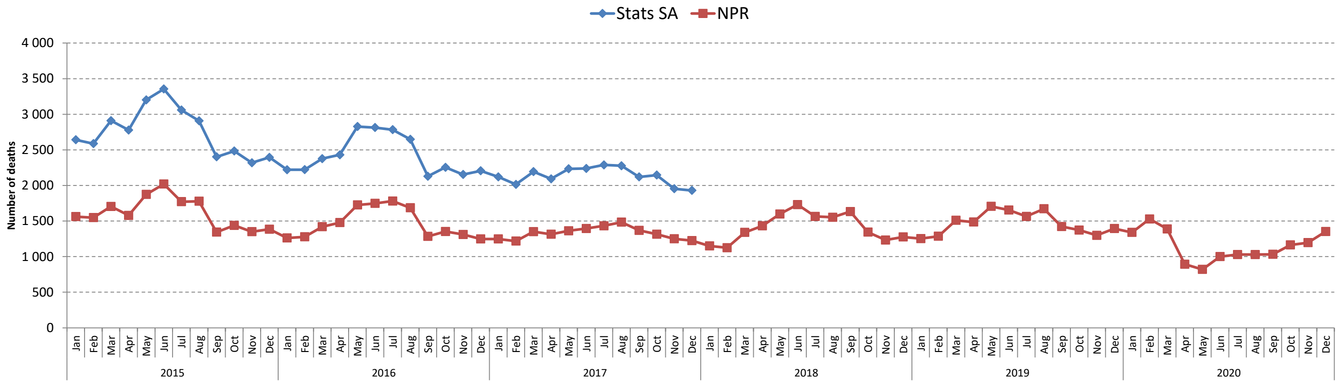


Figure 16: Monthly number of child deaths under 5- years from Stats SA and NPR, 2015-2020

The trends in the numbers of deaths by selected causes in the Stats SA data for 2012-2017 are shown in **Figure 17**. Both diarrhoeal deaths (ICD code A09) and pneumonia deaths (ICD code J18) have characteristic seasonal patterns which have attenuated over time. A summer peak in Feb-March for diarrhoeal deaths (ICD code A09) has almost disappeared. A winter peak in the pneumonia deaths (ICD code J18) as well as deaths from diarrhoea (ICD code A09) persist. 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 one would expect given the severity of the epidemic, 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. As mentioned above, the 2016 data suggests that deaths in the last two months, particularly in deaths from causes in the perinatal period, were not captured by Stats SA at the time of release of those data[7].

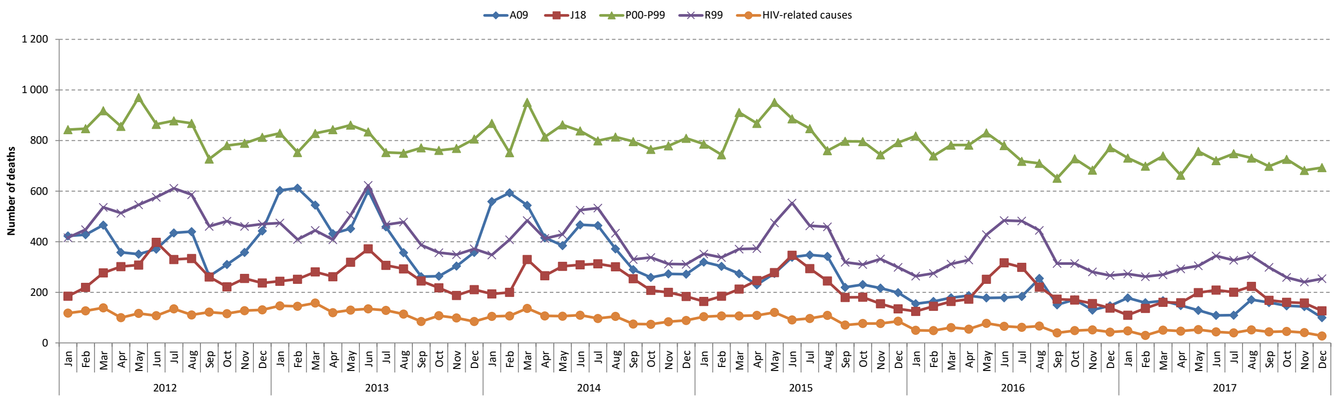


Figure 17: Number of child deaths under- 5 years of age by selected cause of death, Stats SA 2012-2017

Figure 18 shows the monthly number of deaths under age 5 from the NPR by year (with the lines becoming darker as the years progress to 2020). From 2013, 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. The May to August 'hump'

[7] These late registrations were captured by the time of the release of the data on deaths up to 2017 death data in 2020.

is missing from the deaths in 2017 but returned in 2018. The reason for this is, at this stage, unclear. In 2020 the deaths are much lower than reported in previous years, from March to November which is probably due to impact of both severe lockdown conditions and non-pharmaceutical interventions on communicable diseases. Health facility surveillance data show marked declined in influenza and respiratory syncytial virus (RSV) during 2020 (Tempia et al, 2021). However, it is likely that some of the drop in numbers in April and May is due to the halting of registration of births for part of that period. This is because a death will not be recorded on the NPR if the child is not on the NPR, and the child will not be on the register if the birth is not registered. Thus, the NPR numbers understate the numbers of deaths in these two months.

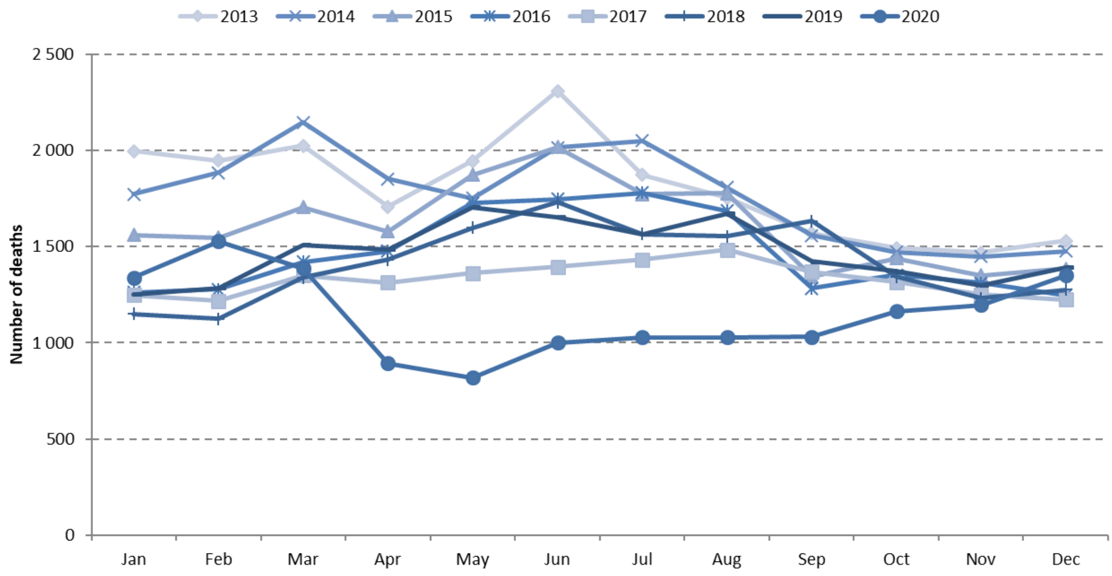


Figure 18: Number of child deaths under 5 years by month, NPR 2013-2020

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 the neonatal mortality rate (NMR). Figure 19 shows the number of neonatal deaths and stillbirths from the DHIS compared to the corresponding deaths from the cause-of-death vital registration (VR). Also included on the figure are the early and late neonatal rates from the DHIS, based on deaths per 1000 live births in the first 7 deaths and the next 21 days after birth, respectively. 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, 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, followed by a decline from 2015-2017, whereas the stillbirths captured by the DHIS has declined steadily over the whole period, particularly from 2015 to 2016, before increasing from 2016 to 2017 and remaining more or less stable up to 2020. The decline from 2015 to 2016 is a similar decline in the neonatal VR deaths.

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 number of the VR neonatal deaths, 75% in 2009, and 86% in 2010. By 2011, the number of neonatal deaths in the DHIS matched the number of the VR neonatal deaths and since then the number 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 on 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 after 2013) it seems more appropriate to assume that part, if not all, the decline in VR neonatal deaths in this period is due to a decline in completeness of registration commented on in previous reports. Thus, from 2016 the neonatal mortality is estimated directly from the DHIS record of neonatal deaths (instead of VR neonatal deaths) and live births recorded by the DHIS.

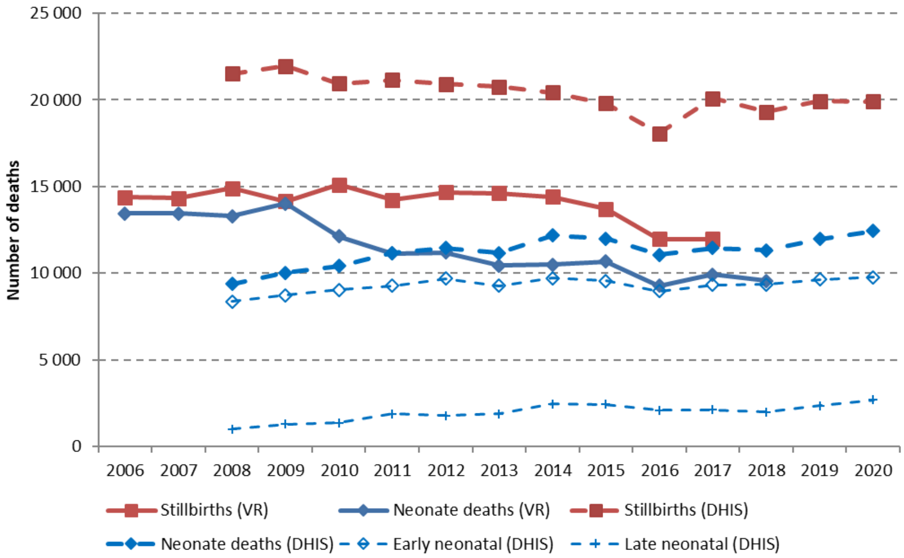


Figure 19: Stillbirths and neonatal deaths from VR and DHIS 2006-2020

Estimates of the key indicators of mortality for children are shown in Table 4 for the period 2015-2020. Figure 20 shows the U5MR, IMR and NMR. The U5MR and IMR are calculated from VR data for the period 2006-2017 and from the NPR data for the period 2009-2020, once the data have been adjusted for under-registration. The NMR is estimated from the registered deaths (adjusted for under-registration assumed to be at the same level as deaths under 1) for the period 2000-2017 and the DHIS (adjusted for under-coverage, relative to the registered deaths, and the incompleteness of the vital registration) for the period 2011-2020. From Figure 20, 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 for the period 2009-2013, then increased slightly to 12 per 1 000 in 2014 and has remained stable up to 2020 apart from a slight drop to 11 per 1 000 in 2018. There was a slight increase in the IMR and U5MR in 2018, however the IMR and U5MR experienced a significant reduction in 2020 to 21 and 28 per 1 000 live births respectively, probably as a consequence of the very restrictive lockdown implemented from the end of March 2020, which, limited social interaction, and infection (through non-pharmaceutical interventions).

