ESTIMATING COMPLETENESS OF

ADULT MORTALITY DATA

AT SUB-NATIONAL LEVEL

Report: 03-09-14

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Estimating completeness of adult mortality data at sub-national level

Statistics South Africa

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Preface

This report is a response to the need for data at subnational levels, to meet the national and global health and developmental targets. Subnational mortality levels make up the aggregate national picture, which ultimately makes up the world picture. Therefore, identifying and addressing subnational health and mortality inequalities commonly linked to the health gradient is key to meeting national and global developmental agenda. Mortality is a marker of population health and explains the continuous pursuit to estimate mortality levels to establish the state of health in the country that affects the various aspects of society. The importance of adult mortality in particular has also been highlighted in relation to its social consequences – child orphanhood and living arrangements. This is so especially in the context of HIV/AIDS for individuals who are in their childbearing years and are likely to have children for whom they are materially and socially responsible. This is particularly important in South Africa with a record high parental absence in the world and a disproportionate HIV burden. Younger adults are also economically active, and their deaths affect their households' socio-economic status, particularly if they are household heads.

The rallying call of the 2030 global development agenda – the Sustainable Development Framework – is leaving no one behind, which includes the overarching principle of disaggregation of data by geography among other targets, for different indicators where relevant. The country's domestic National Development Plan (NDP) indicators are also to be disaggregated by geography. The level of geography used in the report is the provincial level, which is the first administrative tier below the national level. The provincial government plays a crucial role in the structure of government in the country. Statistics South Africa is also due to conduct a census in 2021 as part of the 2020 Round of Population and Housing Censuses, and needs to build on the experience from the preceding censuses.

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Executive summary

Providing demographic indicators at subnational levels is important for tracking progress and providing interventions. This is because national estimates often mask the greater variations that exist at the lower levels of geography. Disaggregating data by geography is also important in the context of limited resources – mainly financial and human – to address the underlying socio-economic issues affecting mortality in the country. Adult mortality estimates are important because the indicator measures "premature" adult mortality, which has implications at household and community levels. Lower levels than the provincial level would be ideal, because commonly the lower the geography level, the wider the variation. Unfortunately, at the lower levels of geography there is usually noise in the data. In the absence of adequate data, deriving mortality estimates (particularly at the lower levels of geography) requires ingenuity through applying demographic techniques and making reasonable assumptions, and taking advantage of the relatively good data available in the country. It is in this context that CRVS should continue to be strengthened to provide indisputable mortality statistics.

In the report, the context for adult mortality in general and more specifically for South Africa is provided. Completeness of adult deaths by province is derived using indirect techniques and a discussion is provided on the complexities of direct estimation of completeness of deaths using infant deaths. The provincial variation in adult mortality completeness is expected due to socio-economic factors underlying the social determinants of health, but the extent of completeness helps the relevant provincial government departments and other stakeholders achieve evidence-based planning. It is important to continue to strengthen the CRVS systems, as this is considered to be the best source of mortality data. It is also to avoid missing the opportunity to have complete census data in the 2020 round of censuses by improving the adult mortality data to complement the complete infant deaths from the previous round of censuses.

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i. Definition of terms

Adult mortality: Probability of dying between 15 and 60 years of age (${}_{45}q_{15}$), also 15 to 50 years of age (${}_{35}q_{15}$), which is the conditional probability of dying by age 59 or 49 given survival to age 15, respectively.

Birth: The complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of pregnancy, which, after such separation, breathes or shows any other evidence of life, such as beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles, whether or not the umbilical cord has been cut or the placenta is attached; each product of such a birth is considered live born (all live-born infants should be registered and counted as such, irrespective of gestational age or whether alive or dead at the time of registration, and if they die at any time following birth, they should also be registered and counted as deaths) (UN 2014: 3).

Death: The permanent disappearance of all evidence of life at any time after live birth has taken place (post-natal cessation of vital functions without capability of resuscitation) (UN 2014:3).

Household: Person/persons who occupy one or more housing unit, may be related or not related, characterised by shared resources. South African censuses are *de-facto based,* so individuals are captured in relation to presence at the given location during the reference period – 10 October in census year.

Maternal death: The death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes (WHO 2019).

Civil registration: Continuous, permanent, compulsory, universal recording of the occurrence and characteristics of vital events pertaining to the population, as provided through decree or regulation in accordance with the legal requirements in each country, with full respect of rules regulating the protection and privacy of individual information (UN 2001).

Statistics South Africa: South African national statistical agency abbreviated and popularly known as Stats SA.

ii. List of abbreviations and acronyms

AHDSS	Agincourt Health and Demographic Surveillance Site/System
AHRI	Africa Health Research Institute
AIDS	Acquired Immunodeficiency Syndrome
ALPHA	Analysing Longitudinal Population-based HIV/AIDS data on Africa
ART	Antiretroviral therapy
CDR	Crude death rate
CRVS	Civil registration and vital statistics system
DDM	Death Distribution Methods
DHIS	District Health Information System
GGB	Generalised Growth Balance Method
HIV	Human Immunodeficiency Virus
ICPD	International Conference on Population and Development
INDEPTH	International Network for the Demographic Evaluation of Populations and Their Health
IPC	International Population Conference
LSHTM	London School of Hygiene & Tropical Medicine
MAUP	Modifiable Areal Unit Problem
NIDS	National Income Dynamics Study
PES	Post-enumeration Survey
RMS	Rapid Mortality Surveillance
SAMRC	South African Medical Research Council
SBH	Summary Birth History
SEG	Synthetic extinct generations
SRHR	Sexual and reproductive health and rights
Stats SA	Statistics South Africa
UN	United Nations

CHAPTER 1: INTRODUCTION AND BACKGROUND

1. Introduction

Mortality levels are considered sensitive indicators of the level of development in societies. Adult mortality – particularly at subnational levels – is high on the global agenda. Although there is no direct reference to adult mortality, the current global development agenda: the 2030 Sustainable Development Goal (SDG) framework includes adult mortality-related targets that are key to the achievement of Sustainable Development Goal No. 3: *Ensure healthy lives and promote wellbeing for all at all ages*, and ultimately key to achievement of the entire global agenda designed to be "integrated, indivisible and interlinked" (UN 2018). These targets are in line with South Africa's domestic 2030 National Development Plan, which is the blueprint for addressing poverty and inequality in the country (Africa u.d):

3.1: By 2030, reduce the global maternal mortality ratio to less than 70 per 100 000 live births.

3.3: By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.

3.4: By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.

3.5: Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.

3.6: By 2020, halve the number of global deaths and injuries from road traffic accidents.

3.9: By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.

In addition, the NDP includes the target indicator of life expectancy at birth of 70 years by 2030.

