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SOUTH AFRICAN NATIONAL CAUSE-OF-DEATH VALIDATION PROJECT

REPORT 3 | SOUTH AFRICAN NATIONAL CAUSE-OF-DEATH VALIDATION PROJECT: AGREEMENT AND CORRECTED CAUSE-SPECIFIC PROFILES BASED ON DATA LINKAGE

SAMRC Burden of Disease Research Unit | December 2024

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DATA FOR HEALTH INITIATIVE

South African National Cause-of-Death Validation Project:
Underlying cause of death based on a sample of Medical Records from Public Sector Hospitals and Forensic Pathology Service Mortuaries

SUGGESTED CITATION

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DISCLAIMER

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position of the funding agencies.

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A copy of this resource is available at: *www.mrc.ac.za/bod/reports.htm*

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Abbreviations and Acronyms

ACME	-	Automated classification of medical entities
ADS	-	Associate Director for Science
AIDS	-	Acquired immune deficiency syndrome
ANACONDA	-	Analysis of national causes of death for action
CCVA	-	Computer coded verbal autopsy
CDC	-	U.S. Centers for Disease Control and Prevention
CEU	-	Continuing education units
CI	-	Confidence interval
COD	-	Cause of death
COMCATs	-	Circumstances of mortality categories
CRVS	-	Civil Registration and Vital Statistics
CSMF	-	Cause specific mortality fraction
DHA	-	Department of Home Affairs
DNF	-	Death notification form
DOH	-	Department of Health
FP	-	Funeral Parlor
FPS	-	Forensic Pathology Services
HDSS	-	Health and demographic surveillance site
HPCSA	-	Health Professions Council South Africa
HIV	-	Human immunodeficiency virus
ICD-10	-	International Classification of Diseases and Related Health Problems (Tenth Edition)
ID	-	Identity number
IMS	-	Injury Mortality Survey
Iris	-	Automatic system for coding of cause of death software
QA	-	Quality assurance

MIA	-	Minimally invasive autopsy
MCCOD	-	Medical certificate of cause of death
MR	-	Medical record
NBD	-	National burden of disease
NDOH	-	National Department of Health
NOK	-	Next of kin
NPR	-	National population register
ODK	-	OpenDataKit
PCVA	-	Physician coded verbal autopsy
POPIA	-	Protection of Personal Information Act
PPV	-	Positive predictive value
SA ID	-	South African Identification Number
SA NBD	-	South African National Burden of Disease Study
SA NCODV	-	South African National Cause-of-Death Validation project
SAMRC	-	South African Medical Research Council
SAS	-	Statistical Analysis Software
SDG	-	Sustainable Development Goals
SES	-	Socio-economic status
SOP	-	Standard operating procedure
Stats SA	-	Statistics South Africa
TB	-	Tuberculosis
UCOD	-	Underlying cause of death
USID	-	Unique study identification
VA	-	Verbal autopsy
WBOTS	-	Ward based outreach teams
WHO	-	World Health Organization

GLOSSARY

Aggregation of causes of death

The analysis of the causes of death in this report makes use of the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). This is a standardized medical classification list developed by the World Health Organization (WHO) which was last updated in 2016. It classifies diseases and related health problems into 22 chapters, of which 19 are used in the reporting of information on underlying causes of death.
(Available at *https://icd.who.int/browse10/2016/en*).

A basic National Burden of Disease (NBD) list, aligned to the South African National Burden of Disease list (available at *https://www.samrc.ac.za/sites/default/files/files/2016-07-04/SANBDReport.pdf*), has been developed for data analysis. The basic NBD list has 143 conditions and is similar to the aggregation in the NBD list but does not make any assumptions about misclassification of causes and includes categories for ill-defined conditions (see supplementary Table A1 in Annexure 8.2).

A number of lists of aggregated causes have been developed for working with verbal autopsy (VA) data. This report uses the 2016 cause of death list for VA comprising 64 causes mapped onto ICD-10. (Available at *https://www.who.int/healthinfo/statistics/verbalautopsystandards/en/* and shown in Table A2 in Annexure 8.2).

Further analysis has been done by grouping the ICD-10 causes into three broad cause groups with an additional category for human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) and Tuberculosis (TB) as has been used in the South African Burden of Disease studies (available at *https://www.samrc.ac.za/sites/default/files/files/2016-07-04/SANBDReport.pdf*).

These are: -

Type	Broad cause group
1	HIV/AIDS and TB
	Other infections, maternal, perinatal and nutritional conditions
2	Non-communicable diseases
3	Injuries.

Cause of death sequence

The cause of death sequence is the chain of events leading directly from the underlying cause to the immediate cause of death.

Community Oriented Primary Care

Community oriented primary care (COPC) is a strategy whereby elements of primary health care and of community medicine are systematically developed and brought together in a coordinated practice.

DHA-1663

Also known as the death notification form, this four-page document is printed by the Department of Home Affairs (DHA) for registration of a death. The first three pages include details about the decedent, the informant, the certifying doctor and the funeral undertaker. The last page, labeled Pg 1 of 1, is completed by the certifying doctor and includes the medical certificate of cause of death. In the case of a perinatal death, the format of the medical certificate of cause of death is different to ensure information about the mother's condition is captured.

Death

The permanent disappearance of all evidence of life at any time after a live birth has taken place, or postnatal cessation of vital functions without capability of resuscitation. This definition excludes fetal deaths, i.e., stillbirths (see definition below). This study inadvertently included some stillbirths which have been described separately in the report.

Decedent/deceased

Persons who died in South Africa and whose body has been taken to a designated funeral parlor registered with the DHA, or whose body has been prepared for burial or cremation by a funeral undertaker, or whose death has been registered directly at a local DHA office by a next of kin (NOK)/carer/friend of the decedent. Foreigners who died in the country were included in the study when an adult (aged ≥18 years) NOK/carer/friend could be contacted within the study timeframe and could speak English or any of the nine most common South African official languages into which VA questions were translated.

ICD-10

The ICD is a classification and coding system developed by the WHO and defines the universe of diseases, disorders, injuries and other related health conditions, listed in a comprehensive, hierarchical fashion. The 10th revision, updated in 2016, is currently used as the international standard for reporting diseases and health conditions and can be found online. It can be used at 3-digit or 4-digit level. The next revision of ICD has been completed and ICD-11 will be adopted by the World Health Assembly.

Injury death

Deaths due to injuries (external causes) are required by law in South Africa to undergo a postmortem investigation at Forensic Pathology Services to determine culpability and cause of death.

International Form of Medical Certificate of Cause of Death

The ICD has outlined principles for certifying the medical cause of death and the rules for coding which are essential for standardizing cause of death statistics. This starts with the form that has a specific layout and needs to be completed in a specific way to ensure that the underlying cause of death can be identified:

> the sequence of the causes of death from the underlying cause to the immediate cause should be reported in part I of the form with immediate cause shown in line a. Other conditions that contributed to the death should be reported in part II.

FRAME A: ▸ **Medical data: Part 1 and 2**				
		▸ **Cause of death**		▸ **Time interval from onset to death**
1. Report disease or condition directly leading to death on line a Report chain of events in due to order (if applicable) State the underlying cause on the lowest used line		a		
		b	Due to:	
		c	Due to:	
		d	Due to:	
2. Other significant conditions contributing to death (time intervals can be included in brackets after the condition)				

Source: International Statistical Classification of Diseases and Related Health Problems (ICD-10).[1]

Iris

Iris is an automated system for coding multiple causes of death and for the selection of the underlying cause of death based on the ICD-10 coding rules. It can be used in batch or interactively.

InterVA

InterVA is a suite of computer algorithms to facilitate interpreting verbal autopsies (VA) towards generating a probable cause of death, using a Bayesian approach. The latest version, InterVA-5 has been used in this project.

Manner of death

According to ICD-10, the manner of injury deaths captures the intent -namely, homicide, suicide, accident, natural, or undetermined. In this study, we divide the accidental category into transport and other unintentional.

Maternal death

A maternal death, as defined by WHO, is the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes.

Medical doctor/physician

A medical doctor is a trained health professional who practices medicine, and who is concerned with promoting, maintaining, or restoring health through the study, diagnosis, prognosis and treatment of disease, injury, and other physical and mental impairments. The term medical doctor is used interchangeably with physician in this report.

Multiple causes of death

When coding and classifying causes of death, you must first assign ICD codes to all the conditions reported on the death certificate. Many coding instructions are based on specific ICD codes and, to determine whether any of the instructions apply, you need to know the ICD codes for all conditions on the certificate. This is called multiple-cause coding.

Next of Kin (NOK)

The deceased's close living relatives are known as the next of kin (NOK) and in this report, the informant is the person who reported the death to the Department of Home Affairs office.

Ninety-five percent confidence interval (95% CI)

The 95% confidence interval (CI) represents the sampling variability around an estimate. A 95% CI of a statistic is a range with an upper and lower number calculated from a sample that describes possible values that the true statistic could be. If multiple samples were drawn from the same population and a 95% CI calculated for each sample, we would expect the population statistic to be found within 95% of these CIs.

Perinatal period

The perinatal period spans the time between 22 weeks after fertilization and 7 days after parturition. ICD-10 has a chapter for conditions that have their origin in the perinatal period even though death or morbidity occurs later.

Stillbirths

The definition recommended by WHO for international comparison is a baby born with no signs of life at or after 28 weeks' gestation. A fresh stillbirth is defined as the intrauterine death of a fetus during labor or delivery, and a macerated stillbirth is defined as the intrauterine death of a fetus some time before the onset of labor, where the fetus showed degenerative changes.

Sustainable development goals (SDG)

The Sustainable Development Goals, also known as the Global Goals, were adopted by all United Nations Member States in 2015 as a universal roadmap to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. Cause of death data are a prerequisite to measure several indicators.

Underlying cause of death (UCOD)

The underlying cause of death, from a public-health point of view, is considered the most informative cause of death data element, and therefore was designated the cause of death for primary tabulation and comparisons. From the perspective of prevention of death, "it is necessary to break the chain of events or to effect a cure at some point. The most effective public health objective is to prevent the precipitating cause from operating. For this purpose, the underlying cause has been defined as (a) the disease or injury which initiated the train of morbid events leading directly to death, or (b) the circumstances of the accident or violence which produced the fatal injury".[1] To properly select the underlying cause of death, coders are taught to apply the ICD rules and instructions to the sequence of causes as indicated on the *International Form of Medical Certificate of Cause of Death*. Automated software developed by the Iris Institute is available to facilitate coding of multiple causes of death and selection of the correct underlying cause. There are instances where the ICD-10 guidelines specify that certain combinations of codes be recoded to a single code that captures all the information. An important example of this, in the South African context, is the 4-digit code B20.0 for *HIV disease resulting in mycobacterial infection which includes HIV disease resulting in tuberculosis*.

Unusable code

Unusable codes (also referred to as 'garbage codes') are any ICD code that cannot or should not be considered an underlying cause of death, such as septicemia, senility or headache. They may also be the code for a cause that belongs in some other part of the morbid sequence of events leading to death such as the immediate or intermediate cause; or a cause of death that is insufficiently specified. Essentially, an unusable code is one that has no use in informing public health policy, as the related underlying cause of death (UCOD) is too vague, or simply impossible. Mikkelsen et al. (2017)[2] have defined five categories of unusable codes in the ANACONDA tool:

- Category 1 – Symptoms, signs and ill-defined conditions
- Category 2 – Impossible as underlying causes of death
- Category 3 – Intermediate causes of death
- Category 4 – Immediate causes of death
- Category 5 – Insufficiently specified causes within ICD chapters.

Verbal autopsy (VA)

A method of determining an individual's probable cause/s of death using a trained interviewer to administer a questionnaire during a face-to-face or telephonic interview to collect information about the signs, symptoms, treatment, and demographic characteristics of a recently-deceased person from another individual – ideally a close caregiver or family-member – with knowledge about the deceased person during his/her terminal illness/event.

Ward-Based Outreach Teams (WBOTS)

A ward-based outreach team is comprised of 10-20 community health workers with a team leader (professional or enrolled nurse) who are responsible for primary health care service delivery in a defined municipal ward comprised of about 200 households.

Executive summary

South Africa National Cause-of-Death Validation Project

South Africa has a well-established Civil Registration and Vital Statistics (CRVS) System with a high proportion of deaths being registered. However, the quality of the cause of death statistics is considered sub-optimal with a high proportion of ill-defined causes, extensive underreporting of HIV as an underlying cause of death and misclassification of injury deaths.

The South African National Cause-of-Death Validation (SA NCODV) project was implemented by the South African Medical Research Council (SAMRC) and partners to validate CRVS cause of death information by linking CRVS data to cause of death information obtained from medical records, forensic pathology records, and VA interviews for a national sample of deaths. The main purpose of the study was to compare the underlying cause of death from the CRVS data with the highest level of information collected in the study (based on the hierarchy of forensic pathology record followed by medical records and then VA) in order to estimate correction factors to derive cause of death profiles that are adjusted for the poor-quality information.

This study was reviewed and approved by the SAMRC Ethics Committee[i§]. Support was obtained from the National Department of Health (NDOH), the Department of Home Affairs (DHA) and Statistics South Africa (Stats SA). Permissions were obtained from each provincial Department of Health (DOH) and health facility included in the study. At the time of registering a death, information about the study was provided and consent obtained from informants for the research team to contact them at a later date. Informed consent was obtained from the respondent for each completed VA interview.

Purpose of this report

- This is the *third project report* and describes the agreement between the cause of death identified from data collected from a national sample of medical and forensic pathology records and VAs with the cause of death information identified by Stats SA based on death notifications.
- The *first project report* provided detailed information on the study rationale, aims and objectives together with the initial findings from the national sample of verbal autopsies (VA). The *second project report* provided initial findings based on the medical records (MR) and Forensic Pathology Services (FPS) records including an evaluation of the quality of the cause of death information that could be obtained from the records.

Study design and method

A sample size of >13,000 deaths of all ages from 27 randomly selected sub-districts across the country was determined to provide sufficient precision for the correction factors for deaths caused by four selected conditions including HIV, cerebrovascular disease, diabetes mellitus, and interpersonal violence (homicide). Originally planned as a fixed three-month census of the deaths registered in the sub-districts during the period 1 September 2017 - 30 November 2017; the study period needed to be extended to nearly 8 months (1 September 2017 - 13 April 2018) due to low recruitment of NOK for VA interviews in the first phase of the study. Only 26% of the 36,973 total deaths registered in the sample area were identified during recruitment. The sampling strategy was therefore revised to include all the deaths that occurred in the facilities in the selected sub-districts during the study period.

Fieldwork for the second phase of the study started in August 2018 following a three-week national training and was completed in March 2019. The trained fieldworkers contacted the NOK who had been recruited in Phase 1 to arrange for a face-to-face interview using the three questionnaires of the WHO 2016 instrument that had been translated into nine official languages.

i§ *See 45 C.F.R. part 46.101(c); 21 C.F.R. part 56*

In addition, all medical records and forensic pathology records of decedents who passed away in the facilities within the selected sub-districts during the study census period (1 September 2017 to 13 April 2018) were collected. Once permission was obtained to collect data in a facility, the team leaders requested a list of all decedents who had passed away during the study census period and access to their patient records. The fieldworkers allocated a unique study identity (ID) number to each decedent and captured basic details into a customized KoBoTool questionnaire. They then anonymized and scanned the records and uploaded them against the unique study ID. Quality assurance (QA) involved daily review of the hospital and forensic pathology records, ensuring that records were correctly de-identified and numbered, and weekly review by the project team to monitor ongoing data collection and data quality.

Response rate

Data obtained from the DHA indicated that 36,973 deaths were registered with place of occurrence in the 27 sampled sub-districts during the study census period 1 September 2017 – 13 April 2018. A total of 5,387 VAs were successfully conducted, and 17,625 medical records and 5,742 forensic pathology records collected. In total, information was collected for 26,514 decedents yielding a ratio of 72% relative to the target population of registered deaths and well over the number of deaths identified in the sample size determination (10,000-12,000). The apparent overall response rate of deaths that had data from at least one source was relatively high (72%). The initial response rate for VA interviews had been very low and the sampling strategy was amended to extend the study period, include DHA officials to recruit next-of-kin (NOKs) and to collect all medical records and forensic pathology records from facilities serving the selected sub-districts. The response rate for NOKs was 15%.

To save costs, a total of 10,128 medical records were reviewed, accounting for 57.5% of the records collected, focusing on deaths that occurred in 2017 or had a VA interview. Forty stillbirths were identified and reported separately. A total of 5,320 FPS records were reviewed accounting for 92.6% of the 5,742 records collected which included some duplicate records. There were 145 FPS cases excluded from further analysis as they either had no information or for specific reason such as non-viable fetus or stillbirth, skeletal remains etc. The balance of the medical records and FPS records will be archived securely and made available for further analysis or under a new study with appropriate ethics approval.

Identification of cause of death

We recruited medical doctors (including some doctors with paediatric and neonatal experience, some with forensic pathology training and one with obstetrics and gynaecology training), who were required to attend face-to-face training for one day and to successfully complete three home assignments and pass a competency test. The main aim of the training was to ensure that the doctors were competent in certifying deaths according to ICD-10 guidelines and able to use the data capture tool, to understand the WHO 2016 VA tool, and to interpret the VA narrative and interview. A total of 49 doctors were contracted to review VAs. Anonymized responses to the VA interviews were batched into groups of 40 records and independently reviewed by two doctors who submitted their medical certificates of the causal sequence via KOBOTools, overseen by a QA team.

Clinician reviewers who had experience in reviewing verbal autopsy interviews were re-orientated to review medical records and to complete a medical certificate of cause of death and an additional 16 reviewers were recruited, including some doctors with training in forensic pathology who were trained to review FPS records and certify the cause of death. Records were batched and shared with clinician reviewers on Microsoft Teams. On completion, QA reviewers selected a 10% sample of the records to review. If there were any concerns about the underlying cause, the whole batch was reviewed by a QA reviewer and feedback was provided to the clinician reviewer. In addition, all the forensic records were checked to ensure that the certification of cause of death included the circumstances of the death as well as the manner of death. Any record with unknown underlying cause of death was reviewed against the forensic record to ensure that no information had been missed.

All the medical certificates were coded to ICD-10 using Iris automated software to provide multiple cause and underlying cause of death codes (4-digit). Rejects were manually coded by members of the research team. Data cleaning was done with a focus on ensuring correct ID numbers and removing duplicate records. Implausible causes for age or sex (e.g. cervix cancer in a male, or Alzheimer's in a child) were reviewed and a decision made based on a relook by the principal investigator at the record and data submitted by the reviewer.

Data linkage

Both deterministic and probabilistic linkage were used to link SA NCODV and Stats SA data. Deterministic linking was done based on a valid SA ID number, and records from the two datasets were considered a pair if they matched on the ID number. The probabilistic linking was used to match SA NCODV and Stats SA records that could not be linked deterministically, including the records that did not have a SA ID number. Probabilistic linkage was based on a set of common variables; a pair of records were considered a match based on the statistical probability that the values of these common variables belong to the same individual. These variables were surname, day of birth, month of birth, day of death, month of death and the province.

Analysis of data

To assess the agreement between Stats SA and SA NCODV information, the causes of death were aggregated into a short NBD list of 44 causes (Table A1 in Annexure 8.2). The short NBD list is aligned with the South African SA NBD list of 143 causes, which was developed to suit the characteristics of the country's disease profile and the quality of routine data but does not make any assumptions about misclassification of causes and includes categories for ill-defined conditions. Some decedents in the SA NCODV project had cause of death information from more than one source. In such cases, a hierarchy of evidence is applied with the information obtained from FPS records, taking precedence followed by medical records and lastly the VA information.

Individual level agreement was assessed using the simple proportion of deaths that match exactly, and Cohen's kappa statistic was used to assess the agreement having adjusted for agreement that could have resulted by chance. Population level agreement was assessed using the cause-specific mortality fractions (CSMF) accuracy and a Spearman rank correlation. Post-survey weights based on age, sex, place of occurrence (in facility or out of facility), and whether the death was due to a natural or unnatural cause were calculated to allow the characteristics of the weighted NCOVD sample to match those of Stats SA. 95% CIs were calculated making use of the Survey Set command in Stata to define the sub-districts as the primary sampling units and the provinces as strata. National correction factors calculated for each cause as the ratio of the frequency in the NCOVD relative to the frequency in Stats SA. The application of the national correction factors for sub-national estimates was explored by comparing the provincial profile from the weighted sample with the provincial profile obtained using the national correction factor.

Key findings

Despite challenges, it was feasible to link cause of death information from the study with vital statistics data. There was poor agreement between the underlying cause of death obtained from the study and the official cause of death data. Only 36.9% of the causes agreed for the 15,367 linked deaths when using a shortened NBD list of 44 causes. The kappa statistic of 0.342 (95%CI 0.339-0.349) indicated minimal agreement. There was notable underreporting of HIV/AIDS deaths and inaccuracies in injury causes with severe under-reporting of suicide.

When the SA NCODV data were weighted to represent all registered deaths, HIV/AIDS dominates the profile, accounting for 23.3% (95%CI: 22.7%-24.0%) of the deaths. Tuberculosis together with cardiometabolic causes, injuries and lower respiratory infections were among the top ten causes reflecting the ongoing quadruple burden of disease in South Africa. Homicide and road traffic accidents feature in the top ten causes for males but not for females. The proportion of deaths due to tuberculosis is much higher in males while deaths from non-communicable diseases account for higher proportions among females, but they follow a similar ranking as for males. While HIV/AIDS is the leading cause in the young adult age groups 25-44 years and 45-59 years, it was the 2nd leading cause in the age group under-25 years, following conditions

originating in the perinatal period and the 3rd highest in older persons 60+ years, being overtaken by stroke and hypertensive heart disease. Perinatal and congenital conditions feature in the younger age group as well as homicide and road traffic accidents. While HIV/AIDS, homicide, road traffic accidents and tuberculosis are the leading causes of death among young adults, suicide is ranked 5th for males 25-44 years and maternal deaths is ranked 2nd for females with suicide ranked 9th in this age group.

The overall proportion of HIV/AIDS deaths in the study sample was higher than anticipated, indicating potential bias towards in-facility deaths in the public sector. The strong association between TB and HIV was highlighted, with TB accounting for 45.7% of deaths among people with HIV, and 63.0% of TB deaths associated with HIV.

Applying correction factors enhanced the accuracy of the national cause of death profile, particularly for HIV/AIDS and injuries. However, extrapolation of national correction factors to provincial cause of death profiles was problematic which may be due to regional variations in medical certification.

Verbal autopsies provided valuable population-level cause of death information, particularly in identifying HIV/AIDS as a leading cause of death and highlighting the mortality due to specific injuries.

Discussion

Strengthening case finding, follow-up, prevention and treatment for HIV/AIDS and TB would help in reducing the high mortality due to HIV/AIDS and TB. In addition, efforts to address the underreporting of HIV/AIDS on the death notification form particularly where this information is documented in medical records and the patient died in hospital would assist in monitoring the impact of any interventions. While these correction factors may be applied to national data for the years not affected by COVID, further exploration of the data to assess the feasibility of deriving sub-national correction factors might identify priority areas for targeted interventions.

A Burden of Disease approach is currently recommended for public health planning purposes as official cause of death data need cautious interpretation. However, this would require more timeous access to official cause of death information.

In the longer term, collaboration and a shared vision among key partners in CRVS has the potential to greatly improve cause of death data quality. Training of doctors in medical certification, systematically reviewing the quality of medical certificates, improving the standards of medical record keeping and implementing routine collection of data for facility-based deaths are likely to advance this goal. An amendment of the South African death notification form to include manner of death would meet the international standard and improve information about the causes of injuries. Implementation of an electronic death certification system may allow timeous access to cause of death information and provide opportunities for monitoring the quality of cause of death information. Developing an online medical cause of death certification system might improve the efficiency of data collection and may be a step towards an electronic death registration system. Implementation of VA may be considered for areas where it is not possible for a doctor to certify the cause of death, and the cost benefit may be assessed.

1. Introduction

1.1 Cause-of-death data in South Africa

As outlined in the first report of the South African National Cause-of-Death Validation (SA NCODV) project,[3] the ideal source of a country's mortality data is a well-functioning, national, full-coverage civil registration and vital statistics (CRVS) system with high levels of completeness of death registration, through ascertainment of the cause/s of death by medical doctors well-trained in the medical certification of the cause of death, and timely-published vital statistics reports.[4-6]

The 2030 Agenda for Sustainable Development[7,8] clearly illustrates the importance and advantage of countries having a national CRVS system in that 67 of 230 proposed indicators to monitor progress in 12 of the 17 total Sustainable Development Goals (SDGs) can be measured from data derived from well-functioning CRVS systems. The prominence of mortality reduction among the health-related SDGs has intensified countries' need for robust national mortality measurements to monitor levels and causes of mortality.[9]

South Africa has a mature civil registration, vital statistics and identity management system which has evolved since the establishment of the Union of South Africa in 1920 and is currently framed by the Births and Deaths Registration Act (Act no 51 of 1992).[10] Despite improvements in the completeness of death registration since 1994, major challenges remain with the way that doctors complete the medical certificate of the cause/s of death and the consequent quality of cause of death information.[11] These include a high proportion of deaths with ill-defined causes (13%), and an additional 13% having a cause of death not valid as an underlying cause in 2016, under-reporting and misclassification of HIV deaths and an inaccurate profile of injury deaths (for example accidental gun deaths are disproportionately high and that of reported homicides are low).[12]

Over the past 15 years, between 41% and 48% of annual deaths in South Africa occurred in health facilities[13] where there is an expectation that the decedent's medical records would be available to inform the medical certificate of death. For injury deaths in South Africa, forensic autopsy records have been shown to provide a suitable reference source for attributing or validating causes of death.[14] With about half of the annual deaths occurring outside health facilities, reference sources other than hospital record reviews are required for validation purposes. For deaths that occur outside health facilities, study results from Health and Demographic Surveillance Systems sites (HDSSs) have illustrated that verbal autopsies can result in reliable cause of death results, despite acknowledged limitations. Data from the Agincourt HDSS has shown that there is potential for VA diagnoses to be used as a reference diagnosis for CVRS data.[15,16]

1.2 Rationale for a national cause-of-death validation project

Substantial misclassification of CRVS cause of death data has been documented, particularly for HIV, tuberculosis, injuries, and cardiovascular causes, as well as a large proportion of deaths certified with ill-defined/non-specific causes.[11] Moreover, valid cause of death data are critical to inform health planning and prioritize and evaluate interventions aiming to improve population health and reduce health inequalities. Despite this knowledge, the validity of national CRVS cause of death data has not been studied in a nationally representative sample of deaths in South Africa.

A national validation study of cause of death statistics is critically important because deaths due to HIV/AIDS and TB need to be accurately quantified, as these have become endemic[17,18] and were major contributors to the rapidly-reduced life expectancy seen until 2006,[19-22] and there are alternative sources of information that can be used to assess causes of death. These include hospital and forensic pathology records for health facility and injury deaths, respectively, and the standardised WHO instruments for conducting verbal autopsies for deaths occurring outside health facilities.

2. Aims and Objectives

2.1 Aim

The overall aim of the SA NCODV project was to derive estimates of cause-specific mortality patterns in South Africa in 2017 at national, provincial, and district levels, using civil registration data validated and corrected against cause of death data from hospital, forensic, and VA records.

2.2 Objectives

The study has three interrelated objectives:

1. **To verify causes of death reported on death notification forms in a nationally representative sample of deaths occurring within and outside health facilities.**
    a. For deaths occurring in health facilities, agreement between the underlying cause of death reported on the DHA-1663 and the underlying cause of death based on medical records was measured.
    b. For deaths occurring outside health facilities, the agreement between the underlying cause of death reported on the DHA-1663 and the underlying cause of death obtained from an interviewer-administered household VA was measured.
    c. For deaths requiring a forensic investigation, the agreement between the underlying cause of death (external or natural) reported on the DHA-1663 and the underlying cause of death (external or natural) reported in forensic records was measured.

2. **To derive correction factors to adjust cause-specific mortality data from vital registration according to reference diagnoses at national, provincial, and district level.**
    a. Correction factors for reference diagnoses were derived from national sample data.
    b. The nationally derived correction factors for reference diagnoses were applied to cause of death profiles from vital registration data at national and provincial level.

3. **To design and test a standardized methodology for household VA for deaths occurring outside health facilities, with a view towards broader implementation within the routine CVRS system.**
    a. The agreement between physician coded VA underlying cause of death and the underlying cause of death obtained from medical and forensic records, were measured for deaths occurring in health facilities and those requiring a forensic investigation.
    b. The agreement between the CSMF produced through automated coding of VA and CSMF from medical and forensic records, were measured for deaths occurring in health facilities and those requiring a forensic investigation.
    c. The feasibility and community acceptability of implementing VA as a routine part of the CVRS system was assessed based upon interviewer experience in the field.

2.3 Purpose of report

This is the *third project report*. *The first project report*[2] outlined the study methodology and described the sample realisation. It also presented and discussed initial results from the national sample of verbal autopsies. *The second project report*[23] provided additional methodological details concerning the collection of medical records from a national sample of public sector hospitals and forensic pathology mortuaries, the process of identifying the underlying cause of death by a panel of doctors trained in medical certification of cause of death and data analysis. This third report provides the results from the evaluation of cause of death data collected in the national sample and the data linkage with underlying cause of death from the CRVS. It also provides an evaluation of the VA, MR and FPS data and provides a corrected cause of death profile at national and provincial levels and discusses limitations for using correction factors to extrapolate to district level.

3. Methods

3.1 Study design and sample

Full details of the study design, target population, sampling, sample size determination and revised sample are provided in the *first project report*.[3]

Briefly, this was a data linkage study based on the cross-sectional data collected for a fixed-period census of deaths registered in a nationally representative sample of health sub-districts in South Africa during part of 2017 and 2018. Families of decedents were recruited through undertakers at the time of registration and later contacted to arrange for a face-to-face VA interview with the NOK/carer. At the same time, medical records (MR) and FPS records were collected from facilities serving the selected areas. The underlying cause of death reported in the CRVS was validated against the underlying cause identified through the highest level of evidence collected in the study for each decedent. The forensic pathology information was considered the highest level of evidence, followed by the medical record, and then the VA.

A nationally representative random sample of 27 sub-districts (Figure 1) was selected using pseudo stratification according to socio-economic status (SES) based on the poverty headcount within each province. This was done to ensure representation of the range of living conditions in the country. It was considered that a sample size of 13,000 deaths would provide sufficient precision to estimate of the correction factors for selected causes of death (HIV/AIDS, stroke, diabetes mellitus and homicide). Based on the national cause of death data, it was anticipated that a sample of 13,000 deaths would result in 5,980 hospital deaths in hospital and just over 1,000 forensic pathology deaths (Figure 2).

Despite successful piloting of the method of recruitment, considerable challenges were experienced as the study team moved into other geographic areas. It became necessary to amend the protocol to increase the sample size of the decedents by extending the study period and including all patients who died in a health facility or were referred to forensic pathology services and permission was obtained from health facilities to collect data from the records of all the deaths that occurred in the identified health facilities and forensic pathology laboratories during the period September – December 2020. It was anticipated that records for 16,000-17,000 deaths would be collected.

In the amended protocol, it was noted that although the study will provide invaluable information about the implementation of verbal autopsies, there is a possibility of bias in the data collected for the second validation sub-objective (Objective 1b). It was proposed that, in the analysis of the linked data, it would be necessary to investigate the pattern of non-response and explore the possibility of doing a post-survey weighting, based on the basic characteristics of the registered deaths that occurred in the sampled areas when calculating the correction factors.

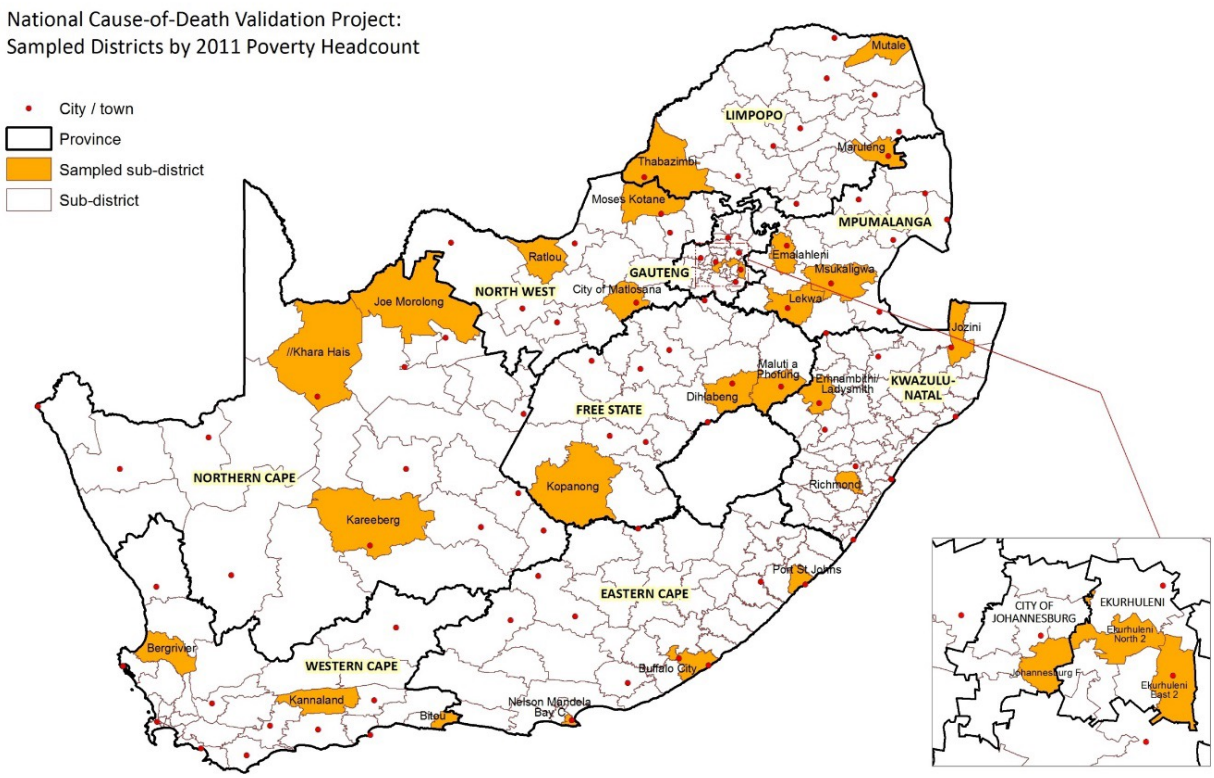


Figure 1: Map of selected health sub-districts and provincial boundaries, SA NCODV Project 2017/18.
SA NCODV - South African national cause of death validation project

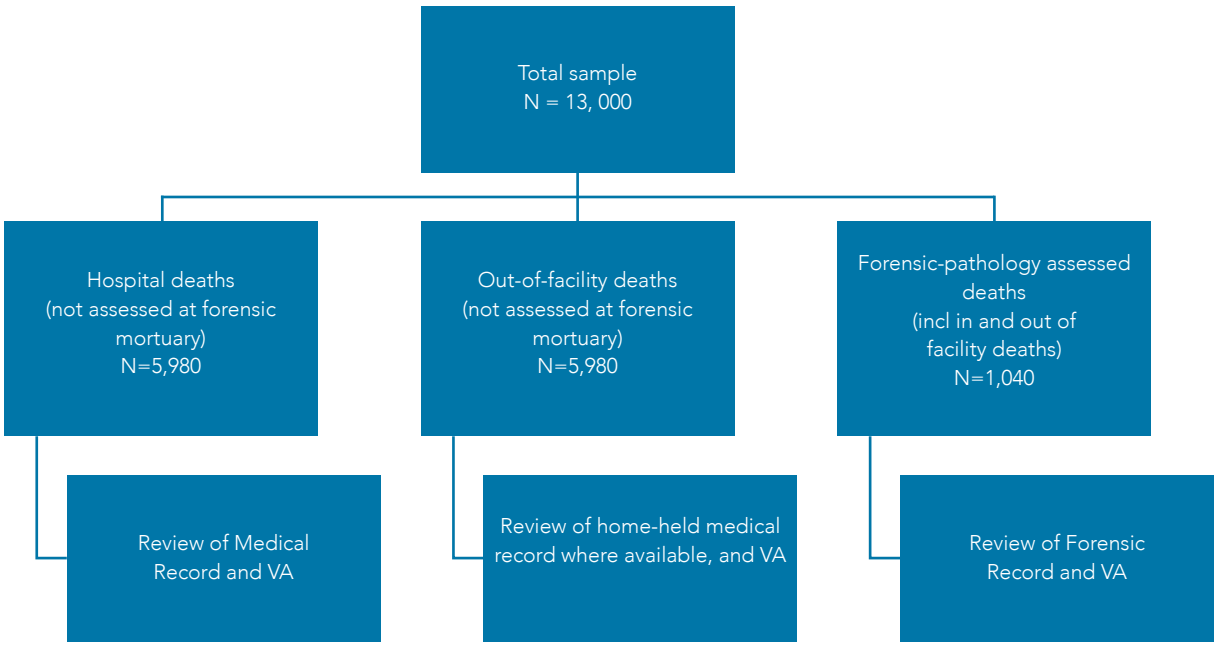
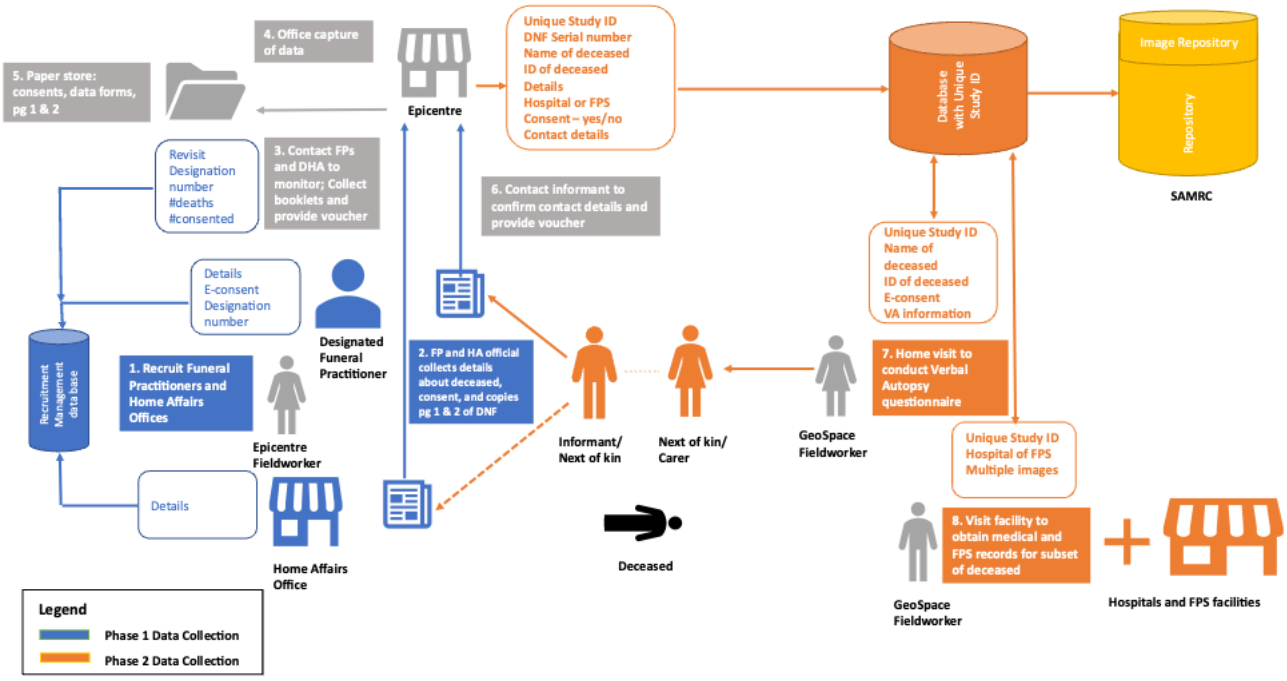


Figure 2: Graphical presentation of the sampling plan, SA NCODV Project 2017/18.
SA NCODV - South African national cause of death validation project

3.2 Data collection

3.2.1 SA NCODV data

As outlined in the *first report*,[3] the data for this project were collected in two phases (Figure 3). In the first phase, designated funeral undertakers and DHA Officers in the selected sub-districts were recruited to provide NOK with information that the South African Medical Research Council (SAMRC) was undertaking a study about the causes of death and seek permission for the SAMRC to contact them at a later stage to collect more information about the deceased person. In the second phase of the project, contact was made with the NOK who had agreed to be contacted to arrange for a face-to-face VA interview. During this phase, medical and forensic pathology records were also collected for the deaths that had occurred during the study period.



SA NCODV - South African national cause of death validation project
Figure 3: Data collection phases for SA NCODV Project 2017/18.

Details about the training for the fieldwork and conducting the VAs can be found in the *first project report*[3] and further details about the collection of records can be found in the *second project report.*[23] Briefly, a team of 84 fieldworkers were trained from 24 July 2018 – 7 August 2018 in Pretoria to conduct VA interviews and scan copies of medical and forensic pathology records using digital data collection tools developed using KoBoToolbox,[24] an open-source secure online/tablet platform set up by the Harvard Humanitarian Initiative for field-data collection in challenging environments. Inclusion criteria included a date of death during the period 1 September 2017 to 30 April 2018, and the hospital being in the selected health sub-districts.

Fieldwork began on 16 August 2018 in the Gauteng area so that the fieldwork implementors, GeoSpace International, could monitor and provide support from their headquarters. QA was set up at GeoSpace headquarters with daily review of the hospital and forensic pathology records, ensuring that records were correctly de-identified and numbered. The project team reviewed the data collected on KoBoToolbox on a weekly basis and any issues were discussed with the field team manager.

3.2.2 *Deaths from the National Population Register*

In November 2018, the DHA provided details of the registered deaths recorded on the National Population Register (NPR) of people who resided in the 27 selected sub-districts and who had died during the extended study period 1 September 2017 – 13 April 2018. The list of place names for the sampled areas was generated from the place names recorded on the NPR. The details included the name, surname, SA ID number, date of death, whether natural or unnatural cause, the office of registration and the place name of residence. Data were transferred using a secure server with password protection.

3.2.3 *Cause of death data from Stats SA*

The SA NCODV data were linked to the cause of death data processed by Stats SA, the national statistical agency. The notification and registration of deaths in South Africa are mandated by the Births and Deaths Registration Act of 1992[10] and the capturing, processing and dissemination of cause of data is governed by the Statistics Act of 1999.[25] Death notification forms (DHA-1663), containing the cause of death information, are transferred from the DHA Head Office to Stats SA Pretoria for processing. Deaths that occurred in 2017 were processed by Stats SA during the period 1 January 2018 to 20 December 2019[26] but the processing period for deaths that occurred in 2018 was not reported.[27] If a medical practitioner could not certify the occurrence of death and provide information about the cause of death, a traditional leader (such as a chief, induna or headman) completes Form DHA-1680 which includes a field to describe the cause of death.[28] It is not known what percentage of deaths are notified on such a form.

Cause of death data, regardless of the source, are classified using the 10th revision of theICD-10.[1] The tabulations are based on the underlying cause of death, defined as the disease or injury that initiated the train of events leading directly to death; or the circumstances of the accident or violence which produced the fatal injury.[29] Stats SA uses the software Automated Classification of Medical Entities (ACME)[30] and Iris[31] software for the automated derivation of the underlying cause of death. Both ACME and Iris software are based on the international death certificate form provided by WHO and apply ICD-10 rules on the selection of the underlying cause of death. The Iris automated system codes multiple causes of death for the selection of the underlying cause of death and is used for comparison of results with ACME. In instances where one software fails to derive the underlying cause, the results of the alternative software are used. In instances where both software packages fail to derive the underlying cause of death, experienced Stats SA coders manually derive the underlying cause of death.