Also included on the figure are estimates of the 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 from DHIS deaths and births. These estimates confirm that it is possible to produce accurate estimates of the NMR and IMR from the recorded data directly. From 2013, the NMR is being estimated from the DHIS deaths and births directly.

Table 4: Estimated U5MR, IMR and NMR per 1 000 live births, RMS and DHIS 2014-2020

INDICATOR	2014	2015	2016	2017	2018	2019	2020
Under-5 mortality rate (U5MR)	42	39	36	33	34	36	28
Infant mortality rate (IMR)	29	28	26	23	26	27	21
Neonatal mortality rate (<28 days) (NMR)*	12	12	12	12	11	12	12

* NMR is calculated from DHIS data

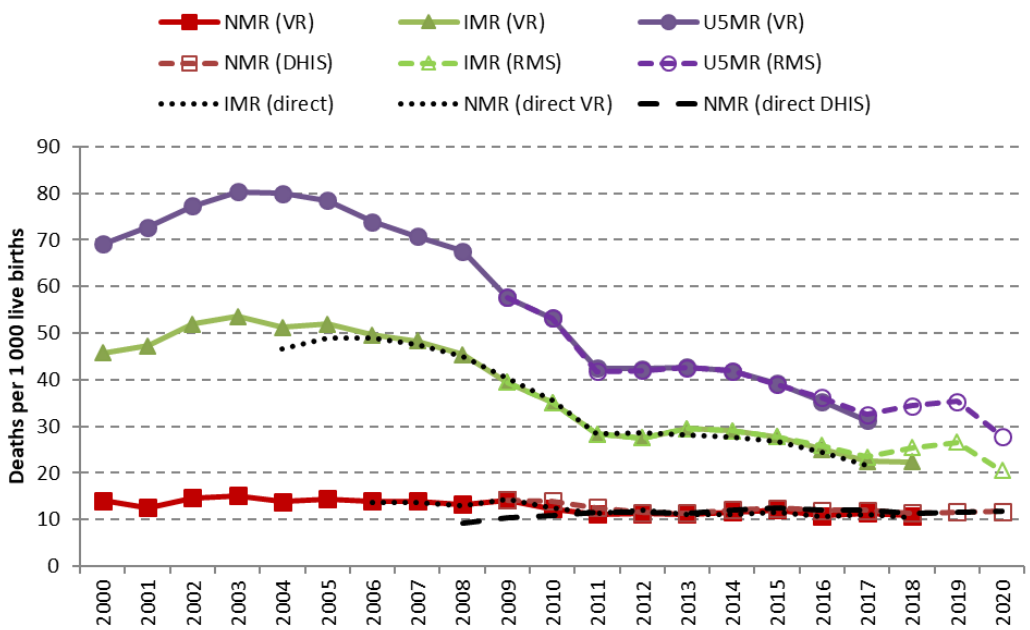


Figure 20: Under-5 mortality rate (U5MR) and infant mortality rate (IMR) from VR/RMS and neonatal mortality rate (NMR) from VR/DHIS, 2000-2020 (after adjusting for incompleteness)

OLDER CHILDREN, ADOLESCENT AND YOUTH MORTALITY

This indicator has been included in this report because the growing interest in tracking the mortality of older children, adolescents and the youth (Hill, Zimmerman and Jamison, 2015 & 2017; Masquelier, Hug and Sharrow, 2018; UN IGME, 2018). From Table 5 and Figures 21 and 22 one can note that although both indicators peak in 2004, ${}_{10}q_5$, the probability of a five-year old dying before age 15, is similar to under-5 mortality in that the male and female rates trend in parallel, with males higher than females. On the other hand, ${}_{10}q_{15}$, the probability of a 15-year-old dying before age 25, the trend in rates cross over, with female rates showing a distinctly higher peak in 2004 than males and then falling to below male rates from 2012. The sharp uptick in 2012 (and slight uptick in 2010) seen in the mortality of older children and young adolescents (${}_{10}q_5$) in Figure 21 is associated with a higher number of deaths attributed to ill-defined natural causes in those years making an epidemiological interpretation impossible. It is possible that these increases were associated with campaigns to improve the registration of deaths. The rapid decline in mortality of older adolescent and youth (${}_{10}q_{15}$) among females since 2004 coincides with the provision of ARTs to pregnant women. This mortality rate is an essential impact indicator related to this campaign "She Conquers" campaign[8] launched by government in June 2016 seeking to reduce HIV infections, improve overall health outcomes, and expand opportunities for adolescent girls and young women (AGYW). However, the rate of decline slowed down since 2014 despite the introduction of the campaign. The mortality rate among males aged 15-24 remained constant at around 25 per 1 000 from 2011 until 2019. The level decreased to 22.7 per 1 000 in 2020, reflecting the substantial reduction in unnatural deaths brought about by the severe limitations of travel and social interaction and alcohol consumption under the lockdown introduced in April 2020.

Table 5: Estimated mortality rates of older children & young adolescents and older adolescents & youth 2014-2020

INDICATOR	2014	2015	2016	2017	2018	2019	2020
Older children & young adolescents (${}_{10}q_5$ per 1000)							
Total	7.3	7.0	6.5	6.0	6.2	5.9	5.3
Male	8.2	7.8	7.4	7.0	7.0	6.7	6.1
Female	6.5	6.2	5.6	5.1	5.3	5.0	4.5
Older adolescents & youth (${}_{10}q_{15}$ per 1000)							
Total	22.6	22.3	21.7	21.4	20.8	20.5	18.7
Male	25.8	26.3	25.8	26.0	25.2	25.5	22.7
Female	19.5	18.4	17.5	16.9	16.4	15.5	14.8

[8] National Department of Health. She Conquers. Available: http://sheconquerssa.co.za. Accessed: 14 September 2020.

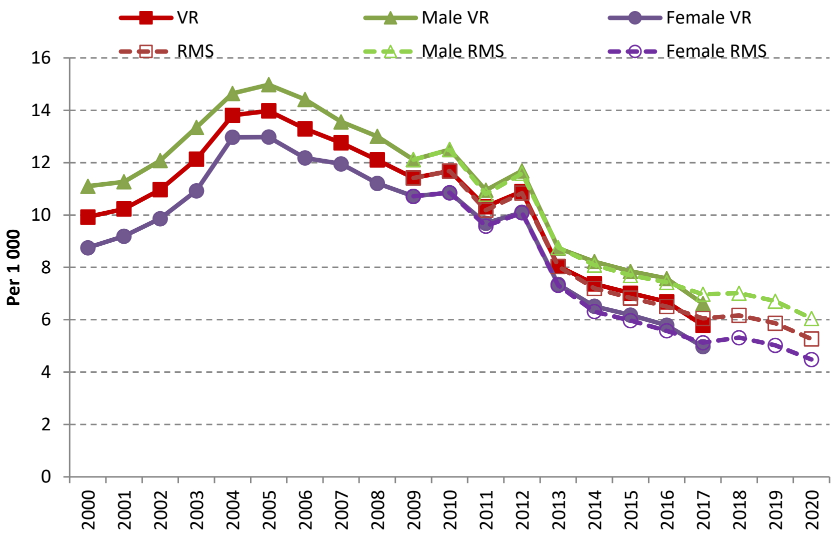


Figure 21: Estimate of $_{10}q_5$, the probability of five-year old dying before age 15, for males, females and both, 2000-2020

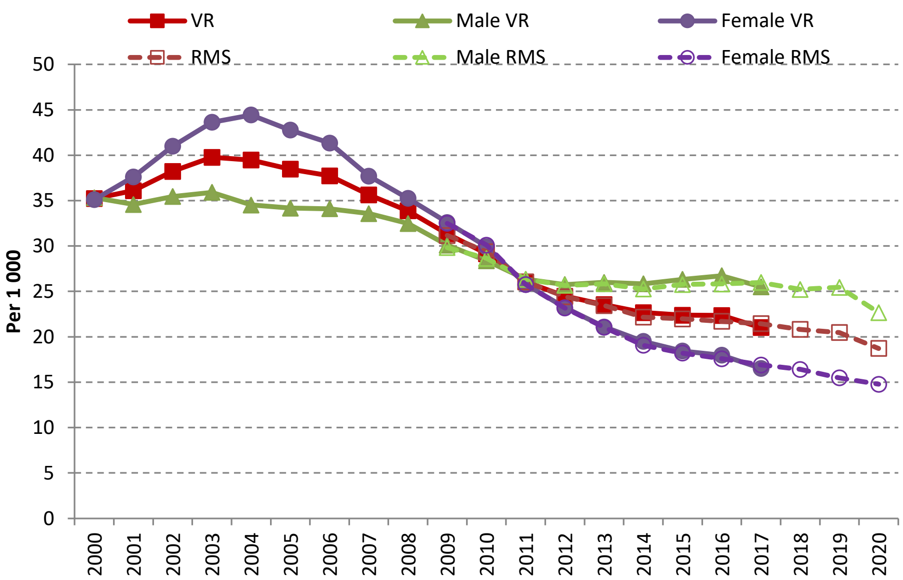


Figure 22: Estimate of $_{10}q_{15}$, the probability of 15-year-old dying before age 25, for males, females and both, 2000-2020

MATERNAL DEATH

The estimated MMR rose from 232 per 100 000 live births in 2006 to peak at 302 per 100 000 live births in 2009 before dropping substantially to 109 per 100 000 live births in 2017 (Table 6). The uncertainty about the level of maternal mortality is well recognised (HDACC, 2011; Bradshaw and Dorrington, 2013; Stats SA, 2013b; Dorrington and Bradshaw, 2016). However, the steep drop in the PRMR from the VR data shown in Figure 6 suggests there may be an issue with the VR data. Investigation shows that the percentage of deaths of females aged 12 to 50 that were recorded as either "not applicable" or "unknown" rose from 0.1% in 2015 to 3.8% in 2016 and 6.6% in 2017.