This report is a response to the need to address adult mortality in the country, and the focus at subnational levels is important in its own right and is consistent with the principles of the SDG framework.

1.1 Background

Mortality, like other demographic measures, has a spatial dimension (Del Panta, Rettaroli et al. 2006) and interest in variability in subnational mortality is long-standing (Ahmed and Hill 2011; Msemburi, Pillay-van Wyk et al. 2014; Menashe-Oren and Stecklov 2018). In the context of the SDG agenda, disaggregation of data by geography is one of the overarching principles. According to the General Assembly Resolution 68/261, "Sustainable Development Goal indicators should be disaggregated, where relevant, by income, sex, age, race, ethnicity, migratory status, disability and geographic location, or other characteristics …".

Furthermore, globally, there is a growing demand for disaggregated data. This is for the following reasons:

1. Increasingly there are limited resources (financial, material and human) to address different and competing societal needs, giving rise to the need for targeted interventions that are more effective and efficient. Time is also of essence; health and developmental initiatives (including the MDGs, SDGs and NDP) are time-bound.

2. Data at national level have the potential to mask the differences at lower subnational levels. Research has shown that there is greater variability at lower levels of geography. Disaggregated data may also be essential to another of the SDG principles of "not to leave anyone behind" (UN 2016). The Preamble to the Resolution on the agenda for the SDG adopted by the United Nations General Assembly reads: *"As we embark on this great collective journey, we pledge that no one will be left behind ..." (UN 2015: para 4).* Disaggregating data is one way of identifying areas that are least likely to achieve the set goals, potential areas that could be left behind, and need intervention to catch up with the rest, in the terminology of the SDGs – "*to reach the furthest behind first*", and geographic disaggregation may be one of the key steps. Furthermore, this is important in the context of equity in health (given the socio-economic gradient in mortality) and particularly as key to achieving social justice and realising the fundamental human right for survival. This is important for South Africa, in particular, given that it is one of the most unequal countries in the world (Sulla and Zikhali 2018).

3. Data are needed for policy formulation, monitoring and evaluation and decision-making at the different levels of government – in South Africa this includes national, provincial and local government levels.

However, there are challenges to deriving mortality measures at subnational levels and even at national level for that matter. In South Africa and many other low–middle-income countries, such challenges are largely due to inadequate civil registration and vital statistics system (CRVS) data, which is the gold standard (WHO 2012; UN 2014). Some ingenious methods are employed to make the best use of the available data. This then results in limitations to the number of subnational levels at which data can be disaggregated. This is due to the diminished data quality that occurs as an increasing number of subnational levels are used. The survival advantages at all ages over time have made the age pattern of mortality almost universal; it is highest in childhood and older adults, and lowest in adults, even with the advent of the nearly 4-decade-old HIV epidemic that resulted in an upsurge in adult mortality. Therefore, adult mortality data tend to be sparse at lower levels of geography, given that from an epidemiological perspective, adult mortality is rare although the population at risk may be bigger (Timæus and Graham 1989; Timaeus 1991). Indirect methods are widely used, and to date there is no consensus on the method to do this (Dorrington and Timaeus 2015); and it is in this context that Dorrington and Bradshaw (2018) highlight the importance of in-country generated mortality indicators by national statistical agencies and research organisations familiar with the respective countries' contexts.

In the absence of adequate CRVS data, population censuses are the classic source for disaggregated adult mortality data because they have universal coverage, although they also may not be entirely complete. The issue of deficient CRVS – particularly for sub-Saharan Africa – has always been central for demographers, giving rise to inclusion of mortality related questions in census questionnaires.

Another source of mortality data are sample surveys, but their use at subnational levels is limited. South Africa has a complex geography hierarchy, but the provincial level (an administrative tier below the national level) is more stable over time than the localised municipal level, which boundaries are continually determined as provided by an act of government – the Local Government: Municipal Demarcation Act of 1998 (Lehohla 2003). This is a phenomenon of aggregated data analysis that poses a problem for comparison over time known as "the modifiable areal unit problem or MAUP" (Wong 20014).

1.2 Context

1.2.1 South Africa

According to the 2011 Census, South Africa has a population of 51,7 million with a population density of 42 persons per square kilometres, which varies greatly by province (Table 1). The most densely populated province is Gauteng, and the least populated is Northern Cape with 675 and 3 people per square kilometre, respectively.

South Africa's nine provinces are at the first tier below the national level, and at the second tier are three categories of municipalities – 278 municipalities comprising 8 metropolitan municipalities, 44 district municipalities and 226 local municipalities that are categorised using the criteria in the Local Government Municipal Structures Act, 117 of 1998. These also represent a complex government structure that constitutes three autonomous (sometimes overlapping) spheres of government: national, provincial, and lastly, municipal.

In a short space of time, South Africa has transformed a historically fragmented and incomprehensive census and vital statistics system that existed prior to the advent of democracy, which is a reason for optimism for the rest of the continent (Bah 1999; Khalfani, Zuberi et al. 2005; Garenne, Collinson et al. 2016; Garenne, Collinson et al. 2016). Post-1994 censuses have provided widely available, comprehensive and nationally representative demographic data not available hitherto (Moultrie and Timæus 2002). However, for censuses, there are reported limitations of coverage and data quality issues, and the quality of data varies from one census to the next. For the most recent 2011 Census, infant mortality data are known to be complete, but the adult mortality data – although usable – are not complete. This is comparing the CRVS system with an estimated >90 per cent completeness of adult deaths (Statistics South Africa 2018; Dorrington, Bradshaw et al. 2019).

The CRVS system has improved dramatically (AbouZahr, de Savigny et al. 2015; Statistics South Africa 2018; Dorrington, Bradshaw et al. 2019), and South Africa is the only country with usable CRVS data in the region (World Bank, 2014; Mikkelsen et al. 2015). Notwithstanding; the level of completeness of mortality data is not without contestation (Rao, Bradshaw et al. 2004; Udjo 2017; Phillips, Adair et al. 2018). There is still room for improvement, considering that Agincourt, a DHSS located in a deprived rural part of the country (expected to have relatively low completeness of deaths) has 96 per cent overall completeness (Garenne, Collinson et al. 2016). Notwithstanding, it is a research surveillance site and may have external influences and therefore may not be representative of other such deprived rural areas in the country. For the rest of the country, the analysis of mortality completeness is usually at the national level.