A total of 446,544 deaths occurred in 2017. The method of ascertainment for the highest proportion of deaths was not specified (33.3%). The most common method of ascertainment after unspecified was through post-mortem examination (26.0%), followed by 14.5% of deaths ascertained through the opinion of an attending medical practitioner. About 11.8% of the deaths were ascertained through the opinion of a registered professional nurse and 1.2% of causes of death were ascertained by conducting an interview with the NOK to establish the cause of death. In 2018, the proportion of death notification forms that did not specify the method of ascertainment had increased to 53.7% of the total 454,014 deaths.[27] Following unspecified causes of death, 17.3% received ascertainment through a post-mortem examination, 10.5% of deaths through the opinion of an attending medical practitioner, (7.9%) through the opinion of a registered professional nurse and 7.9% by means of an autopsy. NOKs provided information about the cause of death in a small proportion of deaths (0.7%).

3.3 Data Processing

3.3.1 *Doctor review of verbal autopsies*

As has been described in the *first report*,[3] doctors were trained to review VAs and certify the medical cause of death on the international MCCOD form. Medical doctors were recruited to participate in the study through an advertisement posted on the SAMRC website and shared with colleagues. The doctors were required to attend face-to-face training for one day and to successfully complete a home assignment and pass a competency test before they were offered a contract. A total of 105 doctors attended the initial training of whom 75 successfully completed the assignments and were appointed to review VA interviews. Seventeen doctors resigned between March 2019 and November 2019, and by the time of the completion of the VA reviews, 49 doctors were employed by the project. Most of the doctors were doing the reviews after routine work hours.

Each VA interview was allocated a unique study identity number (USID) and the data were anonymised. The VA interview answers submitted by field workers were summarized in an Excel worksheet and the narratives for each interview were saved as pdf files, named by the USID, and grouped into batches of 40 verbal autopsies using Microsoft Teams. Each batch of VA records were independently reviewed by two doctors who accessed the data in Teams and captured their record reviews in KoboCollect on an android tablet or KoBoToolbox using a personal computer. We developed a customised VA record review form.[21] The doctors reviewed the VA answers then used this form to capture a short summary of the case, information on HIV and TB, the manner of death and the sequence of medical conditions leading to the death as would be reflected on a certificate of cause of death according to ICD-10 guidelines. Reviewers also had space to provide feedback about each case, if desired. Given the interrelatedness of TB and HIV, where a positive HIV result was disclosed in the VA, it was possible to determine if a TB death was due to or related to HIV. However, where HIV was not disclosed, the reviewer used their best medical opinion to decide if the TB death was due to HIV.

A team of five medical doctors, who demonstrated excellent competency in medical certification, were recruited to quality assure and ensure consensus on the independent reviews. The QA reviewers were allocated batches of VA reviews to assess. Each review was assessed and where the two independent reviews had different underlying cause of death the reviewers were informed and asked to come to consensus on the casual sequence in Part 1 of the medical certificate of cause of death. Where they could not come to consensus, they were asked to inform the QA reviewer who either sided with one of the reviewers or brought it to a panel for review by the whole QA panel where the UCOD selected by the majority after discussion was captured. Once the review of the batch was completed, it was signed off by the QA reviewer.

Awotiwon *et al*[32] reported on the quality of the cause of death information obtained from VA data elsewhere. The doctors used a subjective score on a scale of 1 (very poor) – 5 (excellent) based on the consistency and coherence of clinical information provided in the narratives and the questionnaire responses. In addition, they scored the sufficiency of the information, on a scale of 1 (very poor) - 5 (excellent), to make a decision about the UCOD. These authors found that more than 80% of the VA information was assessed by the reviewers to be of good quality (scoring 3-5) and about 65% of the VA's had information assessed as being sufficient to certify cause of death by the doctors (scoring 3-5).

3.3.2 Doctor review of medical records

A subset of the medical records was reviewed, prioritizing all the medical records for deaths that occurred in 2017 as well as the 2018 cases for which there was a VA interview.

The training for the doctors reviewing medical and FPS records was similar to the training for the verbal autopsies and is described in the second report.[23] Additional training materials[ii] and five test medical records[iii] were provided to orientate the reviewers to the medical record reviews and the medical record review data capture form. Only reviewers who provided reviews of acceptable standard were asked to continue with medical record reviews (30/49). Additional recruitment was undertaken to assist with the medical record reviews and a further 16 reviewers were recruited following face-to-face training on ICD-10 guidelines on medical certification of cause of death[iv] and the KoBoToolbox medical record review data capture form.[v] The new reviewers were required to successfully complete the home assignment and competency test as well as five test medical records before they were offered a contract.

As described in *the second report*,[23] a similar process of batching and then allocating the medical records to the reviewers, to access on Teams, occurred as for the VA records. Reviewers viewed the records then captured the information extracted using a medical record review form in KoboCollect on an android tablet, or KoboTools on a laptop. This review form was similar to the VA record review form (see 3.3.1 above) and the FPS record form (see 3.3.3 below), all with the same data capturing fields. Each medical record was reviewed by a single reviewer.

ii *Available upon request from pamela.groenewald@mrc.ac.za*

iii *Available upon request from pamela.groenewald@mrc.ac.za*

iv *https://www.samrc.ac.za/sites/default/files/bod/nationaldeath/TrainingManualMedicalDoctors.pdf*

v *http://www.samrc.ac.za/sites/default/files/attachments/2020-02-17/NCODVP%20Medical%20record%20checklist.pdf*

Groenewald *et al.* (2022)[23] reported on the quality of cause of death information obtained from the medical and FPS records. In the case of medical record, reviewers were asked to specify how the diagnosis of each cause reported in Part 1 was made (medical history, clinical findings, special investigations, surgery, autopsy and other) and to specify the most important results used to confirm the diagnosis. Based on this information they provided a level of certainty of the diagnosis for each cause which was used to rate the level of certainty for the UCOD. The quality of the cause of death information in the medical records was assessed subjectively. The reviewers considered that the information about cause of death in the records were of reasonable quality. The quality of the information was assessed as adequate to excellent in 78% of records by the clinician reviewers, and only 22% of the records were rated to have poor or very poor information. The level of certainty of the UCOD was assessed as adequate to excellent in 85% of cases and 15% were considered poor or very poor.

For deaths due to TB, where a positive HIV test was found in the MR, it was assumed that HIV was the underlying cause. Where no HIV result or a negative HIV result was recorded then TB was assumed to be the underlying cause.

3.3.3 Forensic pathologist review of FPS records

A total of 11 doctors were trained to perform forensic record reviews, including three doctors who participated in the VA reviews and an additional eight doctors who were recruited solely for the forensic record review.[23] Once they were oriented to the Forensic record review process, they were required to conduct 2-5 forensic record reviews prior to being allocated batches of 40 forensic pathology records for review in a similar manner to the medical records. Only 4 went on to perform reviews, mainly due to work commitments.[23]

The forensic record review form in KoBoToolbox completed by the reviewer was similar to the VA and Medical record forms. There was also a field where the reviewer could give an indication of the quality of the forensic record and level of certainty for the underlying cause of death.

A small team of QA reviewers reviewed all the forensic records to ensure that the certification of cause of death included the circumstances of the death as well as the manner of death. All records with unknown underlying cause of death were reviewed against the forensic records to ensure that no information had been missed. Where necessary, these cases were discussed with the reviewer to reach consensus on manner and circumstances of the death. Where consensus could not be reached between the original reviewer and the QA reviewer, the case was referred to the panel of QA reviewers for discussion and a decision on the underlying cause.

While reviewing the forensic records to ascertain the case history of the patient and identify the cause of death identified during autopsy, the forensic pathologist reviewer assessed whether the admission/case history and autopsy records were consistent and allocated these to one of the following 3 categories: not consistent, unclear, consistent. They then scored the quality and coherence of the case / admission history and the autopsy findings using a rating score ranging from 1 (very poor) to 5 (excellent) with 3 being adequate. The reviewers assessed the admission and case history and autopsy findings as consistent in 81.0% of records. Groenewald et al. (2022)[23] reported that the reviewers rated the quality and coherence of these as adequate or better in 85.8% of cases. Overall, 78.3% (4,159/5,315) were assessed to have consistent information and were rated adequate or better on the quality.

3.3.4 Quality assurance (QA) procedures

Report 2 describes in detail the QA procedures.[23] A QA panel comprising of eight medical doctors, who had participated in the study as Reviewers, was formed to assist with standardization of the review process, through developing standard operating procedures (SOPs) for the reviewers and doing ongoing QA. Each case was briefly assessed by one of the QA team to confirm the validity of the underlying cause of death and the causal sequence was correct, without evaluation of the medical record (see Annexure 8.2.1 in second report).[23] This process also allowed for the identification of any cases requiring in-depth review of the medical record. The panel and the co-principal investigator met weekly to discuss and

reach consensus on complicated cases. Where additional information was found by the QA reviewers, the final underlying cause was decided by consensus among the panel. Overall, the QA team agreed with the reviewers UCOD in more than 90% of reviews, and only 922/10,353 (8.9%) of causal sequence and/or UCODs required changing.

In addition to the brief review of each case, four records from each batch were randomly sampled (10.0%) for QA to check whether the QA reviewer agreed with the underlying cause selected by the medical reviewer. If the QA reviewer's opinion on cause of death differed with the medical reviewer for two or more records, then the whole batch was assessed, and feedback was given to the medical reviewer (see Annexure 8.2.2 in Report 2)[23] and the cases were resubmitted.

3.3.5 Certainty of information obtained from medical and FPS records

While reviewing medical and FPS records to identify the UCOD, the medical doctor reviewer indicated the level of certainty (confirmed, highly probable, possible, or unknown) of the diagnosis specified in each line of the MCCOD (based upon whether the diagnosis was confirmed with specific diagnostic tests, clinical findings, or medical history). Groenewald *et al*. (2022)[23] report that while only 45.2% of the records had a confirmed diagnosis in Part 1a, about 70% of the diagnoses on other lines in Part 1 and 65.2% of diagnoses in Part 2 were confirmed. This pattern is a result of the necessity of reporting an immediate cause diagnosis in line 1a (even if it is less certain) and only choosing to report a diagnosis in subsequent lines when there is strong evidence. Of the 269 perinatal deaths, 63% were confirmed.

3.3.6 Coding causes of death

Cause of death coding, for VAs and record reviews, was performed by the researchers using Iris automated software[31] which codes the text terms for the multiple causes of death to 4-digit ICD-10 codes and selects the underlying causes of death by applying the ICD coding rules, supplemented by a dictionary of additional terms used for causes of death in the South African context. The rejects, or deaths for which an underlying cause of death could not be selected, were mainly due to spelling errors, additional words (e.g., *poorly controlled* hypertension, *HIV defaulted*, carcinoma, ca, Ca) and conditions not included in the IRIS software dictionary of medical terms. The rejects were manually coded and the "dictionary" was updated with additional medical terms. All external causes were checked manually in Excel to identify the most common terms reported for external causes and nature of injury and the dictionary was updated to include these terms. The final codes were checked against the manner of death selected in the FPS record review for consistency.[23]

3.4 Data management, cleaning and analysis

3.4.1 Data management

In compliance with SAMRC Information Technology policy, images of anonymised medical and forensic records were stored on Microsoft Teams for access by the medical reviewers. The batching of records was done in the Teams folder and allowed for restricted access and provided a secure platform for data storage. The doctor reviewers accessed relevant records on Microsoft Teams on their laptops and, once they had reviewed the content, they captured the record review data in KoBoToolbox data collection forms that had been installed on their password-protected android tablets. The data submitted into KoBoToolbox form, without personal identifiers other than the USID number, were automatically uploaded to a secure server from which the data could be downloaded by the research team at the SAMRC.

Data access was restricted to authorized users only, with a full audit trail maintained to guarantee data integrity. User access was limited to the information pertinent to that user. U.S. CDC staff were not involved in data collection and did not have access to participants' identifying information. Once the study was completed, a backup of the patient records data, excluding the identifying information, was archived, and the identifying information deleted from the server of the service provider.

Analytical data sets, identified by the USID number, have been created in Excel and STATA for further analysis. The final anonymized dataset will be archived and stored with metadata for 20 years in Medat, a data repository set up by the SAMRC. Electronic records will be retained for five years after the completion of the study on the MRC secure server,

after which it will be destroyed unless ethics approval is obtained for further research. Following the U.S. CDC operational policy document "Policy on Public Health Research and Non-research Data Management and Access"[vi] dd. 26 Jan 2016 (Policy #: CDC-GA-2005-14), the final anonymised data set will be made available coincident with publication of a paper reporting the findings of this study.

3.4.2 Data cleaning

The identifiers (including names, SA ID, date of birth, date of death and sex) from the three datasets (verbal autopsies, the medical record checklist, and the forensic pathology checklist) were merged on the unique study identifier to create a consolidated Master List of the decedents in the study. We checked that the SA ID numbers were valid. Invalid SA ID numbers were identified through the Luhn algorithm and the last digit (13th), corrected according to the sequence of the first 12 digits.[33] In the cases where the first 6 digits of the invalid SA ID numbers did not reflect the date of birth, these were corrected accordingly and again verified using the algorithm. The corrected SA ID numbers were then linked to the Rapid Mortality Surveillance database[34] to verify that the death had been registered. The linking was done on date of birth, date of death, sex and province for records that did not have ID numbers. When a definite match was found, the SA ID number was included in the consolidated Master List.

The identification of duplicate records of the same decedent was conducted on SA ID number as well as on the combination of date of birth and date of death. In cases where duplicates were identified across any of the three data sources, cases with exactly the same characteristics were identified and dropped from the Master List. There was an occasional duplication in USID numbers within the MR and FPS data which arose during data collection from the algorithm that we applied to cater for simultaneous data capture from multiple facilities. These cases were identified and a new unique USID number was allocated.

The ICD-10 codes for the underlying cause of death identified through Iris based on the medical certification by the doctors were run through the ANACONDA tool[2] in two stages, to ensure that no biologically implausible causes had been assigned. Underlying cause of death from the VAs, the MRs and the FPS records were evaluated and causes with implausible age or sex were identified. Fourteen cases were identified as having biologically implausible causes, based on sex or age of the decedent. On review of the records, the incorrect sexes and/or ages of these records were corrected, making the causes plausible. In the second stage of cleaning and data verification, the final underlying cause of death for the complete NCODV data were evaluated using the ANACONDA tool. Six implausible causes were identified: five cases where the cause of death code was for conditions arising during the perinatal period but the age of the decedent was above 10 years, and one case where a woman was recorded as having benign prostatic hyperplasia. On review of the data, the sex of the last case was corrected to male, and one of the cases with a neonatal cause above the age of 10 was excluded from the analysis as there was no obvious indication in the record of an error. The remaining four cases identified with an implausible cause/age combination had cerebral palsy as the underlying cause. We kept these in the dataset. For babies who were often recorded against their mother's SA ID number, care needed to be taken to ensure the correct age was recorded for the baby.

Given the high proportion of deaths identified with HIV/AIDS as the UCOD, a small team of clinicians reviewed the medical records of the cases that had been identified as HIV/AIDS in the study data but not in the linked Stats SA record.
Criteria for assigning the underlying cause of death to HIV/AIDS included the following considerations:

1. HIV positive status or on ARV treatment (ARV naive, currently on ARVs, ARV defaulted treatment) plus
   - an AIDS defining condition present at time of death,
   - and/or CD4 count below 500,
   - and/or viral load count >=> 50.

2. High clinical suspicion of HIV/AIDS in younger adult with no other co-morbidities. HIV status not confirmed by HIV serology at time of death.

vi *https://www.cdc.gov/chronicdisease/pdf/nofo/extramural-guidance-dmp-508.pdf*

A small handful of these cases with other serious co-morbidities were reassigned to a non-HIV related cause after review, but the large majority were considered to have clear information indicating that HIV/AIDS was, indeed, the underlying cause. The age details of the suicides among children aged 5-14 years were also reviewed for accuracy.

3.4.3 Data linkage

Both deterministic and probabilistic linkage were used to link SA NCODV and Stats SA data. Deterministic linking was done using a valid SA ID number. Records from the two datasets were considered a match if they matched on the ID number. A pilot test of the data linkage using only the 2017 data was undertaken. This highlighted the importance of ensuring that the SA NCODV data were clean, that the availability and accuracy of the ID number was optimal and that the linkage of SA NCODV records from different sources were based on true matches. The result of the pilot linkage guided the data cleaning outlined in Section 3.4.2.

Probabilistic linking was used to match SA NCODV and Stats SA records that could not be linked deterministically using SA ID number. The probabilistic linkage approach used a set of common variables available in the SA NCODV and Stats SA datasets. For this approach, a pair of records were considered a match based on the statistical probability that the values of these common variables belong to the same individual. The variables used were surname, day of birth, month of birth, day of death, month of death and province of residence. In order to reduce the number of record pair comparisons required to find potential matches, the data were first blocked using the following blocking variables: year of birth, year of death, sex and first letter of the surname. A score was calculated for each record pair and a cut-off threshold was identified to designate each record pair as a match or non-match.

3.4.4 Data analysis

Descriptive statistics of the basic characteristics of the deaths were calculated using Stata IC/14.2 (StataCorp, USA) and Excel for Microsoft Office 365 ProPlus Version 1902 (Build 11328.20480 Click-to-run). Different cut-offs for age groups were used to suit the characteristics of each data set and the comparison being done.

The quality of the medical certification of cause of death information collected in the SA NCODV project was evaluated using the updated classification of "garbage" codes. Naghavi *et al.* (2010)[35] had published a typology for garbage codes, categorising them into four groups. The list was extended for the 2017 Global Burden of Disease Study36 and evaluated by an expert group convened by the Bloomberg Philanthropies Data for Health Initiative and the Civil Registration and Vital Statistics Improvement project of the University of Melbourne in 2017[37] for incorporation in ANACONDA. Five categories of "unusable" codes were identified including immediate causes of death (e.g., Disseminated intravascular coagulation [defibrination syndrome]), Impossible as underlying causes of death (e.g., Viral warts), Insufficiently specified causes within ICD chapter (e.g., Cancer with unknown primary site), Intermediate causes of death (e.g., Other cardiac arrhythmias) and Symptoms, signs and ill-defined conditions (e.g., Headache, Other abnormal findings of blood chemistry).

For descriptive purposes, the proportion of usable codes in the SA NCODV data have been assessed by source i.e.VA, MR and FPS. Awotiwon et al. (2022)[32] reported that the VAs had a high percentage of usable codes (67%) in the dataset. However, according to the potential public health impact outlined by Mikkelsen *et al.*,[2] half of the garbage codes (54.4%) were very high severity as insufficient information was provided for the doctors to assign a cause of death during certification. Most of the remaining garbage codes were classified as low severity, consistent with a VA interview having limited clinical information. In the case of medical records, a high proportion of the causes (74.4%) were coded to usable codes, indicating good quality certification. There were very low proportions of ill-defined causes (3.3%) or impossible or intermediate causes (3.7%). However, 18.3% of the causes were considered to have insufficient specification within an ICD chapter, indicating that there are gaps in the information available in a medical record. For the FPS records, a high proportion of the causes (80.6%) were coded to usable codes. Similar to the MR, 13.9% of the causes of the FPS data were considered to have insufficient specification within an ICD chapter, indicating that there were gaps in the information available in an FPS record.

To assess the agreement between Stats SA and SA NCODV information, the causes of death were aggregated into a short National Burden of Disease (NBD) list of 44 causes (Table A3 in Annexure 8.2). The short NBD list is aligned with the South African National Burden of Disease (SA NBD) list[38] of 143 causes, which was developed to suit the characteristics of the country's disease profile and the quality of routine data, but does not make any assumptions about misclassification of causes and includes categories for ill-defined conditions. Some decedents in the SA NCODV study have cause of death information from more than one source. In such cases, a hierarchy of evidence is applied with the information obtained from FPS records taking precedence followed by medical records and lastly the VA information.

Individual levels of agreement were assessed using the simple proportion of deaths that matched exactly. Cohen's kappa statistic was used to assess the individual level agreement having adjusted for agreement that could have resulted by chance. Kappa values of < 0 indicates no agreement, while 0–0.20 indicates slight agreement, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 substantial, and 0.81–1 almost perfect agreement.[39]

For assessment of agreement between PCVA and CCVA algorithms, a short list of 25 conditions (Table A4 in Annexure 8.2) was used to align the short NBD list with the WHO VA cause list and the CSMF accuracy was calculated as a population level measure of agreement to quantify how closely the CCVA CSMF values approximate the PCVA CSMF values on a scale 0-1.[40]

Post-survey weights were necessary to make the NCDOV sample represent the same proportional distribution of selected characteristics in the Stats SA data because the realisation of the SA NCODV sample did not follow the original sampling strategy. Hospital and FPS records were over sampled, and the geographic distribution of the realised sample of deaths spilt beyond the boundaries of the sampled geographic areas. Post-survey weights were based on age, sex, place of occurrence (whether the death was in facility), and whether the death was due to a natural or unnatural cause. The categories for sex were male and female. The age categories are neonates (0-28 days), >29 days – 24 years, 25-44 years, 45-59 years and 60 years and older. The place of occurrence categories were in-facility, out of facility and unknown. The age categories were selected such that each cell aimed to have at least 30 cases in the SA NCODV sample.

The post-survey weights were calculated as follows:

$$w_{a,s,f,n} = \frac{PS_{a,s,f,n}}{PN_{a,s,f,n}}$$

$$a=1,..5;\ s=1,2;\ p=1,2;t=1,2,$$

where PSa,s,f,n is the proportion of Stats SA death records in a cell and PNa,s,f,n is the proportion of the SA NCODV sample (excluding ill-defined natural deaths) in the corresponding cell.

The weighted proportion the i^{th} cause in the SA NCODV sample became:

$$WPN_i = \sum_{a,s,f,n} w_{a,s,f,n}\, PN_{i,a,s,f,n}.$$

Confidence intervals (95% CI) were calculated for the weighted proportions using the Survey Set command in Stata to define the sub-districts as primary sampling units and the provinces as strata. The design effect for each cause of death has been calculated as the ratio of the variance based on complex sampling relative to the variance had it been based on simple random sampling.

Without taking post-survey analysis weights into account, correction factors for the i^{th} cause of death would have been:

$$C_i = \frac{PN_i}{PS_i}$$

$i = 1...44.$

where PN_i was the proportion in the SA NCODV data (excluding stillbirths, ill-defined natural deaths), and PS_i was the proportion in the Stats SA 2017/18 data (excluding stillbirths).

After applying with post-survey weights, the correction factor for the ith cause of death is:

$$C_i = \frac{WPN_i}{PS_i}$$

3.5 Ethical consideration and permissions

3.5.1 Informed consent

The Protection of Personal Information Act (POPIA) of 2013[vii] precludes the DHA and the DOH from sharing the personal information of the NOK of decedents without the kin's consent. Hence, we worked through funeral practitioners and Home Affairs officials as an intermediary who could request consent from the NOK for their contact details to be shared with the project field team to seek permission to conduct a VA interview. In addition, data were collected through the review of patient records held in the health information systems of public hospitals and forensic pathology mortuaries.

Informed consent was obtained from participating funeral practitioners and Home Affairs officials when they recruited informants as outlined in the methods section. Their electronic signature was obtained along with their name and surname, and the designation number and contact details of the funeral parlour at the time of their training. An information booklet, including space to capture details of decedents and signatures of the NOK if they consented, was provided to each participating funeral practitioner and Home Affairs officials. Funeral undertakers and Home Affairs officials obtained permission from the NOK for the project to contact them to arrange an interview from the person/s who reported the death to the funeral parlor. The NOK were informed about the aim of the project by the undertaker, using an information sheet which explained the aim, methods, and envisaged outcomes of the project. The undertakers and Home Affairs officials requested signed consent on the information sheet and contact details for the NOK and recorded these on the Funeral Practitioner Death Register Form. Non-literate informants were asked to identify a person that they would be comfortable with to serve as an impartial witness to support them through the consent process, after which the volunteer provided a cross (X) to indicate consent. These forms were signed by the witness.

In the second phase of fieldwork, the fieldworker explained the aim, methods, and envisaged outcomes of the project to the family again to ensure that the participant was fully informed before signing consent for the VA interview on the tablet. Provision was made for illiterate respondents to identify an impartial witness to support them through the consent process, after which the volunteer drew a cross with his/her finger on the tablet, and a witness signed a document to declare that the cross belonged to that particular participant.

3.5.2 Permission

Since access to individuals' medical records were required only for the purpose of retrospective record review after death, to assess the cause of death, a waiver of the need for individual consent for this access was requested based on the public health benefit.

vii *Protection of Personal Information Act (POPIA). To promote the protection of personal information processed by public and private bodies. https://popia.co.za/act/.*

Permission to access information of decedents from medical and forensic records at public hospitals and forensic autopsy facilities was obtained from the national, provincial, and district health departments as well as individual facilities. Permission to access forensic pathology records in KwaZulu-Natal could not be secured so it was not possible to collect forensic record data from this province. The protocol was presented to the National Forensic Pathology Services Committee to obtain their support.

3.5.3 Confidentiality

Another major ethical consideration in the project was ensuring the confidentiality of information from medical and forensic records and informants. Strict confidentiality measures were adhered to regarding the protection of information obtained from medical and forensic records.

The importance of confidentiality was explained to all fieldworkers during training and all other project staff including field supervisors, researchers, QA staff, data managers, and research/administrative staff, information technology support staff and the doctors undertaking the reviews. All project staff were required to sign a confidentiality agreement to handle all project data ethically and confidentially.

Researchers and field workers had access to individual patient records in multiple formats, including individual paper-based or electronic in-patient records, and paper-based or electronic registers which include entries for individual patients and VA interviews. Individual decedent data were de-identified, as described in the Data Collection section, once a USID was allocated. Data provided to the doctors to review were anonymised and identified through a USID number. A master index was created with names and other identifiers and the study ID number only was used for the final analysis data set. The master index file, with restricted access, comprises the identifiers of all the decedents but has no data concerning the cause of death.

Results produced from the project will be in aggregate form and will not be able to be traced back to individual decedents.

3.5.4 Reimbursement

The funeral parlor directors were reimbursed for their time with a voucher of R35.00 (USD2.5 at the time of the study) per NOK recruited. Record clerks in hospitals and forensic mortuaries were compensated for their support with a small edible gift of biscuits, valued at R35.00 (USD2.5 at the time of the survey) per institution. A token of airtime or electricity worth R35.00 (USD2.5 at the time of the survey) was given to the interviewee at the time of the interview.

3.5.5 Potential risks and benefits

This study was reviewed and determined to involve minimal risk to participants. However, since participants were asked questions about the circumstances around the death of a family member which may have caused emotional distress, VA interviewers were provided with skills to understand grieving, not to over-identify with interviewees, and to show sensitivity in questioning and probing. They were given skills to address any potential stress or discomfort that may result from study participation, and to help make participants manage their grief.

In cases where potentially unlawful acts were disclosed during the interviews, or instances of suspected child abuse, project staff were required to report this to the relevant authorities for further investigation, under section 110 of the Children's Amendment Act, No. 41 of 2007. However, where the interviewee expressed the opinion that the death was intentional, either due to self-harm or homicide, the interviewer informed them that, if they suspected that the death was caused by unnatural causes, they are legally required to report it to the police, under the Inquests Act, No. 58 of 1959. Since the interviewer would only have hearsay evidence, they were not required to report this to authorities themselves.

As part of the informed consent procedure, all potential participants were informed that could withdraw from the study at any time with no consequences. Field staff assured interviewees that all responses and information would remain confidential. Field staff were trained to refer participants for counselling support, if necessary. Project staff identified referral networks and social workers linked to clinics in the study areas prior to commencing fieldwork. All participants, irrespective of demonstration of pain, stress or trauma, were informed of available support services in their communities, should they have felt the need for further support.

Benefits included improved quality of cause of death data for health policy makers, as well the strengthening of research and analytic capacity through the methods and staff development for the project, but also via consultation with and technical inputs by expert co-investigators and technical advisors working with the research team.

All adverse events were reported to the Principal Investigator and an action plan implemented and reported to the SAMRC Ethics Committee. Five cases were referred to the principal investigator, of which three were confirming that the study was genuine, one wanted to report that her child's murderer had not yet been charged, and one had gone to the hospital where her child had died to request her medical records. A staff member from the hospital had called to investigate this request. The interviewee had misunderstood the VA question about whether she had any medical records for the decedent. The interviewer reported that the interviewee had been emotional and a little confused during the interview – she called her back to explain and resolve the situation. None of these cases required formal intervention or retraining of study staff.

3.5.6 Data linkage with national CRVS mortality dataset

The SA NCODV data were linked with the CRVS mortality data and involved handling of electronic records that included identifiable information of the decedents. Physical and electronic safety measures were taken to ensure confidentiality of the identity, and protection of private information of all decedents. The matching was done in compliance with the legal requirements of the South African Statistics Act,[25] and according to standard in-house procedures of ensuring confidentiality and protection of the data.

The Act requires that the confidentiality of the identity of the decedent, and the information provided by informants reporting the death, must be protected, and that any results of the analysis of statistical information may not be disseminated in a way which is likely to enable the identification of an individual.[25] The linkage will be conducted within the Head Office premises of Statistics South Africa in Pretoria under supervision of the Director: Births and Deaths. The data, with ID numbers, are stored in the onsite SAS library for mortality and causes of death at Stats SA. Access to this library is restricted to authorised staff members only, including the cause of death processing team, and the Births and Deaths Directorate. Access was only granted onsite at the Head Office to a member of the Birth and Death Directorate who received guidance from an experienced cause of death analyst (CK) and the study statistician (TG).

The final analysis dataset was de-identified in a manner that no re-identification of any decedent was possible.

3.5.7 Ethics review

The project protocol was reviewed by the SAMRC Ethics committee and approved on 27 June 2017 (EC004-2/2017). Amendments were subsequently approved on 28 August 2017 and 26-27 February 2018. Annual renewal of the approval was obtained after submitting a progress report to the committee.

4. Results

4.1 Sample realisation

Based on the National Population Register, there was a total of 36,973 registered deaths of persons who were resident in the 27 selected sub-districts and died during the study period 1 September 2017 – 13 April 2018 (Table 1). As has been reported previously,[3,41] the recruitment of NOK/carers to participate in the study was extremely challenging and it was not possible to obtain a comprehensive list of deaths registered. It became necessary to amend the sampling strategy by extending the study period and, rather than collecting medical and FPS records of decedents identified and recruited in the first phase, it was decided to include all medical records of patients who died in facilities in the sample areas during the study period as well as all the FPS records from facilities serving the sample areas. The numbers of deaths registered on the National Population Register as well as the numbers for which cause of death data were collected from different sources during the study period are shown in Table 1. Some of the numbers differ slightly from numbers previously reported in Table 4 in Report 1 as further data cleaning has been performed. In total, data were collected for 26,514 decedents during all phases of the SA NCODV project. When compared with registered deaths from the NPR, this accounted for 71.7%, with over-representation in Limpopo, Northern Cape, and the Western Cape. Gauteng and Eastern Cape were under-represented when compared with the target sample.

Table 1: Numbers of registered deaths, numbers of deaths for which data were collected during study period, and proportion of deaths with data by province, SA NCODV Project 2017/18.

Province	Registered deaths	Decedents for whom verbal autopsy was completed	Deaths in which medical records were collected	Deaths in which forensic pathology reports were collected	Deaths with at least one data collection source	Ratio of number of deaths with at least one data collection source relative to deaths registered (%)
Eastern Cape	12,778	575	4,550	1,318	6,147	48.1
Free State	3,674	656	1,504	391	2,313	63.0
Gauteng	9,183	463	3,139	809	4,262	46.4
KwaZulu-Natal	2,248	890	1,674	0*	2,214	98.5
Limpopo	610	377	1,090	606	1,918	314.4
Mpumalanga	3,146	610	1,282	721	2,336	74.1
Northern Cape	1,255	506	849	570	1,667	132.8
North West	3,573	1,108	1,870	853	3,449	96.5
Western Cape	506	202	1,667	474	2,208	436.4
Total	**36,973**	**5,387**	**17,625**	**5,742**	**26,514**	**71.7**

* Permission was not granted by the KwaZulu-Natal Department of Health to collect data from their FPS facilities

SA NCODV - South African national cause of death validation project

To reduce study costs, all medical records for deaths that occurred in 2017 were reviewed, but for the deaths 2018, only those for patients who had data from VA or FPS records were prioritised for medical review. In total, data were reviewed for 18,660 decedents. Of these, 13 were stillbirths (11 from MRs and 2 from FPS records), leaving a total of 18,647 decedents with reviewed data for linking with Stats SA data. As can be seen from Table 2, the SA NCODV reviewed sample included cause of death data from 5,374 VAs, 10,128 MRs and 5,320 FPS records.

Table 2: Number of VAs, medical records and FPS records collected and reviewed (N=18,647 excluding stillbirths), SA NCODV Project 2017/18.

Year of death	Number Verbal Autopsies reviewed	Total Medical Records reviewed	Total Forensic Pathology Services records reviewed	Total decedents with COD data
2017	1,668	8,665	3,300	12,860
2018	3,706	1,463	2,020	5,787
Total	**5,374**	**10,128**	**5,320**	**18,647**

SA NCODV - South African national cause of death validation project

The agreement between the independent clinical reviews of the VAs was assessed. for 5,409 pairs (including 35 deceased whose NOKS/carers had mistakenly been interviewed on 2 separate occasions by different interviewers). Aggregating the causes into 14 categories to ensure adequate numbers in each cell, the overall agreement was 69.8% with a kappa statistic of 0.663 (95%CI: 0.654 – 0.672) indicating substantial agreement. Details of the agreement including the average agreement for each of the 14 cause categories are shown in Table A5 in Annexure 8.3.

4.2 Data linkage

4.2.1 Linking target sample with Stats SA data

Out of the 36,973 decedents identified to be in the target sample from the NPR, a total of 34,875 (94.3%) were linked to Stats SA data. Deaths in the youngest age group (0-9 years) and the oldest age group (aged 100+ years), had the highest proportions of unlinked cases (Table 3). In addition, the Eastern Cape and the Western Cape had the highest proportions of unlinked cases. The DHA offices with the highest number of unlinked cases are shown in Table A6 in Annexure 8.4. The linkage was the same for natural and unnatural deaths but was not uniform across all offices: out of the 248 offices serving the study area, there were 13 offices that accounted for 62% of the unlinked cases (Table A6 in Annexure 8.4).

Table 3: The number and percentage of linked and unlinked deaths for the target sample based on DHA death registrations and Stats SA data by selected characteristics, SA NCODV Project 2017/18.

Characteristic	Linked		Unlinked		Total	
	Number	%	Number	%	Number	%
Death year						
2017	19,541	93.8	1,286	6.2	20,827	100.0
2018	15,334	95.0	812	5.0	16,146	100.0
Sex						
Female	16,832	94.4	994	5.6	17,826	100.0
Male	18,044	94.2	1,105	5.8	19,149	100.0
Age category						
0-9 years	1,352	92.9	103	7.1	1,455	100.0
10-19 years	650	93.8	43	6.2	693	100.0
20-29 years	2,438	94.5	143	5.5	2,581	100.0
30-39 years	4,277	94.8	233	5.2	4,510	100.0
40-49 years	4,576	94.1	286	5.9	4,862	100.0
50-59 years	5,546	94.6	316	5.4	5,82	100.0
60-69 years	6,265	94.5	367	5.5	6,632	100.0
70-79 years	5,231	94.0	332	6.0	5,563	100.0

Characteristic	Linked		Unlinked		Total	
	Number	%	Number	%	Number	%
80-89 years	3,411	94.0	219	6.0	,629	100.0
90-99 years	1,061	95.6	49	4.4	1,110	100.0
100+ years	69	89.6	8	10.4	77	100.0
Province						
Eastern Cape	11,310	88.5	1,468	11.5	12,778	100.0
Free State	3,587	97.6	87	2.4	3,674	100.0
Gauteng	8,914	97.1	269	2.9	9,183	100.0
KwaZulu-Natal	2,220	98.8	28	1.2	2,248	100.0
Limpopo	578	94.8	32	5.2	610	100.0
Mpumalanga	3,067	97.5	79	2.5	3,146	100.0
Northern Cape	1,242	99.0	13	1.0	1,255	100.0
North West	3,503	98.0	70	2.0	3,573	100.0
Western Cape	454	89.7	52	10.3	506	100.0
Death type						
Natural	31,068	94.3	1,867	5.7	32,935	100.0
Unnatural	3,807	94.3	231	5.7%	4,038	100.0
Total	**34,875**	**94.3**	**2,098**	**5.7**	**36,973**	**100.0**

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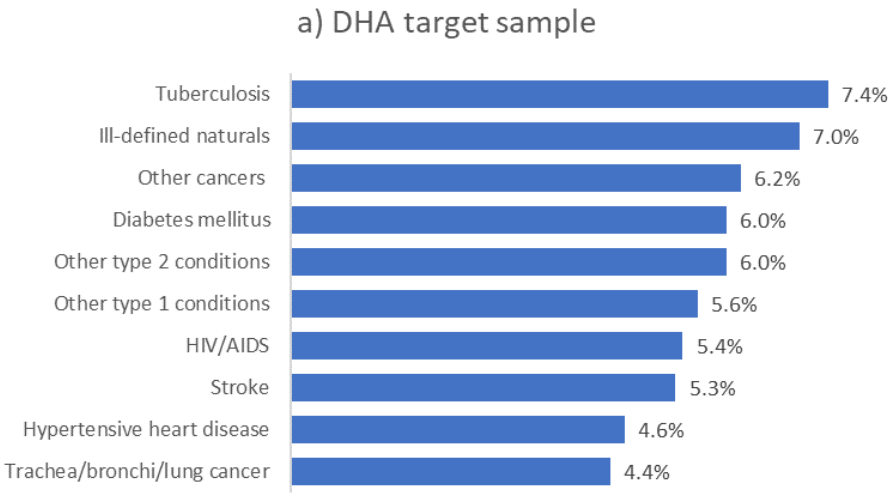
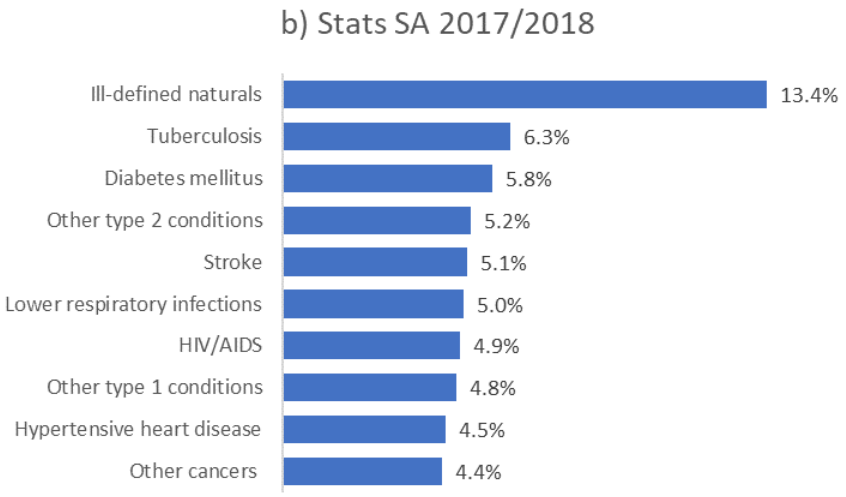
The cause of death profile for the 34,875 deaths in the target population, based on the information from Stats SA after linking, is shown in Table 4 by sex according to the NBD short list. The overall cause of death profile is also presented for persons and is compared with the Stats SA data for 2017/18. The results suggest that the decedents from the target sample that could be linked have a similar cause of death profile with the full data set, with the exception of slightly fewer deaths from ill-defined natural causes and ill-defined cardiovascular conditions. However, more variation can be seen in the ranking of the top 10 causes of death (Figure 4).



Other type 1 conditions combines less common infectious diseases (see Table A1)



Other type 2 conditions combines less common non-communicable conditions (see Table A1)

Figure 4: Top ten causes of death for a) DHA target sample linked to Stats SA data (N=34,875) and b) Stats SA records (N=913,082), Stats SA 2017/18.

Table 4: Cause of death profile for DHA target sample linked to Stats SA (N=34,857) by sex and total Stats SA records (N=913,082), Stats SA 2017/18.

NBD short list of causes	Male *		Female *		Persons *		Stats SA 2017/18
	N	%	N	%	N	%	%
1. Tuberculosis	1,611	9.0	981	5.8	2,592	7.4	6.3
2. HIV/AIDS	874	4.9	1,013	6.0	1,887	5.4	4.9
3. Diarrhoeal diseases	189	1.1	222	1.3	411	1.2	1.5
4. Lower respiratory	806	4.5	722	4.3	1,528	4.4	5.0
5. Maternal	97	0.5	126	0.7	223	0.6	0.4
6. Perinatal conditions	83	0.5	60	0.4	143	0.4	1.8
7. Malnutrition	116	0.6	151	0.9	267	0.8	0.7
8. Other type 1 conditions#	951	5.3	1,004	6.0	1,955	5.6	4.8
9. Oesophagus cancer	137	0.8	131	0.8	268	0.8	0.6
10. Trachea/bronchi/lung cancer	412	2.3	208	1.2	620	1.8	1.3
11. Breast cancer	6	0.0	431	2.6	437	1.3	0.8
12. Cervix cancer	0	0.0	374	2.2	374	1.1	0.9
13. Prostate cancer	354	2.0	0	0.0	354	1.0	0.8
14. Other cancers	1,088	6.0	1,061	6.3	2,149	6.2	4.4
15. Ill-defined cancers	219	1.2	228	1.4	447	1.3	0.9
16. Diabetes mellitus	838	4.7	1,247	7.4	2,085	6.0	5.8
17. Epilepsy	192	1.1	116	0.7	308	0.9	0.8
18. Ischaemic heart disease	685	3.8	506	3.0	1,191	3.4	2.9
19. Stroke	809	4.5	1,047	6.2	1,856	5.3	5.1
20. Inflammatory heart disease	177	1.0	162	1.0	339	1.0	0.7
21. Hypertensive heart disease	576	3.2	1,028	6.1	1,604	4.6	4.5
22. Peripheral vascular disease	66	0.4	82	0.5	148	0.4	0.3
23. Ill-defined cardiovascular	605	3.4	691	4.1	1,296	3.7	4.3
24. Other cardiovascular	137	0.8	214	1.3	351	1.0	0.7
25. Chronic obstructive pulmonary disease	542	3.0	396	2.3	938	2.7	2.4
26. Other chronic respiratory	390	2.2	325	1.9	715	2.1	2.0
27. Peptic ulcer	75	0.4	64	0.4	139	0.4	0.3
28. Cirrhosis of liver	128	0.7	69	0.4	197	0.6	0.5
29. Other digestive	377	2.1	400	2.4	777	2.2	1.8
30. Nephritis/nephrosis	325	1.8	330	2.0	655	1.9	1.9
31. Other genitourinary conditions	61	0.3	49	0.3	110	0.3	0.3
32. Congenital	86	0.5	75	0.4	161	0.5	0.6
33. Other type 2 conditions&	965	5.4	1,119	6.6	2,084	6.0	5.2
34. Ill-defined naturals	1,161	6.5	1,285	7.6	2,446	7.0	13.4
35. Road traffic accidents	254	1.4	112	0.7	366	1.1	1.3
36. Falls	14	0.1	2	0.0	16	0.0	0.0
37. Fires	122	0.7	81	0.5	203	0.6	0.6

NBD short list of causes	Male *		Female *		Persons *		Stats SA 2017/18
	N	%	N	%	N	%	%
38. Drowning	106	0.6	18	0.1	124	0.4	0.3
39. Suffocation and foreign bodies	274	1.5	76	0.5	350	1.0	1.2
40. Other unintentional injuries specified	602	3.3	180	1.1	782	2.2	2.2
41. Ill-defined other unintentional	972	5.4	337	2.0	1,309	3.8	3.8
42. Undetermined intent	81	0.5	58	0.3	139	0.4	0.4
43. Suicide	23	0.1	7	0.0	30	0.1	0.1
44. Homicide	411	2.3	72	0.4	483	1.4	1.7
Total	**17,997**	**100.0**	**16,860**	**100.0**	**34,857**	**100.0**	**100.0**

* Excludes the 18 unknown sex in linked Stats SA records

Other type 1 conditions combines less common infectious diseases (Table A1)

& Other type 2 conditions combines less common non-communicable conditions (Table A1)

4.2.2 Linking SA NCODV realized sample with Stats SA data

The linking was effected in two steps - namely, a deterministic link of the SA NCODV cases with SA ID numbers followed by a probabilistic link of the remaining cases. A relatively high proportion of the Stats SA data for 2016-2018 had a SA ID number. There was a total of 1,425,284 death records of which 40,311 were stillbirths. Out of the remaining death records, 1,290,130 (93.2%) had a unique SA ID number. Of the 18,649 reviewed SA NCODV records, 15,722 (84.3%) had a valid ID number with which this linking was possible.