Table 6: Estimated MMR per 100 000 live births, Stats SA 2013-2017

INDICATOR	2013	2014	2015	2016	2017
Maternal mortality ratio (MMR)	153	166	153	137	109

Figure 23 shows the estimates of the maternal mortality ratios (MMRs) and pregnancy-related mortality ratios (PRMRs) produced from different data sources, including the institutional MMR (iMMR) based on confidential enquiry. 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 of the iMMR reported by the National Committee for Confidential Enquiry into Maternal Deaths (NCCEMD 2018; Moodley et al, 2020) are about 30% higher than those estimated from VR data. After the peak they both decline to values that are much lower than the RMS/MDG/SDG estimates until recent years when the estimates are very similar. It is somewhat implausible that the RMS estimates is now well below that of the confidential enquiry. This is the result of the decline in the reliability of the reporting on pregnancy status in the VR data in 2017.

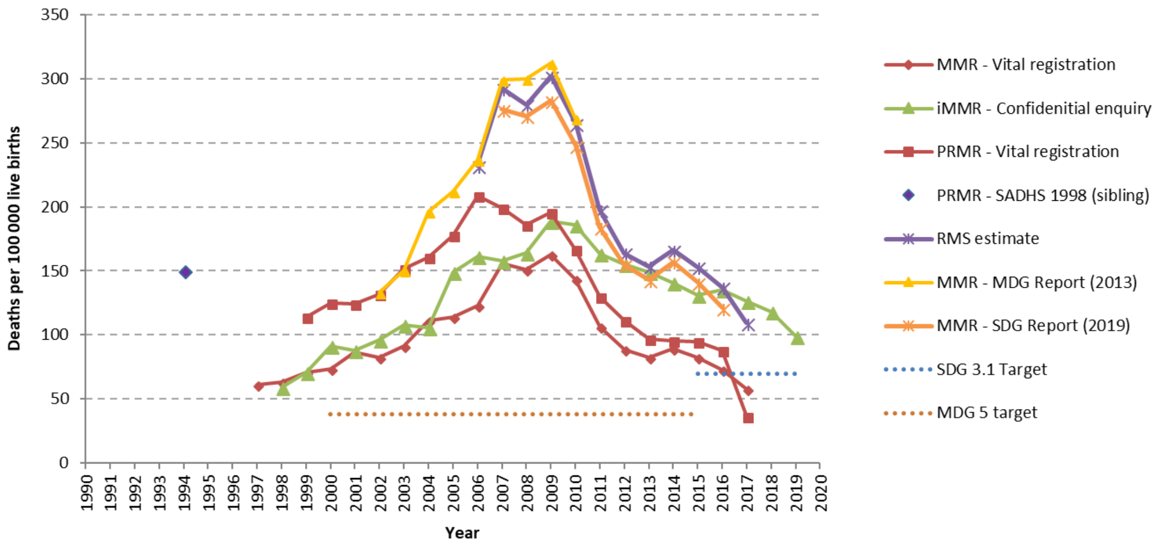


Figure 23: Estimate of MMR from various sources, 1995-2017

Nonetheless, the RMS estimates, as well as those reported in the 2013 and 2015 MDG Country Reports (Stats SA, 2013b; Stats SA, 2015a) and the 2019 SDG Report (Stats SA, 2020) the institutional MMR reported by the National Committee for Confidential Enquiry into Maternal Deaths (NCCEMD 2018; Moodley et al, 2020), 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 24 indicate a marked increase in the number of indirect maternal deaths since 2003. As noted by Bradshaw and Dorrington (2013), 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 around 2000 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 24 is the fact that there appears to have been a drop in the numbers of deaths from every cause since 2009, with a sizeable decline in “Complications from other conditions” from 2011 to 2012. 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 was no decline in “Complications from other conditions” for 2012-2014 but a steady decline after that, yet deaths from these causes are still twice the level they were in 2003. The rapid drop in numbers due to other causes from 2016 to 2017, again points to a possible deterioration in recording of causes of maternal deaths. Moodley et al (2020) highlight that by 2019, there had been a steady rise in early pregnancy deaths and deaths due to pre-existing medical and surgical conditions.

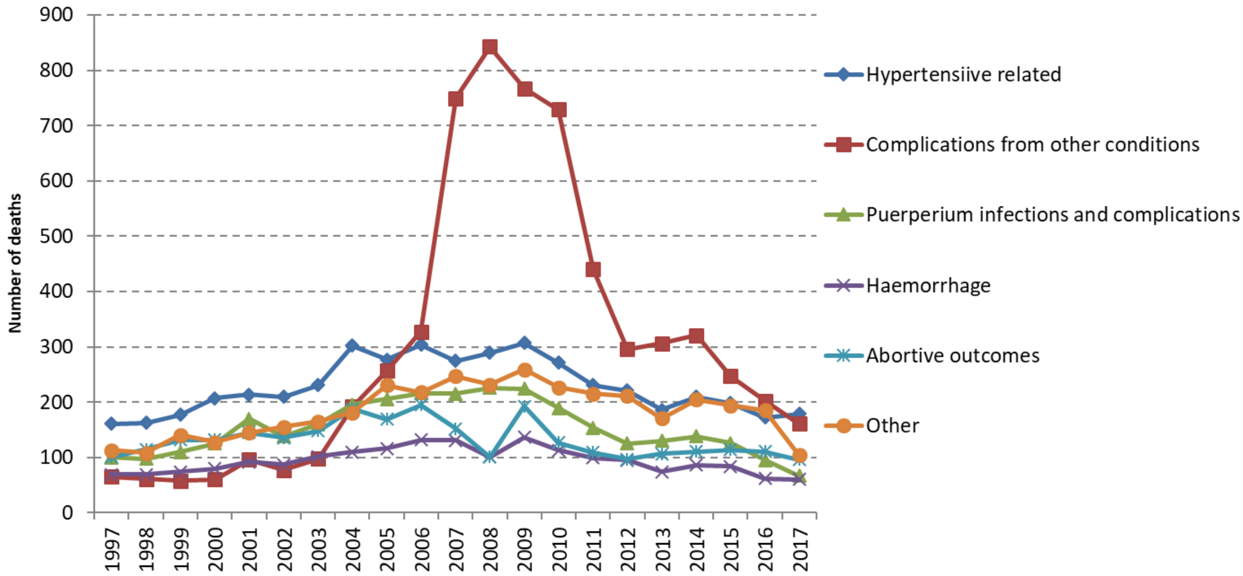


Figure 24: Trend in the number of maternal deaths by cause, Stats SA 1997-2017

MORTALITY DUE TO NON-COMMUNICABLE DISEASES (30-69 YEARS)

Since the 2017 report an indicator for tracking mortality due to non-communicable diseases (NCDs) has been monitored. These indicators ($_{40}q_{30}$) are estimated by applying the proportions of deaths observed in the VR data due to cardiovascular disease (CVD; ICD-10 codes I00-I99), cancer (ICD-10 codes C00-C97), chronic respiratory disease (CRD; ICD-10 codes J30-J98) and diabetes (ICD-10 codes E10-E14), adjusted for a proportion on the ill-defined natural causes (ICD-10 codes R00-R99) to the estimated total number of deaths. A life table method is used to calculate the probability, expressed as a percentage, that a 30-year-old-person would die before their 70th birthday from cardiovascular disease, cancer, diabetes, or chronic respiratory disease, assuming that s/he would experience current mortality rates at every age, and s/he would not die from any other cause of death (e.g., injuries or HIV/AIDS).

The overall NCD $_{40}q_{30}$ is shown in Table 7 as well as the component for each disease category. Although, with the exception of a small decline in premature mortality from cardiovascular diseases for both men and women, and chronic respiratory disease for women, there was very little evidence of a change in rates of NCD mortality in the period 2013-2017, the rates have dropped significantly between 2016 and 2017. This is particularly noticeable in cardiovascular disease for men and women, and cancers for men. However, these results should be treated with caution as they may be, in part at least, the result of a decline in completeness of reporting or increase in the proportion being recorded late, and some deterioration in the quality of attribution of cause of death in recent years.

It should be noted that the South African National Burden of Disease Study (Pillay-van Wyk et al 2014, Pillay-van Wyk et al 2016) uses a more complex methodology to adjust for additional forms of misclassification of causes of death and produces slightly different estimates for these indicators.

Table 7: Estimated mortality rates (NCD $_{40}q_{30}$) due to non-communicable diseases (NCD), Stats SA 2013-2017

INDICATOR		2013	2014	2015	2016	2017
NCD $_{40}q_{30}$	Total	29%	29%	30%	30%	29%
	Male	34%	34%	35%	35%	34%
	Female	24%	24%	24%	24%	24%
INDICATOR		**2012**	**2013**	**2014**	**2015**	**2016**
Cardiov. disease $_{40}q_{30}$	Total	14%	14%	14%	14%	14%
	Male	18%	17%	18%	18%	17%
	Female	12%	11%	11%	11%	11%
Cancer $_{40}q_{30}$	Total	9%	9%	9%	9%	9%
	Male	10%	11%	11%	11%	10%
	Female	7%	7%	8%	8%	8%
Diabetes $_{40}q_{30}$	Total	5%	5%	5%	5%	5%
	Male	5%	5%	6%	6%	5%
	Female	5%	5%	5%	5%	5%
Chronic resp. disease $_{40}q_{30}$	Total	4%	4%	4%	4%	4%
	Male	6%	6%	6%	6%	6%
	Female	3%	2%	2%	2%	2%

Figure 25 shows the estimates of $_{40}q_{30}$, the probability of 30-year-old dying before age 70, due to non-communicable diseases, for males, females and both sexes combined for 2000-2017. Although the rates for women are about 70 per cent of those for men, the trends over time are very similar, rising to a peak (of 37% for men and 28% for women) in 2003 and then declining to 33% for men and 24% for women by 2012, after which the rates remain more or less level.