The worst affected are child (<5 year) death registrations (Dorrington et al. 2014), in part because most infant deaths occur shortly after birth, so the birth registration would most likely not have taken place to begin with (Rao, Bradshaw et al. 2004), especially in the remotest parts (Al-Rabee & Alkafajei, 2006), possibly compounded by the lack of perceived benefits for registration for child deaths (Ndong, Gloyd et al. 1994). The low registration in child deaths compared to adult deaths is consistent with research (Hill, Choi, & Timæus 2005). Notwithstanding, the opposite has also been seen to be true by Abouzahr (cited in Boseley, 2007).

Furthermore, corresponding late birth registrations can occur. For example, it appears that by the 6th year (time of school entry), most of the births would have been registered (illustrated by the estimated completeness of births by Nannan, Dorrington et al. (2015) and the registered deaths 6 years later). However, there may be little or no incentive for late registration of infant deaths and there is not always the luxury of time to allow for complete registration.

Table 1: Land area and population by province

(A)Province	B) Land area (km^2)	(C) Population	(D) Population density (B/C)	GDP contribution	Gini coefficient
WC	129 462	5 822 734	45,0	13,6	0,61
EC	168 966	6 562 053	38,8	7,8	0,64
NC	372 889	1 145 861	3,1	2,1	0,60
FS	129 825	2 745 590	21,1	5,1	0,60
KZN	94 361	10 267 300	108,8	16,0	0,61
NW	104 882	3 509 953	33,5	6,5	0,60
GP	18 178	12 272 263	675,1	34,1	0,61
MP	76 495	4 039 939	52,8	7,5	0,61
LP	125 754	5 404 868	43,0	7,1	0,61
RSA	**1 220 812**	**51 770 560**	**42,4**	**100**	**0,64**

*Estimates are from Stats SA or based on data from Stats SA – population and land area estimates are from the 2011 census (Statistics South Africa 2012), GDP (Statistics South Africa 2018) and Gini coefficient from Sulla and Zikhali (2018).

In South Africa, registration of births and deaths is guided by the Births and Deaths Registration Act, (Act No. 51 of 1992) and its amendments and administered by the Department of Home Affairs for the purposes of updating the National Population Register (NPR) (Statistics South Africa 2018). Deaths data that include deaths from non-citizens or non-permanent residents not otherwise eligible for inclusion into the National Population Register (NPR) (Statistics South Africa 2014) are collated by Statistics South Africa (Stats SA), the national statistical agency, for processing for statistical purposes. Births data also originate from Home Affairs (Statistics South Africa 2018) and both constitute the CRVS data.

A slightly different process is followed for births. Stats SA gets already captured birth details from DHA offices. However, currently the births to parent/s that are non-South African citizens or non-permanent residents (under consideration in the draft regulations to the Births and Deaths Registration Act (BDRA) 51 of 1992), get "confirmation of birth" which is not yet part of the births registered as CRVS. South Africa follows the UN recommendations that births are to be registered at place of birth, so this is done at the magisterial district office where the birth occurred. However, the place of birth may not necessarily occur at the nearest health facility but at the best (real or perceived) health facilities.

1.2.2 Adult mortality

Compared to child mortality, little is known about adult mortality (Timæus and Graham 1989; Timaeus 1991; Timæus, Dorrington et al. 2013). Notwithstanding, the importance of adult mortality measurement has long been recognised (Timæus and Graham 1989; Timaeus 1991), and it is also now gaining traction in terms of contribution to the global mortality burden partly because of the progress seen in child mortality (Ram, Jha et al. 2015). The relationship between child and adult mortality has also long been recognised – with child mortality used as an indicator of the overall mortality, particularly where adequate data for adult mortality are not readily available[1] (Preston 1985; Timæus and Graham 1989). The main method of estimating adult mortality is extrapolation from commonly available child mortality and through indirect estimation (Udjo 1991; Adair and Lopez 2018).

The interest in adult mortality has also been renewed by the HIV epidemic that saw an increase in analysis of adult mortality, due to its disproportionate effect on individuals in their prime ages. This has had socio-economic implications, particularly in South Africa with a disproportionate HIV burden. Maternal mortality, a subsection of adult mortality, has also become very important in the context of HIV/AIDS, and because of global initiatives to improve maternal health as a component of women's sexual and reproductive health and rights (SRHR) championed by the 1994 International Conference on Population and Development (ICPD) (UN 1994).

1.2.3 Sources of adult mortality in South Africa

1.2.3.1 Civil registration and vital statistics system

From a programmatic perspective, the CRVS data are the gold standard for adult mortality (usually ${}_{45}q_{15}$ or ${}_{35}q_{15}$) and mortality in general because of the seven Cs (WHO 2012; Boerma, Requejo et al. 2017; Bamford, McKerrow et al. 2018; UN 2018):

1. CRVS systems produce data on a <u>continuous</u> basis.
2. CRVS systems produce data that are <u>consistent</u> and <u>comparable</u> across time and space.
3. CRVS have universal <u>coverage</u>.
4. Vital statistics from CRVS systems are more likely to be <u>correct</u> than those from other sources.
5. CRVS systems are <u>cost-effective</u> for producing statistics because the data required are produced as a by-product of the established administrative and legal registration system.
6. CRVS systems can produce statistics on <u>cause of death</u> for all deaths.

1.2.3.2 Retrospective cross sectional surveys

In South Africa, there are a number of surveys that include mortality-related questions or a mortality module from which adult mortality estimates can be derived. Censuses and surveys are important in sub-Saharan Africa, which has none or limited death records because of deficient CRVS systems (UN 2014). Three censuses have been conducted in post-1994 South Africa in 1996, 2001 and 2011. The Constitution allows for a quinquennial census; but the national statistical agency has negotiated for a decennial census and an intercensal survey with a significantly larger sample size in place of the resource-intensive census. This was

[1] However, this assumption may be violated in the context of HIV/AIDS Adair, T. and A. D. Lopez (2018). "Estimating the completeness of death registration: An empirical method." <u>PLoS One</u> **13**(5) where distinct mortality patterns have emerged.

long before 2016, contrary to Spencer, May et al. (2017). To date, two community surveys (CS) have been conducted – 2007 and 2016. Mortality data from censuses are obtained from the mortality module found in the household questionnaire, and sample surveys are mainly household-based.

a. Censuses

The 2001 and 2011 censuses collected mortality data using the main questionnaire (household questionnaire mortality module) administered to the household proxy. Questions include age and sex of the deceased, whether death is natural or non-natural and for women of reproductive age whether the respective death was pregnancy-related (deceased died during pregnancy, while giving birth or within six weeks of giving birth). Adult deaths are extracted using the reported age at death of the deceased household members.