Of the 15,722 SA NCODV records with ID numbers, 14,718 deaths (93.6%) were linked with Stats SA data based on the SA ID number. As part of the confirmation of the linkage, an assessment of the characteristics of the linked information was done. This identified 98 deaths with discrepant information between SA NCODV and Stats SA on sex. Nine deaths had discrepant information on date of birth. The majority were minor differences that would not affect any statistical analysis. However, two of the cases had very different year of birth, resulting in a large age discrepancy. A list of 98 cases has been shared with Stats SA for review, but it should be noted that the sex information from the SA NCODV study is consistent with the sex implied by the ID number and the sex recorded on the NPR.

A probabilistic linking was conducted on the remaining 3,927 unlinked deaths which did not have a valid ID number. An additional 649 SA NCODV records were linked with Stats SA data using the following variables: surname, day of birth, month of birth, day of death, month of death and the province.

In total, it was possible to link 15,367 (82.4%) of the SA NCODV decedents with Stats SA data. The source of SA NCODV data for the linked cases is shown in Table 5. The majority of cases had information from a single source (87.0%) while a total of 13.0% had information from multiple sources, mainly VA and medical record (10.8%). Medical records were the most common source of information, 42.4% drawing on medical record information alone and a further 11.3% in combination with at least one other source with a total of 53.7%. VAs were available for 31.2% of the linked information and FPS for 28.0%.

Table 5: Number of linked decedents according to source of information (N=15,367), SA NCODV Project 2017/18.

Source of information	Frequency	Percentage
VA records only	2,874	18.7
Medical records only	6,520	42.4
FPS records only	3,975	25.9
VA and medical records	1,661	10.8
VA and FPS records	252	1.6
Medical and FPS records	66	0.4
VA, Medical and FPS records	19	0.1
Total	**15,367**	**100.0**

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4.3 Characteristics of sample

The sex, age, and provincial profiles of the SA NCODV data sets were contrasted with those of the Stats SA cause of death data for 2017 and 2018 combined in Table 6 (excluding those classified as stillbirths or coded to P95). While the SA NCODV data set has national coverage, it is not a statistically representative sample of the registered deaths reported by Stats SA. The SA NCODV linked and unlinked data sets have higher proportions of male decedents than the DHA target sample or the Stats SA data. This is likely due to the over sampling of FPS records. There are considerable differences in the age distributions of the data sets. The DHA target sample and the SA NCODV data sets have a much lower proportion of child deaths than the Stats SA data. The SA NCODV data sets have higher proportions of young adults than either the DHA target sample or the Stats SA data, again likely due to the over sampling of FPS records. Stats SA has a higher proportion of older decedents than DHA target sample and the SA NCODV data sets.

The overall cause of death profile is shown for the SA NCODV sample, regardless of source, by sex and age in Table 7. There is a strong gender pattern resulting from some sex specific causes of death such as maternal deaths and cervical cancer among females and prostate cancer among males. In addition, males experience higher proportions of TB and injury deaths when compared with females and females experience higher proportions of HIV/AIDS, diarrheal disease, breast and other cancers, diabetes, stroke, and hypertensive heart disease. There is also a distinct age pattern. The majority of deaths among neonates are due to causes originating in the peri-natal period, followed by ill-defined natural causes and congenital conditions. Road traffic accidents are the leading cause among children 29 days – 14 years, followed by ill-defined natural causes and a range of infectious diseases (HIV/AIDS, diarrheal diseases, lower respiratory infections, other type 1 conditions). HIV/AIDS accounts for a third of the deaths of adults aged 15-44 years, followed by sizable proportions of homicide, road traffic accidents and suicide. HIV/AIDS accounts for 28.1% of the deaths of adults aged 45-59 years. Relative to the younger age group, the proportion of deaths due to injuries decline while those due to cancers, diabetes and cardiovascular conditions increase. This pattern continues into the oldest age group, age 60+ years together with an increase in the proportion of deaths due to ill-defined natural causes. Stroke and hypertensive heart disease become the leading causes of death and the proportion of deaths due to HIV/AIDS drops to 7.2% for this age group.

Table 6: Basic socio-demographic characteristics of DHA target sample (N=36,973), SA NCODV unlinked sample (N=3,289), SA NCODV linked sample (N=15,367), SA NCODV linked sample excluding ill-defined (N=14,396) and Stats SA data (N=913,082) for 2017/2018.

	DHA (N=36,975)		SA NCODV (unlinked) (N=3,289)		SA NCODV (linked) (N=15,367)		SA NCODV (linked excluding ill-defined) (N=14,396)		Stats SA^ (N=913,082)	
Sex										
Female	17,824	48.2%	1,236	37.6%	6,472	42.1%	6,018	41.8%	429,744	47.1%
Male	19,149	51.8%	2,042	62.1%	8,895	57.9%	8,378	58.2%	481,083	52.7%
Unknown	-	-	11	0.3%	-	-	-	-	2,255	0.3%
Age group										
0 to 28 days	196	0.5%	388	11.8%	63	0.4%	54	0.4%	19,885	2.2%
29 days to 14 years	1,492	4.0%	258	7.8%	663	4.3%	595	4.1%	44,631	4.9%
15 to 44 years	9,941	26.9%	1,316	40.0%	5,784	37.6%	5,585	38.8%	248,310	27.2%
45 to 59 years	8,334	22.5%	535	16.3%	3,583	23.3%	3,382	23.5%	186,546	20.4%
60 years and older	17,012	46.0%	792	24.1%	5,274	34.3%	4,780	33.2%	410,637	45.0%
Missing ages	-	-	-	-	-	-	-	-	3,073	0.3%
Province										
Eastern Cape	12,778	34.6%	843	25.6%	3,040	19.8%	2,905	20.2%	135,348	14.8%
Free State	3,674	9.9%	198	6.0%	1,502	9.8%	1,349	9.4%	60,475	6.6%
Gauteng	9,183	24.8%	664	20.2%	2,127	13.8%	2,068	14.4%	184,930	20.3%
KwaZulu-Natal	2,248	6.1%	244	7.4%	1,370	8.9%	1,248	8.7%	166,363	18.2%
Limpopo	610	1.7%	325	9.9%	1,114	7.3%	1,049	7.3%	86,353	9.5%
Mpumalanga	3,146	8.5%	262	8.0%	1,535	10.0%	1,434	10.0%	59,701	6.5%
Northern Cape	1,255	3.4%	150	4.6%	1,167	7.6%	1,042	7.2%	26,976	3.0%
North West	3,573	9.7%	368	11.2%	2,313	15.1%	2,148	14.9%	64,365	7.1%
Western Cape	506	1.4%	233	7.1%	1,199	7.8%	1,153	8.0%	94,882	10.4%
Missing	-	-	2	0.1%	-	-	-	-	33,689	3.7%
Health facility*										
In facility	17,399	47.1%	-	-	8,301	54.0%	8,061	56.0%	401,706	44.0%
Out of facility	9,587	25.9%	-	-	3,151	20.5%	2,676	18.6%	278,569	30.5%
Unknown	7,888	21.3%	-	-	3,915	25.5%	3,659	25.4%	232,807	25.5%
Unlinked	2,101	5.7%	3,289	100.0%	-	-	-	-	-	-
Total	**36,975**	**100.0%**	**3,289**	**100.0%**	**15,367**	**100.0%**	**14,396**	**100.0%**	**913,082**	**100.0%**

^ Excludes stillbirths and deaths coded to P95

*Based on information from Stats SA data

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Table 7: Cause specific mortality fractions by sex and age group using shortened NBD list (N=15,367), SA NCODV Project 2017/18.

NBD short list of causes	Total N=15,367	Sex		Age group				
		Female N=6, 472	Male N=8,895	Neonates N=63	29 days-14 yrs N=663	15-44 yrs N=5,784	45-59 yrs N=3,583	60+ yrs N=5,274
1. Tuberculosis	4.4%	3.4%	5.2%	0.0%	2.1%	3.3%	6.1%	4.9%
2. HIV/AIDS	21.8%	25.1%	19.4%	0.0%	6.0%	33.0%	28.1%	7.2%
3. Diarrhoeal diseases	1.1%	1.6%	0.7%	3.2%	5.3%	0.2%	0.6%	1.9%
4. Lower respiratory infections	2.5%	2.9%	2.3%	1.6%	7.8%	0.6%	1.8%	4.5%
5. Maternal	0.4%	0.9%	0.0%	0.0%	0.0%	1.1%	0.0%	0.0%
6. Perinatal conditions	0.4%	0.5%	0.4%	68.3%	2.6%	0.0%	0.0%	0.0%
7. Malnutrition	0.3%	0.4%	0.2%	0.0%	3.3%	0.1%	0.2%	0.2%
8. Other type 1 conditions#	1.1%	1.2%	1.0%	1.6%	5.4%	0.7%	1.0%	1.0%
9. Oesophagus cancer	0.7%	0.7%	0.7%	0.0%	0.0%	0.1%	0.8%	1.3%
10. Trachea/bronchi/lung cancer	1.1%	0.8%	1.3%	0.0%	0.0%	0.2%	1.4%	2.1%
11. Breast cancer	0.6%	1.5%	0.0%	0.0%	0.0%	0.3%	1.2%	0.7%
12. Cervix cancer	0.6%	1.4%	0.0%	0.0%	0.0%	0.2%	1.0%	0.9%
13. Prostate cancer	0.7%	0.0%	1.2%	0.0%	0.0%	0.0%	0.2%	1.8%
14. Other cancers	3.4%	4.0%	2.9%	1.6%	1.1%	1.3%	4.0%	5.6%
15. Ill-defined cancers	1.1%	1.4%	0.9%	0.0%	0.3%	0.3%	1.5%	1.8%
16. Diabetes mellitus	3.4%	4.7%	2.5%	1.6%	0.2%	0.7%	3.6%	6.8%
17. Epilepsy	0.6%	0.5%	0.6%	0.0%	0.9%	0.6%	0.8%	0.5%
18. Ischaemic heart disease	2.1%	2.2%	2.0%	0.0%	0.0%	0.7%	2.4%	3.6%
19. Stroke	5.6%	7.6%	4.2%	0.0%	0.0%	1.1%	5.4%	11.5%
20. Inflammatory heart disease	0.4%	0.4%	0.4%	0.0%	0.6%	0.4%	0.4%	0.3%
21. Hypertensive heart disease	4.0%	5.9%	2.6%	0.0%	0.0%	0.7%	3.7%	8.5%
22. Peripheral vascular disorders	0.6%	0.8%	0.5%	0.0%	0.0%	0.1%	0.5%	1.3%
23. Ill-defined cardiovascular	0.8%	0.9%	0.7%	0.0%	0.2%	0.3%	1.0%	1.2%
24. Other cardiovascular	0.4%	0.5%	0.3%	0.0%	0.2%	0.3%	0.4%	0.6%
25. Chronic obstructive pulmonary disease	2.0%	1.8%	2.0%	0.0%	0.0%	0.2%	2.0%	4.2%
26. Other chronic respiratory	0.8%	1.0%	0.6%	0.0%	0.5%	0.3%	1.0%	1.2%
27. Peptic ulcer	0.6%	0.8%	0.5%	0.0%	0.0%	0.3%	0.5%	1.2%
28. Cirrhosis of liver	0.6%	0.6%	0.7%	0.0%	0.2%	0.3%	1.0%	0.8%
29. Other digestive	1.4%	1.7%	1.3%	0.0%	1.1%	1.0%	1.5%	2.0%

NBD short list of causes	Total N=15,367	Sex		Age group				
		Female N=6, 472	Male N=8,895	Neonates N=63	29 days-14 yrs N=663	15-44 yrs N=5,784	45-59 yrs N=3,583	60+ yrs N=5,274
30. Nephritis/nephrosis	0.4%	0.4%	0.4%	0.0%	0.3%	0.3%	0.6%	0.4%
31. Other genitourinary	0.4%	0.4%	0.4%	0.0%	0.2%	0.2%	0.3%	0.8%
32. Congenital	0.3%	0.3%	0.2%	6.4%	4.7%	0.1%	0.0%	0.0%
33. Other type 2 conditions[&]	2.0%	2.5%	1.6%	3.2%	4.2%	1.2%	1.3%	3.0%
34. Ill-defined natural	6.2%	6.9%	5.7%	11.1%	8.5%	3.4%	5.6%	9.4%
35. Road traffic accidents	8.5%	4.8%	11.1%	0.0%	15.1%	14.0%	7.4%	2.3%
36. Falls	0.7%	0.8%	0.7%	0.0%	1.7%	0.4%	0.4%	1.3%
37. Fires	0.7%	0.6%	0.8%	0.0%	2.3%	1.0%	0.5%	0.4%
38. Drowning	0.7%	0.2%	1.0%	0.0%	6.6%	0.7%	0.3%	0.1%
39. Suffocation and foreign bodies	0.2%	0.1%	0.2%	0.0%	1.1%	0.1%	0.1%	0.1%
40. Other unintentional injuries specified	1.7%	1.4%	1.9%	0.0%	6.2%	1.7%	1.6%	1.1%
41. Ill-defined other unintentional	0.3%	0.3%	0.3%	0.0%	0.8%	0.2%	0.3%	0.2%
42. Undetermined whether intentional or unintentional	1.6%	1.1%	1.9%	1.6%	3.5%	2.4%	1.4%	0.6%
43. Suicide	4.1%	2.0%	5.5%	0.0%	3.3%	7.6%	2.8%	1.2%
44. Homicide	9.0%	3.2%	13.1%	0.0%	4.2%	18.5%	5.4%	1.7%
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

[#] Other type 1 conditions combines less common infectious diseases (Table A1)

[&] Other type 2 conditions combines less common non-communicable conditions (Table A1)

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4.4 Agreement between SA NCODV linked sample and Stats SA data

The agreement between the cause of death identified on the SA NCODV data and the linked Stats SA data is summarised in Table 8 for different subsets of the sample, indicating the number of conditions included in the comparison. The Cohen Kappa and Spearman rank correlation statistics are also shown in Table 8. When the whole SA NCODV linked sample is considered with the causes aggregated to 19 chapters, the agreement reaches 64.9% and the kappa indicates moderate agreement (0.579). When the decedents considered by the physician reviewer to have quality information to determine UCOD, the agreement increased to 69.0% with a kappa of 0.621. However, when a more detailed list is considered, albeit the NBD short list of 44 conditions, the agreement goes down to 36.9% and the kappa indicates minimal agreement (0.342). From Table 8, the agreement between SA NCODV data and Stats SA data was strongest for the FPS records, followed by medical records and then VA. The agreement for the in-facility deaths was the same as the overall agreement, with those specified as out of facility deaths being worse and the unknown being very slightly better.

Table 8: Agreement between SA NCODV data and Stats SA cause of death information, SA NCODV Project 2017/18.

Subgroup	N	Aggregation (number of conditions)	Agreement	Cohen Kappa Statistic	Rank correlation coefficient
Total SA NCODV sample	15,367	ICD chapter (19)	64.9%	0.579 (0.574 - 0.593)	0.918 (0.743 – 1.093)
Total SA NCODV sample (excl ill-defined natural deaths)	14,396	ICD chapter (19)	67.4%	0.603 (0.598 - 0.610)	0.890 (0.675 - 1.104)
Quality SA NCODV sample (excl ill-defined natural deaths)	11,594	ICD chapter (19)	69.0%	0.621 (0.618 - 0.625)	0.772 (0.435 – 1.108)
Total SA NCODV sample	15,367	NBD full list (124)	35.6%	0.331 (0.327 - 0.340)	0.813 (0.722 – 0.905)
Total SA NCODV sample	15,367	NBD short list (44)	36.9%	0.342 (0.339 - 0.349)	0.573 (0.301 – 0.844)
Total SA NCODV sample (excl ill-defined natural deaths)	14,396	NBD short list (44)	37.6%	0.350 (0.346 - 0.356)	0.548 (0.251 - 0.846)
Quality SA NCODV sample (excl ill-defined natural deaths)	11,594	NBD short list (44)	38.4%	0.357 (0.354 – 0.363)	0.475 (0.173 – 0.777)
FPS (excl ill-defined natural deaths)	4,134	NBD short list (44)	42.2%	0.363 (0.356 - 0.368)	0.870 (0.871 - 0.959)
Medical record (excl ill-defined natural deaths)	7,986	NBD short list (44)	38.9%	0.347 (0.340 - 0.354)	0.777 (0.628 - 0.926)
VA (excl ill-defined natural deaths)	4,178	NBD short list (44)	30.8%	0.275 (0.268 - 0.280)	0.608 (0.373 - 0.843)
In-facility deaths (excl ill-defined natural deaths)	8,060	NBD short list (44)	36.3%	0.329 (0.323 - 0.334)	0.684 (0.476 - 0.891)
Out of facility deaths (excl ill-defined natural deaths)	2,677	NBD short list (44)	33.6%	0.315 (0.309 – 0.323)	0.604 (0.330 - 0.879)
Unknown whether in or out of facility (excl ill-defined natural deaths)	3,659	NBD short list (44)	38.1%	0.353 (0.342 – 0.365)	0.656 (0.423 - 0.890)

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The agreement, at ICD-10-chapter level, is shown in Table 9. The external cause chapter stands out with both a very high PPV (97.3%) and high sensitivity (90.2%). The neoplasms chapter has reasonable agreement with sensitivity of 72.2% and PPV of 76.0%. This is followed by the perinatal chapter with sensitivity of 69.4% and PPV of 82.7%. The sensitivity for the infectious disease and circulatory chapters is lower at 61.2% (PPV 84.7%) and 59.6% (PPV 62.5%) respectively.

The agreement at the level of shortened NBD list is shown in Table 10. Amongst injuries, drowning had a very high sensitivity (92.2%) and high PPV (82.6%) and fires had a high sensitivity (83.0%) but a low PPV (48.4%). Breast cancer has a sensitivity of 78.4% and PPV of 85.4%, suggesting better agreement than for the other specified cancers. HIV/AIDS has a very low sensitivity (25.6%) but a high PPV (90.5%). For other common NCDs, the sensitivity is lower, with stroke having the highest sensitivity (53.2%) and PPV (68.4%); followed by diabetes mellitus (sensitivity of 52.7%; PPV of 40.3%); and ischemic heart disease had low sensitivity (36.4%) and PPV (48.3%).

The agreement at short NBD list level for FPS, MR, and VA linked deaths, are shown in Table A7 - Table A9 in Annexure 8.5 respectively. In the FPS table (Table A7) the highest sensitivities are for fires and drowning, in the MR table (Table A8) the highest sensitivity is for cancers with the VA table (Table A9) showing the highest sensitivities for drowning and fires followed by cancers.

The agreement at short NBD list level for deaths identified as in facility, out of facility and unknown facility are shown in Table A10 - Table A12 in Annexure 8.5. These show similar patterns with highest sensitivities for fires and drownings followed by cancers.

Table 9: Misclassification pattern for all linked deaths (excluding ill-defined natural deaths) using ICD-10 chapters (N=14,396), SA NCODV Project 2017/18.

StatsSA (ICD-10 Chapter)	NCODV (ICD-10 Chapter)																					Grand Total	PPV	Lower 95% CI	Upper 95% CI
	1.Infectious and parasitic diseases	2.Neoplasms	3.Blood and Immune Disorders	4.Endocrine, nutritional and metabolic	5.Mental and behavioural	6.Nervous system	7.Eye	8. Ear and mastoid	9.Circulatory	10.Respiratory	11.Digestive	12.Skin and subcutaneous	13.Musculoskeletal and connective	14.Genitourinary	15.Pregnancy, childbirth and puerperium	16.Perinatal conditions	17.Congenital	20.External causes							
1.Infectious and parasitic diseases	2,633	69	4	58	7	18	-	1	108	86	44	10	5	14	4	5	2	42				3,110	84.7	83.3	85.9
2.Neoplasms	166	907	-	17	5	2	-	-	33	19	24	1	2	7	2	-	1	7				1,193	76.0	73.5	78.4
3.Blood and Immune Disorders	326	10	6	3	2	3	-	-	20	12	8	1	-	3	2	-	-	10				406	1.5	0.5	3.5
4.Endocrine, nutritional and metabolic	113	20	2	305	11	11	-	-	260	67	28	4	2	14	-	1	4	24				866	35.2	32.0	38.5
5.Mental and behavioural	6	-	-	-	14	4	-	-	14	3	3	2	-	1	-	-	-	5				52	26.9	15.6	42.0
6.Nervous system	81	12	-	6	6	87	-	1	25	7	3	1	-	2	-	3	3	23				260	33.5	27.8	39.6
7.Eye	2	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	1				5	-	-	-
8. Ear and mastoid	1	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-				5	40.0	5.3	100.0
9.Circulatory	247	62	6	76	25	35	-	1	1,271	123	52	6	7	28	5	1	3	86				2,034	62.5	60.3	64.6
10.Respiratory	307	41	4	27	14	17	-	-	146	396	31	2	3	8	2	2	3	31				1,034	38.3	35.3	41.3
11.Digestive	106	56	2	12	5	1	-	-	21	5	164	4	-	2	3	-	-	18				399	41.1	36.2	46.1
12.Skin and subcutanenous	7	2	-	9	3	1	-	-	4	4	2	9	1	-	-	-	-	6				48	18.8	8.9	34.2
13.Musculoskeletal and connective	8	2	-	4	-	1	-	-	5	3	1	1	7	1	-	-	-	1				34	20.6	8.7	40.4
14.Genitourinary	100	18	-	23	6	2	-	-	78	27	11	-	-	38	2	-	-	6				311	12.2	8.8	16.5
15.Preganancy, childbirth and puerperium	-	-	-	-	-	-	-	-	1	-	2	-	1	-	25	-	-	2				31	80.6	62.5	92.9
16.Perinatal conditions	5	1	-	1	-	-	-	-	-	-	-	-	-	-	-	43	-	-				52	82.7	69.7	91.9
17.Congenital	4	-	-	1	-	-	-	-	2	-	2	-	-	-	-	-	22	-				31	71.0	52.0	86.3
18.Signs and symptoms	174	50	-	27	11	12	-	-	126	38	28	4	2	7	9	6	3	148				645	-	-	-
20.External causes	18	6	1	13	4	2	-	-	17	13	13	3	2	2	7	1	1	3,779				3,882	97.3	96.8	97.8
Grand Total	4,304	1,256	25	583	113	196	-	5	2,132	804	416	49	32	127	61	62	42	4,189				14,396			
Sensitivity	61.2	72.2	24.0	52.3	12.4	44.4	-	40.0	59.6	49.3	39.4	18.4	21.9	29.9	41.0	69.4	52.4	90.2	Agreement = 67.4%						
Lower 95% CI	59.7	69.6	9.4	48.2	6.9	37.3	-	5.3	57.5	45.7	34.7	8.8	9.3	22.1	28.6	56.3	36.4	89.3	Kappa = 0.603 (0.595 - 0.610)						
Upper 95% CI	62.6	74.7	48.7	56.4	20.5	51.7	-	100.0	61.7	52.8	44.3	33.5	42.6	38.9	54.8	80.7	68.0	91.1	Spearman=0.890 (0.675 - 1.104)						

Table 10: Misclassification pattern based on all linked deaths (excluding ill-defined natural deaths) using the shortened SA NBD list (N=14,396), SA NCODV Project 2017/18.

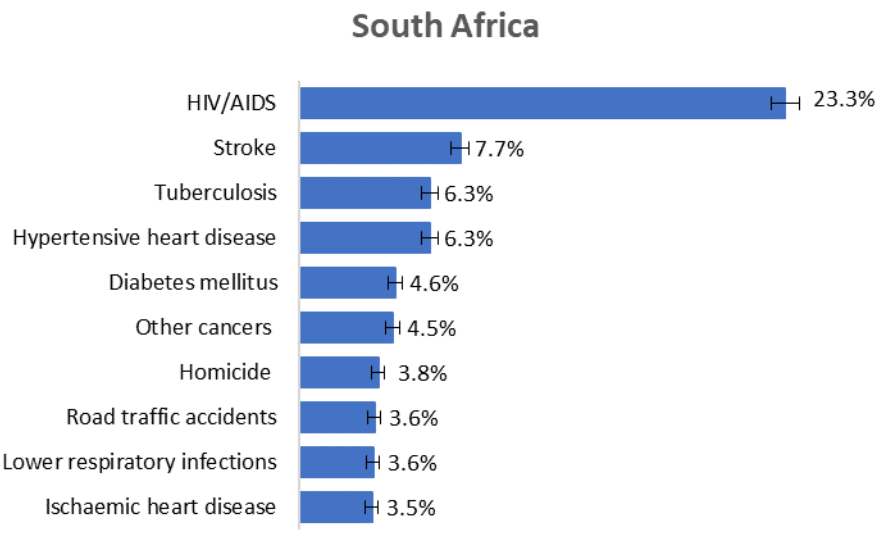
	NCODV (NBD Short list)																				
StatsSA (NBD Short list)	1.Tuberculosis	2.HIV/AIDS	3.Diarrhoeal diseases	4.Lower respiratory infections	5.Maternal	6.Perinatal conditions	7.Malnutrition	8.Other type 1 conditions	9.Oesophagus cancer	10.Trachea/bronchi/lung cancer	11.Breast cancer	12.Cervix cancer	13.Prostate cancer	14.Other cancers	15.Ill-defined cancers	16.Diabetes mellitus	17.Epilepsy	18.Ischaemic heart disease	19.Stroke	20.Inflammatory heart disease	21.Hypertensive heart disease
1.Tuberculosis	323	661	2	29	2	-	-	4	-	5	1	-	2	7	7	9	5	3	10	1	10
2.HIV/AIDS	19	860	1	3	-	-	1	1	1	1	-	1	1	7	5	7	-	1	17	-	4
3.Diarrhoeal diseases	7	60	50	2	-	1	4	7	1	-	-	-	-	2	-	8	1	3	5	-	4
4.Lower respiratory infections	44	144	13	121	1	1	2	5	2	3	-	-	1	5	9	16	5	7	24	1	19
5.Maternal	23	46	-	-	26	-	-	-	-	1	-	-	-	-	1	1	-	-	-	-	-
6.Perinatal conditions	-	-	2	-	-	43	-	3	-	-	-	-	-	1	-	1	-	-	-	-	-
7.Malnutrition	5	25	6	13	1	-	15	5	-	-	-	-	1	3	1	1	-	2	1	-	3
8.Other type 1 conditions	27	580	7	16	1	4	4	55	1	3	1	-	2	21	5	22	4	7	18	-	8
9.Oesophagus cancer	2	4	-	1	-	-	-	-	77	1	-	-	-	9	3	1	-	-	-	-	-
10.Trachea/bronchi/lung cancer	2	7	-	3	-	-	-	1	2	123	2	-	-	6	12	-	-	1	-	-	1
11.Breast cancer	-	1	1	-	-	-	-	-	-	-	76	-	-	2	3	1	-	-	-	-	1
12.Cervix cancer	-	57	-	-	1	-	1	-	-	-	1	64	-	12	4	2	-	-	2	-	4
13.Prostate cancer	3	2	-	-	-	-	-	1	-	1	-	-	68	6	5	3	-	-	3	-	2
14.Other cancers	5	37	2	2	1	-	1	2	3	6	-	12	2	291	33	8	-	2	4	1	3
15.Ill-defined cancers	1	16	-	-	-	-	-	1	1	9	4	1	3	34	29	-	-	-	3	-	-
16.Diabetes mellitus	18	33	13	35	-	-	1	2	-	1	-	-	1	8	4	277	1	28	97	2	80
17.Epilepsy	6	10	1	2	-	1	-	3	-	-	-	-	-	-	1	1	42	-	6	-	-
18.Ischaemic heart disease	6	8	-	3	-	-	-	1	-	-	2	1	1	2	2	7	-	115	10	3	20
19.Stroke	13	35	5	4	1	-	1	7	-	4	-	1	3	5	-	20	8	7	460	-	33
20.Inflammatory heart disease	2	19	-	4	1	-	-	-	-	-	-	-	1	2	-	-	-	4	4	21	23
21.Hypertensive heart disease	14	35	14	39	-	-	1	7	1	4	1	1	4	6	6	18	5	31	66	-	142
22.Peripheral vascular disorders	2	6	-	1	-	-	-	-	-	-	-	-	-	-	-	4	-	2	3	1	1
23.Ill defined cardiovascular	17	40	4	13	2	-	1	2	1	-	1	1	1	8	-	13	3	20	18	11	87
24.Other cardiovascular	5	10	1	1	1	1	1	-	-	1	1	-	-	-	-	6	1	4	6	3	9
25.Chronic obstructuve pulmonary disease	29	23	1	18	1	-	-	2	4	4	-	-	1	5	2	2	1	6	13	2	26
26.Other chronic respiratory	13	26	3	12	-	1	1	4	-	-	1	-	-	2	1	5	3	6	7	2	10
27.Peptic ulcer	1	3	-	1	1	-	-	-	-	-	-	-	-	4	1	1	-	1	1	-	2
28.Cirrhosis of liver	-	11	-	1	-	-	-	4	-	-	-	-	1	3	6	2	1	1	1	3	-
29.Other digestive	9	63	6	2	2	-	1	8	3	-	1	1	2	26	7	9	-	4	2	1	3
30.Nephritis/nephrosis	3	63	10	17	2	-	1	7	1	-	-	2	5	6	3	20	1	3	13	-	45
31.Other genito-urinary	3	13	-	3	-	-	-	-	-	-	-	-	-	1	-	2	-	1	3	-	5
32.Congenital	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1
33.Other type 2 conditions	26	334	10	21	1	3	3	19	2	-	-	1	1	10	9	26	2	15	39	-	27
34. Ill-defined natural	47	106	12	14	9	6	2	11	4	4	5	3	5	20	9	22	9	37	22	3	42
35.Road traffic accidents	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
36.Falls	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37.Fires	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	1	-	-	-	-	-
38.Drowning	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39.Suffocation and foreign bodies	1	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
40.Other unintentional injuries specified	3	4	-	6	5	1	2	1	-	-	-	-	-	2	-	8	-	1	-	-	-
41.Ill-defined other unintent	1	3	1	1	2	-	-	1	-	1	-	-	-	-	-	-	-	4	3	-	3
42.Undetermined intent	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-
43.Suicide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44.Homicide	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Grand Total	680	3,350	168	390	61	62	44	164	105	172	97	89	106	518	168	526	92	316	864	56	618
Sensitivity	47.5	25.7	29.8	31.0	42.6	69.4	34.1	33.5	73.3	71.5	78.4	71.9	64.2	56.2	17.3	52.7	45.7	36.4	53.2	37.5	23.0
Lower 95% CI	43.7	24.2	23.0	26.5	30.0	56.3	20.5	26.4	63.8	64.1	68.8	61.4	54.3	51.8	11.9	48.3	35.2	31.1	49.8	24.9	19.7
Upper 95% CI	51.3	27.2	37.3	35.9	55.9	80.4	49.9	41.3	81.5	78.1	86.1	80.9	73.2	60.5	23.8	57.0	56.4	42.0	56.6	51.5	26.5

22.Peripheral vascular disorders	23.Ill defined cardiovascular	24.Other cardiovascular	25.Chronic obstructive pulmonary diseas	26.Other chronic respiratory	27.Peptic ulcer	28.Cirrhosis of liver	29.Other digestive	30.Nephritis/nephrosis	31.Other genito-urinary	32.Congenital	33.Other type 2 conditions	35.Road traffic accidents	36.Falls	37.Fires	38.Drowning	39.Suffocation and foreign bodies	40.Other unintentional injuries specified	41.Ill-defined other unintent	42.Undetermined intent	43.Suicide	44.Homicide	Grand Total	PPV	Lower 95% CI	Upper 95% CI
4	4	-	19	11	4	1	6	2	2	-	8	4	4	1	-	-	1	1	-	3	4	1,160	27.8	25.3	30.5
1	1	1	-	-	1	-	4	1	3	-	2	1	1	-	-	-	1	-	1	1	1	950	90.5	88.5	92.3
-	1	-	-	1	3	1	3	2	1	-	7	-	-	-	-	-	1	-	-	1	1	177	28.2	21.7	35.5
3	7	2	22	12	6	8	2	1	3	3	13	2	1	-	-	1	5	-	-	3	5	522	23.2	19.6	27.0
1	-	-	1	-	1	-	1	-	-	-	1	-	-	-	-	-	1	-	1	-	-	105	24.8	16.9	34.1
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	86.0	73.3	94.2
1	2	1	1	1	2	-	1	2	1	2	6	-	1	1	-	-	2	-	-	-	1	107	14.0	8.1	22.1
10	1	3	5	2	3	6	13	1	2	2	19	2	2	-	-	-	10	1	-	-	2	870	6.3	4.8	8.1
-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	77.0	67.5	84.8
-	1	-	6	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-	170	72.4	65.0	78.9
-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	89	85.4	76.3	92.0
-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	151	42.4	34.4	50.7
-	-	-	2	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	-	-	99	68.7	58.6	77.6
1	-	-	1	1	4	4	7	1	2	-	5	-	1	-	-	-	3	1	-	-	-	446	65.2	60.6	69.7
-	1	-	2	-	-	1	3	-	2	1	2	-	-	-	-	-	-	-	-	-	-	114	25.4	17.7	34.4
2	4	1	8	3	10	3	8	1	10	-	19	2	5	2	-	-	5	-	-	-	-	684	40.5	36.8	44.3
-	-	-	-	-	-	1	-	1	-	1	6	2	2	-	-	-	3	1	3	-	2	95	44.2	34.0	54.8
6	10	2	8	3	3	2	5	1	1	-	6	1	2	-	-	-	5	-	1	-	1	238	48.3	41.8	54.9
3	5	-	2	3	-	-	2	2	3	-	13	4	6	1	-	-	4	2	5	4	7	673	68.4	64.7	71.9
2	8	4	3	2	1	2	1	-	1	-	6	1	1	-	-	-	1	-	1	1	-	116	18.1	11.6	26.3
9	11	5	7	7	6	2	6	7	4	-	19	-	7	-	-	-	1	2	2	1	1	492	28.9	24.9	33.1
31	1	-	1	-	1	-	2	1	-	-	2	-	-	-	-	-	3	-	-	-	-	62	50.0	37.0	63.0
3	30	9	6	2	2	3	4	6	1	3	9	1	2	1	-	1	5	-	1	2	2	336	8.9	6.1	12.5
3	1	19	4	2	1	-	4	-	1	-	3	1	1	1	-	-	2	-	1	-	1	96	19.8	12.4	29.2
2	5	-	149	14	4	7	2	2	1	-	8	-	1	-	-	-	1	-	1	-	-	337	44.2	38.8	49.7
-	2	-	20	37	-	1	3	-	1	-	6	2	-	-	-	-	3	-	1	1	2	176	21.0	15.3	27.8
-	-	1	-	-	15	1	5	-	-	-	4	-	-	-	-	-	1	-	-	1	-	44	34.1	20.5	49.9
-	-	-	-	-	1	29	7	-	-	-	1	-	-	-	-	-	1	-	1	-	-	74	39.2	28.0	51.2
-	1	-	1	-	12	8	88	1	1	-	4	-	1	-	-	-	7	1	3	-	2	280	31.4	26.0	37.2
1	4	1	6	1	-	5	3	15	8	-	5	-	1	-	-	-	1	1	1	1	-	256	5.9	3.3	9.5
1	-	1	-	-	-	-	3	5	9	-	1	-	-	-	-	-	1	-	-	-	-	52	17.3	8.2	30.3
-	-	-	-	-	-	-	2	-	-	22	-	-	-	-	-	-	-	-	-	-	-	31	71.0	52.0	85.8
7	1	3	8	5	3	5	10	3	2	4	80	7	6	2	-	-	10	2	4	1	5	717	11.2	8.9	13.7
4	13	5	13	10	10	7	11	6	1	3	22	10	9	1	1	2	31	2	31	45	16	645	-		
-	-	-	-	-	-	-	-	-	-	-	-	629	-	-	-	-	5	3	7	1	10	657	95.7	93.9	97.1
-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	1	2	-	11	72.7	39.0	94.0
-	-	-	-	-	-	1	-	-	-	-	-	8	-	93	-	-	12	9	45	5	16	192	48.4	41.2	55.7
-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	95	-	-	-	11	2	5	115	82.6	74.4	89.0
-	-	-	1	-	-	-	1	-	-	-	2	1	-	-	4	13	3	4	5	382	46	469	2.8	1.5	4.7
2	-	-	1	-	2	-	7	2	-	1	5	5	2	-	-	2	82	-	19	38	337	538	15.2	12.3	18.6
-	-	1	2	-	-	-	1	-	-	-	4	608	45	3	3	5	29	9	58	29	283	1,100	0.8	0.4	1.5
-	-	-	-	-	1	-	-	-	-	-	-	1	1	5	-	-	12	-	33	58	9	122	27.0	19.4	35.8
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	37	1	39	94.9	82.7	99.4
-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	3	1	5	5	617	639	96.6	94.8	97.8
97	116	60	299	117	96	99	219	63	62	42	291	1,298	112	112	103	24	256	40	243	624	1,377	14,396			
32.0	25.9	31.7	49.8	31.6	15.6	29.3	40.2	23.8	14.5	52.4	27.5	48.5	7.1	83.0	92.2	54.2	32.0	22.5	13.6	5.9	44.8	Agreement = 37.7%			
22.9	18.2	20.3	44.0	23.3	9.0	20.6	33.6	14.0	6.9	36.4	22.4	45.7	3.1	74.8	85.3	32.8	26.4	10.8	9.5	4.2	42.2	Kappa = 0.351 (0.349 - 0.356)			
42.2	34.8	45.0	55.6	40.9	24.5	39.3	47.0	36.2	25.8	68.0	33.0	51.2	13.6	89.5	96.6	74.4	38.1	38.5	18.5	8.1	47.5	Spearman = 0.548 (0.251 - 0.846)			

4.5 Post-survey weights

4.5.1 Weighted SA NCODV cause of death profile

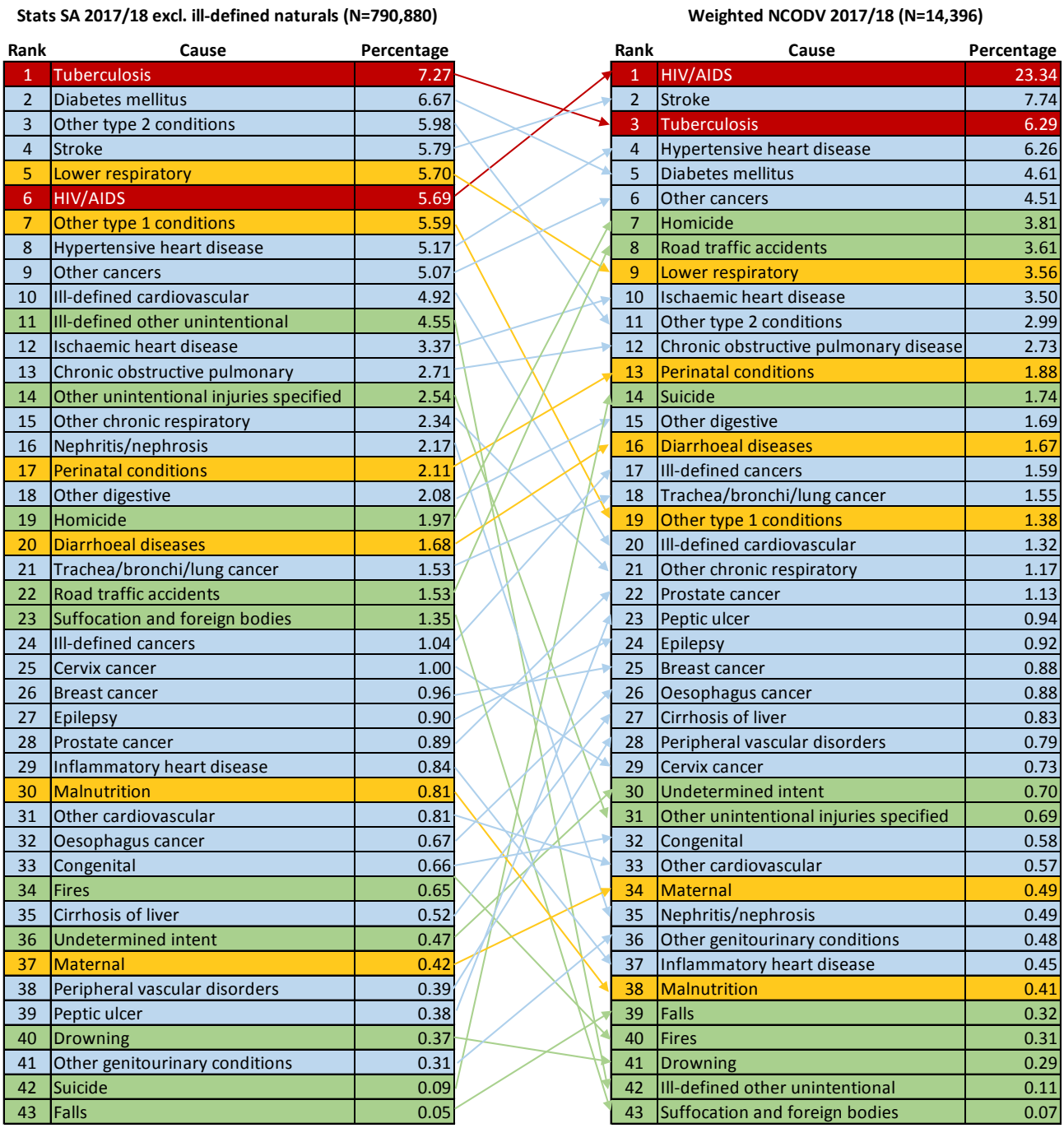
Deaths from ill-defined natural causes accounted for 6.2% of the SA NCODV sample and have been excluded from the weighted sample to provide a cause profile. The top ten identified causes of death are shown in Figure 5, showing the estimated proportion of all deaths with 95%CIs. It can be seen that HIV/AIDS dominated the profile accounting for 23.3% (95%CI:22.7%-24.0%) of the deaths. Tuberculosis, together with clusters of cardiometabolic diseases and injuries, cancers and lower respiratory infections comprise the top causes. The full cause specific mortality fractions based on the weighted SA NCODV data are shown in Table A12 in Annexure 8.6. It should be noted that the category of "*Other cancers*" is a grouping of residual cause which do not feature in the top ten when considered alone. Chronic obstructive pulmonary disease would be the 10th leading cause of death, accounting for 2.7% if groupings of residual causes were not considered in the list.6



SA NCODV - South African national cause of death validation project

Figure 5: Top ten causes of death, weighted SA NCODV 2017/18.