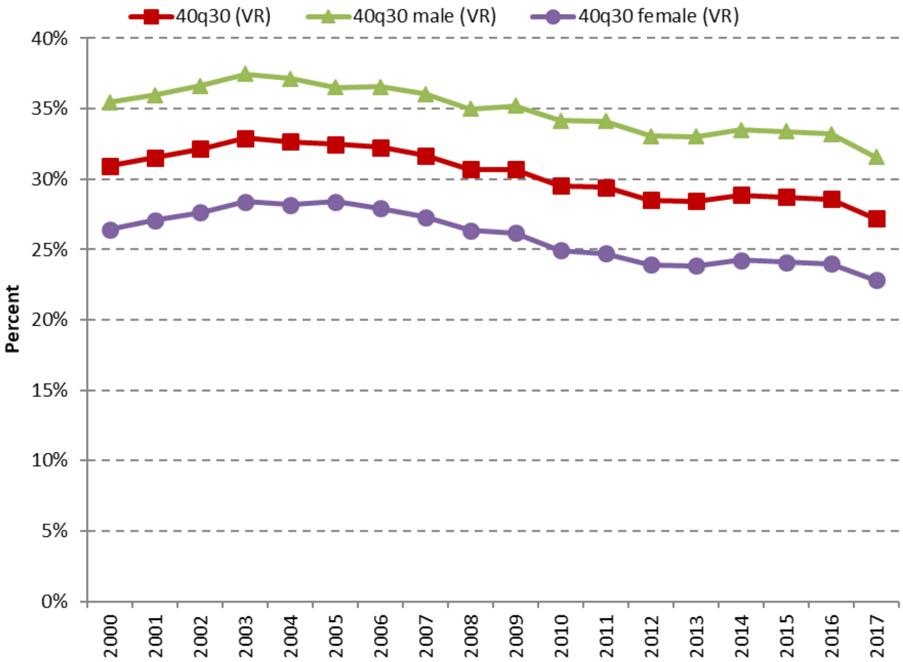


Figure 25: Estimate of $_{40}q_{30}$, the probability of 30-year-old dying before age 70, due to non-communicable diseases, for males, females and both, 2000-2017

Figure 26 presents the mortality rates ($_{40}q_{30}$) by major NCD causes for males and females separately. The trends for each cause differ over time, with CVD clearly declining from a peak in 2003, CRD from a peak in 2005 and Diabetes pretty level over the whole period. Premature mortality from Cancer has been more stable over the period. The gender differences also differ by cause. The Cancer mortality rates for women are about 70% of those for men over the whole period. For CVD, the female to male ratio falls from 74% in 2000 to 65% in 2017 while for CRD, the ratio rises from 46% in 2000 to above 50% in 2005/6 then falls to 42% by 2017. In the case of Diabetes, the rate for females is higher than that for males in the earlier period with the ratio starting at 112% in 2000 and falling to about 98% by 2017.

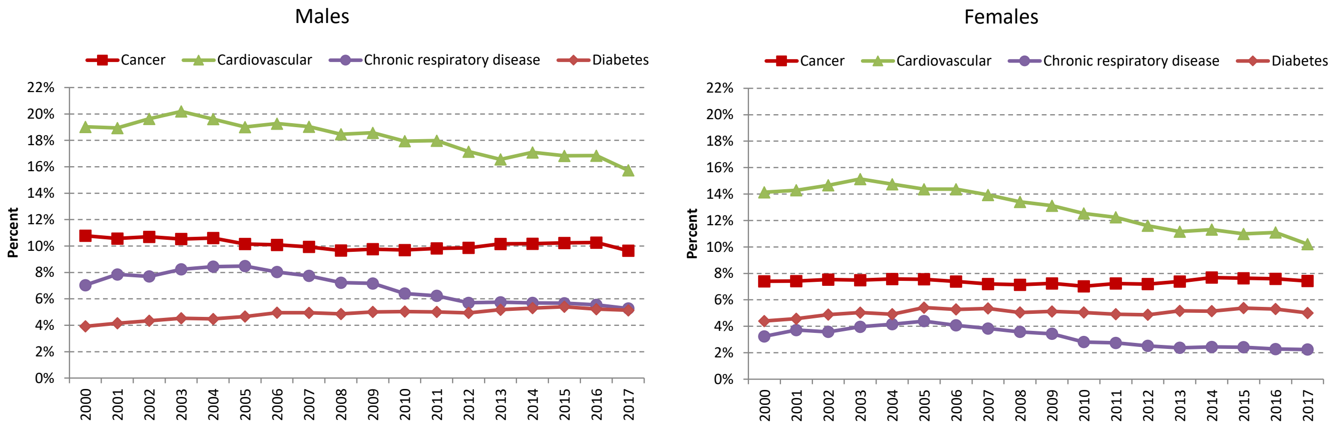


Figure 26: Trend in cause-specific $_{40}q_{30}$, the probability of 30-year-old dying before age 70, due to non-communicable diseases, for males and females, 2000-2017

COMPARISON WITH ESTIMATES FROM OTHER SOURCES

As done previously, the estimates from the Rapid Mortality Surveillance are compared with updated estimates from Stats SA (from 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, 2015 and 2016 Global Burden of Disease (GBD) reports (not shown), and the GBD 2019 report). In addition, estimates of the under-five and neonatal mortality from the 2016 South African Demographic and Health Survey (NDoH, Stats SA, SAMRC & ICF, 2017) are included.

Figure 27 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 2020) and those of the World Population Prospects (WPP), 2019 revision (UN Population Division 2019) over much of the period to 2019, and the SDG (Stats SA 2017b) estimates for 2010 and 2011, and for the first time, the most recent estimates, GBD 2019, from IHME (2018) for much of the period. However, estimates not yet updated for the SARS-CoV-2 pandemic (IGME and WPP) overestimate the mortality of children under-5 for 2020.

In contrast to their 2018 estimates, which were higher than all other estimates from 2010 onwards, the estimates from this year's official mid-year population projection (Stats SA 2021) fall below most of the other estimates until 2013, and, despite apparently taking allowing for the impact of the epidemic, are similar to those of the IGME and WPP. On the other hand, the estimates derived from the 2011 census (Stats SA 2015b) and the SDG estimates after 2011 are lower than all other estimates, suggesting that these probably underestimate under-five mortality. Although the similarity of RMS to UN IGME estimates is probably because UN IGME now consider the RMS estimates when producing their estimates. However, a common feature of estimates produced by models is that they are unable to reproduce periods of stagnation or rapid changes in rates found in estimates derived from empirical data.

The RMS estimates are not consistent with those from the 2016 SADHS (for the period 2002-2006), which is undoubtedly due to the bias in the SADHS estimates due to the 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 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 could suggest that the RMS estimates of IMR may be too low in recent years. However, further investigation suggest that it is possible that the SADHS misclassified stillbirths as neonatal deaths nationally. In addition, the SADHS underestimated the under-five mortality substantially in KwaZulu-Natal. Correcting for these biases would produce estimates for the most recent period that are much more consistent with the RMS estimate.

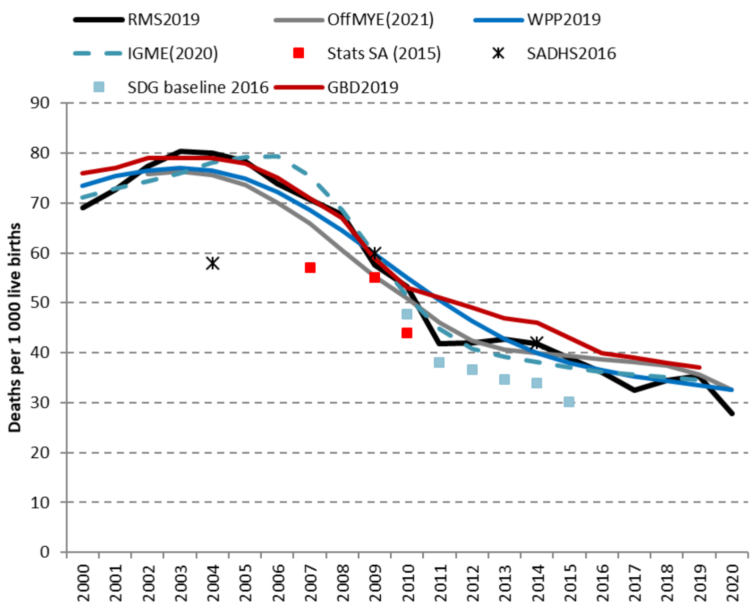


Figure 27: Comparison of estimates of the under-5 mortality rate (U5MR), 2000-2020

Figure 28 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 for the GBD 2019, with the RMS estimates being two years higher than the GBD 2019 estimates until 2015, after which the GBD 2019 estimates increase rapidly to overtake the RMS estimates by 2016. After this, the GBD 2019 estimates continue to increase, a little implausibly by more than 1 year from 2017 to 2018. Although the WPP estimates are similar to the RMS estimates at the minimum they are about 1 year lower outside this period mainly 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, 2021) are almost entirely consistent with the RMS estimates in recent years (despite noticeable difference in the mortality under age five), which implies that Stats SA's adult mortality must be somewhat higher than that of the RMS in the earlier years. The difference in life expectancy in 2020 is probably reflects not only the higher mortality under age 5, but probably higher mortality over other parts of the age range, as their allowance for excess deaths does not reflect the age distribution of the excess deaths.