Census data have been used for estimating adult mortality (Hill, Johnson et al. 2018) or mortality in adult subpopulations (Stanton, Hobcraft et al. 2001; Udjo and Lalthapersad-Pillay 2014). Sampling or other random error that is inherent with sample surveys is eliminated or greatly reduced with a census (Stanton, Hobcraft et al. 2001). Although the mainly quinquennial or decennial census adequately captures trends (Stanton, Hobcraft et al. 2001), it may not be adequate for regular monitoring required for global and national agendas. Censuses also do not provide cause of death and, if at all, it is only classified into natural and non-natural causes.

There are also data problems regarding censuses as detailed by Dorrington, Moultrie et al. (2004) and Statistics South Africa (2014; 2015). These emanate in part from difficulties in identifying the appropriate respondent to report adult deaths; this is in contrast to child deaths where respondents are mainly mothers or caregivers. Households are also likely to be dissolved at the death of an adult household member – in particular the head of household – largely because of the challenge to the continued economic viability of these households; therefore some of the households in which deaths had occurred would have ceased to exist by the time of the survey (UN 2004). Household membership of the deceased may also be an issue in areas where migration is high; compounded by the household definition, because the deceased may not have been a member of the household of origin at time of death. The South African census is *de facto* based, i.e. it captures the household and individuals at the time of the census, and the filter mortality question in the census is "Has any member of this household passed away in the last 12 months…? The other limitation is that because mortality in general is a rare event, and therefore located in a small fraction of households, fieldworkers may in the process stop asking the questions, thereby potentially omitting deaths (Blacker 1977; Timaeus 1991). For example, in the 2011 Census, about 430 000 out of the total 14,5 million households reported one or more death (Statistics South Africa 2015). There is also the problem of reference period – whereby individuals who died before the reference period can be erroneously included or those who died earlier in the reference period are excluded, but the two can potentially cancel each other out.

Adult mortality estimates can also be derived from parental survival status questions (commonly referred to as the orphanhood technique) from the three censuses. The censuses include in the household schedule, the orphanhood question "Is your mother/father alive?" which is asked of every household member, so adult mortality can be estimated for different time locations using the respondents' ages and the survival status of their parents.

Issues with the orphanhood method include the fact that trends in adult mortality cannot be established in the short term, and the survival of children is key to establishing unbiased mortality estimates, and the issues about use at subnational levels also exist in part because of migration (Timaeus 1991). The dependence of parent-offspring mortality has been an issue in the context of the HIV epidemic – although this could be reversed for recent mortality with the massive antiretroviral therapy (ART) roll-out which has improved survival of individuals (Johnson, May et al. 2017). Also germane to this report is the problem of estimation at subnational levels because the child and reported parent may not be resident in the same area. Although there are potential issues as highlighted above, the orphanhood method has been used to make important comparisons at subnational levels in sub-Saharan Africa to show excess urban adult mortality (Menashe Oren and Stecklov 2018).

b. Surveys

Sample survey data have been used for adult mortality estimation (Chisumpa and Dorrington 2011; Chisumpa and Odimegwu 2018; Menashe Oren and Stecklov 2018).

There are various surveys in South Africa, but the common sources of mortality data are the DHS and community surveys that are on the lines of the census. Sample surveys include the 1998 and 2016 SA Demographic and Health Survey (DHS). The 2003 DHS is not in the public domain because of issues of quality raised with some indicators (Health, Council et al. 2007).

The DHS are comparable surveys conducted in many low-middle-income countries and allow comparison for adult mortality with other countries. The DHS surveys use sibling survival histories (commonly known as the sisterhood method), which involves an eligible woman of reproductive age in the sampled households providing detailed histories of their adult siblings by sex, date of birth, survival status, and if dead, their date of death. The method has been widely discussed, including methodology for correction of biases; omission of siblings due to non-knowledge of existence of siblings, recall errors, sibship size and AIDS bias that ultimately affect quality of mortality data and the estimates thereof (Timaeus, Zaba et al. 2001; Obermeyer, Rajaratnam et al. 2010; Helleringer, Pison et al. 2014; Masquelier and Dutreuilh 2014). Also relevant to this report is that the DHS samples are not drawn to provide mortality data that are representative at subnational levels. This is partly because the interpretation may be difficult because of migration – reported siblings may not necessarily be resident in the same geographic location with the respondent, sampling errors and sample size issues that result in large standard errors.

Also falling under the broad method of indirect estimation of adult mortality using survival of close relatives is the parental survival data from the DHS household questionnaire. The DHS parental survival data (also known as orphanhood data) are available for children ages 0–17 years, and are therefore limited to relatively recent mortality (Timaeus 2013). However, the orphanhood data are known to be biased for younger children because of the "*adoption effect*" wherein children whose parents had died would report their foster parent or caregiver as their biological parent, thereby understating adult mortality or vice versa with the "*absentee effect*", wherein the parent who is living elsewhere, especially fathers, are reported as dead, and exaggerating adult mortality. This explains why the orphanhood technique was not designed for younger ages, and recent research in Southern Africa attests to the data quality issues for ages <15 years (Robertson, Gregson et al. 2008; Udjo 2011) and that orphanhood status reporting may be affected by both orphanhood status and living arrangements (Shoko and Ibisomi 2016).

1.2.3.3 Longitudinal surveys

a. Health and socio-demographic surveillance system (HDSS)

Three HDSS sites in the country are Agincourt, the DIMAMO Population Health Research Centre (formerly Dikgale) and the Africa Health Research Institute (AHRI) (formerly Africa center) located in rural parts of Mpumalanga, Limpopo and KwaZulu-Natal provinces, respectively. They are part of the International Network for the Demographic Evaluation of Populations and Their Health (INDEPTH), a network of HDSS Centres found in low and middle-income countries. Agincourt, HDSS and Africa Health Research Institute are also part of the Analysing Longitudinal Population-based HIV/AIDS data on Africa (ALPHA Network) sites coordinated by the London School of Hygiene & Tropical Medicine (LSHTM) (Reniers, Wamukoya et al. 2016). The three current HDSS data have provided important insights for adult mortality, in particular in relation to HIV/AIDS (Clark, Collinson et al. 2007; Yoo, Lee et al. 2018), women (Shoko 2011), migration (Ginsburg, Bocquier et al. 2016), cause-specific mortality (Maredza, Bertram et al. 2015), and in relation to completeness of CRVS data (Garenne, Collinson et al. 2016). The main limitation relevant to this study is the lack of generalisability because of the current limited geography scope. However, together with the new sites to be established in the urban areas of Gauteng, KwaZulu-Natal, the Western Cape and rural areas of the Eastern Cape provinces, which will form the government-funded South African Population Research Infrastructure Network that will potentially be a source for nationally representative longitudinal adult mortality data.

b. National Income Dynamics Study Panel data

The NIDS programme commenced in 2008 with ongoing surveys conducted biennially is the country's first nationally representative panel survey. Although by and large adult mortality from NIDS data meet expectations (Moultrie and Dorrington 2009), there is the problem of attrition, which is characteristic of panel data and has the potential to deplete the sample which needs to be continually addressed. Furthermore, the sampling strategy and study design were not designed for subnational level estimations (Woolard, Leibbrandt et al. 2010).