Figure 6 contrasts the ranking and percentages of the 43 causes in the weighted sample with the ranking and percentages in the Stats SA 2017/18 data. For comparison of the SA NCODV sample with Stats SA 2017/18 data, we have excluded the 13.4% of ill-defined natural causes to highlight the differences in the specified causes. The biggest difference is the increase for HIV/AIDS (5.69% versus (vs) 23.34%), making HIV/AIDS the leading cause of death by a large margin. Smaller increases are observed for stroke (5.79% vs 7.74%), homicide (1.97% vs 3.81%), road traffic accidents (1.53% vs 3.61%) and suicide (0.09% vs 1.74%). Other type 1 conditions are reduced (5.59% vs 1.38%), lower respiratory infections (5.70% vs 3.56%), diabetes mellitus (6.67% vs 4.61%), other chronic respiratory conditions (2.34% vs 1.17%), nephritis/nephrosis (2.17% vs 0.49%), suffocation (1.2% vs 0.07%) and other specified unintentional injuries (2.54% vs 0.69%). The ill-defined cardiovascular category is reduced (4.92% vs 1.32%) as well as the ill-defined unintentional (2.54% vs 0.11%). In contrast, the ill-defined cancer category is increased (1.04% vs 1.59%).



Stats SA 2017/18 excl. ill-defined naturals (N=790,880)		
Rank	Cause	Percentage
1	Tuberculosis	7.27
2	Diabetes mellitus	6.67
3	Other type 2 conditions	5.98
4	Stroke	5.79
5	Lower respiratory	5.70
6	HIV/AIDS	5.69
7	Other type 1 conditions	5.59
8	Hypertensive heart disease	5.17
9	Other cancers	5.07
10	Ill-defined cardiovascular	4.92
11	Ill-defined other unintentional	4.55
12	Ischaemic heart disease	3.37
13	Chronic obstructive pulmonary	2.71
14	Other unintentional injuries specified	2.54
15	Other chronic respiratory	2.34
16	Nephritis/nephrosis	2.17
17	Perinatal conditions	2.11
18	Other digestive	2.08
19	Homicide	1.97
20	Diarrhoeal diseases	1.68
21	Trachea/bronchi/lung cancer	1.53
22	Road traffic accidents	1.53
23	Suffocation and foreign bodies	1.35
24	Ill-defined cancers	1.04
25	Cervix cancer	1.00
26	Breast cancer	0.96
27	Epilepsy	0.90
28	Prostate cancer	0.89
29	Inflammatory heart disease	0.84
30	Malnutrition	0.81
31	Other cardiovascular	0.81
32	Oesophagus cancer	0.67
33	Congenital	0.66
34	Fires	0.65
35	Cirrhosis of liver	0.52
36	Undetermined intent	0.47
37	Maternal	0.42
38	Peripheral vascular disorders	0.39
39	Peptic ulcer	0.38
40	Drowning	0.37
41	Other genitourinary conditions	0.31
42	Suicide	0.09
43	Falls	0.05

Weighted NCODV 2017/18 (N=14,396)		
Rank	Cause	Percentage
1	HIV/AIDS	23.34
2	Stroke	7.74
3	Tuberculosis	6.29
4	Hypertensive heart disease	6.26
5	Diabetes mellitus	4.61
6	Other cancers	4.51
7	Homicide	3.81
8	Road traffic accidents	3.61
9	Lower respiratory	3.56
10	Ischaemic heart disease	3.50
11	Other type 2 conditions	2.99
12	Chronic obstructive pulmonary disease	2.73
13	Perinatal conditions	1.88
14	Suicide	1.74
15	Other digestive	1.69
16	Diarrhoeal diseases	1.67
17	Ill-defined cancers	1.59
18	Trachea/bronchi/lung cancer	1.55
19	Other type 1 conditions	1.38
20	Ill-defined cardiovascular	1.32
21	Other chronic respiratory	1.17
22	Prostate cancer	1.13
23	Peptic ulcer	0.94
24	Epilepsy	0.92
25	Breast cancer	0.88
26	Oesophagus cancer	0.88
27	Cirrhosis of liver	0.83
28	Peripheral vascular disorders	0.79
29	Cervix cancer	0.73
30	Undetermined intent	0.70
31	Other unintentional injuries specified	0.69
32	Congenital	0.58
33	Other cardiovascular	0.57
34	Maternal	0.49
35	Nephritis/nephrosis	0.49
36	Other genitourinary conditions	0.48
37	Inflammatory heart disease	0.45
38	Malnutrition	0.41
39	Falls	0.32
40	Fires	0.31
41	Drowning	0.29
42	Ill-defined other unintentional	0.11
43	Suffocation and foreign bodies	0.07

SA NCODV - South African national cause of death validation project

Figure 6: Comparison of ranking of causes of death based on Stats SA 2017/18 with weighted SA NCODV sample (excluding ill-defined natural deaths), SA NCODV project 2017/18.

HIV-related death was the most common identified cause, accounting for 23.3% of all deaths. HIV and TB together accounted for 29.6% of the sample of deaths. The detailed cause of death combinations are shown in Figure 7 with HIV resulting in TB infection the most common, accounting for 36.0% of HIV and TB deaths. Amongst HIV/AIDS deaths, 45.7% occurred with TB. Overall, 63.0% of TB deaths were related to HIV.

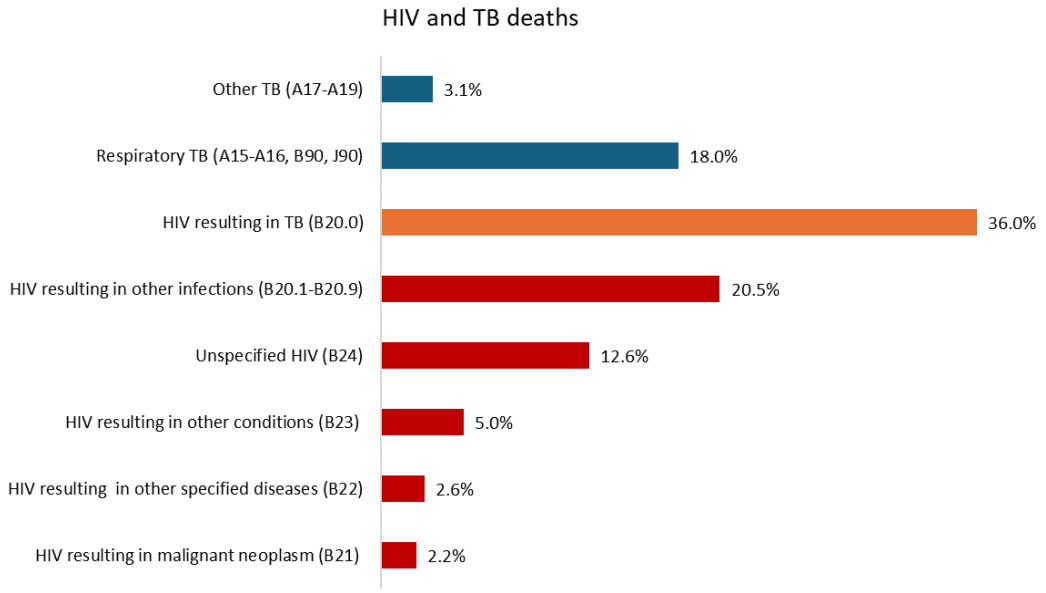


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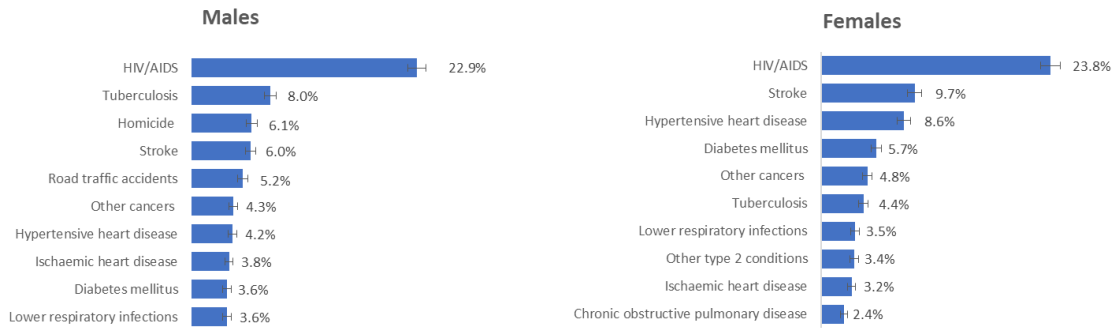
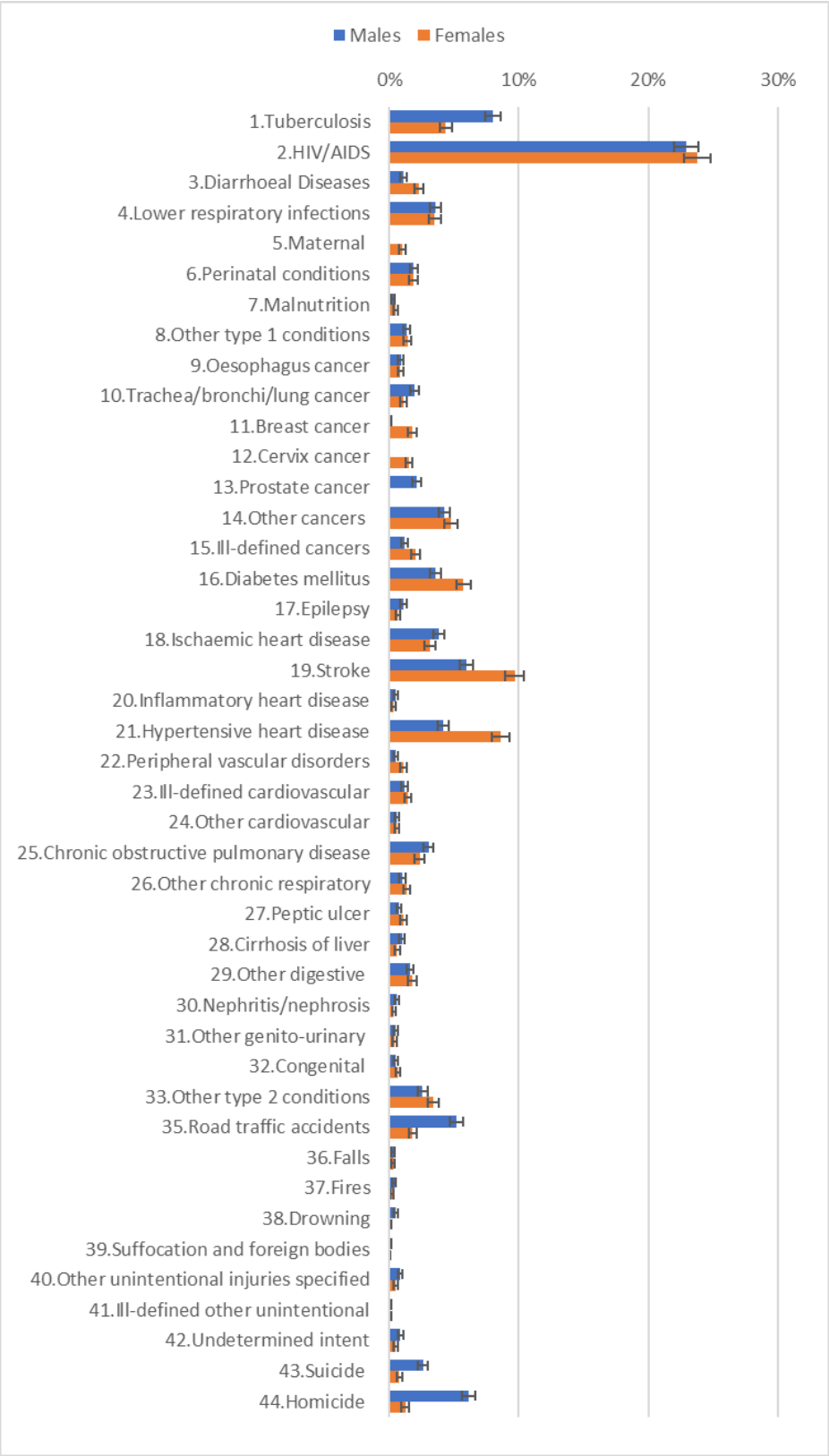
Figure 7: Distribution of HIV and TB related deaths by ICD codes based on weighted NCODV sample, (N=4,022), SA NCOD Validation Project 2017/18.

There are striking differences in the cause of death profile by sex. Homicide and road traffic accidents feature in the top causes for males but not for females (Figure 8), and the proportion of deaths due to tuberculosis is much higher in males. Deaths from non-communicable diseases account for higher proportions among females, but they follow a similar ranking as for males. Figure 9 shows all causes of death and full details can be found in Table A14 in Annexure 8.6.



SA NCODV - South African national cause of death validation project

Figure 8: Top ten causes of death by sex, weighted SA NCODV 2017/18.



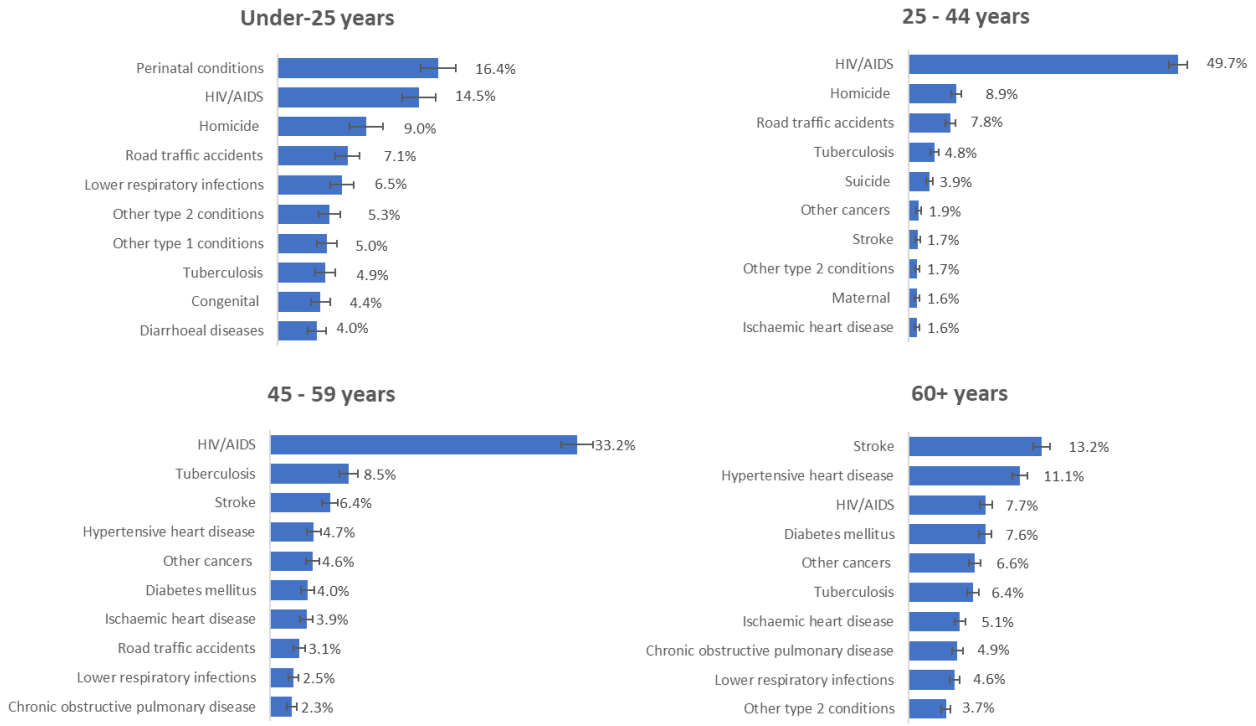
Other type 1 conditions combines less common infectious diseases (see Table A1)

Other type 2 conditions combines less common non-communicable conditions (see Table A1)

SA NCODV - South African national cause of death validation project

Figure 9: Cause of death profile by sex, weighted SA NCODV 2017/18.

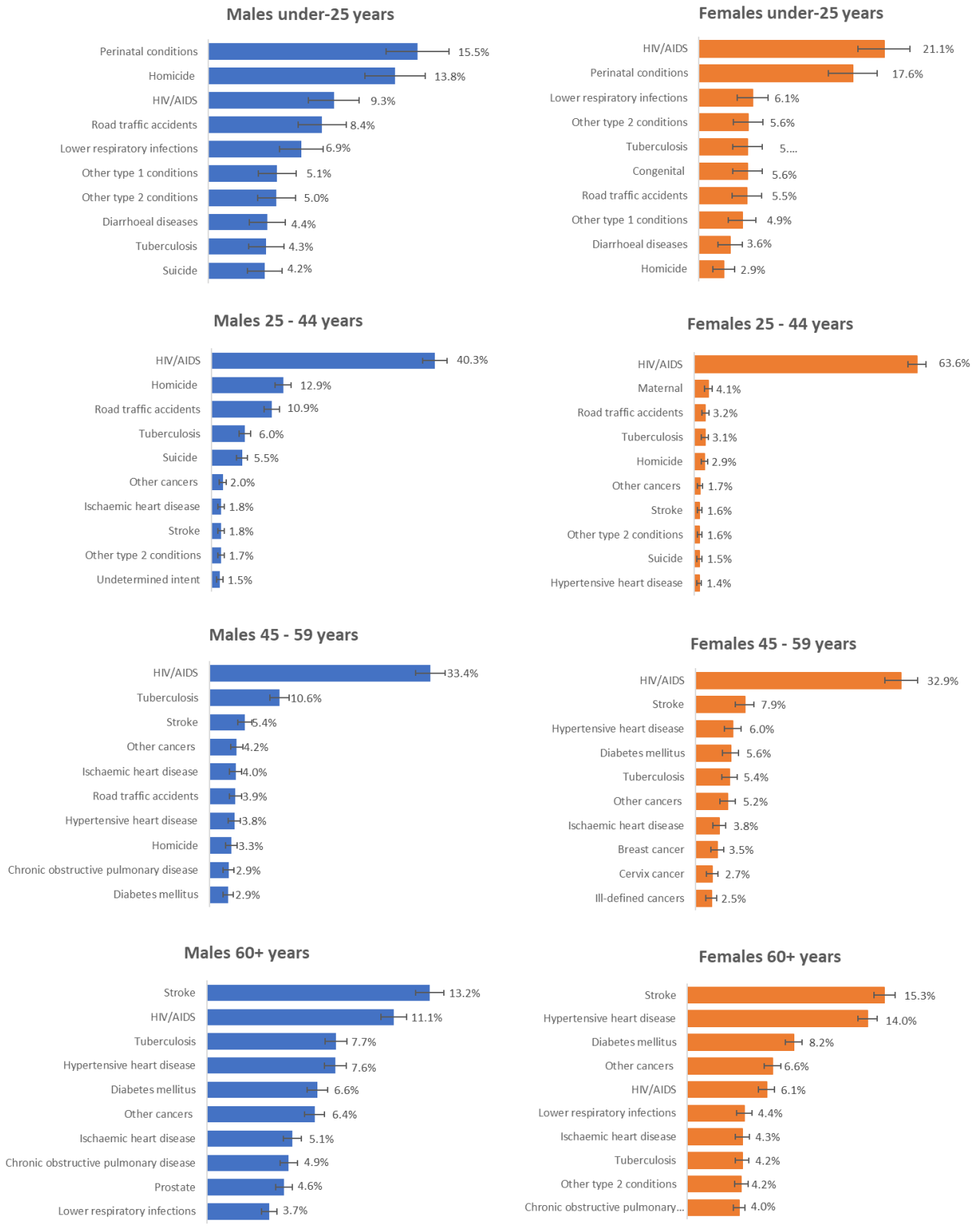
The cause of death profile changes by age group (see Figure 10 with full details in Table A15 of Annexure 8.6). While HIV/AIDS is the leading cause in all adult ages 25-59 years, it was the 2nd leading cause in the under-25 years, being overtaken by conditions originating in the perinatal period and it was the 3rd highest in older persons 60+ years, being overtaken by stroke and hypertensive heart disease. Homicide and road traffic accidents feature in the younger age group as well as congenital conditions. While HIV/AIDS, homicide, road traffic accidents and tuberculosis are the leading causes of death among young adults (aged 25-44 years) suicide is ranked 5th.



Other type 1 conditions combines less common infectious diseases (see Table A1)
Other type 2 conditions combines less common non-communicable conditions (see Table A1)
SA NCODV - South African national cause of death validation project

Figure 10: Top ten causes of death by age group, weighted SA NCODV 2017/18.

Sex differences in the cause of death profile in each age group can be seen in Figure 11. HIV/AIDS accounts for a higher proportion of deaths among females under-25 years than males (21.1% of female deaths vs 9.3% of male deaths) while homicide contributes a much higher proportion of male deaths (13.8%) than female deaths (2.9%). Interestingly congenital conditions accounted for a higher proportion of female deaths (5.6%) than for male deaths (3.5%). As noted above, HIV/AIDS dominated the cause profile in the 25–44-year age group, accounting for 63.6% of female deaths but only 40.3% of male deaths. For this age cohort of males, the next top causes of death were homicide (12.9%), road traffic accidents (10.9%), tuberculosis (6.0%) and suicide (5.5%). Maternal conditions were the 2nd leading cause among females in this age group, accounting for 4.1% of deaths in this age group. Homicide was the 5th leading cause, accounting for 2.9% of the female deaths. In the 45–59-year age group, HIV/AIDS was the leading cause for both males and females, accounting for about 33% of each. For males, this was followed by tuberculosis and a combination of cardiometabolic conditions, cancers and injuries. The same causes of death featured in the top ten for females, excluding injuries and in a different order with diabetes mellitus



Other type 1 conditions combines less common infectious diseases (see Table A1)

Other type 2 conditions combines less common non-communicable conditions (see Table A1)

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Figure 11: Top ten causes of death for males and females by age group, weighted SA NCODV 2017/18.

featuring higher for females. Breast cancer was followed by cancer of the cervix. Similar causes featured in the top ten causes for males and females aged 60 years and older. Stroke was the leading cause which was followed by HIV/AIDS and then tuberculosis for males and by hypertensive heart disease and diabetes mellitus for females. Ischaemic heart disease accounted for 5.1% of male deaths and 4.3% of female deaths in this age group.

Figure 12 shows the top ten causes of death in each province (full details can be seen in Table A16 of Annexure 8.6). While all provinces display the quadruple burden of disease, there are geographic variations with HIV/AIDS ranging from 12.8% of deaths in the Western Cape to 32.2% of deaths in KwaZulu-Natal. However, it must be noted that there were no FPS data from KwaZulu-Natal because the Provincial Department of Health denied requests to collect such data, and the profile for this province is consequently distorted (see Figure 9).

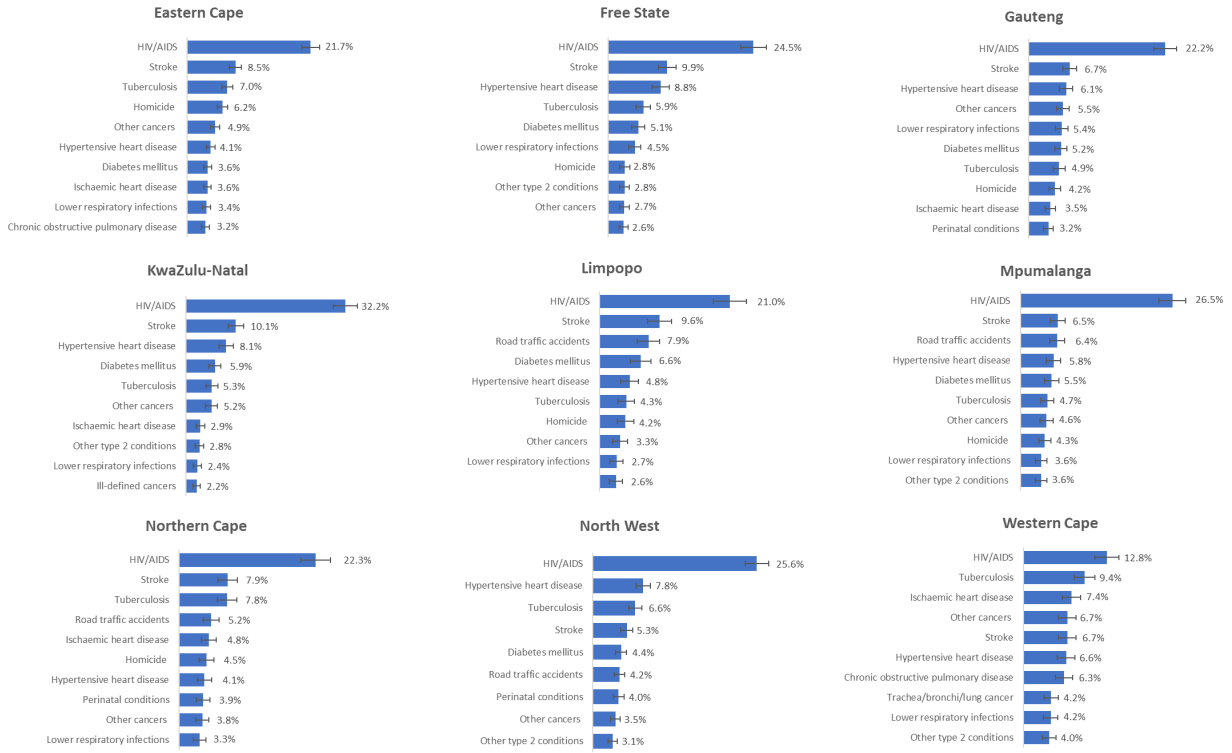

Figure 12: Top ten causes of death by province, weighted SA NCODV 2017/18.

4.5.2 *Correction factors*

Correction factors, based on the weighted NCODV sample, are shown in Table 11 The correction factors are low for non-specific and Ill-defined causes such as Other type 1 conditions (0.266), Ill-defined cardiovascular (0.224) and Ill-defined other unintentional (0.029), with the exception of Ill-defined cancers (1.758). The correction factor for HIV/AIDS is high (4.418) while that for AIDS indicator conditions such as TB (0.937), diarrheal diseases (1.113), lower respiratory infections (0.684), cancer of the cervix (0.801) are generally less than one, reflecting misclassification of HIV/AIDS deaths to indicator conditions. Specified injuries have high correction factors, with falls (8.813) and suicide (17.392) being particularly high.

Table 11: Cause specific mortality fractions for Stats SA, NCODV and weighted NCODV data and cause specific correction factors, SA NCODV Project 2017/18.

NBD short-list of causes	Stats SA	NCODV	Weighted NCODV	Correction factors
1. Tuberculosis	6.7%	4.7%	6.3%	0.937
2. HIV/AIDS	5.3%	23.3%	23.3%	4.418
3. Diarrhoeal diseases	1.5%	1.2%	1.7%	1.113
4. Lower respiratory infections	5.2%	2.7%	3.6%	0.684
5. Maternal	0.4%	0.4%	0.5%	1.231
6. Perinatal conditions	1.9%	0.4%	1.9%	0.988
7. Malnutrition	0.8%	0.3%	0.4%	0.508
8. Other type 1 conditions#	5.2%	1.1%	1.4%	0.266
9. Oesophagus cancer	0.6%	0.7%	0.9%	1.470
10. Trachea/bronchi/lung cancer	1.4%	1.2%	1.6%	1.110
11. Breast cancer	0.9%	0.7%	0.9%	0.980
12. Cervix cancer	0.9%	0.6%	0.7%	0.801
13. Prostate cancer	0.8%	0.7%	1.1%	1.415
14. Other cancers	4.6%	3.6%	4.5%	0.978
15. Ill-defined cancers	0.9%	1.2%	1.6%	1.758
16. Diabetes mellitus	6.1%	3.7%	4.6%	0.754
17. Epilepsy	0.8%	0.6%	0.9%	1.147
18. Ischaemic heart disease	3.0%	2.2%	3.5%	1.168
19. Stroke	5.3%	6.0%	7.7%	1.459
20. Inflammatory heart disease	0.8%	0.4%	0.4%	0.559
21. Hypertensive heart disease	4.8%	4.3%	6.3%	1.304
22. Peripheral vascular disorders	0.4%	0.7%	0.8%	1.983
23. Ill-defined cardiovascular	4.5%	0.8%	1.3%	0.294
24. Other cardiovascular	0.7%	0.4%	0.6%	0.814
25. Chronic obstructive pulmonary disease	2.4%	2.1%	2.7%	1.136
26. Other chronic respiratory	2.0%	0.8%	1.2%	0.587
27. Peptic ulcer	0.4%	0.7%	0.9%	2.345
28. Cirrhosis of liver	0.5%	0.7%	0.8%	1.664
29. Other digestive	1.9%	1.5%	1.7%	0.883
30. Nephritis/nephrosis	2.0%	0.4%	0.5%	0.242
31. Other genitourinary conditions	0.3%	0.4%	0.5%	1.595
32. Congenital	0.6%	0.3%	0.6%	0.964

NBD short-list of causes	Stats SA	NCODV	Weighted NCODV	Correction factors
33. Other type 2 conditions[&]	5.5%	2.0%	3.0%	0.544
34. Ill-defined naturals	9.6%	-	-	-
35. Road traffic accidents	1.4%	9.0%	3.6%	2.580
36. Falls	0.0%	0.8%	0.3%	7.813
37. Fires	0.6%	0.8%	0.3%	0.519
38. Drowning	0.3%	0.7%	0.3%	0.952
39. Suffocation and foreign bodies	1.2%	0.2%	0.1%	0.057
40. Other unintentional injuries specified	2.2%	1.8%	0.7%	0.311
41. Ill-defined other unintentional	3.9%	0.3%	0.1%	0.028
42. Undetermined intent	0.4%	1.7%	0.7%	1.740
43. Suicide	0.1%	4.3%	1.7%	17.392
44. Homicide	1.7%	9.6%	3.8%	2.242
Total	**100.0%**	**100.0%**	**100.0%**	**-**

[#] Other type 1 conditions combines less common infectious diseases (Table A1)

[&] Other type 2 conditions combines less common non-communicable conditions (Table A1)

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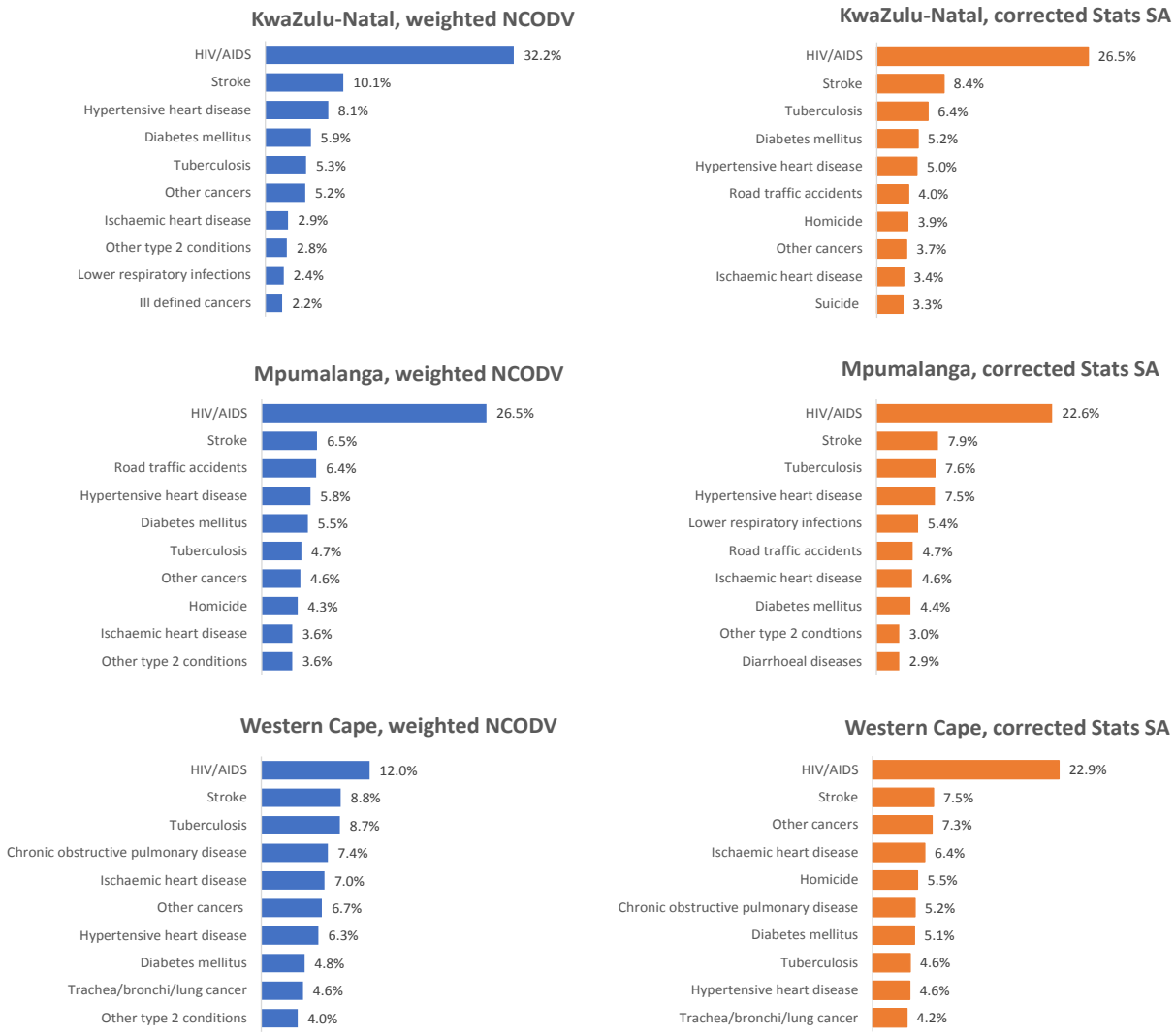
While Figure 6 shows the corrected cause of death profile based on the NCODV project, it was envisaged that the correction factor could be used to correct sub-national cause of death profiles. Three provinces have been selected to explore the applicability of the correction factors to sub-national data. Figure 13 shows the top ten causes of death for the selected provinces based on the weighted NCODV sample alongside the top ten based on Stats SA data after applying the national correction factors reported in Table 11. (Similar graphs for the remaining provinces can be found Figure A7 and Figure A8 in Annexure 8.7). In the case of KwaZulu-Natal, where permission to collect FPS records was not granted, the corrected profile has more realistic proportions than the weighted NCODV sample with HIV/AIDS being reduced from 32.2% to 26.5% and some injuries showing in the top ten causes. In contrast, the proportion of deaths due to HIV/AIDS in Western Cape is not realistic and the 12.0% from the weighted NCODV is more plausible than the 22.9% based on the corrected Stats SA data.

When compared with results from the Injury Mortality Survey (IMS) for 2017,[42] it becomes clear that the corrected Stats SA profile cannot be used for the injury profile. The IMS 2017 found the ranking of homicides, road traffic deaths and suicides to follow this order in five provinces (Eastern Cape, Free State, Gauteng, KwaZulu-Natal, and Western Cape) while road traffic deaths were the same as homicides in Northern Cape and higher than homicides in the remaining provinces (Limpopo, Mpumalanga and North West) as shown in Figure A9 in Annexure 8.8. The rankings of the injury deaths in the provincial estimates based on the weighted NCODV sample was consistent with this pattern but the profile based on corrected Stats SA profiles do not match the rankings in the IMS 2017. Although extremely under-reported, there appears to be a higher reporting of suicide in KwaZulu-Natal than in other provinces. While national Stats SA data reported 37.00 homicides for each suicide, KwaZulu-Natal had proportionally more suicides with the second lowest ratio of 9.33 homicides for each suicide (Table A17 in Annexure 8.8), even although it was the province with the highest suicide rate. Applying the national correction factor results in the corrected proportion of suicides being slightly higher than the proportion of deaths due to homicide. However, the IMS shows that KwaZulu-Natal has the fourth highest ratio of homicides to suicides of 2.72, slightly higher than the median ratio of 2.69 as seen in Table A17 in Annexure 8.8.



Other type 1 conditions combines less common infectious diseases (see Table A1)
Other type 2 conditions combines less common non-communicable conditions (see Table A1)
SA NCODV – South African national cause of death validation study

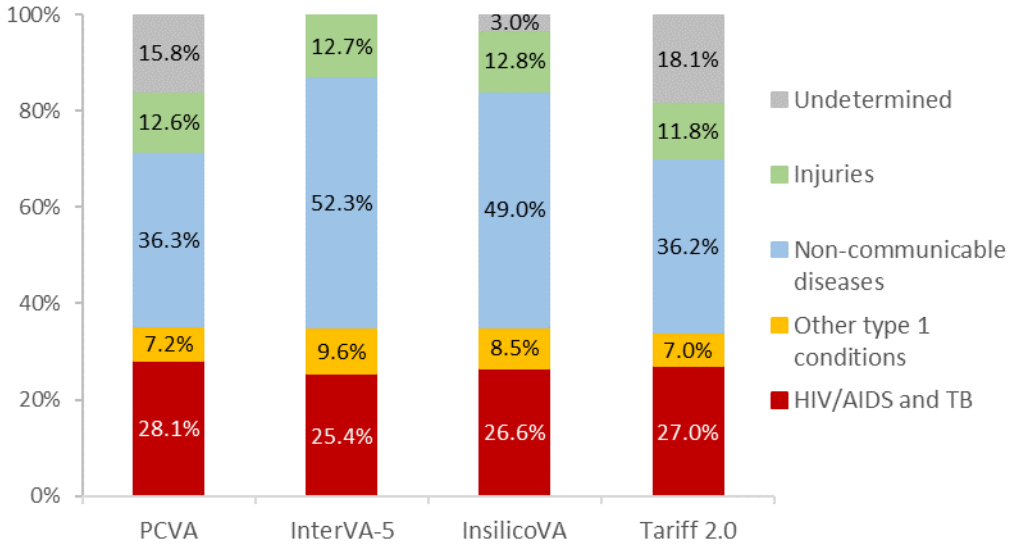
Figure 13: Comparison of top ten causes based on weighted NCODV sample and corrected Stats SA for KwaZulu-Natal, Mpumalanga and Western Cape, SA NCODV 2017/18.

4.6 Evaluation of VA

4.6.1 Agreement between PCVA and algorithm outcomes

The VAs have been coded using the three available computer algorithms, InterVA-5, InSilicoVA and Tariff 2.0 and the results are reported elsewhere.[40] InterVA-5[43] is a deterministic algorithm that uses a physician-provided, pre-defined symptom-cause-information (SCI) that describes the conditional probability of each symptom given each cause. InSilicoVA[44] is a Bayesian hierarchical cause of death assignment method that uses the same SCI as InterVA-5, but jointly estimates both individual- and population-level cause of death distributions under a probabilistic framework. The Tariff 2.0[45] algorithm is deterministic using the SCI derived from the Population Health Metrics Research Consortium (PHMRC) Gold Standard VA Validation Study.[46] Tariff 2.0 is a score-based method that compares different causes of death based on the observed

symptoms. A total of 5,386 VA records were analysed and the broad cause profiles are shown in Figure 14. PCVA and CCVAs had similar cause profiles. The PCVA and all the CCVAs identified HIV/AIDS as the leading COD.



Other type 1 conditions combines perinatal, maternal and nutritional conditions with infectious diseases excluding HIV/AIDS
SA NCODV - South African national cause of death validation project

Figure 14: Broad cause groups including undetermined causes for physician coded verbal autopsy (PCVA) and computer coded verbal autopsy (CCVA) datasets (N=5,386), SA NCODV project 2017/18.

Using a consolidated list of 25 causes based on the VA list, the overall agreement between CCVAs and PCVA for the top single cause ranged from 48.2% - 51.6% (Table 12) and indicated comparable weak agreement between the CCVA method and PCVA. This weak level of agreement at the individual level was echoed by the Cohen Kappa statistics that ranged from 0.43 – 0.47. In contrast, the CCVAs had moderate to strong population level agreement based on the CSMF accuracy which ranged from 0.81 – 0.84. Rank correlation indicated moderate agreement for adults (0.64 – 0.68). Groenewald *et al.*[40] provide further analysis of these data and conclude that there is scope for improving the algorithms for use in South Africa.

Table 12: Overall agreement, kappa, CSMF accuracy and Spearman rank correlation between cause of death assignment three computer coded verbal autopsy (CCVA) methods and physician coded verbal autopsy (PCVA) based on 25 cause list, SA NCODV SA Project 2017/18.

Verbal autopsy coding method	Individual level agreement		Population level agreement	
	Overall Agreement (95% CI)	Kappa (95% CI)	CSMF Accuracy	Spearman Rank correlation (95% CI)
InterVA-5	48.2% (46.7% – 49.7%)	0.43 (0.42 – 0.44)	0.81	0.64 (0.62 – 0.65)
InSilicoVA	51.6% (50.2% – 53.1%)	0.47 (0.46 – 0.48)	0.84	0.68 (0.67 – 0.70)
Tariff 2.0	51.2% (49.8% – 52.7%)	0.46 (0.45 – 0.47)	0.82	0.66 (0.65 – 0.68)

CI = confidence interval
CSMF = cause specific mortality fraction
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4.6.2 *PCVA and medical or FPS records*

A total of 1,821 pairs of UCODs were compared to assess the agreement between that identified from the PCVA with the UCOD from corresponding MR and FPS records, grouped according to the NBD short list. The overall agreement, the Cohen Kappa statistic and the Spearman Rank Correlation as well as sensitivity and the PPV for each cause category are shown in Table 14. The overall agreement for all categories was 47.8% with a Kappa of 0.414, indicating weak agreement between the PCVA and the gold standards of MR and FPS records at individual level. However, the high rank correlation squared of 0.791 reflects the good performance of the PCVA at the population cause. In addition, as seen from Table 14, some individual cause categories showed strong PPV and sensitivity. Common causes of injury deaths and HIV/AIDS deaths showed good agreement. The PPV for PCVA road traffic deaths was 89.5% (95% CI: 81.1%-95.1%), for suicide it was 85.7% (95% CI: 67.3%-96.0%), for homicide deaths it was 81.8% (95% CI: 72.8%-88.9%), and for HIV/AIDS deaths it was 82.1% (95% CI: 78.4%-85.4%). Peripheral vascular disorders had a PPV of 80.0%, but with a wide 95% CI (28.4%-99.5%). The sensitivity for road traffic deaths was also high at 97.5% (95% CI: 91.2%-99.7%), as was the sensitivity for homicides at 89.0% (95% CI: 80.7%-94.6%), and HIV/AIDS deaths at 67.0%% (95% CI: 63.1%-70.7%). In these categories, the PCVA is a good instrument for identifying the correct condition that led to death for individuals.

Table 13: Overall agreement, kappa, cause specific mortality fraction (CSMF) accuracy and Spearman rank correlation between cause of death assignment by physician coded verbal autopsy (PCVA) and medical and forensic pathology records using shortened NBD list (N=1,608), SA NCODV Project 2017/18.