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, declining to a minimum in 2005 (not presented). However, while according to the RMS the difference declined from 5.8 years in 2000 to 3.7 years in 2005 before rising to 5.2 years in 2010 and 6.4 in 2015, the comparable figures for GBD 2019 (IHME 2019) were 6.3 years, 3.6 years, 4.7 years and 5.9 years, much more comparable to the RMS than their previous estimates, and those for WPP, namely, 6.0 years, 4.8 years, 5.7 years and 6.8 years respectively.

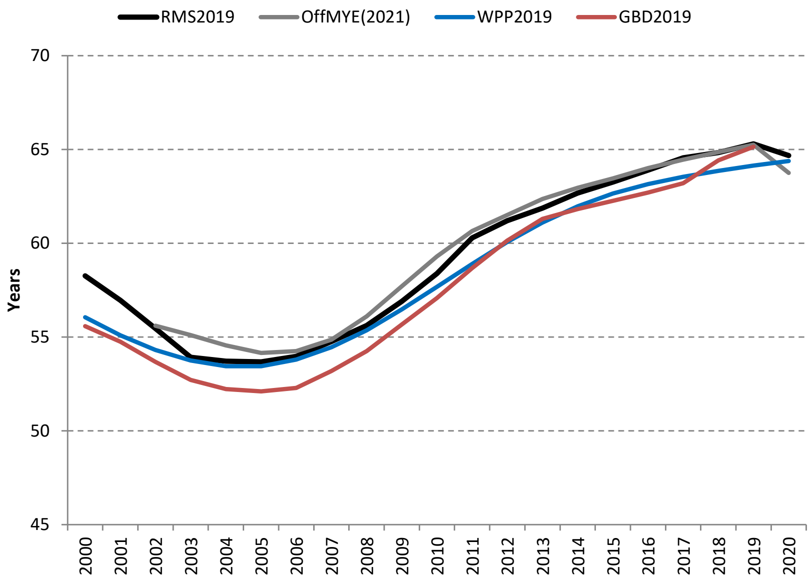


Figure 28: Comparison of estimates of life expectancy at birth (e_0), 2000-2020

Although there is consistency between the RMS and SDG estimates of MMR (Figure 29), 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 four quite different estimates (not shown) produced by IHME (Hogan et al 2010, Lozano et al 2011, and Kassebaum et al 2014, IHME 2015) prior to the latest, and different yet again, to the GBD 2017 (IHME 2018) estimate and the quite different estimates produced by MMEIG (WHO et al 2012 & 2014) (not shown) and the most recent estimate (MMEIG 2016). The latest GBD 2019 estimates from IHME (2019) peak earlier than the RMS estimates and although not as low as their previous estimates, which fell to be implausibly[9] low after 2011, shows an implausible increase in the rate after 2017. However, the fact that the RMS estimates lie comfortably in the cloud of uncertainty suggests that they, even given the possible underestimate for 2016 and 2017 are at least as reliable as any of the estimates shown in Figure 29. Surely, they are more sensible than estimates that suggest that HIV/AIDS had little or no impact on maternal mortality or estimates that suggest the ratio peaked several years before adult mortality rates peaked because of HIV/AIDS.

[9] Implausible because they imply negative MMR for births outside the public facilities.

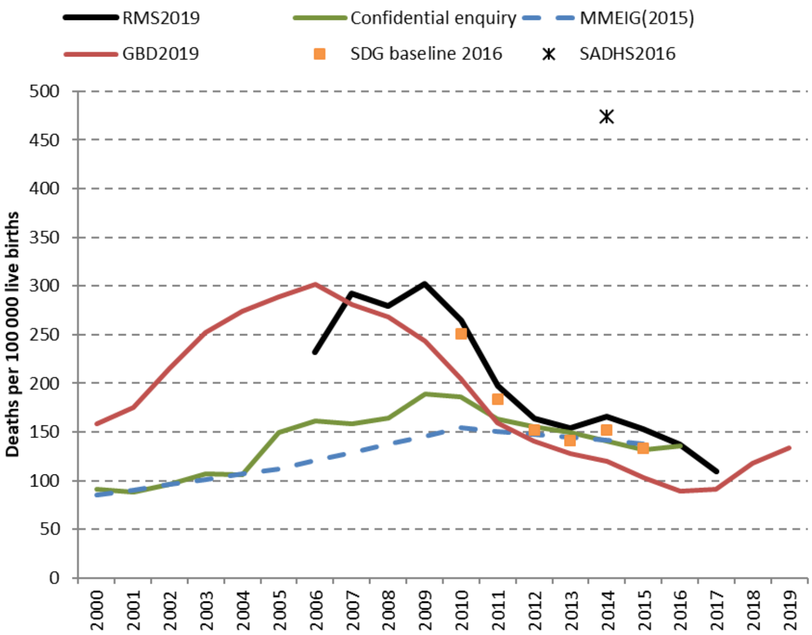


Figure 29: Comparison of estimates of maternal mortality ratio (MMR), 2000-2019

As far as adult mortality is concerned (Figure 30), the RMS estimates lie below the IHME estimates but are very close to the WPP estimates, albeit the most recent point reflects excess deaths in 2020 which are not accounted for by the WPP estimates released in 2019.

As indicated above, the IHME estimates of life expectancy at birth are lower than 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, except for the improbable decline in rates from 2017 to 2018 (Figure 30).

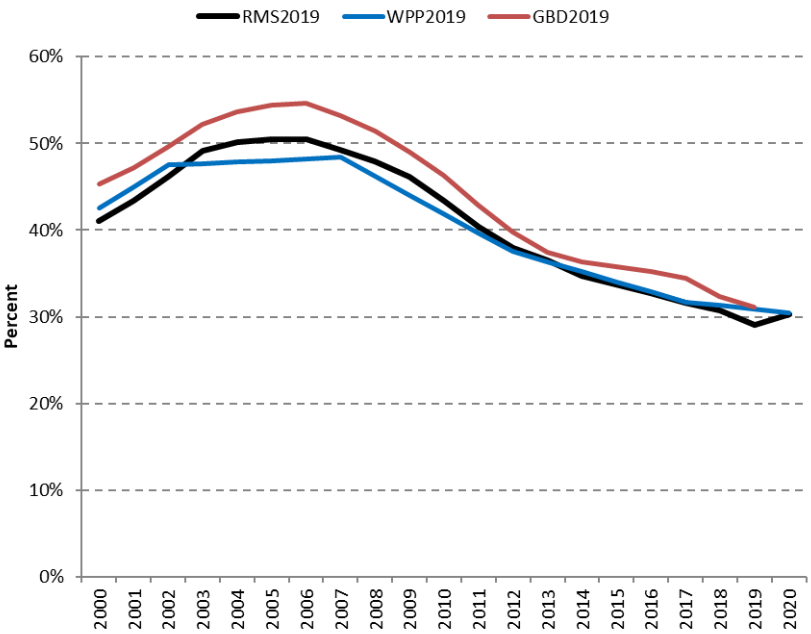


Figure 30: Comparison of estimates of adult mortality ($_{45}q_{15}$) for males and females combined, 2000-2020

Although it is difficult to be sure that the neonatal mortality in South Africa is as low throughout the period as that estimated by the RMS (Figure 31), it is important to point out that although the GBD 2019 estimates (IHME 2019) are more plausible than those of GBD 2017, they still imply a questionable trend in completeness of registration of neonatal deaths over the period rising from an improbable around 55% in 2000 to nearly 70% by late 2000s.

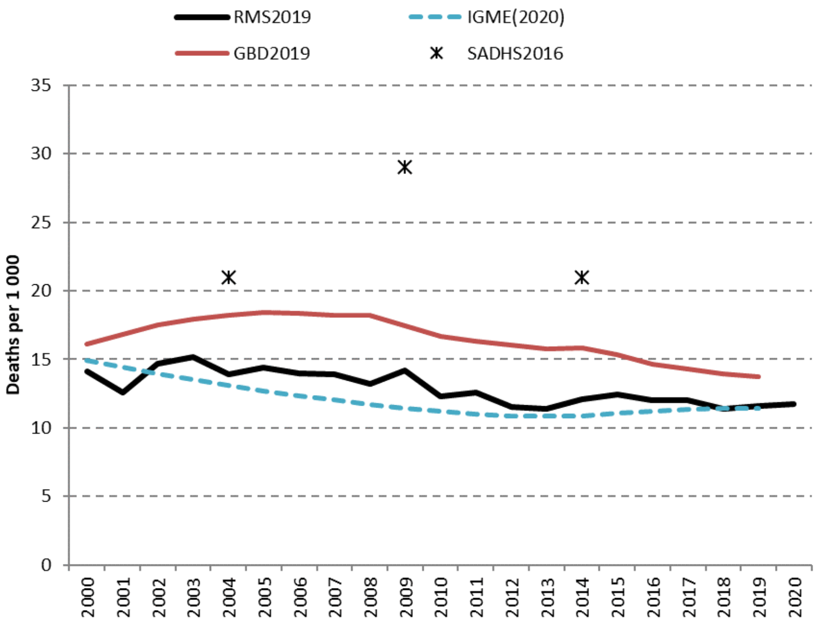


Figure 31: Comparison of estimates of neonatal mortality rates (NMR), 2000-2020

Finally, the RMS estimates of the ${}_{10}q_5$ and ${}_{10}q_{15}$ are reasonably consistent with estimates from GBD 2019 (but this has not always been the case with previous GBD estimates (not shown)) but less so with the WPP 2019 estimates (Figure 32).