1.2.4 Completeness of mortality data

Completeness is a measure of the extent to which births and deaths are registered by the CRVS system (UN 2014). The estimate of completeness is a critical process indicator and provides an indication of the "actual" extent of the mortality burden and the quality thereof. The more complete the data, the more representative the data are, so together with correctness, availability and timeliness are measures of the quality of the CRVS data (UN 2014). This is particularly important at subnational levels where greater variability in completeness is expected to exist. Completeness of CRVS is also important in its own right – as indicators for SDG target 16.9 and 17.19 on legal identity and data quality improvement, respectively (UN 2018). Therefore, data on the extent of completeness of deaths is important to inform equitable promotion of death registration. This has policy relevance for the improvement of the CRVS in the country and for addressing factors explaining mortality variation in the country. Research also shows positive association between functional CRVS and health outcomes (Phillips et al. 2015).

If deaths were complete, then direct estimation of adult mortality would be used. However, for sub-Saharan Africa (with the exception of South Africa), there is a long way to go in order to achieve complete or at least usable CRVS data (UNECA 2017). Ninety per cent is considered complete (UN 2014) and for the purposes of the SDG, the target is 80 per cent completeness for deaths by 2030. For demographers, mortality data that are at least 60 per cent complete are usable, applying an adjustment factor for the missing data (Preston 1984).

There is no standard methodology on estimation of completeness of deaths. If there is a reliable and independent source, completeness is estimated directly – described as evaluation of deaths using an independent source (Preston, 1984; Chandrasekaran and Deming 1949), but this is not as straightforward – as this report is going to show. Record linkage technique was used for South African CRVS and Agincourt HDSS data by Kabudula, Joubert et al. (2014), and although it had great potential, the data yielded relatively low matching rates. In the absence of an independent source, indirect methods are mainly used.

1.2.4.1 Death distribution methods

The classic indirect demographic methods – the Death Distribution Methods (DDM) – are used to evaluate and correct the completeness of deaths by age relative to population at a given time (Hill, You et al. 2009). The DDM refers to the intercensal period, and the assumptions include closed population, constant death coverage and population enumeration across ages, and that age of population and death reports are free of substantial errors. The three main DDM methods are:

i. *The General Growth balance (GGB) – (Hill 1987)*
   The GGB method is derived from the basic demographic balancing equation, which expresses the identity that the growth rate of the population is equal to the difference between its entry rate and exit rate.

ii. *The Synthetic Extinct Generations (SEG) – (Bennett and Horiuchi 1981)*
   The method uses specific growth rates by age for converting an age distribution of deaths into an age distribution of a population. Once the observed deaths from a given age x in a population is equal to the population of age x, adjusted by the rate of population growth by age range, we have the deaths of a population of age x+ that provide an estimate of the population on that age x. The extent of death registration coverage is given by the ratio of deaths estimated by the population above the age x and the observed population above the age x.

iii. *The Synthetic Extinct Generations (Adjusted) – (Hill, You et al. 2009)*

The adjusted SEG consists of applying GGB to obtain estimates of the change in the population enumeration, and use this ratio to adjust the coverage of both census, and then apply the SEG method using the adjusted population for the coverage of mortality data.

Their advantage is the relaxation of the stable population assumption from the original Brass Growth balance (Brass 1975) and Preston-Coale method (Preston, Coale et al. 1980). Migration is a major issue in determining completeness, especially for subnational estimates.

1.2.4.2 Empirical method

An empirical method developed by Adair and Lopez (2018) estimates death registration completeness utilising the commonly available data at the national and subnational levels. This method exploits the already expected relationships among the principal determinants of mortality levels in a population:

i. Registered crude death rate (CDR)

The CDR is a function of the population age structure and a measure of the level of mortality and is positively related with the level of mortality and the size of the older adult population. As a result, there is a strong relationship between registered CDR and completeness of death registration.

ii. The proportion of the population aged 65 years and over

iii. The under-five mortality rate (${}_5q_0$)

There is an established relationship between overall mortality completeness and the ${}_5q_0$. Child mortality estimates are also in many countries readily available in part because of the progress in this regard – as discussed earlier. The 5q0 is included in the model as a proxy measure of overall mortality levels in the population.

iv. The completeness of under-five death registration. This can be easily obtained using the expected and registered under-five deaths.

The method is to counter the limitations of indirect and other direct methods, namely the violation of assumptions in indirect methods and significant data requirements and complexity especially at the subnational levels. However; the method is not appropriate where HIV prevalence is high (Adair and Lopez 2018); using UNAIDS standards (Wilson and Halperin 2008) South Africa has a high prevalence (UNAIDS 2018).