Comparison	Individual level agreement		Population level agreement	
	Overall Agreement (95% CI)	Kappa (95% CI)	Cause specific mortality fraction (CSMF) Accuracy	Spearman Rank correlation (95% CI)
PCVA and Medical records/FPS records	47.9% (45.6% – 50.2%)	0.41 (0.40– 0.42)	0.79	0.69 (0.44 – 0.98)

CI=confidence interval; PCVA=physician coded verbal autopsy; FPS=forensic pathology services
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Several categories showed low PPV and sensitivity, including respiratory conditions such as lower respiratory tract infections and chronic obstructive pulmonary disease but had small sample sizes, which may account for these results. PCVA hypertensive heart disease had low PPV and sensitivity despite relatively large numbers of decedents. The PPV was 17.9% (95% CI: 11.2% – 26.6%) and the sensitivity was 31.7% (95% CI: 20.3%-45.0%). According to the MRs, the UCOD for these decedents were due to a range of conditions including ischemic heart disease, HIV/AIDS, chronic obstructive pulmonary disease and other non-communicable diseases.

A total of 108 cases where the UCOD from MR or FPS was ill-defined have been excluded from the analysis. PCVA assigned 24.1% of these cases to ill-defined naturals, 11.0% to HIV/AIDS, 11.1% to TB, 7.4% to hypertensive heart disease and 5.6% each to diabetes mellitus and stroke (see Table A18 in Annexure 8.9).

Table 14: Misclassification pattern for physician coded verbal autopsy compared with medical and FPS records (excluding ill-defined natural deaths) using shortened NBD list (N=1,821), SA NCODV Project 2017/18.

Physician coded verbal autopsy (NBD short)	Medical records and FPS records (NBD short)																					
	1.Tuberculosis	2.HIV/AIDS	3.Diarrhoeal diseases	4.Lower respiratory infections	5.Maternal	6.Perinatal conditions	7.Malnutrition	8.Other type 1 conditions	9.Oesophagus cancer	10.Trachea/bronchi/lung cancer	11.Breast cancer	12.Cervix cancer	13.Prostate cancer	14.Other cancers	15.Ill-defined cancers	16.Diabetes mellitus	17.Epilepsy	18.Ischaemic heart disease	19.Stroke	20.Inflammatory heart disease	21.Hypertensive heart disease
1.Tuberculosis	43	50	2	7	-	-	-	2	-	6	-	-	1	6	-	1	-	1	3	1	5
2.HIV/AIDS	8	404	2	2	-	-	1	4	1	2	1	2	1	8	4	6	1	2	10	-	5
3.Diarrhoeal diseases	1	2	4	1	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	1
4.Lower respiratory infections	2	1	-	3	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	1
5.Maternal	-	4	-	-	2	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
6.Perinatal conditions	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
7.Malnutrition	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
8.Other type 1 conditions	1	8	1	1	-	-	-	7	-	1	-	-	-	1	-	-	-	-	4	-	-
9.Oesophagus cancer	2	2	-	1	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	1
10.Trachea/bronchi/lung cancer	-	1	-	1	-	-	-	-	1	7	-	1	1	1	-	-	-	-	-	-	-
11.Breast cancer	-	1	-	-	-	-	-	-	-	-	3	-	-	-	1	-	-	-	1	-	-
12.Cervix cancer	-	5	-	-	-	-	-	-	-	-	-	2	-	4	-	-	-	-	-	-	-
13.Prostate cancer	-	-	-	2	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	1
14.Other cancers	2	5	-	1	-	-	-	1	10	1	1	3	2	31	1	-	-	-	1	-	-
15.Ill-defined cancers	1	5	-	-	-	-	-	-	1	1	1	1	1	8	5	-	-	-	-	-	-
16.Diabetes mellitus	1	11	5	2	-	-	-	2	-	-	-	-	-	3	-	34	-	2	9	-	5
17.Epilepsy	1	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	6	-	2	-	-
18.Ischaemic heart disease	1	4	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	8	1	-	4
19.Stroke	2	15	1	2	-	-	-	1	-	1	-	-	1	3	-	5	1	-	59	-	1
20.Inflammatory heart disease	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
21.Hypertensive heart disease	3	9	5	3	-	-	-	1	1	1	1	1	2	3	3	8	1	2	10	3	19
22.Peripheral vascular disorders	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
23.Ill defined cardiovascular	-	2	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	1	3
24.Other cardiovascular	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25.COPD	-	4	-	3	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	2
26.Other chronic respiratory	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	3
27.Peptic ulcer	2	1	1	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
28.Cirrhosis of liver	-	5	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	2	-	-
29.Other digestive	1	5	-	-	-	-	-	1	-	-	-	-	-	2	1	-	-	-	-	-	-
30.Nephritis/nephrosis	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3
31.Other genito-urinary	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
32.Congenital	-	1	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
33.Other type 2 conditions	1	1	3	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	2
34.Ill-defined naturals	11	42	7	20	-	-	1	8	2	-	-	1	1	7	3	15	-	7	19	-	15
35.Road traffic accidents	-	1	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-
36.Falls	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	1	-	2	1	-
37.Fires	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38.Drowning	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40.Other unintentional injuries specified	-	2	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	1	-	1
42.Undetermined whether intentional or un	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43.Suicide	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44.Homicide	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2
Grand Total	87	603	31	56	2	2	3	32	22	25	9	11	18	87	20	70	11	23	128	7	75
Sensitivity	49.4	67.0	12.9	5.4	100.0	50.0	0.0	21.9	18.2	28.0	33.3	18.2	33.3	35.6	25.0	48.6	54.5	34.8	46.1	0.0	25.3
Lower 95% CI	38.5	63.1	3.6	1.1	15.8	1.3	0.0	9.3	5.2	12.1	7.5	2.3	13.3	25.6	8.7	36.4	23.4	16.4	37.2	0.0	16.0
Upper 95% CI	60.4	70.7	29.8	14.9	100.0	98.7	70.8	40.0	40.3	49.4	70.1	51.8	59.0	46.6	49.1	60.8	83.3	57.3	55.1	41.0	36.7

22.Peripheral vascular disorders	23.Ill-defined cardiovascular	24.Other cardiovascular	25.Chronic obstructive pulmonary disease	26.Other chronic respiratory	27.Peptic ulcer	28.Cirrhosis of liver	29.Other digestive	30.Nephritis/nephrosis	31.Other genitourinary condtions	32.Congenital	33.Other type 2 conditions	35.Road traffic accidents	36.Falls	37.Fires	38.Drowning	40.Other specified unintentional injuries	41.Ill-defined other unintentional	42.Undetermined intent	43.Suicide	44.Homicide	Grand Total	PPV	Lower 95% CI	Upper 95% CI
1	-	-	3	-	1	1	1	1	1	-	1	-	-	-	-	-	-	2	-	1	141	30.5	23.0	38.8
-	2	1	6	1	-	1	5	1	1	-	5	-	1	-	-	2	1	-	-	1	492	82.1	78.4	85.4
-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	14	28.6	8.4	58.1
1	-	-	2	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	14	21.4	4.7	50.8
-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	10	20.0	2.5	55.6
-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	5	20.0	0.5	71.6
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.0	0.0	97.5
1	-	-	1	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	28	25.0	10.7	44.9
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	40.0	12.2	73.8
-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	50.0	23.0	77.0
-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	42.9	9.9	81.6
-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	13	15.4	1.9	45.4
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	66.7	29.9	92.5
-	-	-	-	-	-	-	4	1	-	-	1	-	-	-	-	-	-	-	-	-	65	47.7	35.1	60.5
-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	26	19.2	6.6	39.4
1	1	1	1	-	-	2	1	1	1	-	4	-	1	-	-	-	-	-	-	-	88	38.6	28.4	49.6
-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	2	-	-	-	-	17	35.3	14.2	61.7
-	1	-	4	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	29	27.6	12.7	47.2
-	-	1	1	1	1	1	-	-	1	-	5	-	-	-	-	3	-	-	1	-	107	55.1	45.2	64.8
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.0	0.0	84.2
2	1	1	7	1	1	1	2	3	1	-	9	-	-	-	-	1	-	-	-	-	106	17.9	11.2	26.6
4	0	0	0	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	5	80.0	28.4	99.5
1	2	1	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	15	13.3	1.7	40.5
-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	0.0	0.0	97.5
-	1	-	7	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	21	33.3	14.6	57.0
-	-	-	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21	19.0	5.4	41.9
-	-	-	2	-	1	-	4	-	-	-	-	-	1	-	-	-	1	-	-	-	16	6.3	0.2	30.2
-	-	-	-	-	-	3	-	1	-	-	1	-	-	-	-	-	-	-	-	-	14	21.4	4.7	50.8
-	-	1	-	-	1	2	5	1	1	-	1	-	-	-	-	1	-	-	-	-	23	21.7	7.5	43.7
-	-	-	-	-	-	-	-	1	1	-	2	-	-	-	-	-	-	-	-	-	12	8.3	0.2	38.5
-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0.0	0.0	70.8
-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	4	25.0	0.6	80.6
-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	1	-	-	16	12.5	1.6	38.3
-	4	1	8	4	2	1	3	2	5	1	7	-	-	-	-	3	-	7	3	2	212			
-	-	-	0	1	-	-	-	-	-	-	-	77	-	-	-	1	-	1	2	1	86	89.5	81.1	95.1
-	-	-	1	-	-	-	1	-	-	-	-	-	4	-	-	2	-	-	1	-	15	26.7	7.8	55.1
-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	4	-	-	7	42.9	9.9	81.6
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	0.0	0.0	97.5
2	1	-	-	-	-	-	1	-	-	-	1	1	-	1	-	5	-	1	2	1	23	21.7	7.5	43.7
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0	0.0	97.5
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	24	3	28	85.7	67.3	96.0
-	-	1	-	-	-	1	1	-	-	-	1	1	-	-	1	1	-	3	2	81	99	81.8	72.8	88.9
13	13	10	49	14	7	15	33	12	15	2	49	79	9	4	1	22	2	22	37	91	1,821			
30.8	15.4	0.0	14.3	28.6	14.3	20.0	15.2	8.3	0.0	50.0	4.1	97.5	44.4	75.0	0.0	22.7		0.0	64.9	89.0	Agreement = 47.8%			
9.1	1.9	0.0	5.9	8.4	0.4	4.3	5.1	0.2	0.0	1.3	0.5	91.2	13.7	19.4	0.0	7.8		0.0	47.5	80.7	Kappa = 0.414 (0.404 - 0.421)			
61.4	45.4	30.8	27.2	58.1	57.9	48.1	31.9	38.5	21.8	98.7	14.0	99.7	78.8	99.4	97.5	45.4		15.4	79.8	94.6	Spearman = 0.791 (0.643 - 0.939)			

5. Discussion

5.1 Key findings

- Despite extensive challenges, this study has demonstrated that it was feasible to link independently obtained cause of death information with the vital statistics data. Careful management of SA ID number information enabled the successful linkage of a high proportion of records (93.6%). Prospective recruitment of a random sample of deaths was not possible in this study setting, making it necessary to rely on post-survey weighting of the data.
- This study has found poor agreement in the UCOD reported by Stats SA and the underlying cause of death obtained from alternative data collected for deaths that were registered in 27 randomly selected health sub-districts between 1 September 2017 and 13 April 2018. Only 36.9% of the causes agreed for the 15,367 linked deaths when using a shortened NBD list of 44 causes. The kappa statistic of 0.342 (95% CI 0.339-0.349) indicated minimal agreement and the Spearman rank correlation coefficient of 0.573 (95% CI 0.301-0.844) raises concerns about the agreement at the population level.
- Our findings confirmed that HIV/AIDS was grossly underreported as the UCOD in the official cause of death data and that the injury cause of death data were inaccurate. Problematic causes of death include:
    - HIV/AIDS required a correction factor of 4.418
    - Suicide required a correction factor of 17.392
    - Homicide and road traffic injuries required a correction factor of 2.242 and 2.580, respectively
    - Falls required a correction factor of 8.813.
- Maternal deaths are under-reported in Stats SA data and needed a correction factor of 1.231.
- The cause of death profile in South Africa in 2017/18 was dominated by HIV/AIDS and TB, with these causes accounting for 29.6% of all registered deaths. The profile continued to reflect the quadruple burden of disease[47] with HIV/AIDS and TB, other infections and poverty related conditions (type 1), non-communicable disease (type 2) and injuries (type 3). Stroke (7.7%), hypertensive heart disease (6.3%), and diabetes mellitus (4.6%) were among the leading non-communicable causes while homicide (3.8%), road traffic accidents (3.6%), and suicides (1.7%) fell in the top twenty causes. Lower respiratory infection (3.6%) was the leading other type 1 condition followed by perinatal conditions (1.9%), and diarrhoeal diseases (1.7%).
- The proportion of deaths from HIV/AIDS from this study was higher than anticipated based on observed declines in adult mortality.[48] The Thembisa 4.6 model[49] estimates that for the 12-month period from July 2017 – June 2018, only 12% of deaths were due to AIDS and a further 9% occurred in persons with HIV but due to other causes of death, making a total of 21% with mention of HIV. Data from a rural health and demographic surveillance site[50] observed that HIV and TB together accounted for 17% of the deaths in 2017/18. The cases identified with HIV/AIDS as the UCOD in our sample were reviewed independently and the possibility that HIV/AIDS might have been overstated by our team of clinician reviewers was excluded. However, there are several reasons that might contribute to a higher proportion in this study. Firstly, the weighted NCODV sample aims to represent the registered deaths in the country, and it is known that deaths in rural areas and child deaths are under-represented. Secondly, deaths that occurred in private sector hospitals are not represented. Finally, although the sample was weighted to reflect the characteristics of the Stats SA data, there could be a residual bias towards deaths that occurred in public health facilities. Before applying the post-survey weights, 56.0% of the NCODV sample deaths were recorded to be in facility and this has been weighted down to match the 44.0% in the Stats SA data (with 25.5% considered unknown whether in or out of

facility). HIV/AIDS accounted for 32.9% of the deaths obtained from medical records, and it is possible that there is a residual bias in the cause profile towards deaths that occurred in public health facilities. However, it must be noted that HIV/AIDS accounted for 22.8% of all the VA deaths.

- This study highlighted the strong HIV-TB association, which is still a major public health concern globally, with TB being the main cause of mortality amongst people living with HIV.[51] A recent mathematical modeling analysis estimated that 68.5% of TB deaths in South Africa were attributable to HIV,[52] similar to our finding of 67.5%. A systematic review of postmortem studies suggests that TB is the cause of 40% of facility-based deaths in PLHIV, and that TB is undiagnosed in almost half of these decedents.[53] The high proportion (45.6%) of HIV/AIDS related deaths associated with TB in our study supports this finding and suggests that proactive case finding needs to be strengthened.
- Correction factors could be calculated for national causes of death and applied to the 2017/18 Stats SA cause of death data, resulting in HIV/AIDS moving from rank 6 to the leading cause of death, and homicide and road traffic injuries moving into the top ten causes of death. However, application of the national correction factors at provincial level produced implausible results for HIV in the Western Cape and were not suitable for correcting the injury profiles due to the variability of reporting of suicides across the country. It is necessary to consider how best to utilize this data set for subnational corrections; for example, whether it is possible to consider a different set of weights or whether it is possible to apply provincial correction factors.
- This study has contributed to the ongoing evaluation of VA as an instrument to determine cause of death. We found that physician coded VA provides a reasonable population cause of death profile, particularly for HIV and certain injuries, but it is less useful for other causes and at individual level. The Agincourt Health and Socio-Demographic Surveillance System site,[54] set in the rural northeast region of South Africa, used VA interviews to track causes of death. The site was founded coincidentally in the early stages of the HIV epidemic and the amassed VA data[55] found that VA was effective in detecting a very significant epidemic of HIV-related mortality. A study from Karonga Health and Demographic Surveillance Site[56] located in a rural area of northern Malawi, compared data on HIV status (actual test records and self-report) and the use of ART (clinic records and self-report) to VA data, which had been systematically collected since 2003. The aim was to assess the accuracy and validity of data on HIV status and ART usage reported in VAs and their influence on physician attribution of cause of death. The findings reported that HIV/ART information disclosed during a VA, matched well with other data sources and was reliable. However, Karat *et al.*,[57] published a study using data from HIV-positive adults in Agincourt to estimate the sensitivity and specificity of the existing WHO 2012 VA questionnaire in detecting HIV status. The results showed that CCVA underestimated mortality due to HIV/AIDS. Our study, which made use of the WHO 2016 questionnaire assessed individual and population level agreement of UCOD determined using three computer coded VA algorithms (InterVA-5, InSilicoVA and Tariff 2.0) and physician coded VA as the reference standard. The findings suggest that both physician coded and computer coded VA were able to demonstrate reasonable performance in identifying HIV/AIDS as the leading underlying cause of death.[40] Further investigation into the performance of CCVA for identifying confirmed HIV could be done using the NCODV VA data that are linked with medical records.
- Implementation of VA may be considered for geographic areas where it is not possible for a doctor to certify the cause of death. This would require careful consideration about who is best placed to conduct the interviews and how they should be trained and supported. Timely reporting of cause profiles is important to enable public health responses. Physician coding may provide a more robust cause of death profile than computer coded VA, however it might be important to assess the cost benefit of setting up such a system.
- Our findings highlight the need for improved record quality and adherence to testing guidelines within the medical community. As reported previously,[23] the subjective rating of information quality provided in the medical records by reviewers rated information quality in most records as good to excellent, however a notable proportion received poor to very poor ratings (22.4% for MRs and 14.2% for FPS records) which posed challenges for the study reviewers in determining a cause of death for this study. The reviewers also identified treatment and management concerns in 15% of MRs, with issues primarily related to poor record keeping (51%) inadequate patient assessments and work-up (35%).

- Poor record keeping included incomplete documentation of clinical findings and results. Previous research has identified similar issues with record keeping when conducting archival research. Wegner and Rhoda[58] were only able to locate 39% of patient records in a sample of patients admitted for lower limb amputations and an audit of anesthetic records by Raff and James[59] showed that only 25% were complete and legible. Mutsahtsi *et al.*[60] and Nkoane[61] report the challenges faced by nursing staff in South Africa with respect to adequate record keeping despite clear requirements of the South African Nursing Council (SANC) Rules and Regulation R387 relating to Acts and Omissions.[viii] Whilst the main concern is related to the impact poor record keeping may have on patient management, they also mention the impact on the research and teaching component of the medical profession. The importance of this is well recognized and the South African Medical Protections Society record keeping guidelines[62] suggest that poor record keeping is a significant cause of adverse events. The Health Professions Council of South Africa (HPCSA) has clear guidelines on how patient information should be recorded and retained, as well as the importance of maintaining and retaining these records[63] yet many records fall short of these standards.
- Inadequate patient assessments included situations where certain tests were indicated but not requested or documented, and where missed opportunities for HIV testing and TB testing were identified by the clinical reviewers. Almost half of the reviewed MRs (45%) lacked documentation on HIV or TB status and demonstrated missed opportunities for HIV and TB testing which is not in keeping with current testing and treatment guidelines.[64] Beckwith *et al.*[65] recently highlighted the under investigation of TB even in patients with advanced HIV. The inadequate identification and management of TB was recognized to have worsened during the COVID-19 pandemic, motivating the National Department of Health to introduce a TB recovery plan[66] to locate "missing" patients with TB[67] as part of a multi-pronged strategy including improved linkage to care and improving data systems.

5.2 Study limitations

- The sampling strategy in the first phase of the study aimed to recruit a prospective sample of deaths in the 27 sub-districts that were selected. Despite being successful in the pilot study that was undertaken, the response was very low in the selected areas, making it necessary to extend the study recruitment period and revise the sampling strategy. While enough deaths were obtained to validate Stats SA data, based on the original sample size calculation, it was necessary to introduce a post-survey weight to calculate correction factors. The stratification for these weights was not ideal as the sub-district level information was not available leaving a potential bias in the results.
- The study included data from public sector hospitals only. It is unknown what proportion of deaths occur in private health facilities and how this would bias the results.
- Due to the large number of MRs obtained during Phase 2 of data collection, it was not necessary to review all of them to provide an adequate number of records. All the deaths that occurred in 2017, but only those with a corresponding VA or FPS for the decedent for deaths that occurred in 2018 were reviewed. It is unknown how this would bias the results.

viii *Chapter 2 Section 5 of the Rules setting out the acts or omissions in respect of which the Council may take disciplinary steps includes "Willful or negligent omission to keep clear and accurate records of all actions which he performs in connection with a patient: https://www.sanc.co.za/r387/#:~:text=A%20nurse%20may%20not%20impede,to%20consult%20such%20a%20person.*

- Permission to collect data from FPS facilities could not be secured from the KwaZulu-Natal Department of Health. This may have resulted in bias in the national injury cause of death profile, and the overall provincial cause of death profile estimated for KwaZulu-Natal, despite the introduction of post-analysis weights.
- Despite the large number of cases in the study, it was necessary to analyze the data with a burden of disease short list of 44 causes, making it impossible to assess the performance of vital statistics for the less frequent and some specific causes of death.
- This project was a very large national study using methodology that had never been used in South Africa before and made the planning and budgeting difficult. Additional time and resources were required to complete all objectives.

5.3 Study strengths

- Cause of death data of high quality has been collected from across the country, independently of CRVS.
    - Thorough training of doctors to identify the underlying cause of death and conduct the reviews of verbal autopsies and medical and forensic pathology records was undertaken.
    - Materials from previous trainings for doctors in medical certification provided the basis for the training of study doctors, together with input that was provided by experienced collaborators during pre-testing phases.
    - The fieldwork to collect facility records was very well prepared, conducted, and monitored. There was a low refusal rate by facilities to participate – only the 3 FPS facilities in KwaZulu-Natal did not provide permission for data collection.
    - Digital data collection tools using KoBoToolbox enabled ongoing monitoring and immediate identification of data quality issues. This QA has ensured high quality data.
- This study provides the cause specific mortality fractions for South Africa, based on empirical data.
- The project has built capacity for cause of death determination, a health system strengthening activity, which will remain beyond the study. In particular, an online course in medical certification of cause of death has been made available (*death certification training*), with continuing education units (CEU) for doctors who satisfactorily complete an assessment.
- In addition to the cause of death profile, the data collected for this project provides a wealth of information about the performance of verbal autopsies, and opportunities to assess automated algorithms in comparison with physician coded cause of death, and information from medical and forensic pathology records.

6. Considerations

6.1 Strengthen efforts to reduce HIV and TB mortality

6.1.1 Improve prevention and treatment of HIV and TB

Despite a dramatic decline in HIV/AIDS-related mortality since 2006, attributable to ART, HIV/AIDS remains the leading cause of death in South Africa followed by TB. This study supports previous research suggesting that there are missed opportunities for case finding for HIV and TB during hospital admissions,[65] and that proactive case finding could be encouraged.

6.1.2 Reduce underreporting of HIV on death notifications

HIV status is severely underreported on death notifications, with only 26% of in-facility deaths with medical records documenting an HIV-related death having HIV/AIDS reported on the death notification form. Additional attention to ensure that doctors provide correct information about the medical cause of death on the DHA-1663 may help to resolve this. Encouraging doctors to complete the online training in medical certification and ongoing checking of the medical certificates could be integrated in routine mortality and morbidity review sessions in each hospital's death notifications.

6.2 Careful interpretation of official cause of death data is needed

This study has identified extensive discordance between cause of death profile in 2017/18 based on the official data and the data collected independently. It suggests that careful interpretation of the official data is required before using it for planning or resource allocation. It is important to use a Burden of Disease approach making use of multiple sources of data to develop consistent and coherent cause of death profiles.

6.3 Opportunity for key partners responsible for CRVS to develop a shared vision and road map for improving the cause of death data

The development of a shared vision between key partners responsible for CRVS and users of the information is one important step in ensuring that the cause of death information is fit for purpose. A number of possible solutions are suggested below, some of which could be implemented immediately by the relevant institution and others which would require collaboration and cooperation between the key stakeholders.

6.3.1 Expand the training of doctors in medical certification, ideally as part of medical curriculum

The high quality of the cause of death information provided by the study doctors emphasizes the importance of training doctors in the ICD principles of underlying cause of death and how to complete the medical certificate. The training resources used for this study have been adapted into an online training platform that will enable self-learning and assessment offering ethics CEUs which would provide an incentive for both public and private doctors to complete the course (www.deathcertification.org). It could be ideal if medical certification of cause of death could be included in the medical curriculum. The platform could be tested and evaluated for use in academic settings during medical training (under-graduate and internships). The online platform could also be made a requirement in the public sector during compulsory community service year and when doctors are newly appointed in both the public and private sectors.

6.3.2 *Amend the DHA-1663 to include manner of death*

The discordant COD profile for injury related deaths identified from the FPS records and that reported by Stats SA highlights the importance of amending the DHA-1663 to include a field for information about the manner of death. This could serve to improve South Africa's official data and also align the death notification form with the International Medical Certificate of Death recommended by the International Statistical Classification of Diseases and Related Health Problems (ICD-10).[29]

6.3.3 *Record keeping standards in hospitals*

A common concern flagged by clinical reviewers was around poor quality of record keeping including inadequate recording of patient history and presenting complaints, lack of clear documentation regarding medical management, missing or incomplete test results, illegible handwriting, and use of non-standard medical abbreviations. The Health Professions Council of South Africa has issued *Guidelines on the keeping of patient records* (Booklet 9 of the Guidelines for good practice in the health care professions).[63] This guideline outlines the elements of clinical records but may benefit by adding additional details. The Medical Protection Society Guide on Medical Records in South Africa[62] emphasizes the purpose of medical records in supporting continuity of care and highlights medico-legal aspects of keeping records. While these guidelines will be helpful, it may be useful for facilities to ensure that they have procedures in place to monitor record-keeping standards.

6.3.4 *Routine collection of facility-based death data*

Since large numbers of deaths occur in health facilities and FPS, implementing systems for the routine capture of information about such deaths could improve the accuracy and timeliness of mortality data. Data on the numbers and causes of deaths in facilities would provide important outcome measures which could then be monitored in all facilities and provide opportunities for health services to improve care and programs to improve resource allocation.

6.3.5 *Digitisation of medical certification of cause of death*

Timeous cause of death information is critical for planning health services and to enable public health responses. Electronic death registration has been implemented in a growing number of countries and proved valuable during the COVID-19 pandemic to inform their response. Future initiatives may include engaging with key partners responsible for CRVS, including Departments of Health and Home Affairs, to develop a secure electronic medical certification of cause of death with a view to establish an electronic death registration system.

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8. Annexure

8.1 Data management

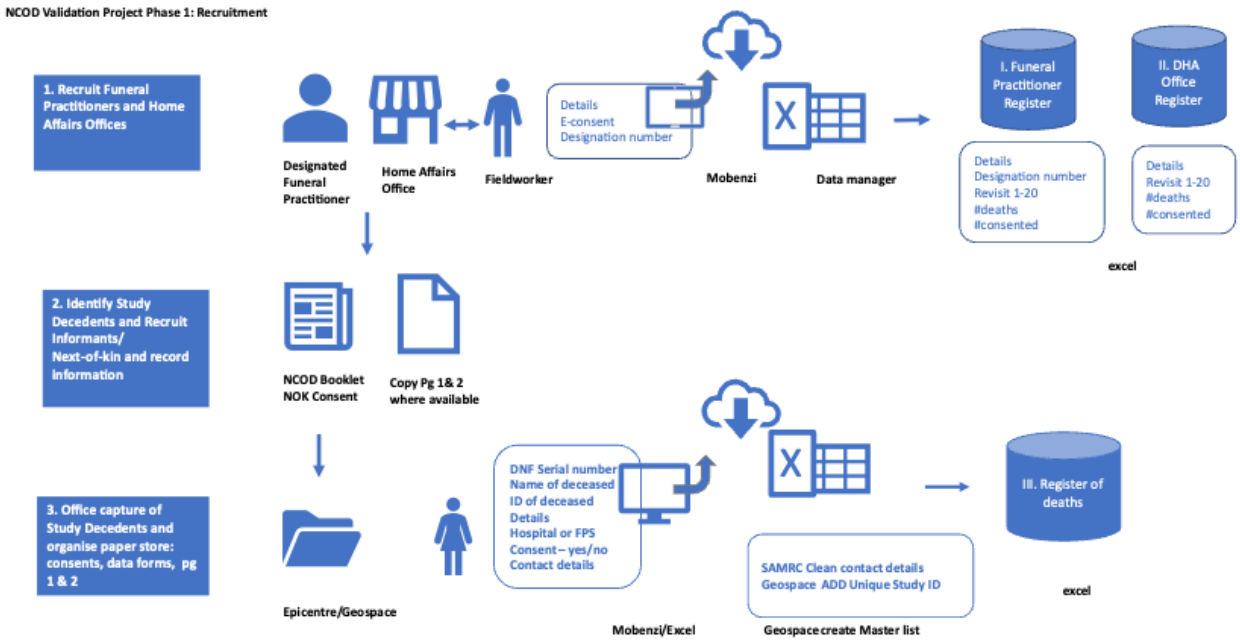


Figure A1: Information flow during Phase 1 of data collection.

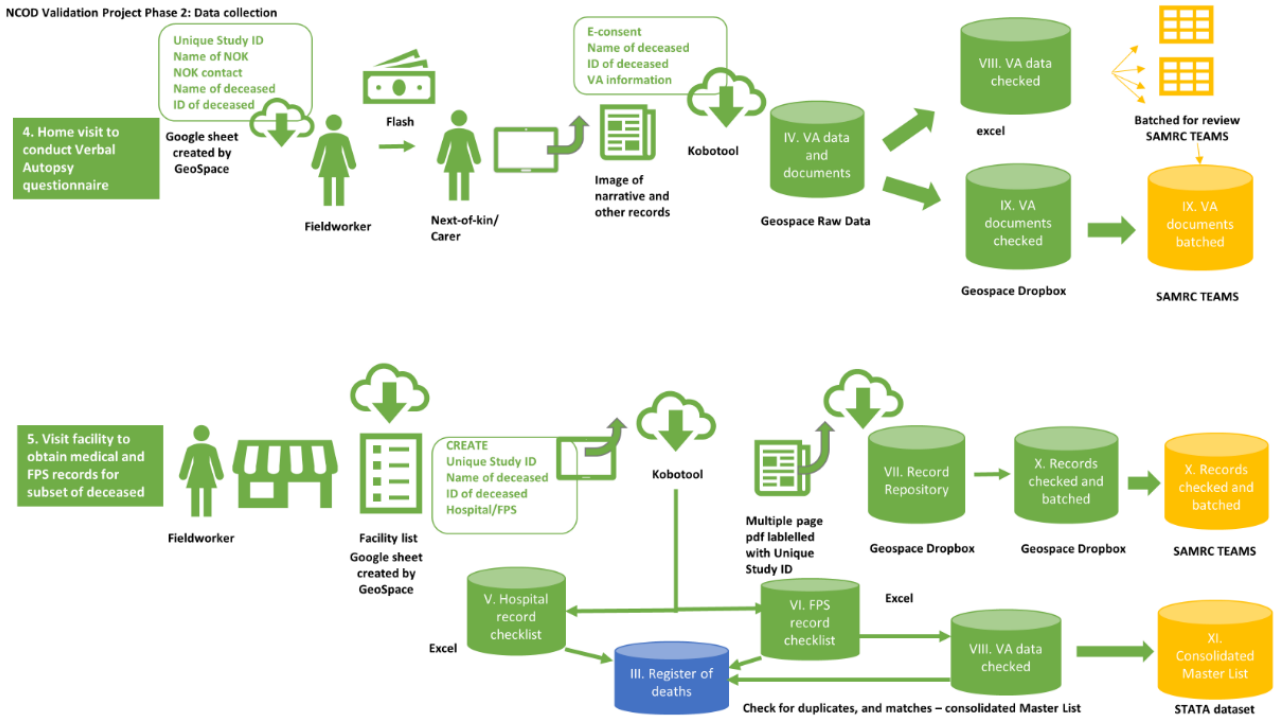


Figure A2: Information flow during Phase 2 of data collection.

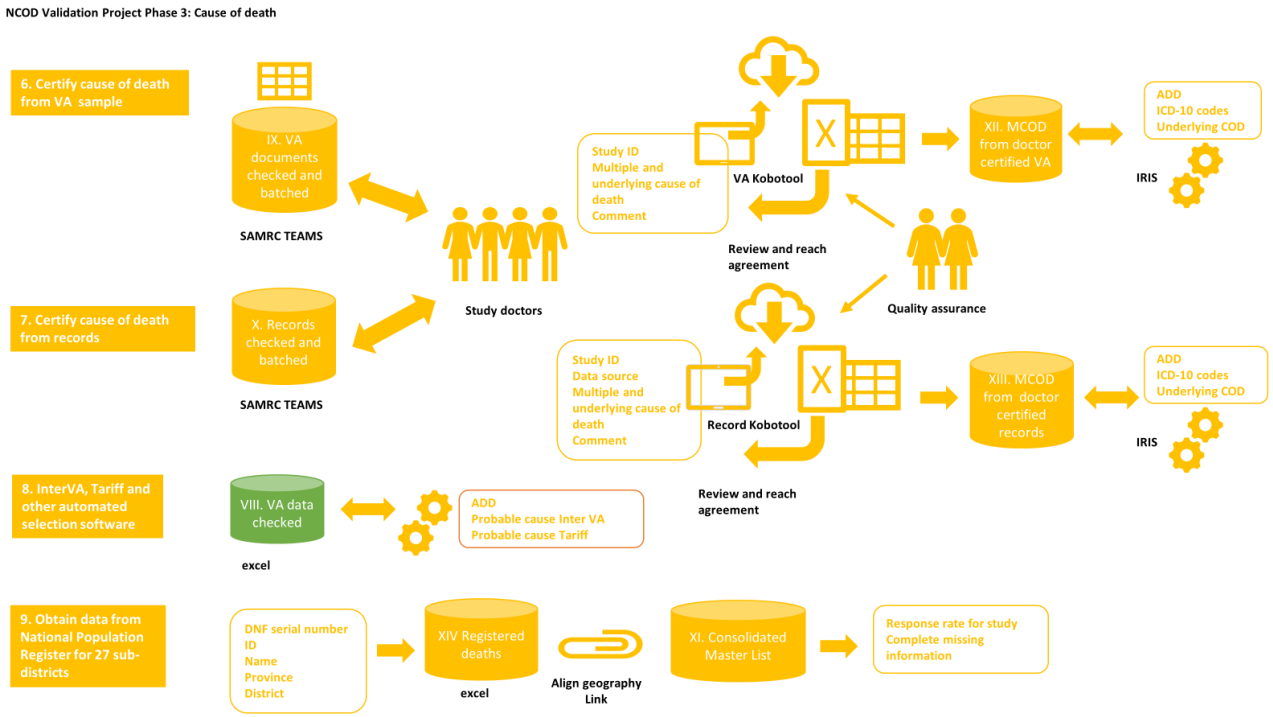


Figure A3: Data management during clinical review of VAs, MR and FPS records.

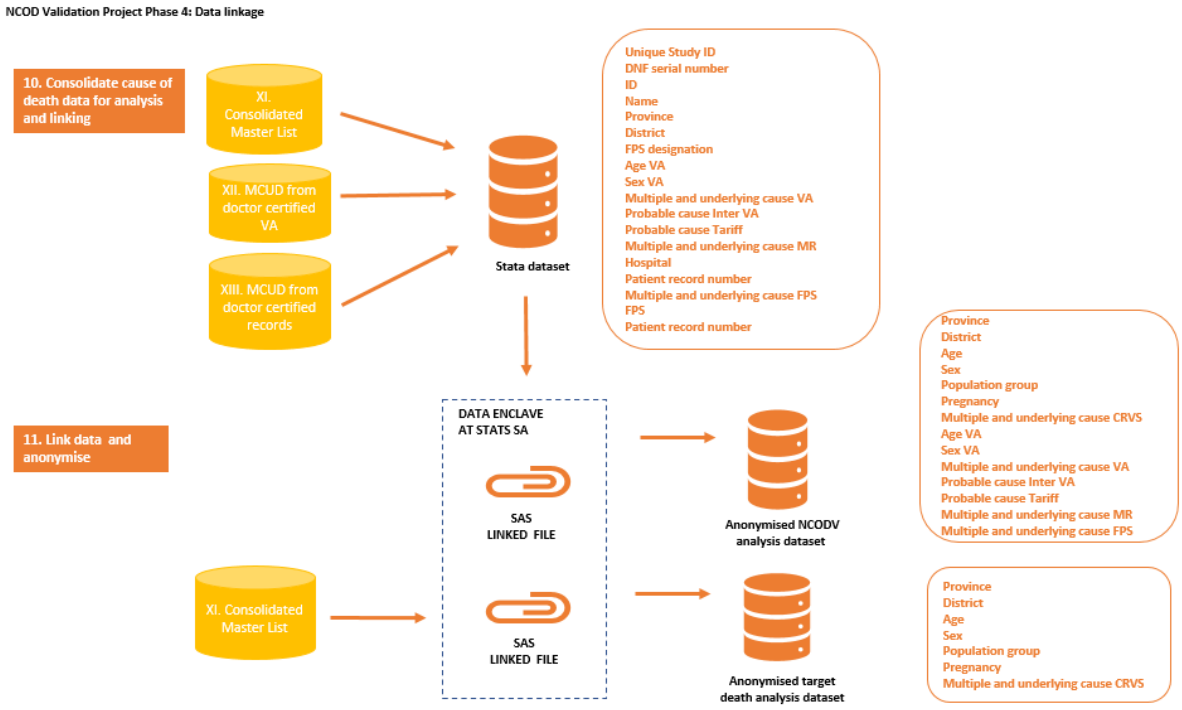


Figure A4: Data management during data linkage.

8.2 Disease lists for analysis

A basic National Burden of Disease (NBD) list, aligned to the South African National Burden of Disease list (available at *https://www.samrc.ac.za/sites/default/files/files/2016-07-04/SANBDReport.pdf*), has been developed for the analysis of the data. The basic NBD list has 143 conditions (Table A1) and is similar to the aggregation in the NBD list but does not make any assumptions about misclassification of causes and includes categories for ill-defined conditions.

Table A1: ICD-10 codes for each category of the basic NBD list.

Basic NBD list		ICD-10 code
1	Tuberculosis	A15 - A19; U51 & U52; B90; J90
2	STD/excl HIV	A50 - A64; N70 - N73
3	HIV/AIDS	B20 - B24; C46
4	Diarrhoeal diseases	A00 - A04; A06 - A09
5	Childhood (vaccine preventable) cluster	A33 - A37; A80; B03; B05; B06; B91
6	Bacterial meningitis	A39; G00; G03
7	Hepatitis	B15 - B19
8	Malaria	B50 - B54
9	Schistosomiasis and other tropical diseases	B55 - B56; B65; B74
10	Leprosy	A30; B92
11	Intestinal parasites	B76 - B81
12	Septicaemia	A40; A41
13	Other infectious and parasitic	A05; A20 – A28; A31; A32; A38; A42 – A49; A65 - A69; A70 - A74; A75 - A79; A81 - A89; A90 - A99; B00 - B02; B04; B07 - B09; B25 - B34; B35 - B49; B57 – B64; B66 – B73; B75; B82 – B89; B94 – B99
14	Lower respiratory infections	J09 - J18; J20 - J22
15	Upper respiratory infections	J00 - J06
16	Otitis media	H65; H66
17	Maternal haemorrhage	O20; O44 - O46; O67; O72
18	Maternal sepsis	O85
19	Hypertension in pregnancy	O10 - O16
20	Obstructed labour	O64 - O66
21	Abortion	O00 - O08
22	Other maternal	O21 - O29; O30 - O43; O47 - O48; O60 - O63; O68 - O71; O73 - O75; O80 - O84; O86 - O92; O95 - O99
23	Low birth weight	P05 - P07; P22
24	Birth asphyxia and trauma	P03; P10 - P15; P20 - P21
25	Other perinatal respiratory conditions	P23 - P29
26	Neonatal infections	P35 - P39
27	Other perinatal	P00 - P02; P04; P08; P29; P50 - P61; P70 - P94; P96
28	Ill-defined perinatal	P95
29	Protein-energy malnutrition	E40 - E46; D50 - D53; D64

Basic NBD list		ICD-10 code
31	Pellagra and other nutritional deficiencies	E00 - E02; E50 - E64
32	Mouth and oropharynx ca	C00 - C14
33	Oesophagus ca	C15
34	Stomach ca	C16
35	Colo-rectal ca	C18 - C21
36	Liver ca	C22
37	Pancreas ca	C25
38	Larynx ca	C32
39	Trachea/bronchi/lung ca	C33 - C34
40	Bone and connective tissue ca	C40; C41; C47; C49
41	Melanoma of skin	C43
42	Other skin cancer	C44
43	Breast ca	C50
44	Cervix ca	C53
45	Corpus uteri ca	C54; C55
46	Ovary ca	C56
47	Prostate ca	C61
48	Bladder ca	C67
49	Kidney ca	C64 - C66; C68
50	Brain ca	C71
51	Lymphoma	C81 - C90; C96
52	Leukemia	C91 - C95
53	Other malignant neoplasms	C17; C23 - C24; C26; C30 - C31; C37 - C39; C45; C48; C51 - C52; C57 - C58; C60; C62 - C63; C69 - C70; C72 - C75
54	Ill-defined cancers	C76 - C80; C97
55	Benign neoplasms	D00 - D48
56	Diabetes mellitus	E10 - E14
57	Albinism	E70
58	Other endocrine and metabolic	D55 - D63; D65 - D89; E03 - E07; E15 - E16; E20 - E34; E65 - E68; E71 - E89
59	Alcohol dependence	F10
60	Drug use	F11 - F16; F18 - F19
61	Schizophrenia	F20 - F29
62	Unipolar	F32 - F33
63	Bipolar	F30 - F31
64	Anorexia Nervosa	F50
65	Obsessive compulsive/ panic disorders	F40 - F42
66	Hyperkinetic disorders	F90
67	Adjustment reaction (PTSS)	F43
68	Mental disability	F70 - F79

Basic NBD list		ICD-10 code
69	Other mental disorders	F17; F34 - F39; F44 - F48; F51 - F59; F60 - F69; F80 - F89; F91 - F98; F99
70	Alzheimer and other dementias	G30 - G31; F01 - F09
71	Parkinson'sParkinson's disease	G20 - G21
72	Multiple sclerosis	G35
73	Epilepsy	G40 - G41
74	Encephalitis and brain abscess	G04; G06; G09
75	Other nervous system disorders	G08; G10 - G12; G23 - G25; G36 - G37; G36 - G37; G43 - G47; G50 - G58; G60 - G64; G70 - G72; G80 - G83; G90 - G98
76	Glaucoma	H40
77	Cataracts	H25 - H26
78	Other visual disorders	H00 - H21; H27 - H35; H42 - H59
79	Hearing loss and other ear disorders	H60 - H62; H68 - H95
80	Rheumatic heart disease	I01 - I09
81	Ischaemic heart disease	I20 - I25
82	Stroke	I60 - I69
83	Inflammatory heart disease	I30; I33; I38; I40; I42
84	Hypertensive heart disease	I10 - I13
85	Non-rheumatic valvular disease	I34 - I37
86	Pulmonary embolism	I26
87	Aortic aneurism	I71
88	Peripheral vascular disorders	I72 - I78; I80 - I84; I86 - I89;
89	Other cardiovascular	I00; I28; I31; I44 - I45; I95 - I99
90	Ill-defined cardio - heart failure etc	I46 - I49; I50 - I51; J81
91	Atherosclerosis	I70
92	COPD	J40 - J44; I27
93	Asthma	J45 - J46
94	Aspiration pneumonia/ lung abscess	J69; J85 - J86
95	Other respiratory	J30 - J39; J47; J60 - J68; J70; J80; J82 - J84; J92 - J98
96	Peptic ulcer	K25 - K28
97	Appendicitis	K35 - K37
98	Noninfective gastroenteritis and colitis	K50 - K52
99	Cirrhosis of liver	K70; K74; K76; I85
100	Hepatic failure	K72
101	Gall bladder disease	K80 - K83
102	Pancreatitis	K85; K86
103	Other digestive	K20 - K22; K29 - K31; K38; K40 - K46; K55; K66; K71; K73; K75; K90; K91
104	Ill-defined digestive	K92
105	Nephritis/nephrosis	N00 - N19
106	Benign prostatic hypertrophy	N40
107	Other genito-urinary	N20 - N23; N25 - N39; N41 - N50; N60 - N64; N75 - N98

Basic NBD list		ICD-10 code
108	Skin disease	L00 - L98
109	Rheumatoid arthritis	M05 - M06
110	Osteoarthritis	M15 - M19
111	Other musculo-skeletal	M00 - M02; M08; M10 - M13; M20 - M99
112	Neural tube defects	Q00 - Q07
113	Cleft lip/palate	Q35 - Q37
114	Congenital heart disease	Q20 - Q28
115	Congenital disorders of GIT	Q38 - Q45
116	Down syndrome and other chromosomal anomalies	Q90 - Q99
117	Fetal alcohol syndrome	Q86
118	Other congenital abnormalities	Q10 - Q18; Q30 - Q34; Q50 - Q56; Q60 - Q64; Q65 - Q79; Q80 - Q85; Q87
119	Ill-defined congenital	Q89
120	Dental caries	K02
121	Periodontal disease	K05
122	Other oral health	K00; K01; K03; K04; K06 - K14
123	Cot death	R95
124	Ill-defined natural	R00 - R09; R10 - R19; R20 - R23; R25 - R29; R30 - R39; R40 - R46; R47 - R49; R50 - R69; R70 - R79; R80 - R82; R83 - R94; R96 - R98; R99
125	Road traffic accidents	V01 - V04; V06; V09 - V80; V87; V89; V99
126	Non motor vehicle traffic accidents	V05; V81 - V86; V88; V90 - V94; V95 - V98
127	Mining accidents	Y37
128	Poisoning	X40 - X49
129	Surgical / medical misadventure	Y60 - Y69; Y70 - Y82; Y83 - Y84; Y88
130	Falls	W00 - W19
131	Fires	X00 - X09
132	Natural and environmental factors	W53 - W64; X20 - X29; X30 - X39; X50 - X57
133	Drowning	W65 - W74
134	Suffocation and foreign bodies	W75 - W84
135	Other unintentional injuries specified	W20 - W49; W50 - W52; W85 - W99; X10 - X19; X58; Y38; Y39; Y40 - Y59
136	Ill-defined transport	Y85
137	Ill-defined other unintentional	X59; Y86
138	Undetermined whether intentional or unintentional	Y10 - Y34; Y87; Y89
139	Suicide	X60 - X84
140	Homicide with firearm	X93 - X95
141	Homicide without firearm	X85 - X92; X96 - X99; Y00 -Y08
142	Ill-defined homicide	Y09
143	War	Y35; Y36

Table A2: ICD-10 codes for each category of the VA list.