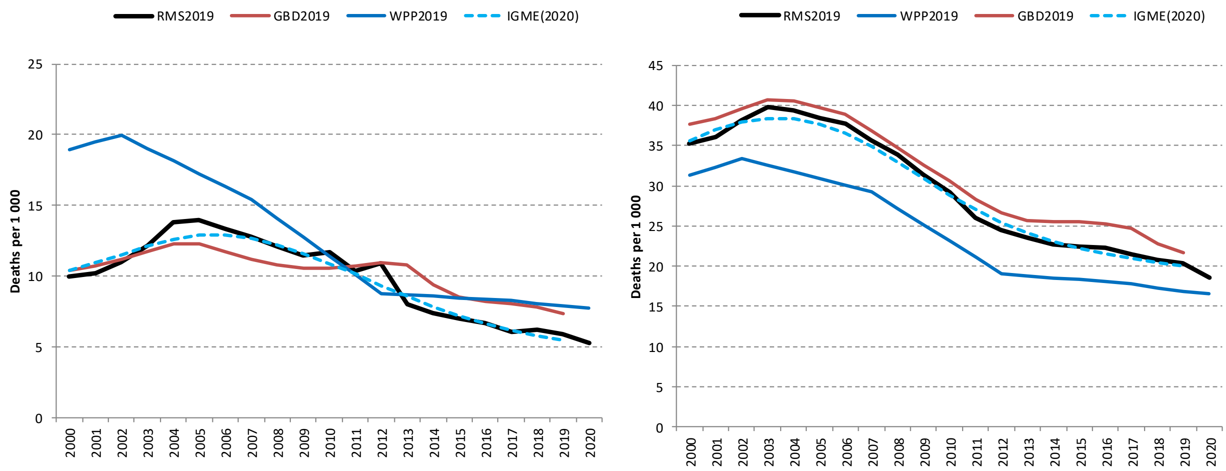


Figure 32: Comparison of estimates of older children & young adolescent and older adolescent & youth mortality rates (${}_{10}q_5$ and ${}_{10}q_{15}$), 2000-2020

CONCLUSIONS

The 2019-2020 mortality estimates show that South Africa's progress in extending life expectancy and reducing mortality since 2005 has been interrupted by the SARS-CoV-2 pandemic. Estimates derived from empirical data indicate that life expectancy increased by more than ten years from the low of 53.7 years in 2005 to reach 65.3 in 2019 only to fall by 0.6 years to 64.7 in 2020. The drop in life expectancy in South Africa is less than has been the case where it has been measured in other, mostly developed, countries (Aburto *et al*. 2021). However, it should also be noted that the apparent drop of only 0.6 of a year represents a gap of about 1.6 years from what might have been anticipated had the mortality improvements of the previous period continued. In addition, in contrast to the experience in the majority of countries reported by Aburto *et al.* (2021), the impact on life expectancy in South Africa has been greater for females who experienced a drop of 1 year than for males who experienced a drop of 0.2 years. The muted impact of COVID-19 is mainly due to the impact of the severe lockdown (restricting social interaction and travel) and non-pharmaceutical interventions (NPIs) on non-COVID mortality. In the case of males, the marked reduction in the number of deaths from unnatural causes during periods of stringent lockdowns including alcohol restrictions (Moultrie et al 2021) has contributed to their improved life expectancy.

Life expectancy at age 60 is a useful summary of the mortality experienced by older South Africans. For the first time since 2000, there have been marked changes in older age mortality. The life expectancy at age 60 has been about 17.5 years (15.5 years for men and 19.5 years for women) from 2000 to 2019, but in 2020 the life average life expectancy at age 60 years fell to 16.5 years (14.7 years for men and 18 years for women), reflecting the impact of COVID-19 mortality. The drop was greater for females (1.6 years) than for males (1.3 years). Even before the COVID-19 pandemic, South Africa's life expectancy at age 60 was lower than the global average life expectancy at age 60 years of around 21 years for 2020 as estimated by the UN (2019).

Infant and under-five mortality has been declining since 2003, except for periods of stagnation between 2011 and 2014 and 2017 and 2019, reaching new national lows of 21 and 28 per 1 000 live births in 2020 respectively. Of concern is that rates were on the increase after 2017, with most of the decline between 2019 and 2020 due to the impact of lockdown and NPIs. In contrast, the neonatal mortality rate that had shown little change since 2010 and remained 12 deaths per 1 000 in 2020. Examination of the data show that the low infant and under-5 morality rates in 2017 were associated with an unusually low winter peak in deaths, particularly among infants 1-11 months old. It is not clear whether this was possibly a result of health system success (e.g., community out-reach) or milder than usual conditions.

The data suggest that the Medium-Term Expenditure Framework targets for 2019 of the U5MR (33 per 1000 live births), IMR (23 per 1000 live births) and NMR (6 per 1000 live births) were not met (in particular for U5MR and IMR because of the increase in rates after 2017). As highlighted previously, by 2011, neonatal causes of death had overtaken HIV/AIDS as the leading causes of death among under-5-year-olds. A further reduction in child mortality will require further efforts to improve and equitably implement across districts, the basic health services aimed at preventing neonatal deaths, elimination of mother-to-child transmission of HIV, the Expanded Programme of Immunisation as well as reducing the incidence of pneumonia and diarrhoea (Nannan *et al,* 2019). In addition to strengthening primary health care, promoting exclusive breast-feeding and addressing environmental and social factors associated with poor infant and child health are needed (Goga *et al*, 2019). Such efforts are critical to counter the longer-term impact of COVID-19 - direct and indirect.

The MMR was estimated at 137 per 100 000 live births in 2016 and 109 per 100 000 live births in 2017, after having stagnated between 150 and 165 deaths per 100 000 live births for several years. Although the estimates of maternal mortality suggest that the rate declined in 2016 and particularly 2017, there are growing concerns about the quality of the VR data, with increasing numbers where pregnancy status is either "not applicable" or "unknown". So, as reported previously, South Africa still has some way to go to reach the SDG target of 70 per 100 000 live births by 2030.

An indicator of the mortality of older children and young adolescents aged 5-14 years (${}_{10}q_5$) was introduced in the 2017 report. Global estimates have highlighted concerns that although mortality is low, most of these deaths are preventable and the need for the public health community not to lose sight of the fact that decades of growth and development in the transition to adulthood also involve complex processes and crucial ages or age-intervals or periods in the life cycle that are sensitive to intervention (Bundy et al, 2018). Although the mortality rates have declined, and South Africa is keeping more children alive, greater attention is needed to prevent illness and injury and promote optimal health, growth and development which include key challenges of malnutrition, HIV, violence and mental health conditions (Lake *et al*., 2019). The 3rd Disease Control Priorities project has identified two cost-effective and scalable health interventions including a school package during older childhood years (5–9 years) and phase-specific support during adolescence (10–19 years) enabling substantial catch-up from early growth failure and support brain maturation (Bundy et al, 2018). In South Africa, mortality of the older children and young adolescents has declined from a (HIV/AIDS) peak in 2004 with the provision of ARVs, although, for males the rate stagnated from 2011 to 2019, it dropped significantly in 2020 due to the impact of strict lockdown on unnatural deaths in particular.

As reported previously, there has been no improvement in NCD mortality over the period 2011- 2017. The risk of a 30-year-old dying before age 70 from the selected NCDs considered to be preventable is 32% for males and 23% for females. The risk factors associated with these NCDs, including overweight and obesity, raised blood pressure, increased blood glucose levels and non-optimal blood cholesterol levels (particularly raised LDL cholesterol), are considered modifiable through changes in behaviours or medications. The key behaviours that would reduce the risk factors for NCDs are eating a healthy diet, participating in regular physical activity, not using tobacco and avoiding harmful use of alcohol. The 2016 SADHS has identified concerning levels of raised blood pressure, overweight and obesity, tobacco use and alcohol use (NDoH, Stats SA, SAMRC & ICF, 2017). These were also observed in the 2012 SAHNAHES, including a high prevalence of diabetes and low levels of physical activity (Shisana et al, 2014). Renewed focus on NCDs is required to reduce premature mortality from these conditions. The National Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2013-17 (NDoH, 2013) identified important policy options to influence these risk factors which need to be implemented together with community-based interventions as well as improving primary health care to diagnose and manage these risk factors and their complications.

During 2020, the RMS was modified to track the weekly number of deaths and thereby provide critical insight into the impact of COVID-19 in near to real time (Bradshaw et al, 2021; Moultrie et al, 2021, Dorrington et al, 2021). These data have revealed that mortality in 2021 can be expected to be somewhat higher than in 2020 because of the devastating 2nd and 3rd waves of the COVID-19 pandemic associated with new variants of the virus. The identification of excess deaths also highlighted the need for Government to fast track cause-of-death information and to **change the administrative system to ensure that the NDoH has access to cause-of-death information at the time of death registration** to inform public health actions (Bradshaw et al, 2021). It also remains essential to expand the analysis in this report to provide provincial estimates of the key mortality indicators.

REFERENCES

Aburto JM, Schöley J, Kashnitsky I, Zhang L, Rahal C, Missov TI, Mills MC, Dowd JB, Kashyap R. Quantifying impacts of the COVID-19 pandemic through life-expectancy losses: a population-level study of 29 countries. *International Journal of Epidemiology* 2021, dyab207 https://doi.org/10.1093/ije/dyab207 Online ahead of print

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

Bradshaw D, Dorrington RE, Laubscher R. *Rapid mortality surveillance report 2011*. Cape Town: South African Medical Research Council, 2012. ISBN: 978-1-920618-00-1. https://www.samrc.ac.za/sites/default/files/files/2017-05-26/RapidMortality2011.pdf. Accessed 7 October 2021.

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

Bradshaw D, Dorrington RE, Laubscher R, Moultrie TA, Groenewald P. Tracking mortality in near to real time provides essential information about the impact of the COVID-19 pandemic in South Africa in 2020. *S Afr Med J* 2021;111(8):732-740. https://doi.org/10.7196/SAMJ.2021.v111i8.15809

Bradshaw D, Laubscher R, Dorrington R, Groenewald P, Moultrie TA. *Report on weekly deaths in South Africa 1 January - 15 March 2020*. Burden of Disease Research Unit, South African Medical Research Council, 2020. https://www.samrc.ac.za/sites/default/files/files/2020-04-17/WeeklyDeaths_15March2020.pdf Accessed 6 October 2021.

Bundy DAP, de Silva N, Horton S, Patton GC, Schultz L, Jamison DT, Disease Control Priorities-3 Child and Adolescent Health and Development Authors Group. Investment in child and adolescent health and development: key messages from Disease Control Priorities, 3rd Edition*.* *Lancet* 2018; **391**(10121):687-699.