CHAPTER 2: METHODOLOGY

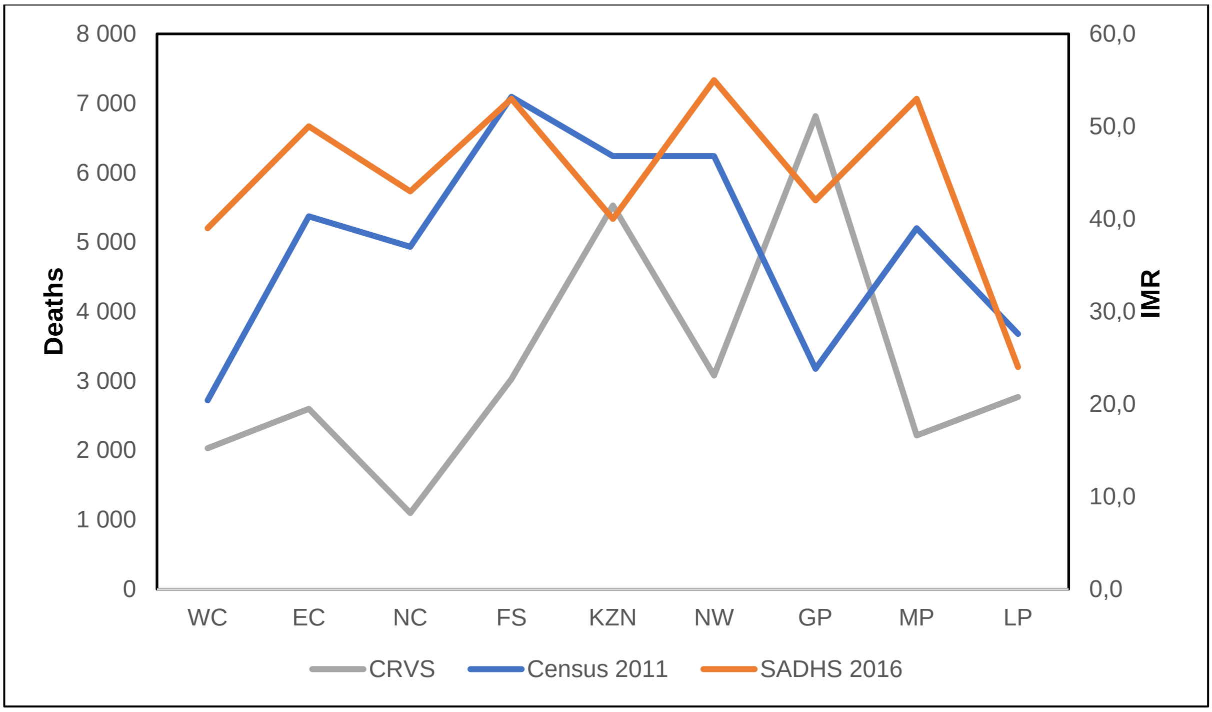
2.1 Introduction

This study seeks to estimate the completeness of census adult deaths at national and provincial levels in South Africa, and this is important in the context of measurement of age-specific mortality and adult mortality burden in general. The report is an endeavour to contribute to the generation of knowledge invaluable in the drive for estimation of human development and well-being indicators at subnational levels. It also contributes to the discourse around the use of multiple data sources to address gaps that exist in demographic data sources that characterise many low-middle income countries and the complexities thereof. The report builds on the paper presented at the IUSSP (Shoko, Lefakane, Chisumpa et al. 2017), which provides estimates of completeness for infant deaths. This is then extended to adult mortality data completeness and to show that even though there is an option to estimate completeness of census adult deaths directly using CRVS adult deaths, it is not that straightforward. This informed the use of the direct and indirect estimation of completeness used for adult mortality in this report.

2.1.1 Infant deaths - 2011

Globally, there is concerted effort to reduce preventable child deaths through various interventions: "Every Woman Every Child Global Strategy for Women's, Children's and Adolescent's Health", "Committing to Child Survival: A Promise Renewed" and the 2030 Agenda for Sustainable Development (SDGs). Overall, child mortality has dramatically reduced in recent history but remains an unfinished agenda. Infant deaths constitute the majority of child deaths and are mostly preventable (WHO and UNICEF 2013; UNICEF 2018). The census can capture deaths that may not have been registered in the CRVS system, but the limitations are that deaths may be inadvertently or otherwise under- or over-reported by inclusion of stillbirths or by incomplete census coverage, and they exclude deaths that occurred to individuals in non-household set-ups, i.e. in institutions or living on the streets, which should in any case be very small – especially for this age-group. Under-five mortality rates are considered to be more robust than infant mortality rates when estimates are based on information drawn from household surveys (UN 2012), but the opposite seems to be true with the South African 2011 Census (Statistics South Africa 2015). In the first instance, the deaths from CRVS and surveys (Census and DHS) are plotted. It is evident that the same pattern for mortality across provinces exits for surveys (Figure 1), although the magnitude is different because the reference period is one and ten years before the survey, respectively. The CRVS pattern is different from the surveys, specifically for KZN, NW and GP. At national level, the approximately 42 000 Census 2011 infant deaths compare well with independent sources (UN 2011) and so are assumed to be reasonably complete (Statistics South Africa 2015), and the corresponding adult deaths – although usable – are not complete, while the opposite is true for CRVS adult deaths (Statistics South Africa 2018; Dorrington, Bradshaw et al. 2019). Furthermore, the IMR derived from using direct estimation from household deaths and indirectly from women's summary birth history from the fertility module are comparable (Statistics South Africa 2015). Therefore, Census 2011 infant death data provide an opportunity for directly estimating the infant mortality rate (IMR) and a standard for measuring the completeness of CRVS infant deaths. Direct completeness estimation of infant deaths is convenient because of the complexity of indirect estimation that is largely used for post-childhood estimates (Preston 1984).

Figure 1: Infant deaths – CRVS and surveys



The study by Shoko, Lefakane, Chisumpa et al. (2017) estimated completeness of CRVS infant deaths. This involved adjustment of births from the summary birth history (SBH) from the fertility module and the observed household deaths data for individuals aged zero (<1 year) at the time of death from Census 2011 data and corresponding CRVS mortality data. The census was conducted on 10 October 2011, and the births and deaths pertain to a year prior, and CRVS data are the census equivalent. The method used was adopted from that of estimating of completeness for deaths overall from WHO (2010):

YD = (RID ÷ IMR * B) * 100

Wherein:

YD = Estimated infant death registration completeness (%)

RID = Actual number of registered infant deaths

IMR = Infant Mortality Rate (per 1 000)

AB = Adjusted census births

Estimates for completeness for Eastern Cape and KwaZulu-Natal were very low in comparison to other provinces (Figure 4). The process of addressing this has proved to be complex. While there are real differences in completeness of death data at provincial level, it could also be due to factors to do with the census itself. The births are from SBH – the census is *de facto* based and the default province of the mother is cumulated for the births for the province. The deaths are obtained from the household deaths. In countries affected by migration, this can result in a mismatch between the enumerator and denominator – even though general surveys "ensure a high degree of correspondence between the deaths reported in a region and the regional population exposed to the risk of dying" (Dorrington and Timaeus 2015). So, the birth may have occurred in a different province than that of death. There could be independent mother migration wherein migrant mothers left their children at the place of origin – child migration is limited compared to adults (Statistics South Africa 2015) and complex – migrant mothers upon birth may send children away to their place of origin (Hall 2017). In this report, firstly, an effort was made to explore migrant mothers who gave birth in the reference period – every migrant mother is used to approximate births although these numbers do not represent adjusted births or take into account multiple births. This is represented in a migration matrix, which shows mothers according to provinces of origin and destination. Eastern Cape records the highest number of out-migrant mothers (Table 2). The table below shows that migration of mothers is not unidirectional, and this makes the estimation of a factor to redistribute births complex.