VA List		ICD-10 code
101	Sepsis	A40 - A41
102	Acute respiratory infection, including pneumonia	J00 - J22
103	HIV/AIDS related death	B20 - B24
104	Diarrhoeal diseases	A00 - A09
105	Malaria	B50 - B54
106	Measles	B05
107	Meningitis and encephalitis	A39; G00 - G05
108	Tetanus	A33 - A35
109	Pulmonary tuberculosis	A15 - A16; U51 - U52
110	Pertussis	A37
111	Haemorrhagic fever	A92 - A99
112	Dengue fever	A91
199	Other and unspecified infectious disease	A17 - A19; A20 - A38; A42 - A44; A46; A48 - A89; B00 - B19; B25- B49; B55 - B99
201	Oral neoplasms	C00 - C06
202	Digestive neoplasms	C15 - C26
203	Respiratory neoplasms	C30 - C39
204	Breast neoplasms	C50
205	Female reproductive neoplasms	C51 - C58
206	Male reproductive neoplasms	C60 - C63
299	Other and unspecified neoplasms	C07 - C14; C40 - C49; C60 - D48
301	Severe anaemia	D50 - D64
302	Severe malnutrition	E40 - E46
303	Diabetes mellitus	E10 - E14
401	Acute cardiac disease	I20 - I25
402	Stroke	I60 - I69
403	Sickle cell with crisis	D57
499	Other and unspecified cardiac disease	I00 - I09; I10 - I15; I26 - I52; I70 - I99
501	Chronic obstructive pulmonary disease (COPD)	J40 - J44
502	Asthma	J45 - J46
601	Acute abdomen	K35 - K37; K40 - K46; K56; R10
602	Liver cirrhosis	K70 - K76
701	Renal failure	N17 - N19
801	Epilepsy	G40 - G41
9800	Other and unspecified non-communicable disease	D55 - D89; E00 - E07; E15 - E35; E50 - E90; F00 - F99; G06 - G09; G10 - G37; G43 - G47; G50 - G99; H00- H95; J30 - J39; J47 - J99; K00 - K31; K35- K38; K40 - K93; L00 - L99; M00 - M99; N00- N16; N20 - N99; R00 - R09; R11 - R94
901	Ectopic pregnancy	O00
902	Abortion-related death	O03 - O08

VA List		ICD-10 code
903	Pregnancy-induced hypertension	O10 - O16
904	Obstetric haemorrhage	O46; O67; O72
905	Obstructed labour	O63; O66
906	Pregnancy-related sepsis	O85
907	Anaemia of pregnancy	O99
908	Ruptured uterus	O71
999	Other and unspecified maternal cause	O01 - O02; O20 - O45; O47 - O62; O68 - O70; O73 - O75; O76 - O84; O86 - O98
1001	Prematurity	P05 - P07
1002	Birth asphyxia	P20 - P22
1003	Neonatal pneumonia	P23 - P25
1004	Neonatal sepsis	P36
1005	Neonatal tetanus	A33
1006	Congenital malformation	Q00 - Q99
1099	Other and unspecified perinatal cause of death	P00 - P04; P08 - P15; P26 - P35; P37 - P94; P96
1100	Stillbirths	P95
1201	Road traffic accident	V01 - V89
1202	Other transport accident	V90 - V99
1203	Accidental fall	W00 - W19
1204	Accidental drowning and submersion	W65 - W74
1205	Accidental exposure to smoke, fire and flames	X00 - X19
1206	Contact with venomous animals and plants	X20 - X29
1207	Accidental poisoning and exposure to noxious substance	X40 - X49
1208	Intentional self-harm	X60 - X84
1209	Assault	X85 - Y09
1210	Exposure to force of nature	X30 - X39
1299	Other and unspecified external cause of death	S00 - T99; W20 - W64; W75 - W99; X50 - X59; Y10 - Y98
9900	Cause of death unknown	R95 - R99

A shortened list of 44 categories, based on an aggregation of the 145 categories in the basic NBD list as shown in Table A3 was used for the analysis of the NCODV sample and a shortened list of 25 categories based on the VA list was used to assess the agreement between PCVA and the algorithms (Table A4).

Table A3: Mapping of the NBD short list to the basic NBD list and ICD-10 codes.

NBD shortlist		Basic NBD list		ICD-10 code
1	Tuberculosis	1	Tuberculosis	A15 - A19; U51 & U52; B90; J90
2	HIV/AIDS	3	HIV/AIDS	B20 - B24; C46
3	Diarrhoea	4	Diarrhoeal diseases	A00 - A04; A06 - A09
4	Pneumonia	14	Lower respiratory infections	J09 - J18; J20 - J22
5	Maternal	17	Maternal haemorrhage	O20; O44 - O46; O67; O72
		18	Maternal sepsis	O85
		19	Hypertension in pregnancy	O10 - O16
		20	Obstructed labour	O64 - O66
		21	Abortion	O00 - O08
		22	Other maternal	O21 - O29; O30 - O43; O47 - O48; O60 - O63; O68 - O71; O73 - O75; O80 - O84; O86 - O92; O95 - O99
6	Perinatal	23	Low birth weight	P05 - P07; P22
		24	Birth asphyxia and trauma	P03; P10 - P15; P20 - P21
		25	Other perinatal respiratory conditions	P23 - P29
		26	Neonatal infections	P35 - P39
		27	Other perinatal	P00 - P02; P04; P08; P29; P50 - P61; P70 - P94; P96
		28	Ill-defined perinatal	P95
7	Malnutrition	29	Protein-energy malnutrition	E40 - E46; D50 - D53; D64
		31	Pellagra and other nutritional deficiencies	E00 - E02; E50 - E64
8	Other type 1 conditions	2	STD/excl HIV	A50 - A64; N70 - N73
		5	Childhood (vaccine preventable) cluster	A33 - A37; A80; B03; B05; B06; B91
		6	Bacterial meningitis	A39; G00; G03
		7	Hepatitis	B15 - B19
		8	Malaria	B50 - B54
		9	Schistosomiasis and other tropical diseases	B55 - B56; B65; B74
		10	Leprosy	A30; B92
		11	Intestinal parasites	B76 - B81
		12	Septicaemia	A40; A41
		13	Other infectious and parasitic	A05; A20 – A28; A31; A32; A38; A42 – A49; A65 - A69; A70 - A74; A75 - A79; A81 - A89; A90 - A99; B00 - B02; B04; B07 - B09; B25 - B34; B35 - B49; B57 – B64; B66 – B73; B75; B82 – B89; B94 – B99
		15	Upper respiratory infections	J00 - J06
		16	Otitis media	H65; H66

NBD shortlist		Basic NBD list		ICD-10 code
9	Oesophagus ca	33	Oesophagus ca	C15
10	Trachea/ bronchi/lung ca	39	Trachea/bronchi/lung ca	C33 - C34
11	Breast ca	43	Breast ca	C50
12	Cervix ca	44	Cervix ca	C53
13	Prostate ca	47	Prostate ca	C61
14	Other ca	32	Mouth and oropharynx ca	C00 - C14
		34	Stomach ca	C16
		35	Colo-rectal ca	C18 - C21
		36	Liver ca	C22
		37	Pancreas ca	C25
		38	Larynx ca	C32
		40	Bone and connective tissue ca	C40; C41; C47; C49
		41	Melanoma of skin	C43
		42	Other skin cancer	C44
		45	Corpus uteri ca	C54; C55
		46	Ovary ca	C56
		48	Bladder ca	C67
		49	Kidney ca	C64 - C66; C68
		50	Brain ca	C71
		51	Lymphoma	C81 - C90; C96
		52	Leukemia	C91 - C95
		53	Other malignant neoplasms	C17; C23 - C24; C26; C30 - C31; C37 - C39; C45; C48; C51 - C52; C57 - C58; C60; C62 - C63; C69 - C70; C72 - C75
		55	Benign neoplasms	D00 - D48
15	Ill-defined cancers	54	Ill-defined cancers	C76 - C80; C97
16	Diabetes mellitus	56	Diabetes mellitus	E10 - E14
17	Epilepsy	73	Epilepsy	G40 - G41
18	Ischaemic heart disease	81	Ischaemic heart disease	I20 - I25
19	Stroke	82	Stroke	I60 - I69
20	Inflammatory heart disease	83	Inflammatory heart disease	I30; I33; I38; I40; I42
21	Hypertensive heart disease	84	Hypertensive heart disease	I10 - I13
22	Peripheral vascular disorders	88	Peripheral vascular disorders	I72 - I78; I80 - I84; I86 - I89;

NBD shortlist		Basic NBD list		ICD-10 code
23	Ill-defined cardiovascular conditions	90	Ill-defined cardio - heart failure etc	I46 - I49; I50 - I51; J81
24	Other cardiovascular	80	Rheumatic heart disease	I01 - I09
		85	Non-rheumatic valvular disease	I34 - I37
		86	Pulmonary embolism	I26
		87	Aortic aneurism	I71
		89	Other cardiovascular	I00; I28; I31; I44 - I45; I95 - I99
		91	Atherosclerosis	I70
25	COPD	92	COPD	J40 - J44; I27
26	Other chronic respiratory	93	Asthma	J45 - J46
		94	Aspiration pneumonia/ lung abscess	J69; J85 - J86
		95	Other respiratory	J30 - J39; J47; J60 - J68; J70; J80; J82 - J84; J92 - J98
27	Peptic ulcer	96	Peptic ulcer	K25 - K28
28	Cirrhosis of liver	99	Cirrhosis of liver	K70; K74; K76; I85
29	Other digestive	97	Appendicitis	K35 - K37
		98	Noninfective gastroenteritis and colitis	K50 - K52
		100	Hepatic failure	K72
		101	Gall bladder disease	K80 - K83
		102	Pancreatitis	K85; K86
		103	Other digestive	K20 - K22; K29 - K31; K38; K40 - K46; K55; K66; K71; K73; K75; K90; K91
		104	Ill-defined digestive	K92
30	Nephritis/ nephrosis	105	Nephritis/nephrosis	N00 - N19
31	Other genito-urinary	106	Benign prostatic hypertrophy	N40
		107	Other genito-urinary	N20 - N23; N25 - N39; N41 - N50; N60 - N64; N75 - N98
32	Congenital	112	Neural tube defects	Q00 - Q07
		113	Cleft lip/palate	Q35 - Q37
		114	Congenital heart disease	Q20 - Q28
		115	Congenital disorders of GIT	Q38 - Q45
		116	Down syndrome and other chromosomal anomalies	Q90 - Q99
		117	Fetal alcohol syndrome	Q86
		118	Other congenital abnormalities	Q10 - Q18; Q30 - Q34; Q50 - Q56; Q60 - Q64; Q65 - Q79; Q80 - Q85; Q87
		119	Ill-defined congenital	Q89

NBD shortlist		Basic NBD list		ICD-10 code
33	Other type 2 conditions	57	Albinism	E70
		58	Other endocrine and metabolic	D55 - D63; D65 - D89; E03 - E07; E15 - E16; E20 - E34; E65 - E68; E71 - E89
		59	Alcohol dependence	F10
		60	Drug use	F11 - F16; F18 - F19
		61	Schizophrenia	F20 - F29
		62	Unipolar	F32 - F33
		63	Bipolar	F30 - F31
		64	Anorexia Nervosa	F50
		65	Obsessive compulsive/ panic disorders	F40 - F42
		66	Hyperkinetic disorders	F90
		67	Adjustment reaction (PTSS)	F43
		68	Mental disability	F70 - F79
		69	Other mental disorders	F17; F34 - F39; F44 - F48; F51 - F59; F60 - F69; F80 - F89; F91 - F98; F99
		70	Alzheimer and other dementias	G30 - G31; F01 - F09
		71	Parkinson'sParkinson's disease	G20 - G21
		72	Multiple sclerosis	G35
		74	Encephalitis and brain abscess	G04; G06; G09
		75	Other nervous system disorders	G08; G10 - G12; G23 - G25; G36 - G37; G36 - G37; G43 - G47; G50 - G58; G60 - G64; G70 - G72; G80 - G83; G90 - G98
		76	Glaucoma	H40
		77	Cataracts	H25 - H26
		78	Other visual disorders	H00 - H21; H27 - H35; H42 - H59
		79	Hearing loss and other ear disorders	H60 - H62; H68 - H95
		108	Skin disease	L00 - L98
		109	Rheumatoid arthritis	M05 - M06
		110	Osteoarthritis	M15 - M19
		111	Other musculo-skeletal	M00 - M02; M08; M10 - M13; M20 - M99
		120	Dental caries	K02
		121	Periodontal disease	K05
		122	Other oral health	K00; K01; K03; K04; K06 - K14
34	Ill-defined natural	123	Sudden infant death syndrome (formerly cot death)	R95
		124	Ill-defined natural	R00 - R09; R10 - R19; R20 - R23; R25 - R29; R30 - R39; R40 - R46; R47 - R49; R50 - R69; R70 - R79; R80 - R82; R83 - R94; R96 - R98; R99

NBD shortlist		Basic NBD list		ICD-10 code
35	Transport accidents	125	Road traffic accidents	V01 - V04; V06; V09 - V80; V87; V89; V99
		126	Non motor vehicle traffic accidents	V05; V81 - V86; V88; V90 - V94; V95 - V98
		136	Ill-defined transport	Y85
36	Falls	130	Falls	W00 - W19
37	Fires	131	Fires	X00 - X09
38	Drowning	133	Drowning	W65 - W74
40	Other unintentional injuries specified	127	Mining accidents	Y37
		128	Poisoning	X40 - X49
		129	Surgical / medical misadventure	Y60 - Y69; Y70 - Y82; Y83 - Y84; Y88
		132	Natural and environmental factors	W53 - W64; X20 - X29; X30 - X39; X50 - X57
		134	Suffocation and foreign bodies	W75 - W84
		135	Other unintentional injuries specified	W20 - W49; W50 - W52; W85 - W99; X10 - X19; X58; Y38; Y39; Y40 - Y59
		137	Ill-defined other unintentional	X59; Y86
42	Undetermined intent	138	Undetermined whether intentional or unintentional	Y10 - Y34; Y87; Y89
43	Suicide	139	Suicide	X60 - X84
44	Homicide	140	Homicide with firearm	X93 - X95
		141	Homicide without firearm	X85 - X92; X96 - X99; Y00 -Y08
		142	Ill-defined homicide	Y09
		143	War	Y35; Y36

Table A4: Mapping of VA short list (25) to WHO VA list and ICD-10 codes.

VA shortlist		VA codelist		ICD-10 codes
1	Pneumonia	102	Acute respiratory infection, including pneumonia	J00 - J22
2	HIV/AIDS	103	HIV/AIDS related death	B20 - B24
3	Diarrhoea	104	Diarrhoeal diseases	A00 - A09
4	Tuberculosis	109	Pulmonary tuberculosis	A15 - A16; U51 - U52
5	Other infectious diseases	105	Malaria	B50 - B54
		101	Sepsis	A40 - A41
		106	Measles	B05
		107	Meningitis and encephalitis	A39; G00 - G05
		108	Tetanus	A33 - A35
		110	Pertussis	A37
		111	Haemorrhagic fever	A92 - A99
		112	Dengue fever	A91
		199	Other and unspecified infectious disease	A17 - A19; A20 - A38; A42 - A44; A46; A48 - A89; B00 - B19; B25- B49; B55 - B99
6	Maternal	901	Ectopic pregnancy	O00
		902	Abortion-related death	O03 - O08
		903	Pregnancy-induced hypertension	O10 - O16
		904	Obstetric haemorrhage	O46; O67; O72
		905	Obstructed labour	O63; O66
		906	Pregnancy-related sepsis	O85
		907	Anaemia of pregnancy	O99
		908	Ruptured uterus	O71
		999	Other and unspecified maternal cause	O01 - O02; O20 - O45; O47 - O62; O68 - O70; O73 - O75; O76 - O84; O86 - O98
7	Perinatal	1001	Prematurity	P05 - P07
		1002	Birth asphyxia	P20 - P22
		1003	Neonatal pneumonia	P23 - P25
		1004	Neonatal sepsis	P36
		1005	Neonatal tetanus	A33
		1006	Congenital malformation	Q00 - Q99
		1099	Other and unspecified perinatal cause of death	P00 - P04; P08 - P15; P26 - P35; P37 - P94; P96
8	Digestive cancer	202	Digestive neoplasms	C15 - C26
9	Respiratory cancer	203	Respiratory neoplasms	C30 - C39
10	Other cancers	204	Breast neoplasms	C50
		205	Female reproductive neoplasms	C51 - C58
		206	Male reproductive neoplasms	C60 - C63
		299	Other and unspecified neoplasms	C07 - C14; C40 - C49; C60 - D48
11	Malnutrition	302	Severe malnutrition	E40 - E46

VA shortlist		VA codelist		ICD-10 codes
12	Diabetes mellitus	303	Diabetes mellitus	E10 - E14
13	Acute cardiac disease	401	Acute cardiac disease	I20 - I25
14	Stroke	402	Stroke	I60 - I69
15	Other cardiac disease	403	Sickle cell with crisis	D57
		499	Other and unspecified cardiac disease	I00 - I09; I10 - I15; I26 - I52; I70 - I99
16	Chronic obstructive pulmonary disease	501	Chronic obstructive pulmonary disease (COPD)	J40 - J44
17	Renal failure	701	Renal failure	N17 - N19
18	Other NCDs	301	Severe anaemia	D50 - D64
		502	Asthma	J45 - J46
		601	Acute abdomen	K35 - K37; K40 - K46; K56; R10
		602	Liver cirrhosis	K70 - K76
		801	Epilepsy	G40 - G41
		9800	Other and unspecified non-communicable disease	D55 - D89; E00 - E07; E15 - E35; E50 - E90; F00 - F99; G06 - G09; G10 - G37; G43 - G47; G50 - G99; H00- H95; J30 - J39; J47 - J99; K00 - K31; K35- K38; K40 - K93; L00 - L99; M00 - M99; N00- N16; N20 - N99; R00 - R09; R11 - R94
19	Stillbirth	1100	Stillbirths	P95
20	Transport accidents	1201	Road traffic accident	V01 - V89
		1202	Other transport accident	V90 - V99
21	Other accidents	1203	Accidental fall	W00 - W19
		1204	Accidental drowning and submersion	W65 - W74
		1205	Accidental exposure to smoke, fire and flames	X00 - X19
		1206	Contact with venomous animals and plants	X20 - X29
		1207	Accidental poisoning and exposure to noxious substance	X40 - X49
22	Homicide	1208	Intentional self-harm	X60 - X84
23	Suicide	1209	Assault	X85 - Y09
24	Other and unspecified external cause	1210	Exposure to force of nature	X30 - X39
		1299	Other and unspecified external cause of death	S00 - T99; W20 - W64; W75 - W99; X50 - X59; Y10 - Y98
25	Undetermined	9900	Cause of death unknown	R95 - R99

8.3 VA inter-rater agreement

Table A5: VA inter-rater agreement on 14 underlying causes of death (N=5,367), SA NCODV Project 2017/18.

Reviewer A (14 causes)	Reviewer B (14 causes)															
	1. Tuberculosis	2. HIV/AIDS	3. Other type 1 conditions	4. Cancers	5. Diabetes mellitus	6. Stroke	7. Hypertensive heart disease	8. Other cardiovascular conditions	9. Other type 2 condtions	10. Ill-defined natural	11. Road traffic injury	12. Other unintentional injury	13. Undetermined intent	14. Intenional injury	Grand Total	Average inter-rater agreement
1. Tuberculosis	251	27	12	6	9	7	13	4	21	12	0	2	0	2	366	66.1%
2. HIV/AIDS	38	988	17	21	5	8	11	5	26	18	1	8	0	1	1,147	86.6%
3. Other type 1 conditions	12	17	183	2	11	7	16	8	27	37	0	1	1	1	323	57.4%
4. Cancers	6	20	3	349	6	7	10	6	18	13	0	1	0	1	440	79.3%
5. Diabetes mellitus	7	4	9	4	168	12	31	11	12	8	0	2	0	0	268	60.6%
6. Stroke	6	13	10	3	14	213	24	8	7	10	1	1	0	0	310	68.7%
7. Hypertensive heart disease	15	15	24	15	41	31	342	36	28	17	1	6	0	2	573	62.5%
8. Other cardiovascular conditions	6	4	3	8	14	7	19	98	25	25	1	2	0	0	212	45.9%
9. Other type 2 condtions	26	23	22	19	11	11	43	27	343	85	2	18	3	4	637	56.6%
10. Ill-defined natural	22	15	27	12	2	6	8	12	58	236	1	12	4	3	418	52.4%
11. Road traffic injury	1	1	0	0	2	0	0	0	0	4	188	3	0	1	200	95.0%
12. Other unintentional injury	5	6	4	0	4	1	5	0	7	17	1	103	0	5	158	63.4%
13. Undetermined intent	0	0	0	1	0	0	1	0	1	3	0	0	6	4	16	38.8%
14. Intenional injury	0	1	1	0	0	0	0	0	4	4	0	8	1	280	299	92.9%
Grand total	395	1,134	315	440	287	310	523	215	577	489	196	167	15	304	5,367	
															Agreement=69.8% Kappa=0.663 (0.654-0.672)	

8.4 Linkage between DHA data and Stats SA data

Table A6: DHA offices with the highest number of unlinked deaths based on DHA death registrations in the target area and Stats SA data by province and DHA office, SA NCODV Project 2017/18.

Province and DHA office	Number unlinked	Total in NCOD sample	% Unlinked
EC			
Mdantsane	1,019	1,202	84.8%
Clearypark	77	577	13.3%
Port Alfred	46	58	79.3%
Grahamstown	40	197	20.3%
Cofimvaba	21	21	100.0%
Butterworth	10	87	11.5%
Willowvale	6	20	30.0%
WC			
Mossel Bay	21	21	100.0%
Ceres	18	27	66.7%
FS			
Harrismith	26	421	6.2%
MP			
Evander	8	55	14.5%
Piet Retief	7	16	43.8%
Eerstehoek	6	19	31.6%

8.5 Supplementary agreement results

Table A7: Misclassification pattern for all linked Forensic Pathology Services deaths (excluding ill-defined natural deaths) using shortened SA NBD list (N=4,134), SA NCODV Project 2017/18.

	Forensic Pathology Services records (NBD shortlist)																			
Stats SA (NBD shortlist)	1.Tuberculosis	2.HIV/AIDS	3.Diarrhoeal diseases	4.Lower respiratory infections	5.Maternal	6.Perinatal conditions	7.Malnutrition	8.Other type 1 conditions	9.Oesophagus cancer	10.Trachea/bronchi/lung cancer	12.Cervix cancer	13.Prostate cancer	14.Other cancers	15.Ill-defined cancers	16.Diabetes mellitus	17.Epilepsy	18.Ischaemic heart disease	19.Stroke	20.Inflammatory heart disease
1.Tuberculosis	47	4	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
2.HIV/AIDS	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.Diarrhoeal diseases	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.Lower respiratory infections	1	0	0	39	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0
5.Maternal	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.Perinatal conditions	0	0	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
7.Malnutrition	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
8.Other type 1 conditions	1	0	0	1	0	1	0	4	0	0	0	0	0	1	0	0	0	0	0
9.Oesophagus cancer	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
10.Trachea/bronchi/lung cancer	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	0
12.Cervix cancer	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
13.Prostate	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
14.Other cancers	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0	0	1	0	0
15.Ill-defined cancers	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
16.Diabetes mellitus	1	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
17.Epilepsy	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	9	0	1	0
18.Ischaemic heart disease	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	58	0	1
19.Stroke	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	14	0
20.Inflammatory heart disease	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	1	7
21.Hypertensive heart disease	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
22.Peripheral vascular disorders	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23. Ill-defined cardiovascular	0	1	0	3	1	0	0	0	0	0	0	0	0	0	0	0	3	0	2
24.Other cardiovascular	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
25. Chronic obstructive pulmonary disease	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.Other chronic respiratory	0	1	0	6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
27.Peptic ulcer	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
28.Cirrhosis of liver	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
29. Other digestive	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
30. Nephritis/nephrosis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32. Congenital	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33. Other type 2 conditions	1	2	0	1	1	0	1	1	0	0	0	0	1	0	0	0	2	1	0
34. Ill-defined natural	12	4	2	8	4	0	2	2	2	0	0	0	2	0	0	3	16	4	2
35.Road traffic accidents	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36.Falls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37.Fires	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
38.Drowning	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39.Suffocation and foreign bodies	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40.Other unintentional injuries specified	0	0	0	1	4	0	0	0	0	0	0	0	0	0	1	0	1	0	0
41.Ill-defined other unintentional	1	0	1	0	2	0	0	1	0	0	0	0	0	0	0	0	3	1	0
42. Undetermined intent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43.Suicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44. Homicide	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	69	17	10	69	27	6	5	9	5	2	2	1	12	4	4	15	89	24	15
Sensitivity	68.1	11.8	30.0	56.5	55.6	66.7	20.0	44.4	40.0	100.0	100.0	100.0	66.7	25.0	50.0	60.0	65.2	58.3	46.7
Lower 95% CI	55.8	1.5	6.7	44.0	35.3	22.3	0.5	13.7	5.3	15.8	15.8	2.5	34.9	0.6	6.8	32.3	54.3	36.6	21.3
Upper 95% CI	78.8	36.4	65.2	68.4	74.5	95.7	71.6	78.8	85.3	100.0	100.0	100.0	90.1	80.6	93.2	83.7	75.0	77.9	73.4

21.Hypertensive heart disease	22.Peripheral vascular disorders	23. Ill-defined cardiovascular	24.Other cardiovascular	25. Chronic obstructive pulmonary disease	26.Other chronic respiratory	27.Peptic ulcer	28.Cirrhosis of liver	29. Other digestive	31. Other genitourinary conditions	32. Congenital	33. Other type 2 conditions	35.Road traffic accidents	36.Falls	37.Fires	38.Drowning	39.Suffocation and foreign bodies	40.Other unintentional injuries specified	41.Ill-defined other unintentional	42. Undetermined intent	43.Suicide	44. Homicide	Grand Total	PPV	Lower 95% CI	Upper 95% CI
0	0	0	0	2	0	0	0	1	0	0	0	2	0	1	0	0	1	0	0	1	0	61	77.0 (	64.5 - 86.8)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	66.7 (	9.4 - 99.2)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	60.0 (	14.7 - 94.7)
0	0	0	1	1	1	0	0	1	0	0	1	2	0	0	0	0	2	0	0	1	4	57	68.4 (	54.8 - 80.1)
0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	20	75.0 (	50.9 - 91.3)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	80.0 (	28.4 - 99.5)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	3	33.3 (	0.8 - 90.6)
0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	2	14	28.6 (	8.4 - 58.1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	100.0 (	15.8 - 100.0)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	66.7 (	9.4 - 99.2)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	(	-)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100.0 (	2.5 - 100.0)
0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	66.7 (	34.9 - 90.1)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	100.0 (	2.5 - 100.0)
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	7	28.6 (	3.7 - 71.0)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	15	60.0 (	32.3 - 83.7)
0	1	4	1	0	0	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	71	81.7 (	70.7 - 89.9)
0	0	0	0	0	0	0	0	1	0	0	2	2	0	0	0	0	1	0	1	0	2	24	58.3 (	36.6 - 77.9)
1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	17	41.2 (	18.4 - 67.1)
8	0	3	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	19	42.1 (	20.3 - 66.5)
0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	75.0 (	19.4 - 99.4)
1	0	10	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2	2	29	34.5 (	17.9 - 54.3)
0	2	0	13	0	0	0	0	2	0	0	0	1	0	0	0	0	1	0	0	0	1	25	52.0 (	31.3 - 72.2)
0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7	42.9 (	9.9 - 81.6)
1	0	0	0	3	6	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	22	27.3 (	10.7 - 50.2)
0	0	0	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	60.0 (	14.7 - 94.7)
0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	1	0	0	7	14.3 (	0.4 - 57.9)
0	0	0	0	0	0	3	0	20	0	0	0	0	0	0	0	0	1	0	1	0	1	27	74.1 (	53.7 - 88.9)
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0.0 (	0.0 - 84.2)
0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	5	80.0 (	28.4 - 99.5)
1	0	0	1	0	1	0	0	1	0	0	2	2	0	0	0	0	0	0	2	0	2	23	8.7 (	1.1 - 28.0)
7	0	10	3	3	2	3	2	6	0	1	5	6	2	1	1	1	20	1	29	42	10	218		
0	0	0	0	0	0	0	0	0	0	0	0	568	0	0	0	0	5	3	7	1	7	591	96.1 (	94.2 - 97.5)
0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	1	2	0	10	70.0 (	34.8 -)
0	0	0	0	0	0	0	0	0	0	0	0	8	0	75	0	0	9	9	44	5	13	164	45.7 (	37.9 - 53.7)
0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	88	0	0	0	11	2	3	106	83.0 (	74.5 - 89.6)
0	0	0	0	1	0	0	0	1	0	0	1	1	0	0	4	12	3	3	4	355	45	432	2.8 (	1.4 - 4.8)
0	0	0	0	0	0	0	0	3	0	0	0	5	0	0	0	2	60	0	18	33	308	436	13.8 (	10.7 - 17.4)
1	0	0	1	0	0	0	0	1	0	0	0	560	28	1	2	5	27	6	53	26	235	955	0.6 (	0.2 - 1.4)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	8	0	29	47	7	95	30.5 (	21.5 - 40.8)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	33	0	34	97.1 (	84.7 - 99.9)
0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	3	1	5	5	574	595	96.5 (	94.7 - 97.8)
20	7	30	25	13	11	10	4	43	1	5	13	1167	39	84	95	20	148	23	214	559	1,218	4,134		
40.0	42.9	33.3	52.0	23.1	54.5	30.0	25.0	46.5	0.0		15.4	0.5	0.0	89.3	92.6	60.0	40.5	26.1	13.6	5.9	47.1	Agreement = 42.2%		
19.1	9.9	17.3	31.3	5.0	23.4	6.7	0.6	31.2	0.0		1.9	0.2	0.0	80.6	85.4	36.1	32.6	10.2	9.3	4.1	44.3	Kappa = 0.363 (0.356 - 0.368)		
63.9	81.6	52.8	72.2	53.8	83.3	65.2	80.6	62.3	97.5		45.4	1.1	9.0	95.0	97.0	80.9	48.9	48.4	18.9	8.2	50.0	Spearman = 0.870 (0.871 - 0.959)		

Table A8: Misclassification pattern for all linked medical record deaths (excluding ill-defined natural deaths) using shortened SA NBD list (N=7,983), SA NCODV Project 2017/18.

	Medical records (NBD shortlist)																			
Stats SA (NBD shortlist)	1.Tuberculosis	2.HIV/AIDS	3.Diarrhoeal diseases	4.Lower respiratory infections	5.Maternal	6.Perinatal conditions	7.Malnutrition	8.Other type 1 conditions	9.Oesophagus cancer	10.Trachea/bronchi/lung canccer	11.Breast cancer	12.Cervix cancer	13.Prostate cancer	14.Other cancers	15.Ill-defined cancers	16.Diabetes mellitus	17.Epilepsy	18.Ischaemic heart disease	19.Stroke	20.Inflammatory heart disease
1.Tuberculosis	233	567	0	27	0	0	0	4	0	5	1	0	2	4	7	4	4	0	8	1
2.HIV/AIDS	7	770	1	1	0	0	0	0	0	1	0	1	1	3	3	7	0	0	11	0
3.Diarrhoeal diseases	4	40	42	1	0	1	4	3	0	0	0	0	0	0	0	4	0	2	4	0
4.Lower respiratory infections	33	104	11	75	0	0	0	5	1	2	0	0	0	4	4	12	1	3	18	1
5.Maternal	17	43	0	0	3	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0
6.Perinatal conditions	0	0	1	0	0	30	0	2	0	0	0	0	0	0	0	1	0	0	0	0
7.Malnutrition	3	20	3	11	0	0	11	3	0	0	0	0	1	1	1	1	0	1	0	0
8.Other type 1 conditions	14	509	7	12	1	0	3	47	1	3	1	0	2	17	1	21	4	5	15	0
9.Oesophagus cancer	2	3	0	1	0	0	0	0	71	0	0	0	0	5	2	1	0	0	0	0
10.Trachea/bronchi/lung cancer	2	6	0	3	0	0	0	1	2	111	1	0	0	5	8	0	0	0	0	0
11.Breast cancer	0	1	1	0	0	0	0	0	0	0	60	0	0	1	1	1	0	0	0	0
12.Cervix cancer	0	48	0	0	0	0	1	0	0	0	0	49	0	11	1	1	0	0	1	0
13.Prostate cancer	2	1	0	0	0	0	0	1	0	1	0	0	55	2	2	1	0	0	2	0
14.Other cancers	3	26	2	2	0	0	1	1	2	4	0	8	1	236	18	6	0	0	3	1
15.Ill-defined cancers	0	13	0	0	0	0	0	1	1	8	3	1	3	28	26	0	0	0	3	0
16.Diabetes mellitus	9	26	13	30	0	0	1	2	0	1	0	0	1	6	2	231	1	23	80	1
17.Epilepsy	4	4	0	1	0	0	0	2	0	0	0	0	0	0	0	1	25	0	4	0
18.Ischaemic heart disease	2	5	0	2	0	0	0	1	0	0	2	1	1	1	2	5	0	44	7	2
19.Stroke	8	26	5	2	0	0	0	6	0	2	0	0	1	4	0	12	6	6	400	0
20.Inflammatory heart disease	1	15	0	3	1	0	0	0	0	0	0	0	1	1	0	0	0	2	3	12
21.Hypertensive heart disease	9	20	11	33	0	0	1	6	1	3	0	0	3	4	3	14	2	16	47	0
22.Peripheral vascular disorders	2	8	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	2	2	1
23.Ill-defined cardiovascular	8	26	4	7	1	0	1	1	0	0	1	1	1	7	0	8	1	15	12	8
24.Other cardiovascular	4	6	1	1	0	0	1	0	0	1	1	0	0	0	0	5	0	3	4	2
25.Chronic obstructive pulmonary disease	21	20	0	14	1	0	0	2	3	4	0	0	1	5	2	1	1	4	7	2
26.Other chronic respiratory	8	20	2	6	0	1	1	2	0	0	1	0	0	1	0	5	2	3	6	2
27.Peptic ulcer	0	1	0	1	1	0	0	0	0	0	0	0	0	3	1	1	0	1	1	0
28.Cirrhosis of liver	0	10	0	0	0	0	0	4	0	0	0	0	1	3	5	2	1	1	1	2
29.Other digestive	5	52	6	2	2	0	1	8	3	0	0	0	2	24	5	4	0	2	1	0
30.Nephritis/nephrosis	3	49	8	16	0	0	1	6	0	0	0	1	5	4	2	17	1	3	11	0
31.Other genitourinary conditions	1	9	0	2	0	0	0	0	0	0	0	0	0	1	0	1	0	0	3	0
32.Congenital	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
33.Other type 2 conditions	13	275	9	17	0	1	2	15	1	0	0	0	1	7	7	23	1	9	25	0
34.Ill-defined natural	8	35	2	4	0	2	0	6	2	2	3	2	1	8	4	7	1	5	6	1
35.Road traffic accidents	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
36.Falls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37.Fires	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
39.Suffocation and foreign bodies	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
40.Other unintentional injuries specified	3	4	0	3	0	1	2	1	0	0	0	0	0	0	0	6	0	0	0	0
41.Ill-defined other unintentional	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
42.Undetermined intent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
43.Suicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44.Homicide	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	431	2768	130	279	10	36	32	131	88	149	74	64	84	397	108	409	51	150	691	37
Sensitivity	54.1	27.8	32.3	26.9	30.0	83.3	34.4	35.9	80.7	74.5	81.1	76.6	65.5	59.4	24.1	56.5	49.0	29.3	57.9	32.4
Lower 95% CI	49.2	26.2	24.4	21.8	6.7	67.2	18.6	27.7	70.9	66.7	70.3	64.3	54.3	54.4	16.4	51.5	34.8	22.2	54.1	18.0
Upper 95% CI	58.8	29.5	41.1	32.5	65.2	93.6	53.2	44.7	88.3	81.3	89.3	86.2	75.5	64.3	33.3	61.3	63.4	37.3	61.6	49.8

21.Hypertensive heart disease	22.Peripheral vascular disorders	23.Ill-defined cardiovascular	24.Other cardiovascular	25.Chronic obstructive pulmonary disease	26.Other chronic respiratory	27.Peptic ulcer	28.Cirrhosis of liver	29.Other digestive	30.Nephritis/nephrosis	31.Other genitourinary conditions	32.Congenital	33.Other type 2 conditions	35.Road traffic accidents	36.Falls	37.Fires	39.Suffocation and foreign bodies	40.Other unintentional injuries specified	41.Ill-defined other unintentional	42.Undetermined intent	43.Suicide	44.Homicide	Grand Total	PPV	Lower 95% CI	Upper 95% CI
8	4	3	0	15	9	2	1	5	2	2	0	6	1	1	0	0	0	1	0	1	2	930	25.1 (	22.3 - 28.0)
1	1	0	1	0	0	0	0	4	1	3	0	2	0	0	0	0	1	0	1	0	0	821	93.8 (	91.9 - 95.3)
3	0	0	0	0	0	0	0	2	2	1	0	4	0	0	0	0	1	0	0	0	0	118	35.6 (	27.0 - 44.9)
15	3	4	1	18	9	4	6	1	0	2	2	10	1	1	0	0	2	0	0	1	0	354	21.2 (	17.0 - 25.8)
0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68	4.4 (	0.9 - 12.4)
0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	36	83.3 (	67.2 - 93.6)
3	1	1	1	0	0	2	0	1	2	1	1	6	0	0	0	0	2	0	0	0	0	77	14.3 (	7.4 - 24.1)
5	10	1	2	5	1	3	5	10	0	2	1	15	1	2	0	0	6	1	0	0	0	733	6.4 (	4.7 - 8.4)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	83.5 (	73.9 - 90.7)
0	0	0	0	5	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	147	75.5 (	67.7 - 82.2)
0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	68	88.2 (	78.1 - 94.8)
3	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	118	41.5 (	32.5 - 51.0)
2	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	72	76.4 (	64.9 - 85.6)
1	1	0	0	1	0	3	1	5	1	1	0	4	0	0	0	0	2	0	0	0	0	334	70.7 (	65.5 - 75.5)
0	0	1	0	1	0	0	0	3	0	1	1	1	0	0	0	0	0	0	0	0	0	95	27.4 (	18.7 - 37.5)
55	2	3	1	7	3	7	1	6	1	10	0	17	2	3	1	0	4	0	0	0	0	550	42.0 (	37.8 - 46.2)
0	0	0	0	0	0	0	1	0	0	0	1	5	0	1	0	0	1	1	0	0	0	51	49.0 (	34.8 - 63.4)
10	5	3	1	6	2	3	0	5	1	1	0	1	0	1	0	0	3	0	1	0	0	118	37.3 (	28.6 - 46.7)
15	3	4	0	2	1	0	0	1	2	2	0	8	2	4	1	0	3	2	4	4	5	541	73.9 (	70.0 - 77.6)
19	1	4	3	3	2	1	1	1	0	1	0	4	1	0	0	0	1	0	0	0	0	81	14.8 (	7.9 - 24.4)
98	7	4	4	6	6	5	2	4	4	3	0	15	0	5	0	0	1	2	1	0	1	341	28.7 (	24.0 - 33.9)
1	26	0	0	1	0	1	0	2	1	0	0	1	0	0	0	0	3	0	0	0	0	54	48.1 (	34.3 - 62.2)
71	3	16	5	4	1	0	2	4	6	0	1	6	0	1	0	0	4	0	0	0	0	226	7.1 (	4.1 - 11.2)
8	1	0	7	3	2	0	0	1	0	1	0	3	0	1	0	0	1	0	1	0	0	58	12.1 (	5.0 - 23.3)
18	2	0	0	135	10	4	5	2	1	1	0	6	0	1	0	0	1	0	0	0	0	274	49.3 (	43.2 - 55.4)
4	0	1	0	12	19	0	0	3	0	1	0	2	0	0	0	0	2	0	1	0	0	105	18.1 (	11.3 - 26.8)
0	0	0	1	0	0	10	1	4	0	0	0	3	0	0	0	0	1	0	0	1	0	31	32.3 (	16.7 - 51.4)
0	0	0	0	0	0	0	27	5	0	0	0	1	0	0	0	0	1	0	0	0	0	64	42.2 (	29.9 - 55.2)
2	0	0	0	0	0	8	7	67	1	1	0	4	0	1	0	0	5	1	2	0	1	217	30.9 (	24.8 - 37.5)
36	1	3	1	5	0	0	2	3	11	7	0	4	0	0	0	0	1	1	1	0	0	203	5.4 (	2.7 - 9.5)
4	1	0	1	0	0	0	0	3	4	8	0	1	0	0	0	0	1	0	0	0	0	40	20.0 (	9.1 - 35.6)
1	0	0	0	0	0	0	0	1	0	0	10	0	0	0	0	0	0	0	0	0	0	16	62.5 (	35.4 - 84.8)
22	6	0	2	8	4	2	5	7	2	1	2	73	2	6	2	0	9	2	3	1	2	567	12.9 (	10.2 - 15.9)
3	3	1	1	3	0	3	2	5	1	1	1	8	2	3	0	1	4	0	2	7	3	153	- (	- - -)
0	0	0	0	0	0	0	0	0	0	0	0	0	13	1	0	0	0	0	0	0	0	16	81.3 (	54.4 - 96.0)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	2	50.0 (	1.3 - 98.7)
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	13	0	5	0	1	0	1	23	56.5 (	34.5 - 76.8)
0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	7	0.0 (	0.0 - 41.0)
0	2	0	0	1	0	2	0	2	1	0	1	4	1	0	0	0	14	0	1	2	9	60	23.3 (	13.4 - 36.0)
2	0	0	0	2	0	0	0	0	0	0	0	4	20	14	2	0	2	3	5	2	20	83	3.6 (	0.8 - 10.2)
0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5	0	4	12	0	23	17.4 (	5.0 - 38.8)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	100.0 (	29.2 - 100.0)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	20	90.0 (	68.3 - 98.8)
410	83	51	32	245	69	61	70	160	44	53	21	224	47	47	19	1	87	14	29	35	62	7,983		
23.9	31.3	31.4	21.9	55.1	27.5	16.4	38.6	41.9	25.0	15.1	47.6	32.6	27.7	2.1	68.4	0.0	16.1	21.4	13.8	8.6	29.0	Agreement = 38.9%		
19.9	21.6	19.1	9.3	48.6	17.5	8.2	27.2	34.1	13.2	6.7	25.7	26.5	15.6	0.1	43.4	0.0	9.1	4.7	3.9	1.8	18.2	Kappa = 0.347 (0.344 - 0.351)		
28.3	42.4	45.9	40.0	61.4	39.6	28.1	51.0	49.9	40.3	27.6	70.2	39.2	42.6	11.3	87.4	97.5	25.5	50.8	31.7	23.1	41.9	Spearman = 0.777 (0.628 - 0.926)		

Table A9: Misclassification pattern for all linked verbal autopsy deaths (excluding ill-defined natural deaths) using shortened SA NBD list (N=4,059), SA NCODV Project 2017/18.