Dorrington RE. *Alternative South African mid-year estimates, 2013*. Centre for Actuarial Research Monograph 13, University of Cape Town, 2013. ISBN: 978-0-7992-2501-3. http://www.care.uct.ac.za/sites/default/files/image_tool/images/561/Downloads/Mono11.pdf. Accessed 7 October 2021.

Dorrington RE, Bradshaw D. Acknowledging uncertainty about maternal mortality ratio estimates. *Bull World Health Organ* 2016; **94**(2):155-6. https://doi.org/10.2471/BLT.15.155036.

Dorrington RE, Moultrie TA. *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 Nov – 4 Dec 2015. Available: https://uaps2015.princeton.edu/papers/151067 Accessed 15 December 2018.

Dorrington RE, Moultrie TA, Laubscher R, Groenewald PJ, Bradshaw D. Rapid mortality surveillance using a national population register to monitor excess deaths during SARS-CoV-2 pandemic in South Africa. *Genus*. 2021;77(1):19. https://doi.org/doi: 10.1186/s41118-021-00134-6. Epub 2021 Sep 3.

Global Burden of Disease Study 2019. *Global Burden of Disease Study 2019 (GBD 2019) Results*. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2019. Available: http://vizhub.healthdata.org/gbd-compare/ Accessed 15 December 2020.

Goga A, Feucht U, Zar HJ, Vanker A, Wiysonge CS, McKerrow N, Wright CY, Loveday M, Odendaal W, Ramokolo V, Ramraj T, Bamford L, Green RJ, Pillay Y, Nannan N. Neonatal, infant and child health in South Africa: Reflecting on the past towards a better future. *S Afr Med J* 2019; **109**(11 Suppl 1): 83-90.

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

Hill K, Zimmerman L, Jamison DT. Mortality risks in children aged 5–14 years in low-income and middle-income countries: a systematic empirical analysis. *Lancet Global Health* 2015; **3** (10): e609–16.

Hill K, Zimmerman L, Jamison DT. *Mortality at Ages 5 to 19: Levels and Trends, 1990–2010*. In (Eds) Bundy DAP, de Silva N, Horton S, Jamison DT, Patton GC. Chapter 2 Child and Adolescent Health and Development. 3rd edition. Volume 8. Washington (DC): World Bank, 2017.

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**(9726): 1609-23.

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

Kassebaum NJ, Bertozzi-Villa A, Coggeshall MS, Shackelford KA, Steiner C, Heuton KR 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.

Lake L, Shung-King M, Hendricks M, Heywood M, Nannan N, Laubscher R, Bradshaw D, Matthews C, Goga A, Ramraj T, Chirindavi W. Prioritising child and adolescent health: A human rights imperative. In: Shung-King M, Lake L, Sanders D & Hendricks M (eds). *South African Child Gauge 2019*. Cape Town: Children's Institute, University of Cape Town, 2019. ISBN: 978-0-620-85838-0. Available: https://www.ci.uct.ac.za/sites/default/files/image_tool/images/367/Child_Gauge/South_African_Child_Gauge_2019/CG2019%20-%20%281%29%20Prioritising%20child%20and%20adolescent%20health.pdf Accessed 15 December 2019.

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.

Masquelier B, Hug L, Sharrow DJ, You D, Hogan D, Hill K, Lui J, Pedersen J, Alkema L, UN Inter-agency Group for Child Mortality Estimation (IGME). Global, regional, and national mortality trends in older children and young adolescents (5–14 years) from 1990 to 2016: an analysis of empirical data. *Lancet Glob Health* 2018; **6**(10): e1087–99.

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. Geneva: WHO, 2016. Available: http://apps.who.int/iris/bitstream/10665/194254/1/9789241565141_eng.pdf Accessed 28 November 2018.

Moodley J, Fawcus S, Pattinson B. 21 years of confidential enquiries into maternal deaths in South Africa: Reflections on maternal death assessments. *O&G Forum* 2020; **30**:04-07.

Moultrie TA, Dorrington RE, Laubscher R, Groenewald P, Parry CDH, Matzopoulos R, Bradshaw D. Unnatural deaths, alcohol bans and curfews: Evidence from a quasi-natural experiment during COVID-19. *S Afr Med J* 2021;**111**(9):834-837. https://doi.org/10.7196/SAMJ.2021.v111i9.15813

Nannan N, Groenewald P, Pillay-van Wyk V, Nicol E, Msemburi W, Dorrington R, Bradshaw D. Child mortality trends and causes of death in South Africa 1997-2012: the importance of a national burden of disease study. *S Afr Med J* 2019; **107**(7):480-485.

National Committee for Confidential Enquiry into Maternal Deaths (NCCEMD). *Saving Mothers 2014-2016: Seventh triennial report on confidential enquiries into maternal deaths in South Africa: Short report*. Pretoria: National Department of Health, 2018. Available: https://www.sasog.co.za/Content/Docs/Saving_Mothers.pdf Accessed 31 October 2018.

National Department of Health (NDoH). *Strategic plan for the prevention and control of non-communicable disease*, 2013. Pretoria: National Department of Health, 2013. Available: www.hsrc.ac.za/uploads/pageContent/3893/NCDs%20STRAT%20PLAN%20%20CONTENT%208%20april%20proof.pdf Accessed 3 December 2018.

National Department of Health (NDoH). *Strategic plan 2020/21 – 2024/25.* Pretoria: National Department of Health, 2020. ISBN: 978-0-621-48280-5. Available: http://www.health.gov.za/wp-content/uploads/2020/11/depthealthstrategicplanfinal2020-21to2024-25-1.pdf Accessed 3 October 2021.

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. Available: www.statssa.gov.za/publications/Report%2003-00-09/Report%2003-00-092016.pdf Accessed 21 June 2016.

National Planning Commission. *National Development Plan: Our Future - make it work*. Pretoria: The Presidency, 2011. Available: https://nationalplanningcommission.files.wordpress.com/2015/02/ndp-2030-our-future-make-it-work_0.pdf Accessed 3 December 2019.

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.

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: https://www.samrc.ac.za/sites/default/files/files/2016-07-04/SANBDReport.pdf Accessed 15 December 2018.

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

Shisana O, Labadarios D, Rehle T, Simbayi L, Zuma K, Dhansay A, Reddy P, Parker W, Hoosain E, Naidoo P, Hongoro C, Mchiza Z, Steyn NP, Dwane N, Makoae M, Maluleke T, Ramlagan S, Zungu N, Evans MG, Jacobs L, Faber M, SANHANES-1 Team. South African National Health and Nutrition Examination Survey, 2012 (SANHANES-1): 2014 Edition. Cape Town: HSRC Press, 2014.

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

Statistics South Africa (Stats SA). *Millennium Development Goals Country Report 2013*. Pretoria: Stats SA, 2013b. Available: http://www.statssa.gov.za/wp-content/uploads/2014/02/MDGR_Report_2013_Final.pdf Accessed 26 October 2013.

Statistics South Africa (Stats SA). *Millennium Development Goals Country Report 2015*. Pretoria: Statistics South Africa, 2015a. Available: http://www.statssa.gov.za/MDG/MDG_Country%20Report_Final30Sep2015.pdf Accessed 26 October 2015.

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

Statistics South Africa (Stats SA). *Sustainable Development Goals (SDGs): Indicator Baseline Report 2017*. Pretoria: Statistics South Africa, 2017b. Available: http://www.statssa.gov.za/MDG/SDG_Baseline_Report_2017.pdf Accessed 28 August 2018.

Statistics South Africa (Stats SA). *Sustainable Development Goals: Country Report 2019.* Pretoria: Statistics South Africa, 2019. ISBN 978-0-621-47619-4 Available: http://www.statssa.gov.za/MDG/SDGs_Country_Report_2019_South_Africa.pdf Accessed 10 October 2021.

Statistics South Africa (Stats SA). *Recorded live births 2013-2019*. Pretoria: Statistics South Africa, 2020a. Available: http://www.statssa.gov.za/publications/P0305/P03052020.pdf. Accessed 16 November 2020.

Statistics South Africa (Stats SA). *Mortality and causes of death in South Africa, 2018: Findings from death notification.* Pretoria: Stats SA, 2020b. Available: http://www.statssa.gov.za/publications/P03093/P030932018.pdf. Accessed 7 October 2021.

Statistics South Africa (Stats SA). *Mid-year population estimates, 2021*. Pretoria: Statistics South Africa, 2021. Available: http://www.statssa.gov.za/publications/P0302/P03022021.pdf. Accessed 15 September 2021

Tempia S, Walaza S, Bhiman JN, McMorrow ML, Moyes J et al. Decline of influenza and respiratory syncytial virus detection in facility-based surveillance during the COVID-19 pandemic, South Africa, January to October 2020. *Euro Surveill* 2021. **26**(29):2001600. https://doi.org/10.28071560-7917.

United Nations, Department of Economic and Social Affairs, Population Division. *World Population Prospects: The 2019 Revision, DVD Edition*, 2019. Available: http://esa.un.org/unpd/wpp/DVD/ Accessed 19 June 2019.

United Nations. *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. New York, United Nations*, 2017. Available:
https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%20refinement_Eng.pdf Accessed 15 December 2018.

United Nations Inter-Agency Group for Child Mortality Estimation (UN IGME). *Levels and trends in child mortality*. New York: UNICEF, WHO, World Bank & United Nations, 2020. Available:

https://childmortality.org/wp-content/uploads/2020/10/UN-IGME-Child-Mortality-Report-2020.pdf.
Accessed 17 November 2019.

World Health Organization (WHO). Trends in Maternal Mortality: 1990 to 2008: Estimates Developed by WHO, UNICEF, UNFPA, and the World Bank. Geneva: WHO, 2010. Available:
http://whqlibdoc.who.int/publications/2010/9789241500265_eng.pdf
Accessed 31 March 2012.

World Health Organization (WHO). Trends in Maternal Mortality: 1990 to 2010: WHO, UNICEF, UNFPA and the World Bank Estimates. Geneva: WHO, 2012. Available:
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. Available:
http://data.unicef.org/corecode/uploads/document6/uploaded_pdfs/corecode/MMR2013 117.pdf Accessed 28 October 2014.