Table 2: Migrant mothers

	Province									
	WC	**EC**	**NC**	**FS**	**KZN**	**NW**	**GP**	**MP**	**LP**	**RSA**
WC		1 065	313	101	223	147	1 390	156	90	**3 484**
EC	7 137		178	503	3 619	1 333	5 626	476	290	**19 162**
NC	432	101		237	134	377	616	171	46	**2 115**
FS	258	182	230		252	647	2 652	314	181	**4 716**
KZN	373	526	56	275		240	6 111	913	112	**8 606**
NW	97	60	445	271	80		3 541	253	438	**5 184**
GP	1 345	942	244	768	1 328	2 075		1 901	1 612	**10 214**
MP	143	88	38	120	344	327	4 152		831	**6 042**
LP	153	74	53	168	135	909	11 053	1 360		**13 905**
RSA	**9 938**	**3 036**	**1 556**	**2 442**	**6 116**	**6 055**	**35 140**	**5 544**	**3 601**	**73 427**

Source: Own calculations using Census 2011 migration data

Secondly, the DHIS, which is an administrative system for public health facilities that is designed to provide aggregated data, together with census and CRVS, are used as an independent source to capture the pattern of death reporting – although the former only captures in-patient deaths. The results also show a potential problem with Eastern Cape – the infant deaths recorded in the CRVS system should be higher than those captured in the DHIS (Table 3). This then suggests that the less than 50 per cent may be closer to the estimation of completeness of deaths (Figure 2).

Table 3: Census, DHIS and CRVS infant deaths

Province	DHIS*	CRVS*	Census
WC	572	2 033	2 300
EC	3 056	2 599	5 843
NC	413	1 097	1 076
FS	1 300	3 026	2 991
KZN	4 314	5 527	11 609
NW	1 144	3 077	3 741
GP	2 896	6 815	6 600
MP	1 157	2 215	3 945
LP	2 168	2 767	3 987
RSA	**17 020**	**29 154**	**42 091**

*Data corresponds to the 2011 census reference period

Thirdly, reallocation of Census 2011 births – the assumption is that the total births are correct but the provincial distributions are not – Census 2011 births compare well with CRVS births (including late registrations) and estimated completeness thereof by (Nannan, Dorrington et al. 2015). The other assumption is that the census deaths are not affected. The procedure involved using births from SBH in the 2007 Community Survey fertility module – representing births in year 2006 – to estimate annual growth rates - the assumption is that the distribution of births in 2006 should not be too different from that of 1 October 2005 to 1 October 2006. The projected provincial percentage distribution of Census 2011 births were used to redistribute the total adjusted Census 2011 births using the ratio method. Results show a similar pattern for completeness, but the IMR changes (results not shown). The following adult deaths completeness is estimated using the indirect method. Firstly, weighted and unweighted numbers are provided to show that weights do not distort the data. Weights that are availed in the datasets are from the undercount adjustment, the extent which is established through an independent Post-enumeration Survey (PES) and which is applied in the analyses. Still, mortality, like other demographic events, is not complete, and the completeness is further determined and adjusted for at analysis level.

2.2 Analysis of completeness of 2011 Census adult deaths

The study estimates provincial level completeness for adult deaths from Census 2011. Estimation of adult mortality at national, provincial and district levels using census and CRVS involves estimation of completeness (higher and lower subnational level, respectively) (Dorrington, Moultrie et al. 2004; Dorrington, Timæus et al. 2004; Chinogurei 2017). The approach followed by Chinogurei (2017) involved estimating subnational adult mortality using a method first used at national level by Dorrington, Moultrie et al. (2004). This involved calculating the intercensal completeness by population group, sex and age for CRVS data; to estimate an adjustment-factor to estimate the completeness of deaths occurring, a year preceding the census; the period for which the 2001 census household deaths pertain. They highlight the limitations that the population group of the household head is used as a proxy for that of the deceased. Furthermore, research has shown the disjuncture between population group as reported in CRVS and surveys (Shoko 2018).

Another method by Dorrington, Timæus et al. (2004) involved deriving completeness of child deaths from Census 1996 to subsequently estimate CRVS adult mortality at subnational levels.

The procedure used in this report included estimation of completeness using census and CRVS data a method used by Dorrington, Moultrie et al. (2004) and Chinogurei (2017). The adjusted CRVS deaths data by province (using the GGB method for deaths inclusive of the late registrations and the population from Census 2001 and Census 2011, and CS 2007). The estimated Census 2011 completeness is from linear interpolation, and using the 2011 CRVS deaths, the provincial deaths are then calibrated to match the national complete deaths and provide the expected provincial deaths and ultimately the provincial adult mortality completeness.

CHAPTER 3: RESULTS, DISCUSSION AND CONCLUSIONS

3.1 Introduction

This part of the report presents findings from analysis.

3.2 Results and discussion

The weights in the census data have not distorted the data, as seen in Figure 2. CRVS data are expected to be above that of census deaths. The pattern of deaths occurring in the CRVS and census data is similar across all provinces with the exception of Eastern Cape (Figure 3). This is an indication that there may be an issue with reported deaths in the EC.