	Physician coded verbal autopsy (NBD shortlist)																			
Stats SA (NBD shortlist)	1.Tuberculosis	2.HIV/AIDS	3.Diarrhoeal diseases	4.Lower respiratory infections	5.Maternal	6.Perinatal conditions	7.Malnutrition	8.Other type 1 conditions	9.Oesophagus cancer	10.Trachea/bronchi/lung cancer	11.Breast cancer	12.Cervix cancer	13.Prostate cancer	14.Other cancers	15.Ill-defined cancers	16.Diabetes mellitus	17.Epilepsy	18.Ischaemic heart disease	19.Stroke	20.Inflammatory heart disease
1.Tuberculosis	88	178	1	3	3	0	0	3	1	0	1	0	0	5	3	7	1	3	5	0
2.HIV/AIDS	28	239	1	3	2	0	1	2	2	0	0	1	0	5	3	2	1	2	8	0
3.Diarrhoeal diseases	6	29	9	1	0	0	0	7	1	0	0	0	0	2	0	5	1	2	1	0
4.Lower respiratory infections	21	54	3	8	1	2	1	2	1	2	0	0	1	1	5	6	4	6	8	0
5.Maternal	5.5	9	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.Perinatal conditions	0	0	1	0	0	11	0	1	0	0	0	0	0	1	0	0	0	0	0	0
7.Malnutrition	3	11	3	2	1	0	3	2	1	0	0	0	0	2	0	0	0	1	2	0
8.Other type 1 conditions	23	148	0	4	0	3	1	10	1	0	0	1	0	5	3	6	1	2	6	0
9.Oesophagus cancer	0	1	0	0	0	0	1	0	8	2	0	0	0	14	2	0	0	0	0	0
10.Trachea/bronchi/lung cancer	4	6	0	1	0	0	0	1	0	16	1	0	1	4	6	0	0	0	2	0
11.Breast cancer	0	1	1	0	1	0	0	0	0	0	17	0	0	1	3	0	0	0	0	0
12.Cervix cancer	0	20	0	0	1	0	0	0	0	1	1	20	0	5	4	1	0	0	1	0
13.Prostate cancer	2	2	0	0	0	0	0	0	0	1	0	0	19	6	4	2	0	0	3	0
14.Other cancers	7	22	0	0	1	0	0	1	1	4	0	7	1	77	24	5	0	1	3	0
15.Ill-defined cancers	2	4	0	0	0	0	0	0	0	1	3	0	0	10	6	0	0	0	0	0
16.Diabetes mellitus	10	13	2	6	0	0	0	0	0	1	1	0	2	5	2	89	0	7	32	1
17.Epilepsy	2	5	1	2	0	1	1	1	0	0	0	0	0	0	0	0	16	1	3	0
18.Ischaemic heart disease	4	4	0	1	0	0	0	0	0	0	0	0	0	2	0	2	0	22	5	1
19.Stroke	6	18	0	2	1	0	1	4	0	2	1	1	2	1	0	12	3	3	95	1
20.Inflammatory heart disease	2	7	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	2
21.Hypertensive heart disease	7	24	4	5	0	0	0	4	0	1	1	1	2	4	3	10	3	16	25	0
22.Peripheral vascular disorders	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	2	0
23. Ill-defined cardiovascular	16	18	0	4	1	0	0	2	1	1	0	0	0	2	0	5	2	4	11	1
24.Other cardiovascular	1	5	0	0	2	0	0	0	0	0	0	0	0	0	0	2	2	2	2	0
25. Chronic obstructive pulmonary disease	12	13	1	5	0	0	0	1	1	0	0	0	0	0	0	3	1	4	7	0
26.Other chronic respiratory	9	8	1	0	0	0	0	3	0	0	0	1	0	1	1	0	1	4	1	0
27.Peptic ulcer	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.Cirrhosis of liver	2	2	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
29. Other digestive	6	19	1	1	0	0	0	0	0	0	1	2	0	4	5	6	0	2	1	0
30. Nephritis/nephrosis	2	28	3	2	2	0	0	2	1	0	0	1	0	3	1	7	1	0	3	0
31. Other genitourinary conditions	2	7	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0
32. Congenital	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33. Other type 2 conditions	22	99	2	4	2	3	0	7	1	1	0	1	0	4	2	12	3	5	23	0
34. Ill-defined natural	34	77	8	2	6	5	0	3	1	2	4	1	4	12	5	16	5	17	14	0
35.Road traffic accidents	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36.Falls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37.Fires	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
38.Drowning	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39.Suffocation and foreign bodies	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40.Other unintentional injuries specified	0	0	1	2	1	1	0	0	0	0	0	0	0	2	0	3	1	1	0	0
41.Ill-defined other unintentional	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
42. Undetermined intent	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
43.Suicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44. Homicide	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Grand Total	336	1,082	44	60	35	26	9	56	22	36	31	37	32	181	83	208	47	109	265	6
Sensitivity	26.2	22.1	20.5	13.3	28.6	42.3	33.3	17.9	36.4	44.4	54.8	54.1	59.4	42.5	7.2	42.8	34.0	20.2	35.8	33.3
Lower 95% CI	21.6	19.6	9.8	5.9	14.6	23.4	7.5	8.9	17.2	27.9	36.0	36.9	40.6	35.2	2.7	36.0	20.9	13.1	30.1	4.3
Upper 95% CI	31.2	24.7	35.3	24.6	46.3	63.1	70.1	30.4	59.3	61.9	72.7	70.5	76.3	50.1	15.1	49.8	49.3	28.9	41.9	77.7

21.Hypertensive heart disease	22.Peripheral vascular disorders	23. Ill-defined cardiovascular	24.Other cardiovascular	25. Chronic obstructive pulmonary disease	26.Other chronic respiratory	27.Peptic ulcer	28.Cirrhosis of liver	29. Other digestive	30. Nephritis/nephrosis	31. Other genitourinary conditions	32. Congenital	33. Other type 2 condtions	35.Road traffic accidents	36.Falls	37.Fires	38.Drowning	39.Suffocation and foreign bodies	40.Other unintentional injuries specified	41.Ill-defined other unintentional	42. Undetermined intent	43.Suicide	44. Homicide	Grand Total	PPV	Lower 95% CI	Upper 95% CI
10	0	1	0	7	3	5	0	0	2	0	0	2	1	3	0	0	0	1	0	0	1	2	340	25.9 (	21.3 -	30.9)
5	0	2	0	0	0	2	1	1	0	0	1	1	1	1	0	0	0	2	0	0	1	1	319	74.9 (	69.8 -	79.6)
1	0	1	0	0	1	3	1	1	2	0	0	5	0	0	0	0	0	0	0	0	0	1	80	11.3 (	5.3 -	20.3)
7	0	4	0	6	5	4	2	0	1	1	2	7	0	1	0	0	1	1	0	0	1	4	173	4.6 (	2.0 -	8.9)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	33.3 (	17.3 -	52.8)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	78.6 (	49.2 -	95.3)
0	0	1	0	2	1	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	38	7.9 (	1.7 -	21.4)
8	1	0	0	2	3	1	2	8	3	0	1	5	3	0	0	0	0	3	0	0	0	1	255	3.9 (	1.9 -	7.1)
1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	32	25.0 (	11.5 -	43.4)
1	0	2	0	2	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	49	32.7 (	19.9 -	47.5)
2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	63.0 (	42.4 -	80.6)
3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58	34.5 (	22.5 -	48.1)
1	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	43	44.2 (	29.1 -	60.1)
2	0	0	0	0	0	1	4	1	0	2	0	2	0	1	0	0	0	1	1	0	0	0	169	45.6 (	37.9 -	53.4)
2	0	0	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	34	17.6 (	6.8 -	34.5)
40	0	1	0	1	0	4	2	2	0	0	0	2	0	2	1	0	0	0	0	0	0	0	226	39.4 (	33.0 -	46.1)
0	0	0	0	0	0	0	0	0	1	0	0	1	2	2	0	0	0	2	0	1	0	1	43	37.2 (	23.0 -	53.3)
15	0	4	0	3	1	0	2	1	0	0	0	5	0	0	0	0	0	2	0	0	0	1	75	29.3 (	19.4 -	41.0)
26	0	2	0	1	2	0	2	0	0	1	0	3	0	3	0	0	0	1	0	0	0	1	195	48.7 (	41.5 -	56.0)
11	1	4	0	0	0	0	1	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	37	5.4 (	0.7 -	18.2)
50	3	4	0	3	2	1	2	1	3	0	1	5	1	3	0	0	0	0	0	0	1	1	191	26.2 (	20.1 -	33.0)
1	4	2	0	0	0	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	20	20.0 (	5.7 -	43.7)
21	0	5	2	3	2	3	1	0	1	1	2	3	1	1	1	0	1	1	0	0	0	1	118	4.2 (	1.4 -	9.6)
3	0	2	0	1	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	27	0.0 (	0.0 -	12.8)
12	0	7	0	15	9	1	3	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	98	15.3 (	8.8 -	24.0)
6	0	1	0	5	18	0	1	0	0	0	0	3	1	1	0	0	0	1	0	0	0	2	69	26.1 (	16.3 -	38.1)
2	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	10	20.0 (	2.5 -	55.6)
3	0	0	0	0	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	22.2 (	6.4 -	47.6)
5	0	1	0	1	0	4	2	9	0	1	0	0	0	0	0	0	0	2	0	0	0	0	73	12.3 (	5.8 -	22.1)
17	0	2	0	1	1	0	2	0	8	1	0	2	0	1	0	0	0	0	0	0	0	0	91	8.8 (	3.9 -	16.6)
1	0	0	0	0	0	0	1	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	23	4.3 (	0.1 -	21.9)
0	0	0	0	0	0	0	0	1	0	0	8	0	0	0	0	0	0	0	0	0	0	0	10	80.0 (	44.4 -	97.5)
10	2	2	1	1	0	1	1	2	2	2	2	10	3	2	0	0	0	2	0	0	1	4	239	4.2 (	2.0 -	7.6)
34	1	2	1	8	11	6	3	2	5	0	1	12	2	4	0	0	0	10	1	2	1	6	328			
0	0	0	0	0	0	0	0	0	0	0	0	0	86	0	0	0	0	0	0	0	0	3	89	96.6 (	90.5 -	99.3)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	100.0 (	2.5 -	100.0)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	3	0	1	1	4	24	58.3 (	36.6 -	77.9)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	3	12	75.0 (	42.8 -	94.5)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	39	10	55	1.8 (	0.0 -	9.7)
0	0	0	0	0	0	1	0	3	1	0	0	2	0	3	0	0	0	15	0	0	5	33	75	20.0 (	11.6 -	30.8)
1	0	0	0	0	0	0	0	0	0	0	0	0	75	9	1	1	0	5	1	1	3	55	155	0.6 (	0.0 -	3.5)
1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	7	2	17	0.0 (	0.0 -	19.5)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1	8	87.5 (	47.3 -	99.7)
0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	1	0	65	71	91.5 (	82.5 -	96.8)
302	12	50	5	64	60	43	39	43	33	12	20	77	181	44	19	10	3	55	4	7	68	203	4,059			
16.6	33.3	10.0	0.0	23.4	30.0	4.7	10.3	20.9	24.2	8.3	40.0	13.0	47.5	2.3	73.7	90.0	33.3	27.3	25.0	0.0	10.3	32.0	Agreement = 30.8%			
12.5	9.9	3.3	0.0	13.8	18.8	0.6	2.9	10.0	11.1	0.2	19.1	6.4	40.1	0.1	48.8	55.5	0.8	16.1	0.6	0.0	4.2	25.7	Kappa = 0.275 (0.268 - 0.280)			
21.2	65.1	21.8	52.2	35.7	43.2	15.8	24.2	36.0	42.3	38.5	63.9	22.6	55.1	12.0	90.9	99.7	90.6	41.0	80.6	41.0	20.1	38.9	Spearman = 0.608 (0.373 - 0.843)			

Table A10: Misclassification pattern for all linked in facility deaths (excluding ill-defined natural deaths) using shortened SA NBD list (N=8,060), SA NCODV Project 2017/18.

	Physician coded verbal autopsy (NBD shortlist)																			
Stats SA (NBD shortlist)	1.Tuberculosis	2.HIV/AIDS	3.Diarrhoeal diseases	4.Lower respiratory infections	5.Maternal	6.Perinatal conditions	7.Malnutrition	8.Other type 1 conditions	9.Oesophagus cancer	10.Trachea/bronchi/lung cancer	11.Breast cancer	12.Cervix cancer	13.Prostate cancer	14.Other cancers	15.Ill-defined cancers	16.Diabetes mellitus	17.Epilepsy	18.Ischaemic heart disease	19.Stroke	20.Inflammatory heart disease
1.Tuberculosis	88	178	1	3	3	0	0	3	1	0	1	0	0	5	3	7	1	3	5	0
2.HIV/AIDS	28	239	1	3	2	0	1	2	2	0	0	1	0	5	3	2	1	2	8	0
3.Diarrhoeal diseases	6	29	9	1	0	0	0	7	1	0	0	0	0	2	0	5	1	2	1	0
4.Lower respiratory infections	21	54	3	8	1	2	1	2	1	2	0	0	1	1	5	6	4	6	8	0
5.Maternal	5.5	9	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.Perinatal conditions	0	0	1	0	0	11	0	1	0	0	0	0	0	1	0	0	0	0	0	0
7.Malnutrition	3	11	3	2	1	0	3	2	1	0	0	0	0	2	0	0	0	1	2	0
8.Other type 1 conditions	23	148	0	4	0	3	1	10	1	0	0	1	0	5	3	6	1	2	6	0
9.Oesophagus cancer	0	1	0	0	0	0	1	0	8	2	0	0	0	14	2	0	0	0	0	0
10.Trachea/bronchi/lung cancer	4	6	0	1	0	0	0	1	0	16	1	0	1	4	6	0	0	0	2	0
11.Breast cancer	0	1	1	0	1	0	0	0	0	0	17	0	0	1	3	0	0	0	0	0
12.Cervix cancer	0	20	0	0	1	0	0	0	0	1	1	20	0	5	4	1	0	0	1	0
13.Prostate cancer	2	2	0	0	0	0	0	0	0	1	0	0	19	6	4	2	0	0	3	0
14.Other cancers	7	22	0	0	1	0	0	1	1	4	0	7	1	77	24	5	0	1	3	0
15.Ill-defined cancers	2	4	0	0	0	0	0	0	0	1	3	0	0	10	6	0	0	0	0	0
16.Diabetes mellitus	10	13	2	6	0	0	0	0	0	1	1	0	2	5	2	89	0	7	32	1
17.Epilepsy	2	5	1	2	0	1	1	1	0	0	0	0	0	0	0	0	16	1	3	0
18.Ischaemic heart disease	4	4	0	1	0	0	0	0	0	0	0	0	0	2	0	2	0	22	5	1
19.Stroke	6	18	0	2	1	0	1	4	0	2	1	1	2	1	0	12	3	3	95	1
20.Inflammatory heart disease	2	7	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	2
21.Hypertensive heart disease	7	24	4	5	0	0	0	4	0	1	1	1	2	4	3	10	3	16	25	0
22.Peripheral vascular disorders	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	2	0
23. Ill-defined cardiovascular	16	18	0	4	1	0	0	2	1	1	0	0	0	2	0	5	2	4	11	1
24.Other cardiovascular	1	5	0	0	2	0	0	0	0	0	0	0	0	0	0	2	2	2	2	0
25. Chronic obstructive pulmonary disease	12	13	1	5	0	0	0	1	1	0	0	0	0	0	0	3	1	4	7	0
26.Other chronic respiratory	9	8	1	0	0	0	0	3	0	0	0	1	0	1	1	0	1	4	1	0
27.Peptic ulcer	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.Cirrhosis of liver	2	2	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0
29. Other digestive	6	19	1	1	0	0	0	0	0	0	1	2	0	4	5	6	0	2	1	0
30. Nephritis/nephrosis	2	28	3	2	2	0	0	2	1	0	0	1	0	3	1	7	1	0	3	0
31. Other genitourinary conditions	2	7	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0
32. Congenital	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33. Other type 2 conditions	22	99	2	4	2	3	0	7	1	1	0	1	0	4	2	12	3	5	23	0
34. Ill-defined natural	34	77	8	2	6	5	0	3	1	2	4	1	4	12	5	16	5	17	14	0
35.Road traffic accidents	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36.Falls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37.Fires	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
38.Drowning	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39.Suffocation and foreign bodies	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40.Other unintentional injuries specified	0	0	1	2	1	1	0	0	0	0	0	0	0	2	0	3	1	1	0	0
41.Ill-defined other unintentional	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
42. Undetermined intent	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
43.Suicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44. Homicide	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Grand Total	336	1,082	44	60	35	26	9	56	22	36	31	37	32	181	83	208	47	109	265	6
Sensitivity	26.2	22.1	20.5	13.3	28.6	42.3	33.3	17.9	36.4	44.4	54.8	54.1	59.4	42.5	7.2	42.8	34.0	20.2	35.8	33.3
Lower 95% CI	21.6	19.6	9.8	5.9	14.6	23.4	7.5	8.9	17.2	27.9	36.0	36.9	40.6	35.2	2.7	36.0	20.9	13.1	30.1	4.3
Upper 95% CI	31.2	24.7	35.3	24.6	46.3	63.1	70.1	30.4	59.3	61.9	72.7	70.5	76.3	50.1	15.1	49.8	49.3	28.9	41.9	77.7

21.Hypertensive heart disease	22.Peripheral vascular disorders	23. Ill-defined cardiovascular	24.Other cardiovascular	25. Chronic obstructive pulmonary disease	26.Other chronic respiratory	27.Peptic ulcer	28.Cirrhosis of liver	29. Other digestive	30. Nephritis/nephrosis	31. Other genitourinary conditions	32. Congenital	33. Other type 2 condtions	35.Road traffic accidents	36.Falls	37.Fires	38.Drowning	39.Suffocation and foreign bodies	40.Other unintentional injuries specified	41.Ill-defined other unintentional	42. Undetermined intent	43.Suicide	44. Homicide	Grand Total	PPV	Lower 95% CI	Upper 95% CI
10	0	1	0	7	3	5	0	0	2	0	0	2	1	3	0	0	0	1	0	0	1	2	340	25.9 (	21.3 -	30.9)
5	0	2	0	0	0	2	1	1	0	0	1	1	1	1	0	0	0	2	0	0	1	1	319	74.9 (	69.8 -	79.6)
1	0	1	0	0	1	3	1	1	2	0	0	5	0	0	0	0	0	0	0	0	0	1	80	11.3 (	5.3 -	20.3)
7	0	4	0	6	5	4	2	0	1	1	2	7	0	1	0	0	1	1	0	0	1	4	173	4.6 (	2.0 -	8.9)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	33.3 (	17.3 -	52.8)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	78.6 (	49.2 -	95.3)
0	0	1	0	2	1	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	38	7.9 (	1.7 -	21.4)
8	1	0	0	2	3	1	2	8	3	0	1	5	3	0	0	0	0	3	0	0	0	1	255	3.9 (	1.9 -	7.1)
1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	32	25.0 (	11.5 -	43.4)
1	0	2	0	2	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	49	32.7 (	19.9 -	47.5)
2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	63.0 (	42.4 -	80.6)
3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	58	34.5 (	22.5 -	48.1)
1	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	43	44.2 (	29.1 -	60.1)
2	0	0	0	0	0	1	4	1	0	2	0	2	0	1	0	0	0	1	1	0	0	0	169	45.6 (	37.9 -	53.4)
2	0	0	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	34	17.6 (	6.8 -	34.5)
40	0	1	0	1	0	4	2	2	0	0	0	2	0	2	1	0	0	0	0	0	0	0	226	39.4 (	33.0 -	46.1)
0	0	0	0	0	0	0	0	0	1	0	0	1	2	2	0	0	0	2	0	1	0	1	43	37.2 (	23.0 -	53.3)
15	0	4	0	3	1	0	2	1	0	0	0	5	0	0	0	0	0	2	0	0	0	1	75	29.3 (	19.4 -	41.0)
26	0	2	0	1	2	0	2	0	0	1	0	3	0	3	0	0	0	1	0	0	0	1	195	48.7 (	41.5 -	56.0)
11	1	4	0	0	0	0	1	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	37	5.4 (	0.7 -	18.2)
50	3	4	0	3	2	1	2	1	3	0	1	5	1	3	0	0	0	0	0	0	1	1	191	26.2 (	20.1 -	33.0)
1	4	2	0	0	0	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	20	20.0 (	5.7 -	43.7)
21	0	5	2	3	2	3	1	0	1	1	2	3	1	1	1	0	1	1	0	0	0	1	118	4.2 (	1.4 -	9.6)
3	0	2	0	1	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	27	0.0 (	0.0 -	12.8)
12	0	7	0	15	9	1	3	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	98	15.3 (	8.8 -	24.0)
6	0	1	0	5	18	0	1	0	0	0	0	3	1	1	0	0	0	1	0	0	0	2	69	26.1 (	16.3 -	38.1)
2	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	10	20.0 (	2.5 -	55.6)
3	0	0	0	0	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	22.2 (	6.4 -	47.6)
5	0	1	0	1	0	4	2	9	0	1	0	0	0	0	0	0	0	2	0	0	0	0	73	12.3 (	5.8 -	22.1)
17	0	2	0	1	1	0	2	0	8	1	0	2	0	1	0	0	0	0	0	0	0	0	91	8.8 (	3.9 -	16.6)
1	0	0	0	0	0	0	1	4	3	1	0	0	0	0	0	0	0	0	0	0	0	0	23	4.3 (	0.1 -	21.9)
0	0	0	0	0	0	0	0	1	0	0	8	0	0	0	0	0	0	0	0	0	0	0	10	80.0 (	44.4 -	97.5)
10	2	2	1	1	0	1	1	2	2	2	2	10	3	2	0	0	0	2	0	0	1	4	239	4.2 (	2.0 -	7.6)
34	1	2	1	8	11	6	3	2	5	0	1	12	2	4	0	0	0	10	1	2	1	6	328			
0	0	0	0	0	0	0	0	0	0	0	0	0	86	0	0	0	0	0	0	0	0	3	89	96.6 (	90.5 -	99.3)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	100.0 (	2.5 -	100.0)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	3	0	1	1	4	24	58.3 (	36.6 -	77.9)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	3	12	75.0 (	42.8 -	94.5)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	39	10	55	1.8 (	0.0 -	9.7)
0	0	0	0	0	0	1	0	3	1	0	0	2	0	3	0	0	0	15	0	0	5	33	75	20.0 (	11.6 -	30.8)
1	0	0	0	0	0	0	0	0	0	0	0	0	75	9	1	1	0	5	1	1	3	55	155	0.6 (	0.0 -	3.5)
1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	7	2	17	0.0 (	0.0 -	19.5)
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1	8	87.5 (	47.3 -	99.7)
0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	1	0	65	71	91.5 (	82.5 -	96.8)
302	12	50	5	64	60	43	39	43	33	12	20	77	181	44	19	10	3	55	4	7	68	203	4,059			
16.6	33.3	10.0	0.0	23.4	30.0	4.7	10.3	20.9	24.2	8.3	40.0	13.0	47.5	2.3	73.7	90.0	33.3	27.3	25.0	0.0	10.3	32.0	Agreement = 30.8%			
12.5	9.9	3.3	0.0	13.8	18.8	0.6	2.9	10.0	11.1	0.2	19.1	6.4	40.1	0.1	48.8	55.5	0.8	16.1	0.6	0.0	4.2	25.7	Kappa = 0.275 (0.268 - 0.280)			
21.2	65.1	21.8	52.2	35.7	43.2	15.8	24.2	36.0	42.3	38.5	63.9	22.6	55.1	12.0	90.9	99.7	90.6	41.0	80.6	41.0	20.1	38.9	Spearman = 0.608 (0.373 - 0.843)			

Table A11: Misclassification pattern for all linked out of facility deaths (excluding ill-defined natural deaths) using shortened SA NBD list (N=2,677), SA NCODV Project 2017/18.

	NCODV OUT OF FACILITY DEATHS (NBD Short list)																					
StatsSA (NBD Short list)	1.Tuberculosis	2.HIV/AIDS	3.Diarrhoeal diseases	4.Lower respiratory infections	5.Maternal	6.Perinatal conditions	7.Malnutrition	8.Other type 1 conditions	9.Oesophagus cancer	10.Trachea/bronchi/lung cancer	11.Breast cancer	12.Cervix cancer	13.Prostate cancer	14.Other cancers	15.Ill-defined cancers	16.Diabetes mellitus	17.Epilepsy	18.Ischaemic heart disease	19.Stroke	20.Inflammatory heart disease	21.Hypertensive heart disease
1.Tuberculosis	57	52	2	2	0	0	0	0	0	0	0	0	1	0	0	3	0	2	1	0	2
2.HIV/AIDS	2	66	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
3.Diarrhoeal diseases	4	17	2	1	0	0	1	3	1	0	0	0	0	0	0	2	0	1	1	0	1
4.Lower respiratory infections	9	25	1	22	1	1	1	1	1	0	0	0	0	1	3	0	0	3	3	0	1
5.Maternal	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.Perinatal conditions	0	0	0	0	0	8	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7.Malnutrition	2	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	1	0	0
8.Other type 1 conditions	5	50	0	2	0	1	0	5	0	0	0	0	0	1	0	0	0	0	1	0	0
9.Oesophagus cancer	0	0	0	0	0	0	0	0	8	0	0	0	0	3	0	0	0	0	0	0	0
10.Trachea/bronchi/lung cancer	0	1	0	0	0	0	0	0	1	22	1	0	0	2	3	0	0	0	0	0	0
11.Breast cancer	0	0	0	0	0	0	0	0	0	0	11	0	0	0	2	0	0	0	0	0	0
12.Cervix cancer	0	6	0	0	0	0	0	0	0	0	1	3	0	3	0	0	0	0	1	0	1
13.Prostate cancer	1	0	0	0	0	0	0	0	0	0	0	0	10	2	2	0	0	0	1	0	1
14.Other cancers	1	4	0	1	0	0	0	1	0	0	0	3	0	36	5	0	0	0	0	0	1
15.Ill-defined cancers	0	3	0	0	0	0	0	0	0	0	0	0	1	4	2	0	0	0	0	0	0
16.Diabetes mellitus	4	4	1	4	0	0	0	0	0	0	0	0	1	1	2	33	0	5	18	0	15
17.Epilepsy	2	3	1	0	0	1	0	0	0	0	0	0	0	0	0	0	15	0	2	0	0
18.Ischaemic heart disease	2	3	0	1	0	0	0	0	0	0	1	0	0	0	1	3	0	34	2	0	6
19.Stroke	2	5	0	2	0	0	1	0	0	0	0	0	2	0	0	6	2	1	39	0	14
20.Inflammatory heart disease	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	2
21.Hypertensive heart disease	9	12	2	5	0	0	0	1	0	2	0	0	4	1	2	1	2	13	17	0	35
22.Peripheral vascular disorders	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
23.Ill defined cardiovascular	9	12	1	4	1	0	0	1	1	0	0	0	0	2	0	3	3	5	6	3	11
24.Other cardiovascular	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	2	0	0
25.Chronic obstructuve pulmonary disease	3	0	0	3	0	0	0	0	2	0	0	0	0	0	0	1	0	2	3	0	3
26.Other chronic respiratory	5	10	0	5	0	0	0	2	0	0	1	0	0	1	1	1	1	3	2	0	6
27.Peptic ulcer	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
28.Cirrhosis of liver	0	1	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
29.Other digestive	1	6	1	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0
30.Nephritis/nephrosis	0	6	3	1	2	0	0	0	1	0	0	1	1	0	1	1	0	0	2	0	1
31.Other genito-urinary	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
32.Congenital	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33.Other type 2 conditions	4	31	0	3	0	0	1	3	0	0	0	0	0	2	1	1	0	5	6	0	2
34. Ill-defined natural	19	54	7	5	0	4	2	3	2	3	3	1	2	7	3	8	2	14	11	1	20
35.Road traffic accidents	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36.Falls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37.Fires	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38.Drowning	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39.Suffocation and foreign bodies	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40.Other unintentional injuries specified	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
41.Ill-defined other unintent	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
42.Undetermined intent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43.Suicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44.Homicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	144	380	23	66	9	16	7	22	17	27	18	9	23	69	30	66	25	93	123	9	124
Sensitivity	39.6	17.4	8.7	33.3	22.2	50.0	0.0	22.7	47.1	81.5	61.1	33.3	43.5	52.2	6.7	50.0	60.0	36.6	31.7	44.4	28.2
Lower 95% CI	31.5	13.7	1.1	22.2	2.8	24.7	0.0	7.8	23.0	61.9	35.7	7.5	23.2	39.8	0.8	37.4	38.7	26.8	23.6	13.7	20.5
Upper 95% CI	48.1	21.6	28.0	46.0	60.0	75.3	41.0	45.4	72.2	93.7	82.7	70.1	65.5	64.4	22.1	62.6	78.9	47.2	40.7	78.8	37.0

22.Peripheral vascular disorders	23.Ill defined cardiovascular	24.Other cardiovascular	25.COPD	26.Other chronic respiratory	27.Peptic ulcer	28.Cirrhosis of liver	29.Other digestive	30.Nephritis/nephrosis	31.Other genitourinary conditions	32.Congenital	33.Other type 2 conditions	35.Road traffic accidents	36.Falls	37.Fires	38.Drowning	39.Suffocation and foreign bodies	40.Other unintentional injuries specified	41.Ill-defined other unintent	42.Undetermined intent	43.Suicide	44.Homicide	Grand Total	PPV	Lower 95% CI	Upper 95% CI
0	0	0	1	2	1	0	1	0	1	0	0	0	1	0	0	0	0	0	1	0	130	43.8	35.2	52.8
1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	74	89.2	79.8	95.2
0	1	0	0	1	2	1	0	0	0	0	3	0	0	0	0	0	0	0	1	1	44	4.5	0.6	15.5
0	3	0	4	2	1	2	0	0	1	1	2	0	0	0	0	0	0	0	1	0	90	24.4	16.0	34.6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	66.7	9.4	99.2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	88.9	51.8	99.7
0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10	0.0	0.0	30.8
0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	68	7.4	2.4	16.3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	72.7	39.0	94.0
0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	31	71.0	52.0	85.8
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	78.6	49.2	95.3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	20.0	4.3	48.1
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	18	55.6	30.8	78.5
0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54	66.7	52.5	78.9
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	11	18.2	2.3	51.8
0	1	1	1	0	2	1	2	0	1	0	4	0	1	1	0	0	0	0	0	0	103	32.0	23.2	42.0
0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	2	0	1	0	32	46.9	29.1	65.3
3	7	0	1	0	0	1	0	0	0	0	5	0	1	0	0	0	0	0	0	1	72	47.2	35.3	59.3
0	0	0	0	1	0	0	0	0	1	0	4	0	0	1	0	0	0	0	2	0	83	47.0	35.9	58.3
1	1	0	1	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	17	23.5	6.8	49.9
3	6	0	1	0	2	0	0	1	0	0	7	0	1	0	0	0	0	0	1	0	128	27.3	19.8	35.9
2	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	6	33.3	4.3	77.7
0	9	1	3	0	2	2	0	1	0	2	3	0	0	0	0	1	1	0	0	2	0	89	10.1	4.7	18.3
0	1	3	2	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	14	21.4	4.7	50.8
0	1	0	14	4	0	2	0	0	0	0	4	0	0	0	0	0	0	0	1	0	0	43	32.6	19.1	48.5
0	1	0	6	14	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	1	63	22.2	12.7	34.5
0	0	0	0	0	3	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	9	33.3	7.5	70.1
0	0	0	0	0	0	3	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	10	30.0	6.7	65.2
0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	17	17.6	3.8	43.4
0	1	0	1	0	0	2	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	28	3.6	0.1	18.3
0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0.0	0.0	36.9
0	0	0	0	0	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	7	71.4	29.0	96.3
1	0	0	0	1	0	0	3	0	0	0	9	2	1	0	0	0	1	0	0	0	1	78	11.5	5.4	20.8
1	6	0	8	3	3	2	2	1	0	1	9	1	3	0	0	1	6	0	8	8	6	240	-		
0	0	0	0	0	0	0	0	0	0	0	0	171	0	0	0	0	2	0	0	1	0	174	98.3	95.0	99.6
0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	3	66.7	9.4	99.2
0	0	0	0	0	0	0	0	0	0	0	0	6	0	14	0	0	1	1	11	1	3	37	37.8	22.5	55.2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	0	3	0	3	42	85.7	71.5	94.6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	1	2	2	161	18	190	2.1	0.6	5.3
0	0	0	0	0	0	0	2	0	0	1	1	0	1	0	0	0	24	0	7	14	107	161	14.9	9.8	21.4
0	0	0	1	0	0	0	0	0	0	0	0	129	3	0	1	2	7	4	11	10	47	219	1.8	0.5	4.6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	3	14	2	21	14.3	3.0	36.3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	20	1	22	90.9	70.8	98.9
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	1	174	179	97.2	93.6	99.1
12	40	6	46	28	19	18	20	6	5	12	58	311	17	20	38	8	48	7	51	240	367	2,677			
16.7	22.5	50.0	30.4	50.0	15.8	16.7	15.0	16.7	0.0	41.7	15.5	55.0	11.8	70.0	94.7	50.0	50.0	57.1	5.9	8.3	47.4	Agreement = 33.6%			
2.1	10.8	11.8	17.7	30.6	3.4	3.6	3.2	0.4	0.0	15.2	7.3	49.3	1.5	45.7	82.3	15.7	35.2	18.4	1.2	5.2	42.2	Kappa = 0.351 (0.297 - 0.319)			
48.4	38.5	88.2	45.8	69.4	39.6	41.4	37.9	64.1	52.2	72.3	27.4	60.6	36.4	88.1	99.4	84.3	64.8	90.1	16.2	12.6	52.7	Spearman= 0.604 (0.330 - 0.879)			

Table A12: Misclassification pattern for all linked missing facility information deaths (excluding ill-defined natural deaths) using shortened SA NBD list (N=3,659), SA NCODV Project 2017/18.

	no ill defined																						
	NCODV UNKNOWN FACILITY DEATHS (NBD Short list)																						
StatsSA (NBD Short list)	1.Tuberculosis	2.HIV/AIDS	3.Diarrhoeal diseases	4.Lower respiratory infections	5.Maternal	6.Perinatal conditions	7.Malnutrition	8.Other type 1 conditions	9.Oesophagus cancer	10.Trachea/bronchi/lung cancer	11.Breast cancer	12.Cervix cancer	13.Prostate cancer	14.Other cancers	15.Ill-defined cancers	16.Diabetes mellitus	17.Epilepsy	18.Ischaemic heart disease	19.Stroke	20.Inflammatory heart disease	21.Hypertensive heart disease	22.Peripheral vascular disorders
1.Tuberculosis	47	60	0	3	0	0	0	0	0	0	0	0	1	0	1	0	1	0	2	0	1	1
2.HIV/AIDS	2	102	0	0	0	0	0	1	0	0	0	0	1	0	2	0	0	0	2	0	0	0
3.Diarrhoeal diseases	0	7	7	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0
4.Lower respiratory infections	6	16	2	23	0	0	0	0	0	1	0	0	1	0	3	2	2	0	4	0	3	1
5.Maternal	3	5	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6.Perinatal conditions	0	0	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.Malnutrition	0	1	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
8.Other type 1 conditions	3	53	0	4	0	1	0	3	0	0	1	0	0	2	2	1	1	0	5	0	1	0
9.Oesophagus cancer	0	0	0	0	0	0	0	0	10	0	0	0	0	0	1	0	0	0	0	0	0	0
10.Trachea/bronchi/lung cancer	0	1	0	0	0	0	0	0	0	15	0	0	0	1	1	0	0	1	0	0	0	0
11.Breast cancer	0	0	1	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0
12.Cervix cancer	0	6	0	0	0	0	0	0	0	0	0	7	0	1	1	0	0	0	0	0	0	0
13.Prostate cancer	0	0	0	0	0	0	0	1	0	1	0	0	9	1	0	0	0	0	1	0	0	0
14.Other cancers	1	4	1	1	1	0	1	0	0	1	0	1	1	39	4	2	0	1	1	1	1	1
15.Ill-defined cancers	1	2	0	0	0	0	0	0	0	2	1	0	0	3	3	0	0	0	0	0	0	0
16.Diabetes mellitus	3	4	2	1	0	0	0	0	0	0	0	0	0	3	1	32	0	4	11	0	10	0
17.Epilepsy	1	1	0	1	0	0	0	2	0	0	0	0	0	0	0	0	6	0	1	0	0	0
18.Ischaemic heart disease	2	3	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	33	3	1	4	0
19.Stroke	1	4	0	1	0	0	0	0	0	1	0	0	1	0	0	4	1	1	48	0	4	0
20.Inflammatory heart disease	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	2	6	0
21.Hypertensive heart disease	0	4	0	5	0	0	0	0	0	1	1	1	0	1	2	3	1	7	10	0	19	0
22.Peripheral vascular disorders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3
23.Ill defined cardiovascular	0	4	0	2	0	0	1	0	0	0	0	0	0	1	0	1	0	5	2	1	10	0
24.Other cardiovascular	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
25.Chronic obstructuve pulmonary disease	5	5	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	3	0
26.Other chronic respiratory	2	3	1	3	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	2	0
27.Peptic ulcer	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0
28.Cirrhosis of liver	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.Other digestive	1	7	2	0	1	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	1	0
30.Nephritis/nephrosis	0	6	1	0	0	0	0	1	0	0	0	0	0	0	1	3	0	0	0	0	4	0
31.Other genito-urinary	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
32.Congenital	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33.Other type 2 conditions	5	31	1	2	0	1	1	1	0	0	0	1	0	2	1	3	1	2	3	0	0	1
34. Ill-defined natural	25	36	3	7	2	2	0	2	2	0	2	1	3	7	2	8	6	19	7	1	19	0
35.Road traffic accidents	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36.Falls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37.Fires	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
38.Drowning	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39.Suffocation and foreign bodies	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
40.Other unintentional injuries specified	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0
41.Ill-defined other unintent	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	2	0	1	0
42.Undetermined intent	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
43.Suicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44.Homicide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grand Total	112	370	24	55	18	9	6	14	13	22	18	12	20	67	26	69	20	79	108	8	94	9
Sensitivity	42.0	27.6	29.2	41.8	66.7	55.6	33.3	21.4	76.9	68.2	72.2	58.3	45.0	58.2	11.5	46.4	30.0	41.8	44.4	25.0	20.2	33.3
Lower 95% CI	32.7	23.1	12.6	28.7	41.0	21.2	4.3	4.7	46.2	45.1	46.5	27.7	23.1	45.5	2.4	34.3	11.9	30.8	34.9	3.2	12.6	7.5
Upper 95% CI	51.7	32.4	51.1	55.9	86.7	86.3	77.7	50.8	95.0	86.1	90.3	84.8	68.5	70.2	30.2	58.8	54.3	53.4	54.3	65.1	29.8	70.1

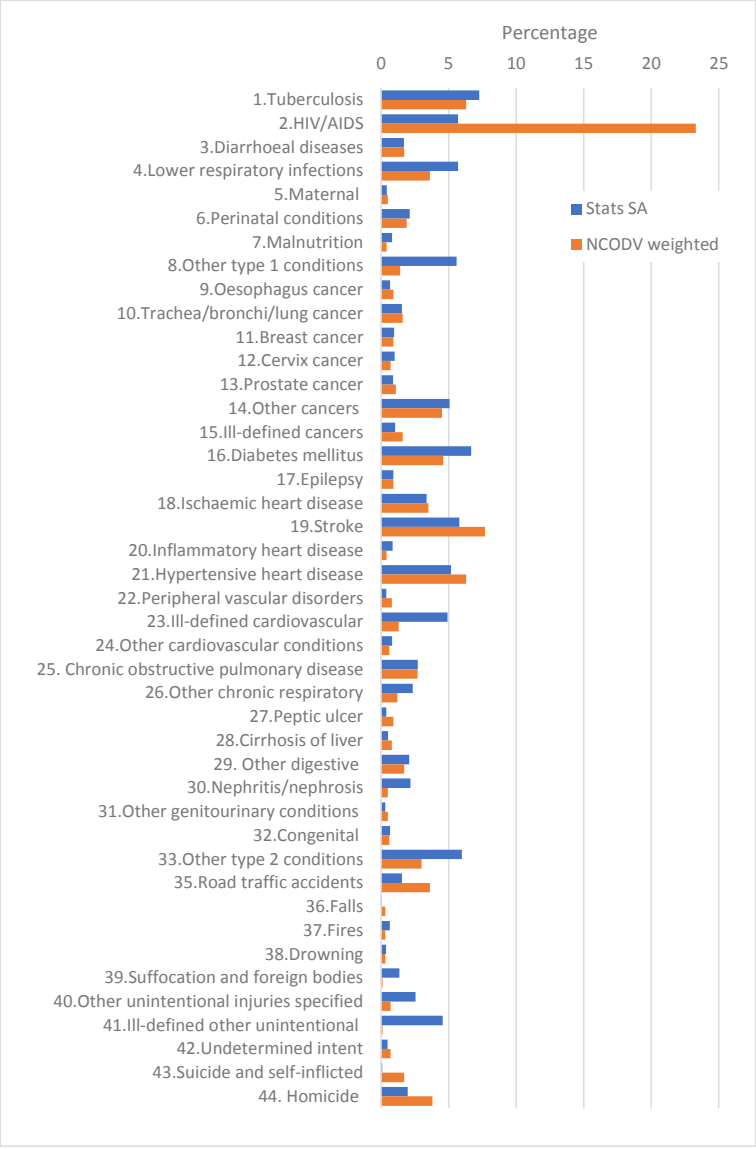
23.Ill defined cardiovascular	24.Other cardiovascular	25.COPD	26.Other chronic respiratory	27.Peptic ulcer	28.Cirrhosis of liver	29.Other digestive	30.Nephritis/nephrosis	31.Other genitourinary conditions	32.Congenital	33.Other type 2 conditions	35.Road traffic accidents	36.Falls	37.Fires	38.Drowning	39.Suffocation and foreign bodies	40.Other unintentional injuries specified	41.Ill-defined other unintent	42.Undetermined intent	43.Suicide	44.Homicide	Grand Total	PPV	Lower 95% CI	Upper 95% CI
0	0	2	2	1	0	0	0	0	0	0	2	1	1	0	0	1	1	0	0	1	129	36.4	28.1	45.4
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	112	91.1	84.2	95.6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	41.2	18.4	67.1
1	1	0	1	0	1	1	0	1	1	1	1	0	0	0	1	1	0	0	2	5	82	28.0	18.7	39.1
0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	25	48.0	27.8	68.7
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	83.3	35.9	99.6
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7	28.6	3.7	71.0
0	1	0	0	0	0	0	0	1	0	2	1	1	0	0	0	4	0	0	0	1	88	3.4	0.7	9.6
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	83.3	51.6	97.9
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	75.0	50.9	91.3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	92.9	66.1	99.8
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	46.7	21.3	73.4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	69.2	38.6	90.9
0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	60.9	47.9	72.9
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	23.1	5.0	53.8
1	0	2	0	1	0	0	0	1	0	1	1	1	0	0	0	1	0	0	0	0	80	40.0	29.2	51.6
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	14	42.9	17.7	71.1
2	1	0	2	0	1	0	0	0	0	1	1	0	0	0	0	2	0	0	0	0	60	55.0	41.6	67.9
1	0	1	1	0	0	1	0	0	0	2	3	0	0	0	0	1	1	2	0	3	82	58.5	47.1	69.3
2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	17	11.8	1.5	36.4
3	2	2	1	2	0	0	2	2	0	2	0	0	0	0	0	1	1	0	0	0	73	26.0	16.5	37.6
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	60.0	14.7	94.7
6	2	0	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	1	0	1	43	14.0	5.3	27.9
0	7	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	20	35.0	15.4	59.2
1	0	18	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	37	48.6	31.9	65.6
0	0	3	5	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	1	1	28	17.9	6.1	36.9
0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	42.9	9.9	81.6
0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	60.0	14.7	94.7
0	0	0	0	2	1	19	0	0	0	1	0	0	0	0	0	1	1	0	0	0	41	46.3	30.7	62.6
0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	18	5.6	0.1	27.3
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	5	0.0	0.0	52.2
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	50.0	1.3	98.7
0	1	0	0	1	0	0	0	0	1	12	1	0	0	0	0	2	1	2	0	1	78	15.4	8.2	25.3
5	3	3	7	5	4	2	3	0	2	10	6	4	1	1	1	15	1	21	23	6	276	-		
0	0	0	0	0	0	0	0	0	0	0	358	0	0	0	0	3	3	4	0	8	376	95.2	92.5	97.1
0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	3	100.0	29.2	100.0
0	0	0	0	0	1	0	0	0	0	0	2	0	54	0	0	8	7	22	2	8	106	50.9	41.0	60.8
0	0	0	0	0	0	0	0	0	0	0	0	1	1	54	0	0	0	8	2	2	68	79.4	67.9	88.3
0	0	1	0	0	0	1	0	0	0	1	1	0	0	3	7	1	2	2	199	25	245	2.9	1.2	5.8
0	0	0	0	1	0	1	0	0	0	0	4	0	0	0	1	38	0	9	18	183	261	14.6	10.5	19.4
0	0	0	0	0	0	1	0	0	0	0	399	17	1	2	1	14	2	23	15	151	634	0.3	0.0	1.1
0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	7	0	23	27	6	68	33.8	22.8	46.3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	14	100.0	76.8	100.0
0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	1	4	2	364	375	97.1	94.8	98.5
24	19	35	22	17	13	29	8	6	5	39	786	30	60	60	11	106	21	124	305	766	3,659			
25.0	36.8	51.4	22.7	17.6	23.1	65.5	12.5	0.0	20.0	30.8	45.5	10.0	90.0	90.0	63.6	35.8	9.5	18.5	4.6	47.5	Agreement = 38.1%			
9.8	16.3	34.0	7.8	3.8	5.0	45.7	0.3	0.0	0.5	17.0	42.0	2.1	79.5	79.5	30.8	26.8	1.2	12.1	2.5	43.9	Kappa = 0.351 (0.335 - 0.354)			
46.7	61.6	68.6	45.4	43.4	53.8	82.1	52.7	45.9	71.6	47.6	49.1	26.5	96.2	96.2	89.1	45.7	30.4	26.5	7.6	51.1	Spearman = 0.656 (0.423 - 0.890)			

8.6 SA NCODV cause of death profile (weighted)

Table A13: Weighted cause specific mortality fractions with confidence intervals, standard errors and design effect for each SA NBD short-list cause, SA NCODV Project 2017/18.