World Health Organisation (WHO). *NCD Global Monitoring Framework: Indicator Definitions and Specifications.* Geneva: World Health Organisation, 2014. Available:
http://www.who.int/nmh/ncdtools/indicators/GMF_Indicator_Definitions_FinalNOV2014.pdf Accessed: 15 December 2018.

APPENDIX 1: 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 (20+) mortality and finally the completeness of reporting of deaths aged 5-19. 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 completeness for under one rose from around 63% in 2000 to around 81% in 2005, 85% for 2006 to 2011, then 82% for 2012 and 75.5% thereafter (to allow for what appears to be a fall in completeness of registration of infant deaths in recent years).

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 number recorded by the District Health Information System (DHIS) as having occurred in public health facilities, the number of children in school and the fertility rates derived from the numbers of births ever and in the past 12 months reported by women in the censuses and Community Surveys.

The completeness in individual years between the years of the point estimates of the expected number of deaths was estimated, in general,[10] 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. More recently, a fall in completeness of registration of deaths under the age of one (by about 10 percentage points between 2011, and 2013 and beyond) has been allowed for[11].

Adults 25+ years

Completeness of reporting of adult deaths was estimated by first estimating completeness for the following intercensal periods using death distribution methods: 1996-2001, 2001-2007 and 2001-2011 applied to data from the 1996, 2001, and 2011 censuses, and the 2007 Community Survey. 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 returned 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 fall in completeness of VR data).

Children and youth 5-24 years

Completeness of reporting by single years of age for ages 5-24 were derived from Beers interpolation from completeness for ages 2, 7, 12, 17, 22 & 27+ (derived as a separate exercise).

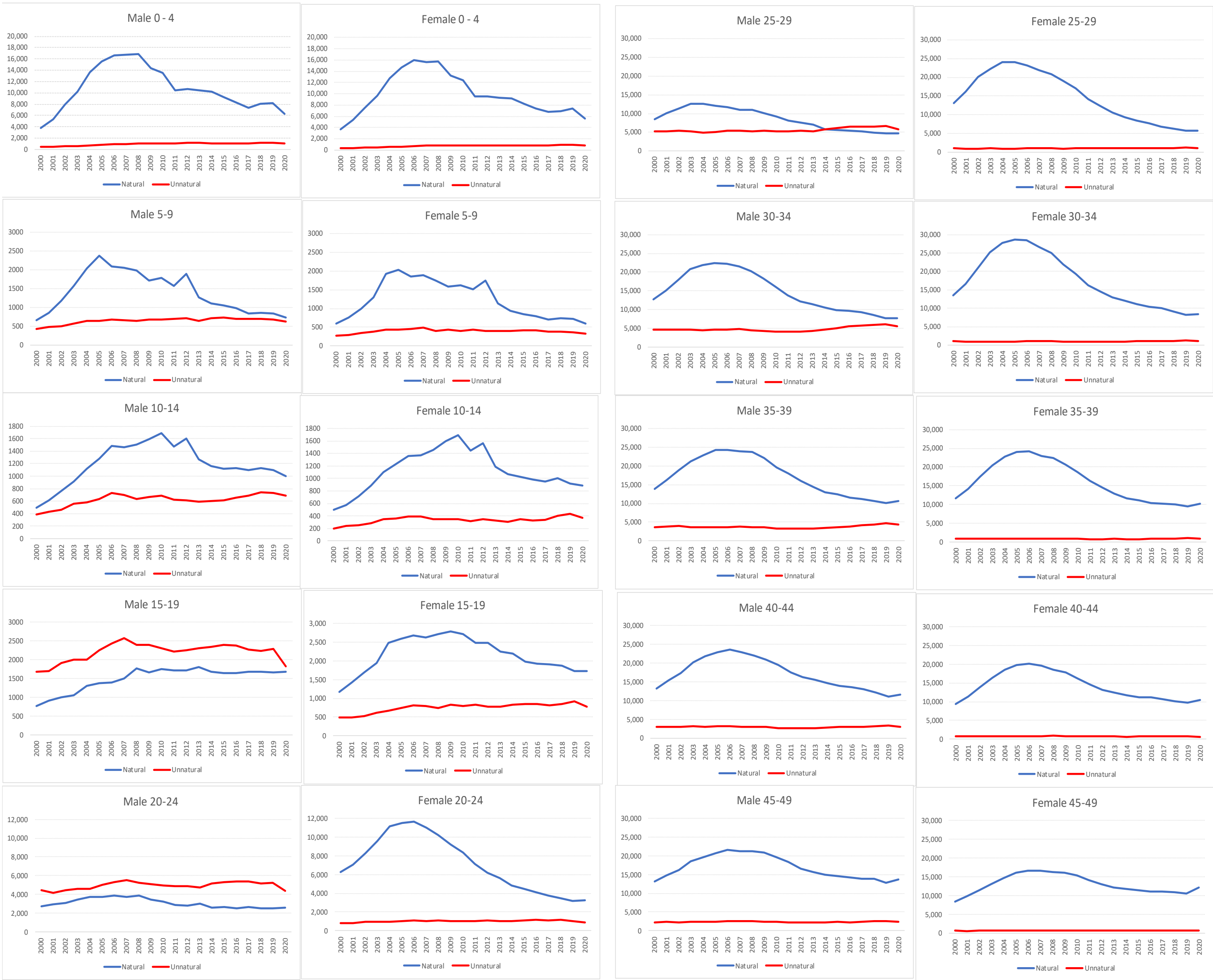
Post-2011

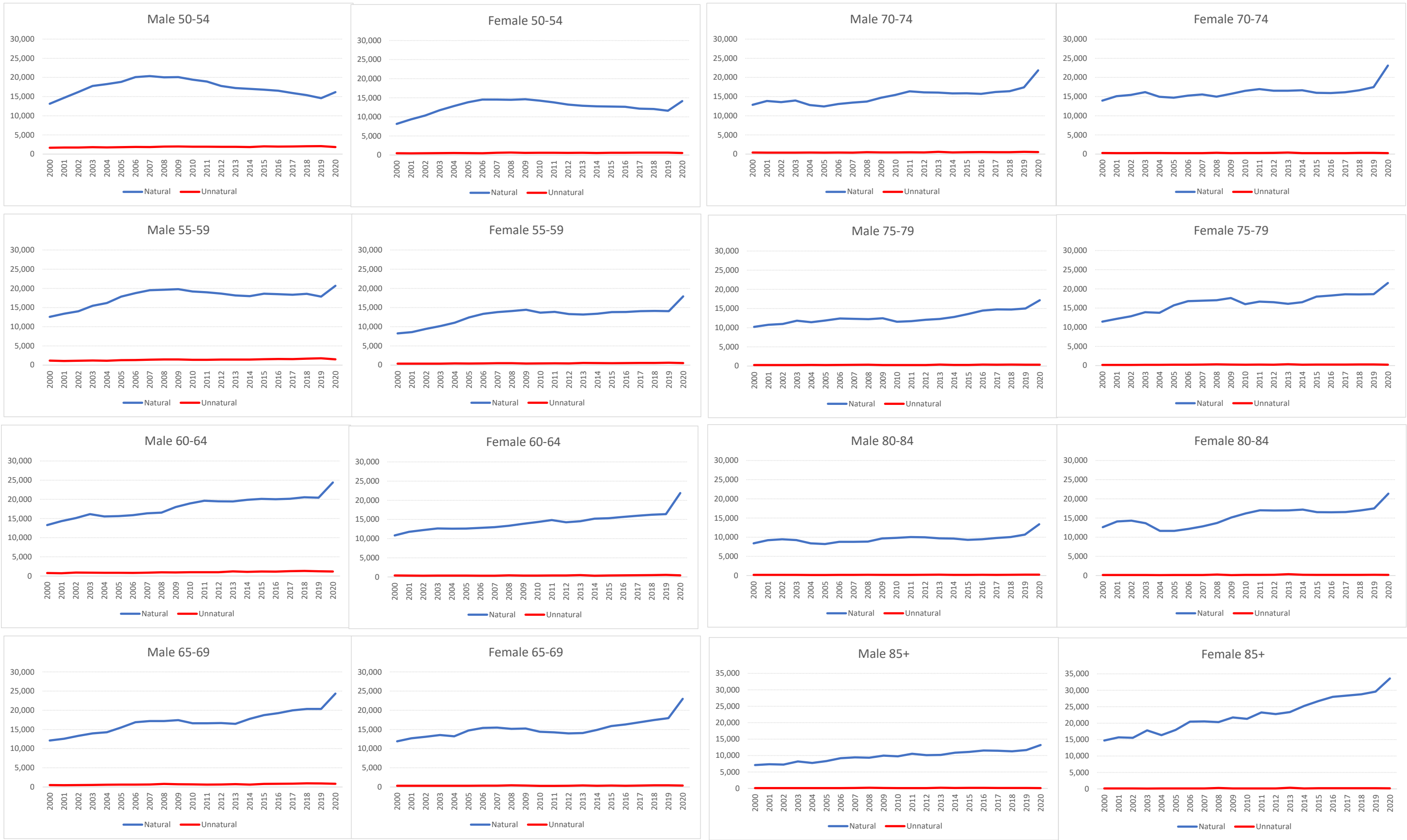
Previously the assumption was that completeness remained constant post 2011. However, in 2017 the estimates were amended slightly to allow for what appears to be a decline in registration of deaths in the period 2011-2013 for adult mortality and 2013 and beyond for childhood mortality (Dorrington et al, 2021).

[10] 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.

[11] To allow for a sudden increase in the ratio of VR to NPR numbers under-1 and to be consistent with the estimate of IMR from the 2016 Community Survey data.

APPENDIX 2: TREND IN THE NUMBER OF NATURAL AND UNNATURAL DEATHS BY AGE AND SEX, NPR 2000-2020




Male 50-54
Female 50-54
Male 70-74
Female 70-74
Male 55-59
Female 55-59
Male 75-79
Female 75-79
Male 60-64
Female 60-64
Male 80-84
Female 80-84
Male 65-69
Female 65-69
Male 85+
Female 85+
Natural
Unnatural
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

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