Figure 2: Weighted and unweighted Census 2011 data

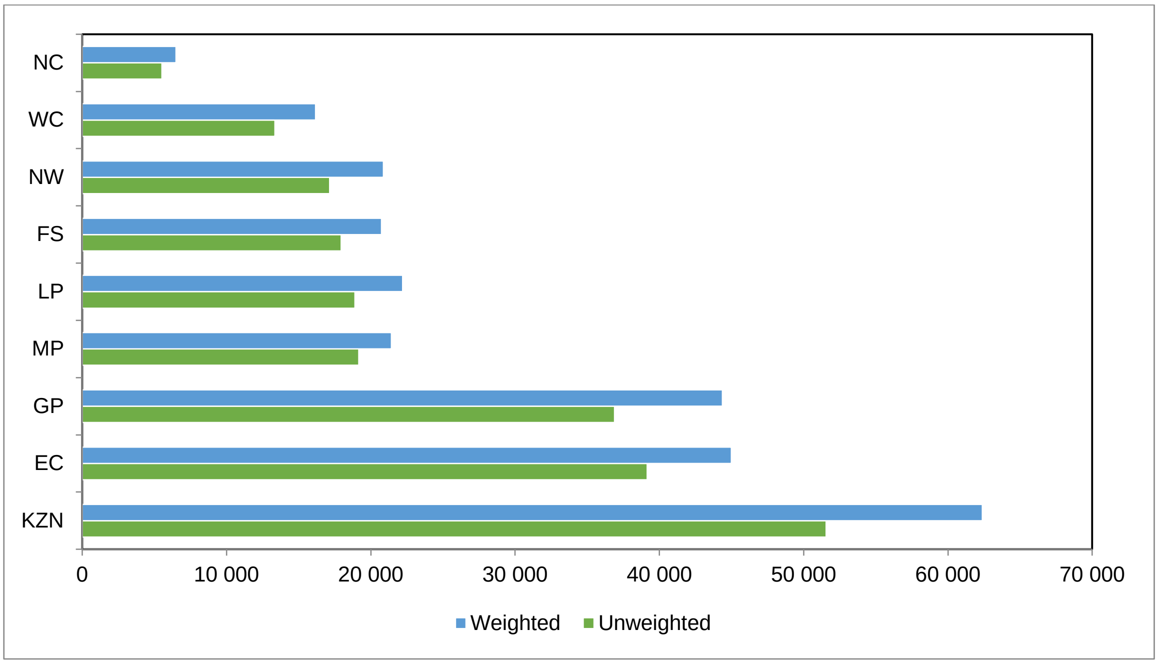
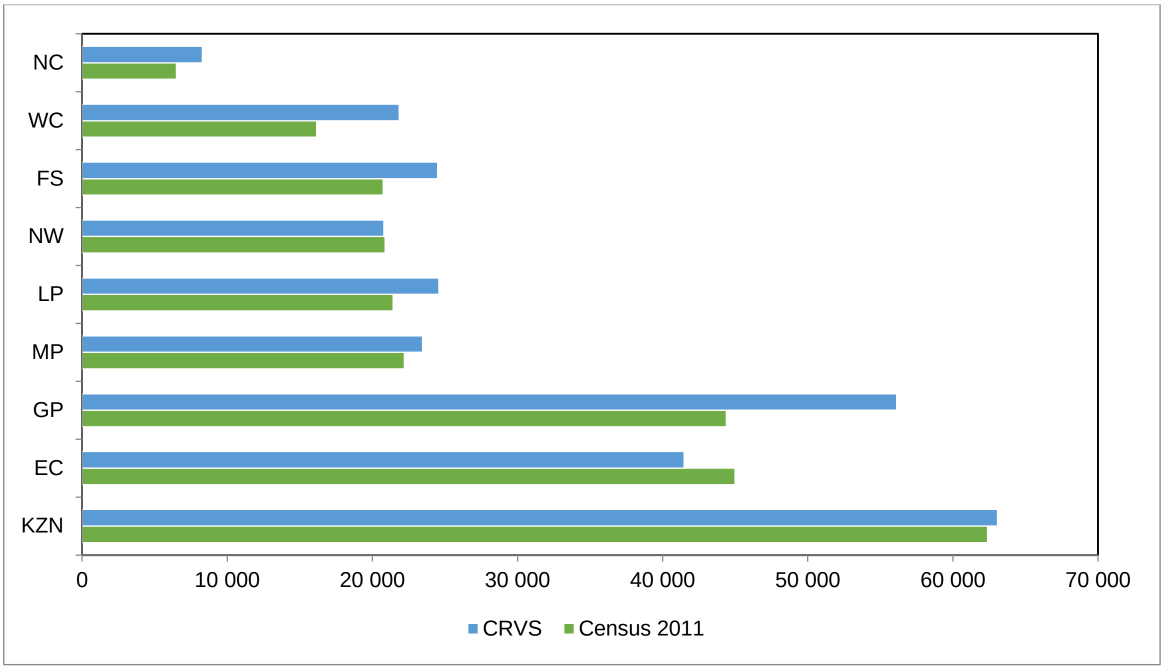
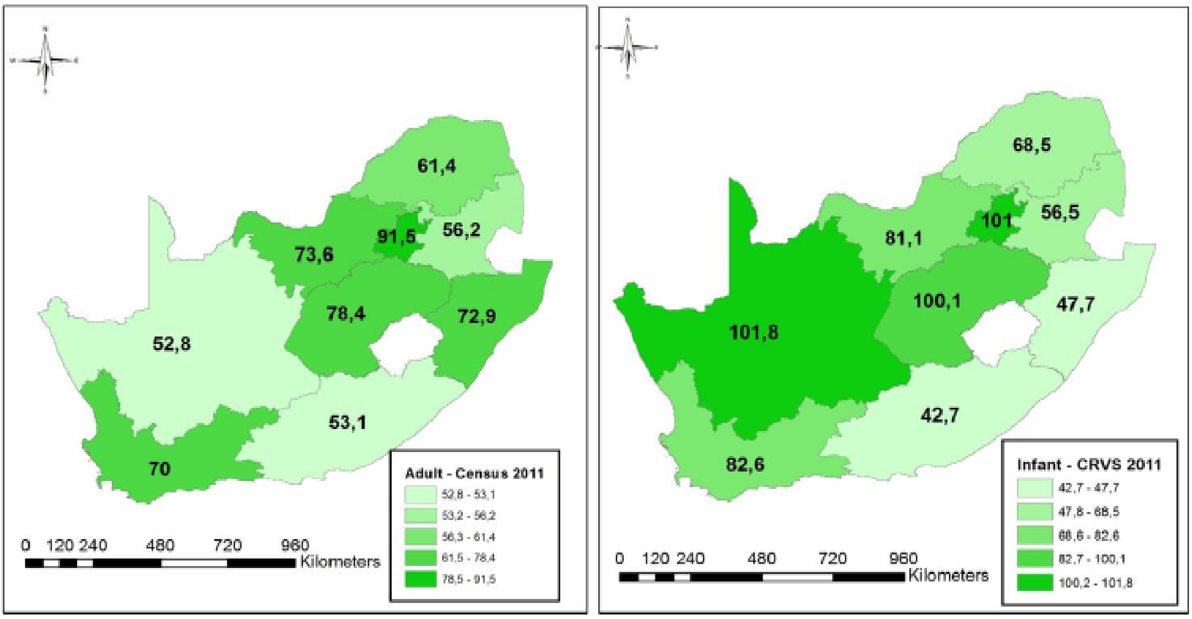


Figure 3: Adult deaths by source of data



The national completeness for census adult deaths is 80 per cent, and this varies by province. Gauteng has the highest completeness with the lowest recorded in Eastern Cape, Northern Cape and Mpumalanga. The low levels in adult mortality completeness compared to the high levels seen in infant death completeness is consistent with issues related to adult deaths in household surveys. The results also suggest that although CRVS infant deaths are lower than adult CRVS deaths (as seen in literature), they are, however, higher than census adult deaths.

Figure 4: Infant and adult deaths completeness – 2011



3.3 Conclusion

The country should be lauded for relatively good quality census and CRVS data. However, six of the nine SDG 3 targets relate to cause-specific mortality and require CRVS data. For easier monitoring and for the success of the SDG agenda, outstanding issues relating to death registration should be addressed as a matter of urgency. Improvement in CRVS systems could be achieved by better coordination for registration of inpatient deaths. The census data are also useful because of related individual and household level data that are not available in CRVS data as a by-product of administrative data. The issue of completeness is an issue for both census and CRVS and is complex for both. With the approaching 2021 census, the country should build on the complete infant deaths and improve adult deaths to achieve universally complete deaths.

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