SA NBD short-list	Proportion	95% confidence interval		Standard error	Design effect
Tuberculosis	6.3%	5.9%	6.7%	0.40%	1.12
HIV/AIDS	23.3%	22.7%	24.0%	0.69%	0.96
Diarrhoeal diseases	1.7%	1.5%	1.9%	0.21%	1.02
Lower respiratory infections	3.6%	3.3%	3.9%	0.30%	1.00
Maternal	0.5%	0.4%	0.6%	0.11%	1.09
Perinatal conditions	1.9%	1.7%	2.1%	0.22%	0.97
Malnutrition	0.4%	0.3%	0.5%	~~0.10%~~	0.92
Other type 1 conditions	1.4%	1.2%	1.6%	0.19%	0.92
Oesophagus cancer	0.9%	0.7%	1.0%	0.15%	0.97
Trachea/bronchi/lung cancer	1.6%	1.4%	1.8%	0.20%	0.96
Breast cancer	0.9%	0.7%	1.0%	0.15%	1.11
Cervix cancer	0.7%	0.6%	0.9%	0.14%	0.96
Prostate cancer	1.1%	1.0%	1.3%	0.17%	1.09
Other cancers	4.5%	4.2%	4.8%	0.34%	0.97
Ill-defined cancers	1.6%	1.4%	1.8%	0.20%	1.05
Diabetes Mellitus	4.6%	4.3%	4.9%	0.34%	0.97
Epilepsy	0.9%	0.8%	1.1%	0.16%	1.21
Ischaemic heart disease	3.5%	3.2%	3.8%	0.30%	1.18
Stroke	7.7%	7.3%	8.2%	0.44%	0.99
Inflammatory heart disease	0.4%	0.3%	0.6%	0.11%	1.00
Hypertensive heart disease	6.3%	5.9%	6.7%	0.40%	1.12
Peripheral vascular disorders	0.8%	0.6%	0.9%	0.14%	0.89
Ill-defined cardiovascular	1.3%	1.1%	1.5%	0.19%	1.32
Other cardiovascular	0.6%	0.4%	0.7%	0.12%	1.00
Chronic obstructive pulmonary disease	2.7%	2.5%	3.0%	0.27%	0.94
Other chronic respiratory	1.2%	1.0%	1.3%	0.18%	1.17
Peptic ulcer	0.9%	0.8%	1.1%	0.16%	1.07
Cirrhosis of liver	0.8%	0.7%	1.0%	0.15%	1.03
Other digestive	1.7%	1.5%	1.9%	0.21%	0.88
Nephritis/nephrosis	0.5%	0.4%	0.6%	0.11%	0.95
Other genitourinary conditions	0.5%	0.4%	0.6%	0.11%	0.85
Congenital	0.6%	0.5%	0.7%	0.12%	1.11
Other type 2 conditions	3.0%	2.7%	3.3%	0.28%	1.13
Road traffic accidents	3.6%	3.3%	3.9%	0.30%	0.99
Falls	0.3%	0.2%	0.4%	0.09%	0.97
Fires	0.3%	0.2%	0.4%	0.09%	0.96
Drowning	0.3%	0.2%	0.4%	0.09%	1.00
Suffocation and foreign bodies	0.1%	0.0%	0.1%	0.04%	0.99

SA NBD short-list	Proportion	95% confidence interval		Standard error	Design effect
Other unintentional injuries specified	0.7%	0.6%	0.8%	0.13%	0.98
Ill-defined other unintentional	0.1%	0.1%	0.2%	0.05%	0.96
Undetermined intent	0.7%	0.6%	0.8%	0.14%	0.98
Suicide	1.7%	1.5%	2.0%	0.21%	1.02
Homicide	3.8%	3.5%	4.1%	0.31%	0.97
					Median: 0.99



Other type 1 conditions combines less common infectious diseases (Table A3)

Other type 2 conditions combines less common non-communicable conditions (Table A3)

Figure A5: Cause of death profile based on Stats SA (N=794,408) and NCODV data (N=14,396), SA NCODV Project 2017/18.

Table A14: Cause specific mortality fractions by sex, SA NCODV Project 2017/18.

NBD short-list of causes	Males			Females		
	Proportion	95% CI		Proportion	95% CI	
1. Tuberculosis	8.0%	7.4%	8.6%	4.4%	3.9%	4.9%
2. HIV/AIDS	22.9%	22.0%	23.9%	23.8%	22.8%	24.8%
3. Diarrhoeal Diseases	1.1%	0.9%	1.4%	2.3%	2.0%	2.7%
4. Lower respiratory infections	3.6%	3.2%	4.0%	3.5%	3.1%	4.0%
5. Maternal				1.0%	0.8%	1.3%
6. Perinatal conditions	1.9%	1.6%	2.2%	1.9%	1.6%	2.2%
7. Malnutrition	0.3%	0.2%	0.5%	0.5%	0.3%	0.7%
8. Other type 1 conditions	1.4%	1.1%	1.7%	1.4%	1.2%	1.7%
9. Oesophagus cancer	0.9%	0.7%	1.1%	0.9%	0.7%	1.1%
10. Trachea/bronchi/lung cancer	2.0%	1.7%	2.3%	1.1%	0.9%	1.4%
11. Breast cancer	0.1%	0.0%	0.2%	1.8%	1.5%	2.1%
12. Cervix cancer				1.5%	1.3%	1.9%
13. Prostate cancer	2.2%	1.8%	2.5%			
14. Other cancers	4.3%	3.8%	4.7%	4.8%	4.3%	5.3%
15. Ill-defined cancers	1.2%	0.9%	1.4%	2.1%	1.8%	2.4%
16. Diabetes mellitus	3.6%	3.2%	4.0%	5.7%	5.2%	6.3%
17. Epilepsy	1.1%	0.9%	1.4%	0.7%	0.5%	0.9%
18. Ischaemic heart disease	3.8%	3.4%	4.3%	3.2%	2.8%	3.6%
19. Stroke	6.0%	5.5%	6.5%	9.7%	9.0%	10.4%
20. Inflammatory heart disease	0.5%	0.4%	0.7%	0.3%	0.2%	0.5%
21. Hypertensive heart disease	4.2%	3.7%	4.6%	8.6%	7.9%	9.3%
22. Peripheral vascular disorders	0.5%	0.4%	0.7%	1.1%	0.9%	1.4%
23. Ill-defined cardiovascular	1.2%	1.0%	1.5%	1.5%	1.2%	1.8%
24. Other cardiovascular	0.6%	0.4%	0.8%	0.6%	0.4%	0.8%
25. COPD	3.1%	2.7%	3.5%	2.4%	2.0%	2.8%
26. Other chronic respiratory	1.0%	0.8%	1.3%	1.4%	1.1%	1.7%
27. Peptic ulcer	0.8%	0.6%	1.0%	1.1%	0.9%	1.4%
28. Cirrhosis of liver	1.0%	0.8%	1.3%	0.6%	0.5%	0.9%
29. Other digestive	1.6%	1.3%	1.9%	1.8%	1.5%	2.1%
30. Nephritis/nephrosis	0.6%	0.4%	0.8%	0.4%	0.3%	0.6%
31. Other genito-urinary	0.5%	0.4%	0.7%	0.5%	0.3%	0.6%
32. Congenital	0.5%	0.4%	0.7%	0.7%	0.5%	0.9%
33. Other type 2 conditions	2.6%	2.3%	3.0%	3.4%	3.0%	3.9%
35. Road traffic accidents	5.2%	4.7%	5.7%	1.8%	1.5%	2.2%
36. Falls	0.3%	0.2%	0.5%	0.3%	0.2%	0.5%
37. Fires	0.4%	0.3%	0.6%	0.2%	0.1%	0.4%
38. Drowning	0.5%	0.3%	0.7%	0.1%	0.0%	0.2%

NBD short-list of causes	Males			Females		
	Proportion	95% CI		Proportion	95% CI	
39. Suffocation and foreign bodies	0.1%	0.1%	0.2%	0.0%	0.0%	0.1%
40. Other unintentional injuries specified	0.8%	0.7%	1.1%	0.5%	0.4%	0.7%
41. Ill-defined other unintentional	0.1%	0.1%	0.2%	0.1%	0.0%	0.2%
42. Undetermined whether intentional or unintentional	0.9%	0.7%	1.1%	0.5%	0.4%	0.7%
43. Suicide	2.6%	2.3%	3.0%	0.8%	0.6%	1.0%
44. Homicide	6.1%	5.6%	6.7%	1.2%	1.0%	1.5%

[#] Other type 1 conditions combines less common infectious diseases (Table A3)

[&] Other type 2 conditions combines less common non-communicable conditions (Table A3)

Table A15: Cause specific mortality fractions by age group, SA NCODV Project 2017/18.

NBD short-list of causes	Under 25 yrs			25 - 44 yrs			45 - 59 yrs			60+ yrs		
	Proportion	95% CI		Proportion	95% CI		Proportion	95% CI		Proportion	95% CI	
1. Tuberculosis	4.9%	3.9%	6.0%	4.8%	4.1%	5.6%	8.5%	7.5%	9.5%	6.4%	4.4%	7.5%
2. HIV/AIDS	14.5%	12.8%	16.2%	49.7%	48.0%	51.4%	33.2%	31.5%	34.9%	7.7%	6.8%	9.4%
3. Diarrhoeal Diseases	4.0%	3.2%	5.1%	0.3%	0.2%	0.6%	0.7%	0.4%	1.0%	2.2%	1.6%	2.8%
4. Lower respiratory infections	6.5%	5.4%	7.9%	1.0%	0.7%	1.4%	2.5%	2.0%	3.1%	4.6%	4.5%	5.9%
5. Maternal	1.0%	0.6%	1.6%	1.6%	1.3%	2.1%						
6. Perinatal conditions	16.4%	14.7%	18.3%									
7. Malnutrition	2.1%	1.5%	2.9%	0.1%	0.0%	0.3%	0.2%	0.1%	0.5%	0.2%	0.2%	0.4%
8. Other type 1 conditions[#]	5.0%	4.1%	6.2%	0.8%	0.6%	1.2%	1.0%	0.7%	1.4%	0.9%	0.7%	1.6%
9. Oesophagus cancer				0.2%	0.1%	0.5%	1.0%	0.7%	1.5%	1.4%	1.1%	2.0%
10. Trachea/bronchi/lung cancer	0.1%	0.0%	0.4%	0.3%	0.1%	0.5%	1.7%	1.3%	2.2%	2.5%	2.1%	3.5%
11. Breast cancer				0.5%	0.3%	0.8%	1.6%	1.2%	2.1%	1.0%	0.6%	1.3%
12. Cervix cancer				0.2%	0.1%	0.5%	1.1%	0.8%	1.6%	1.0%	0.7%	1.4%
13. Prostate cancer				0.0%	0.0%	0.2%	0.3%	0.2%	0.6%	2.4%	1.7%	2.8%
14. Other cancers	1.5%	1.0%	2.2%	1.9%	1.5%	2.4%	4.6%	3.9%	5.4%	6.6%	5.8%	7.8%
15. Ill-defined cancers	0.7%	0.4%	1.2%	0.4%	0.2%	0.7%	1.9%	1.5%	2.5%	2.3%	1.7%	2.7%
16. Diabetes mellitus	0.9%	0.6%	1.6%	1.0%	0.7%	1.4%	4.0%	3.4%	4.8%	7.6%	7.1%	8.7%
17. Epilepsy	1.1%	0.7%	1.8%	1.1%	0.8%	1.5%	1.1%	0.7%	1.5%	0.7%	0.4%	0.8%
18. Ischaemic heart disease	0.3%	0.1%	0.7%	1.6%	1.2%	2.1%	3.9%	3.3%	4.7%	5.1%	3.6%	6.3%
19. Stroke	0.5%	0.2%	1.0%	1.7%	1.3%	2.2%	6.4%	5.6%	7.4%	13.2%	12.2%	14.7%
20. Inflammatory heart disease	0.5%	0.2%	1.0%	0.6%	0.4%	1.0%	0.6%	0.4%	1.0%	0.3%	0.2%	0.5%
21. Hypertensive heart disease	0.2%	0.1%	0.6%	1.2%	0.9%	1.6%	4.7%	4.0%	5.5%	11.1%	8.6%	11.0%
22. Peripheral vascular disorders				0.3%	0.1%	0.5%	0.6%	0.4%	1.0%	1.3%	1.1%	2.2%
23. Ill-defined cardiovascular	0.4%	0.2%	0.9%	0.6%	0.4%	0.9%	1.5%	1.1%	2.0%	1.8%	1.0%	1.9%
24. Other cardiovascular	0.4%	0.2%	0.9%	0.4%	0.2%	0.6%	0.6%	0.3%	0.9%	0.7%	0.5%	1.2%
25. COPD				0.3%	0.1%	0.5%	2.3%	1.8%	2.9%	4.9%	4.4%	6.4%
26. Other chronic respiratory	0.7%	0.4%	1.2%	0.6%	0.4%	0.9%	1.6%	1.2%	2.1%	1.4%	0.9%	2.0%

NBD short-list of causes	Under 25 yrs			25 - 44 yrs			45 - 59 yrs			60+ yrs		
	Proportion	95% CI		Proportion	95% CI		Proportion	95% CI		Proportion	95% CI	
27. Peptic ulcer	0.4%	0.2%	0.9%	0.4%	0.2%	0.7%	0.7%	0.5%	1.1%	1.4%	1.2%	1.8%
28. Cirrhosis of liver	0.1%	0.0%	0.4%	0.5%	0.3%	0.8%	1.2%	0.9%	1.7%	1.0%	0.8%	1.3%
29. Other digestive	1.6%	1.1%	2.3%	1.3%	1.0%	1.8%	1.5%	1.1%	2.0%	2.0%	2.0%	3.0%
30. Nephritis/nephrosis	0.4%	0.2%	0.9%	0.4%	0.3%	0.7%	0.6%	0.4%	1.0%	0.5%	0.3%	0.8%
31. Other genitourinary conditions	0.1%	0.0%	0.4%	0.3%	0.1%	0.5%	0.3%	0.1%	0.5%	0.8%	0.7%	1.3%
32. Congenital	4.4%	3.5%	5.5%	0.1%	0.0%	0.3%	0.0%	0.0%	0.2%	0.1%	0.0%	0.1%
33. Other type 2 conditions	5.3%	4.3%	6.5%	1.7%	1.3%	2.1%	1.6%	1.2%	2.2%	3.7%	3.0%	4.4%
35. Road traffic accidents											0.6%	1.1%
36. Falls	7.1%	6.0%	8.5%	7.8%	6.9%	8.8%	3.1%	2.5%	3.8%	0.8%	0.3%	0.7%
37. Fires	0.3%	0.1%	0.8%	0.2%	0.1%	0.4%	0.2%	0.1%	0.4%	0.4%	0.1%	0.2%
38. Drowning	0.8%	0.4%	1.3%	0.5%	0.3%	0.8%	0.2%	0.1%	0.5%	0.1%	0.0%	0.1%
39. Suffocation and foreign bodies	1.5%	1.0%	2.3%	0.3%	0.2%	0.5%	0.1%	0.1%	0.4%	0.0%	0.0%	0.1%
40. Other unintentional injuries specified	0.2%	0.1%	0.6%	0.1%	0.0%	0.3%	0.1%	0.0%	0.3%	0.0%	0.3%	0.5%
41. Ill-defined other unintentional	1.4%	0.9%	2.1%	1.0%	0.7%	1.4%	0.6%	0.4%	1.0%	0.4%	0.0%	0.1%
42. Undetermined intent	0.2%	0.1%	0.6%	0.1%	0.0%	0.3%	0.1%	0.0%	0.4%	0.1%	0.1%	0.4%
43. Suicide	1.9%	1.3%	2.7%	1.1%	0.8%	1.6%	0.6%	0.4%	0.9%	0.2%	0.3%	0.6%
44. Homicide	3.6%	2.8%	4.6%	3.9%	3.3%	4.6%	1.2%	0.9%	1.7%	0.4%	0.4%	0.8%

[#] Other type 1 conditions combines less common infectious diseases (Table A3)

[&] Other type 2 conditions combines less common non-communicable conditions (Table A3)

Table A16: Cause specific mortality fractions by province, SA NCODV Project 2017/18.

NBD short-list of causes	Eastern Cape			Free State			Gauteng		
	Proportion	95% CI		Proportion	95% CI		Proportion	95% CI	
1. Tuberculosis	7.0%	6.1%	8.1%	5.9%	4.9%	7.3%	4.9%	4.0%	6.0%
2. HIV/AIDS	21.7%	20.2%	23.3%	24.5%	22.4%	26.7%	22.2%	20.4%	24.1%
3. Diarrhoeal diseases	1.5%	1.1%	2.1%	2.1%	1.5%	2.9%	1.7%	1.2%	2.4%
4. Lower respiratory infections	3.4%	2.8%	4.1%	4.5%	3.5%	5.7%	5.4%	4.4%	6.5%
5. Maternal	0.4%	0.2%	0.7%	0.5%	0.2%	1.0%	0.3%	0.1%	0.7%
6. Perinatal conditions	0.7%	0.5%	1.1%	1.0%	0.6%	1.7%	3.2%	2.5%	4.1%
7. Malnutrition	0.5%	0.3%	0.9%	0.7%	0.4%	1.3%	0.4%	0.2%	0.8%
8. Other type 1 conditions#	1.4%	1.0%	1.9%	1.9%	1.3%	2.7%	1.5%	1.1%	2.2%
9. Oesophagus cancer	1.6%	1.2%	2.1%	0.5%	0.2%	1.0%	0.8%	0.5%	1.3%
10. Trachea/bronchi/lung cancer	1.9%	1.5%	2.5%	0.5%	0.3%	1.1%	1.3%	0.9%	1.9%
11. Breast cancer	1.0%	0.7%	1.4%	0.3%	0.1%	0.7%	1.2%	0.8%	1.8%
12. Cervix cancer	0.9%	0.6%	1.3%	1.2%	0.8%	1.9%	0.7%	0.4%	1.2%
13. Prostate cancer	1.3%	0.9%	1.8%	1.5%	1.0%	2.2%	1.1%	0.7%	1.6%
14. Other cancers	4.9%	4.1%	5.7%	2.7%	2.0%	3.7%	5.5%	4.6%	6.6%
15. Ill-defined cancers	1.4%	1.0%	1.9%	1.9%	1.3%	2.7%	1.7%	1.2%	2.4%
16. Diabetes mellitus	3.6%	3.0%	4.4%	5.1%	4.1%	6.3%	5.2%	4.3%	6.3%
17. Epilepsy	1.4%	1.0%	1.9%	0.7%	0.4%	1.3%	0.7%	0.4%	1.1%
18. Ischaemic heart disease	3.6%	2.9%	4.3%	1.6%	1.1%	2.4%	3.5%	2.7%	4.4%
19. Stroke	8.5%	7.5%	9.6%	9.9%	8.5%	11.6%	6.7%	5.6%	7.9%
20. Inflammatory heart disease	0.7%	0.5%	1.1%	0.2%	0.0%	0.6%	0.5%	0.3%	1.0%
21. Hypertensive heart disease	4.1%	3.4%	5.0%	8.8%	7.5%	10.4%	6.1%	5.1%	7.2%
22. Peripheral vascular disorders	0.9%	0.6%	1.4%	0.8%	0.4%	1.4%	1.0%	0.6%	1.6%
23. Ill-defined cardiovascular	1.3%	1.0%	1.9%	2.2%	1.6%	3.1%	0.6%	0.3%	1.1%
24. Other cardiovascular	0.7%	0.5%	1.1%	0.4%	0.2%	0.9%	1.0%	0.6%	1.5%
25. Chronic obstructive pulmonary disease	3.2%	2.6%	3.9%	1.6%	1.1%	2.4%	2.2%	1.7%	3.0%
26. Other chronic respiratory	1.6%	1.1%	2.1%	1.3%	0.9%	2.0%	0.9%	0.5%	1.4%

NBD short-list of causes	Eastern Cape			Free State			Gauteng		
	Proportion	95% CI		Proportion	95% CI		Proportion	95% CI	
27. Peptic ulcer	0.8%	0.5%	1.2%	1.4%	0.9%	2.1%	1.5%	1.0%	2.1%
28. Cirrhosis of liver	0.7%	0.5%	1.1%	1.0%	0.6%	1.6%	0.4%	0.2%	0.8%
29. Other digestive	1.7%	1.3%	2.3%	1.9%	1.3%	2.8%	1.9%	1.4%	2.6%
30. Nephritis/nephrosis	0.3%	0.2%	0.7%	1.1%	0.6%	1.7%	0.5%	0.3%	1.0%
31. Other genitourinary conditions	0.4%	0.2%	0.7%	0.7%	0.4%	1.3%	0.5%	0.3%	0.9%
32. Congenital	0.5%	0.3%	0.8%	0.4%	0.2%	0.8%	0.7%	0.4%	1.3%
33. Other type 2 conditions[&]	2.6%	2.1%	3.3%	2.8%	2.1%	3.7%	2.6%	2.0%	3.4%
35. Road traffic accidents	2.5%	2.0%	3.2%	2.6%	1.9%	3.5%	3.2%	2.5%	4.1%
36. Falls	0.5%	0.3%	0.8%	0.2%	0.1%	0.7%	0.4%	0.2%	0.7%
37. Fires	0.5%	0.3%	0.8%	0.0%	0.0%	0.5%	0.4%	0.2%	0.8%
38. Drowning	0.5%	0.3%	0.8%	0.2%	0.1%	0.6%	0.1%	0.0%	0.4%
39. Suffocation and foreign bodies	0.1%	0.0%	0.3%				0.0%	0.0%	0.4%
40. Other unintentional injuries specified	0.8%	0.5%	1.2%	0.5%	0.2%	1.0%	0.9%	0.6%	1.5%
41. Ill-defined other unintentional	0.1%	0.1%	0.4%	0.2%	0.1%	0.6%	0.1%	0.0%	0.4%
42. Undetermined intent	1.1%	0.8%	1.6%	0.8%	0.5%	1.4%	0.7%	0.4%	1.1%
43. Suicide	1.6%	1.2%	2.2%	1.1%	0.6%	1.7%	1.8%	1.3%	2.5%
44. Homicide	6.2%	5.3%	7.2%	2.8%	2.1%	3.8%	4.2%	3.4%	5.2%

NBD short-list of causes	KwaZulu-Natal			Limpopo			Mpumalanga		
	Proportion	95% CI		Proportion	95% CI		Proportion	95% CI	
1. Tuberculosis	5.3%	4.2%	6.6%	4.3%	3.1%	5.9%	4.7%	3.7%	6.0%
2. HIV/AIDS	32.2%	29.8%	34.6%	21.0%	18.4%	23.8%	26.5%	24.2%	28.9%
3. Diarrhoeal diseases	2.1%	1.5%	3.0%	2.0%	1.3%	3.2%	1.9%	1.3%	2.8%
4. Lower respiratory infections	2.4%	1.7%	3.3%	2.7%	1.8%	4.0%	2.9%	2.1%	3.9%
5. Maternal	0.5%	0.2%	1.0%	1.4%	0.8%	2.4%	0.4%	0.2%	1.0%
6. Perinatal conditions	0.8%	0.5%	1.5%	0.9%	0.4%	1.8%	1.1%	0.6%	1.8%
7. Malnutrition	0.4%	0.2%	0.9%	0.5%	0.2%	1.2%	0.3%	0.1%	0.8%
8. Other type 1 conditions[#]	1.4%	0.9%	2.2%	2.4%	1.6%	3.7%	0.7%	0.4%	1.4%
9. Oesophagus cancer	0.9%	0.5%	1.5%	0.6%	0.2%	1.4%	0.5%	0.2%	1.0%
10. Trachea/bronchi/lung cancer	1.3%	0.9%	2.1%	0.8%	0.4%	1.6%	1.0%	0.6%	1.7%
11. Breast cancer	0.9%	0.5%	1.6%	1.2%	0.7%	2.2%	0.1%	0.0%	0.5%
12. Cervix cancer	0.5%	0.3%	1.1%	1.5%	0.9%	2.5%	1.0%	0.6%	1.7%
13. Prostate cancer	0.5%	0.2%	1.0%	0.8%	0.4%	1.7%	0.4%	0.2%	0.9%
14. Other cancers	5.2%	4.1%	6.5%	3.3%	2.3%	4.7%	4.6%	3.6%	5.8%
15. Ill-defined cancers	2.2%	1.5%	3.1%	1.4%	0.8%	2.4%	1.0%	0.6%	1.7%
16. Diabetes mellitus	5.9%	4.8%	7.2%	6.6%	5.2%	8.5%	5.5%	4.4%	6.8%
17. Epilepsy	0.8%	0.4%	1.4%	0.4%	0.1%	1.1%	1.2%	0.7%	1.9%
18. Ischaemic heart disease	2.9%	2.2%	4.0%	1.2%	0.7%	2.2%	3.6%	2.7%	4.7%
19. Stroke	10.1%	8.6%	11.8%	9.6%	7.8%	11.8%	6.5%	5.3%	8.0%
20. Inflammatory heart disease	0.3%	0.1%	0.8%	1.0%	0.5%	1.9%	0.3%	0.1%	0.9%
21. Hypertensive heart disease	8.1%	6.8%	9.7%	4.8%	3.6%	6.5%	5.8%	4.6%	7.1%
22. Peripheral vascular disorders	1.0%	0.6%	1.6%	0.7%	0.3%	1.5%	0.3%	0.1%	0.8%
23. Ill-defined cardiovascular	0.7%	0.4%	1.3%	2.5%	1.6%	3.7%	0.8%	0.4%	1.4%
24. Other cardiovascular	0.4%	0.2%	0.9%	0.4%	0.1%	1.1%	0.6%	0.3%	1.2%
25. Chronic obstructive pulmonary disease	1.5%	0.9%	2.2%	1.0%	0.5%	1.9%	2.4%	1.7%	3.3%
26. Other chronic respiratory	1.2%	0.7%	1.9%	1.1%	0.6%	2.0%	1.1%	0.7%	1.9%
27. Peptic ulcer	0.5%	0.3%	1.1%	0.5%	0.2%	1.2%	0.5%	0.2%	1.1%

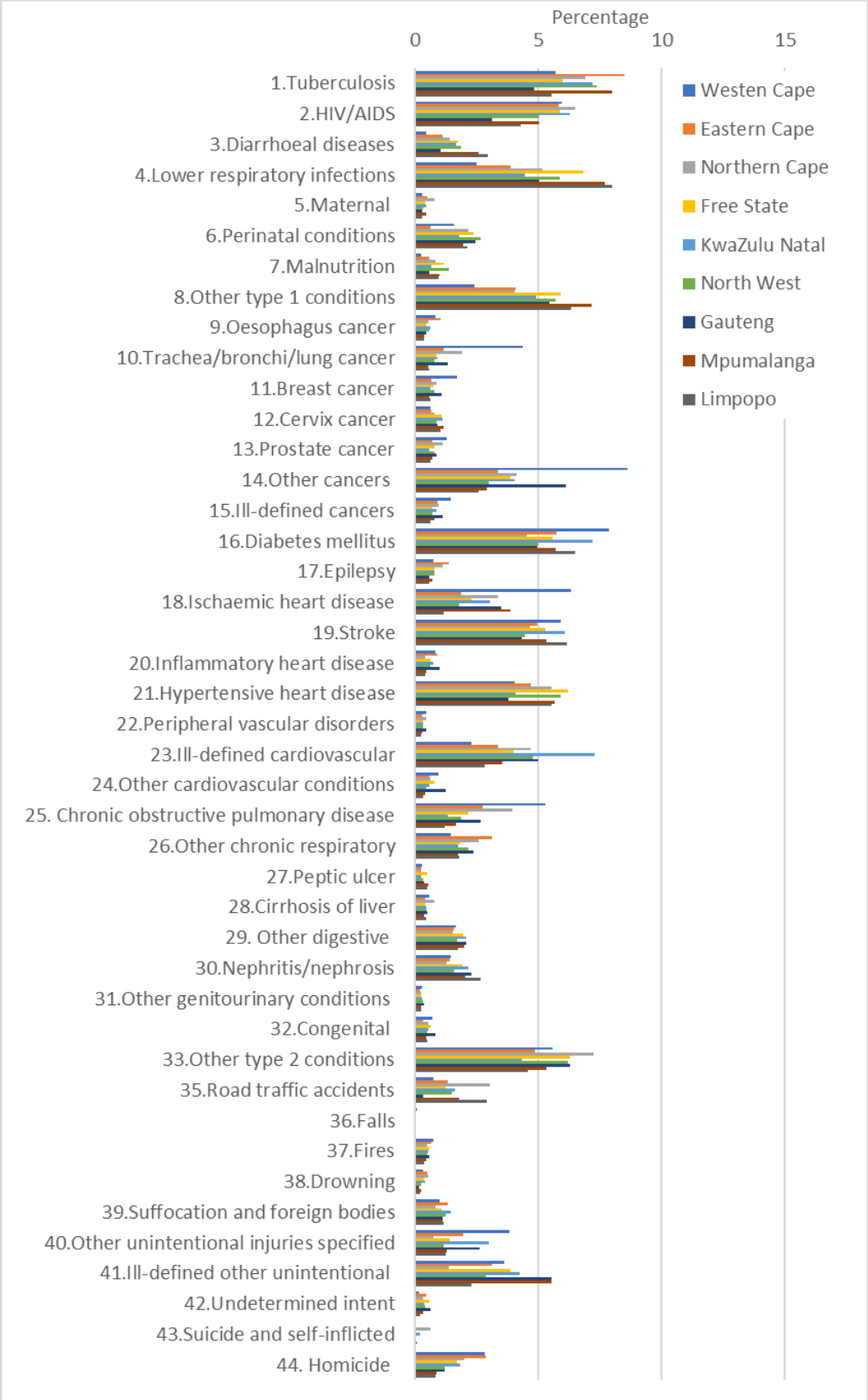
NBD short-list of causes	KwaZulu-Natal			Limpopo			Mpumalanga		
	Proportion	95% CI		Proportion	95% CI		Proportion	95% CI	
28. Cirrhosis of liver	1.0%	0.6%	1.7%	1.1%	0.6%	2.1%	0.7%	0.4%	1.3%
29. Other digestive	1.2%	0.8%	1.9%	2.6%	1.8%	3.9%	1.5%	0.9%	2.3%
30. Nephritis/nephrosis	0.5%	0.3%	1.1%				0.7%	0.4%	1.4%
31. Other genitourinary conditions	0.8%	0.5%	1.5%	0.5%	0.2%	1.3%	0.5%	0.2%	1.0%
32. Congenital	0.2%	0.0%	0.6%	0.7%	0.3%	1.5%	0.8%	0.4%	1.5%
33. Other type 2 conditions[&]	2.8%	2.0%	3.8%	2.6%	1.8%	3.9%	3.6%	2.7%	4.7%
35. Road traffic accidents	0.8%	0.5%	1.5%	7.9%	6.3%	9.9%	6.4%	5.2%	7.9%
36. Falls	0.4%	0.2%	1.0%	0.4%	0.1%	1.1%	0.3%	0.1%	0.8%
37. Fires	0.1%	0.0%	0.5%	0.4%	0.1%	1.1%	0.3%	0.1%	0.9%
38. Drowning	0.1%	0.0%	0.5%	0.4%	0.1%	1.1%	0.3%	0.1%	0.8%
39. Suffocation and foreign bodies	0.0%	0.0%	0.6%	0.3%	0.1%	1.0%	0.1%	0.0%	0.6%
40. Other unintentional injuries specified	0.3%	0.1%	0.8%	1.0%	0.5%	1.9%	0.9%	0.5%	1.6%
41. Ill-defined other unintentional	0.0%	0.0%	0.5%	0.1%	0.0%	0.8%	0.2%	0.0%	0.6%
42. Undetermined intent	0.1%	0.0%	0.5%	0.6%	0.3%	1.4%	1.2%	0.7%	1.9%
43. Suicide	0.8%	0.4%	1.4%	2.6%	1.8%	3.9%	2.7%	2.0%	3.7%
44. Homicide	1.0%	0.6%	1.6%	4.2%	3.0%	5.7%	4.3%	3.3%	5.5%

NBD short-list of causes	Northern Cape			North West			Western Cape		
	Proportion	95% CI		Proportion	95% CI		Proportion	95% CI	
1. Tuberculosis	7.8%	6.4%	9.6%	6.6%	5.6%	7.7%	9.4%	7.9%	11.2%
2. HIV/AIDS	22.3%	19.9%	24.8%	25.6%	23.9%	27.5%	12.8%	11.1%	14.8%
3. Diarrhoeal diseases	0.8%	0.4%	1.6%	1.9%	1.4%	2.5%	1.0%	0.6%	1.7%
4. Lower respiratory infections	3.3%	2.4%	4.6%	2.8%	2.2%	3.6%	4.2%	3.2%	5.5%
5. Maternal	0.4%	0.1%	1.0%	0.7%	0.5%	1.2%	0.1%	0.0%	0.6%
6. Perinatal conditions	3.9%	2.9%	5.2%	4.0%	3.3%	4.9%	0.5%	0.2%	1.1%
7. Malnutrition	0.5%	0.2%	1.1%	0.2%	0.1%	0.5%	0.2%	0.0%	0.6%
8. Other type 1 conditions[#]	1.9%	1.3%	2.9%	1.0%	0.7%	1.5%	0.7%	0.4%	1.3%
9. Oesophagus cancer	0.5%	0.2%	1.1%	1.0%	0.7%	1.5%	0.8%	0.4%	1.4%
10. Trachea/bronchi/lung cancer	1.9%	1.2%	2.9%	1.1%	0.7%	1.6%	4.2%	3.3%	5.5%
11. Breast cancer	0.9%	0.5%	1.7%	1.0%	0.6%	1.5%	1.4%	0.9%	2.2%
12. Cervix cancer	0.4%	0.2%	1.0%	0.4%	0.2%	0.8%	0.3%	0.1%	0.7%
13. Prostate cancer	1.1%	0.7%	1.9%	1.2%	0.9%	1.8%	2.0%	1.4%	3.0%
14. Other cancers	3.8%	2.8%	5.1%	3.5%	2.8%	4.4%	6.7%	5.5%	8.3%
15. Ill-defined cancers	1.9%	1.2%	2.9%	1.3%	0.9%	1.8%	2.0%	1.3%	2.9%
16. Diabetes mellitus	2.6%	1.8%	3.7%	4.4%	3.6%	5.3%	3.7%	2.8%	4.9%
17. Epilepsy	1.7%	1.1%	2.6%	0.5%	0.3%	0.9%	0.7%	0.4%	1.3%
18. Ischaemic heart disease	4.8%	3.7%	6.3%	3.0%	2.4%	3.8%	7.4%	6.1%	8.9%
19. Stroke	7.9%	6.5%	9.6%	5.3%	4.4%	6.3%	6.7%	5.5%	8.2%
20. Inflammatory heart disease	0.1%	0.0%	0.6%	0.3%	0.1%	0.7%	0.5%	0.2%	1.1%
21. Hypertensive heart disease	4.1%	3.1%	5.5%	7.8%	6.8%	9.0%	6.6%	5.3%	8.0%
22. Peripheral vascular disorders	0.9%	0.5%	1.7%	0.6%	0.4%	1.1%	0.8%	0.4%	1.5%
23. Ill-defined cardiovascular	1.6%	1.0%	2.5%	1.1%	0.8%	1.7%	1.9%	1.3%	2.8%
24. Other cardiovascular	0.1%	0.0%	0.6%	0.6%	0.3%	1.0%	0.6%	0.3%	1.2%
25. Chronic obstructive pulmonary disease	2.7%	1.9%	3.8%	3.0%	2.4%	3.8%	6.3%	5.1%	7.7%
26. Other chronic respiratory	1.3%	0.8%	2.2%	0.8%	0.5%	1.3%	1.3%	0.8%	2.0%
27. Peptic ulcer	0.4%	0.1%	1.0%	1.6%	1.1%	2.2%	0.5%	0.2%	1.1%

NBD short-list of causes	Northern Cape			North West			Western Cape		
	Proportion	95% CI		Proportion	95% CI		Proportion	95% CI	
28. Cirrhosis of liver	1.6%	1.0%	2.5%	1.0%	0.7%	1.6%	0.3%	0.1%	0.8%
29. Other digestive	0.6%	0.3%	1.3%	1.6%	1.1%	2.2%	2.4%	1.7%	3.3%
30. Nephritis/nephrosis	0.5%	0.2%	1.2%	0.3%	0.2%	0.7%	0.3%	0.1%	0.8%
31. Other genitourinary conditions	0.4%	0.1%	1.0%	0.3%	0.1%	0.6%	0.5%	0.2%	1.1%
32. Congenital	0.4%	0.2%	1.0%	0.7%	0.4%	1.1%	1.0%	0.6%	1.7%
33. Other type 2 conditions[&]	3.3%	2.4%	4.5%	3.1%	2.5%	3.9%	4.0%	3.0%	5.2%
35. Road traffic accidents	5.2%	4.0%	6.6%	4.2%	3.4%	5.1%	2.6%	1.9%	3.7%
36. Falls	0.1%	0.0%	0.6%	0.2%	0.1%	0.6%	0.2%	0.1%	0.7%
37. Fires	0.4%	0.2%	1.0%	0.3%	0.1%	0.6%	0.4%	0.2%	1.0%
38. Drowning	0.4%	0.2%	1.0%	0.2%	0.1%	0.5%	0.3%	0.1%	0.9%
39. Suffocation and foreign bodies				0.1%	0.0%	0.3%	0.0%	0.0%	0.7%
40. Other unintentional injuries specified	0.5%	0.2%	1.1%	0.7%	0.4%	1.1%	0.6%	0.3%	1.2%
41.Ill-defined other unintentional	0.1%	0.0%	0.6%	0.1%	0.0%	0.3%			
42. Undetermined intent	0.6%	0.3%	1.2%	0.7%	0.4%	1.1%	0.2%	0.0%	0.6%
43. Suicide	1.9%	1.3%	2.9%	2.1%	1.6%	2.8%	1.4%	0.9%	2.2%
44. Homicide	4.5%	3.4%	5.9%	3.0%	2.4%	3.8%	2.6%	1.8%	3.6%

[#] Other type 1 conditions combines less common infectious diseases (Table A3)

[&] Other type 2 conditions combines less common non-communicable conditions (Table A3)

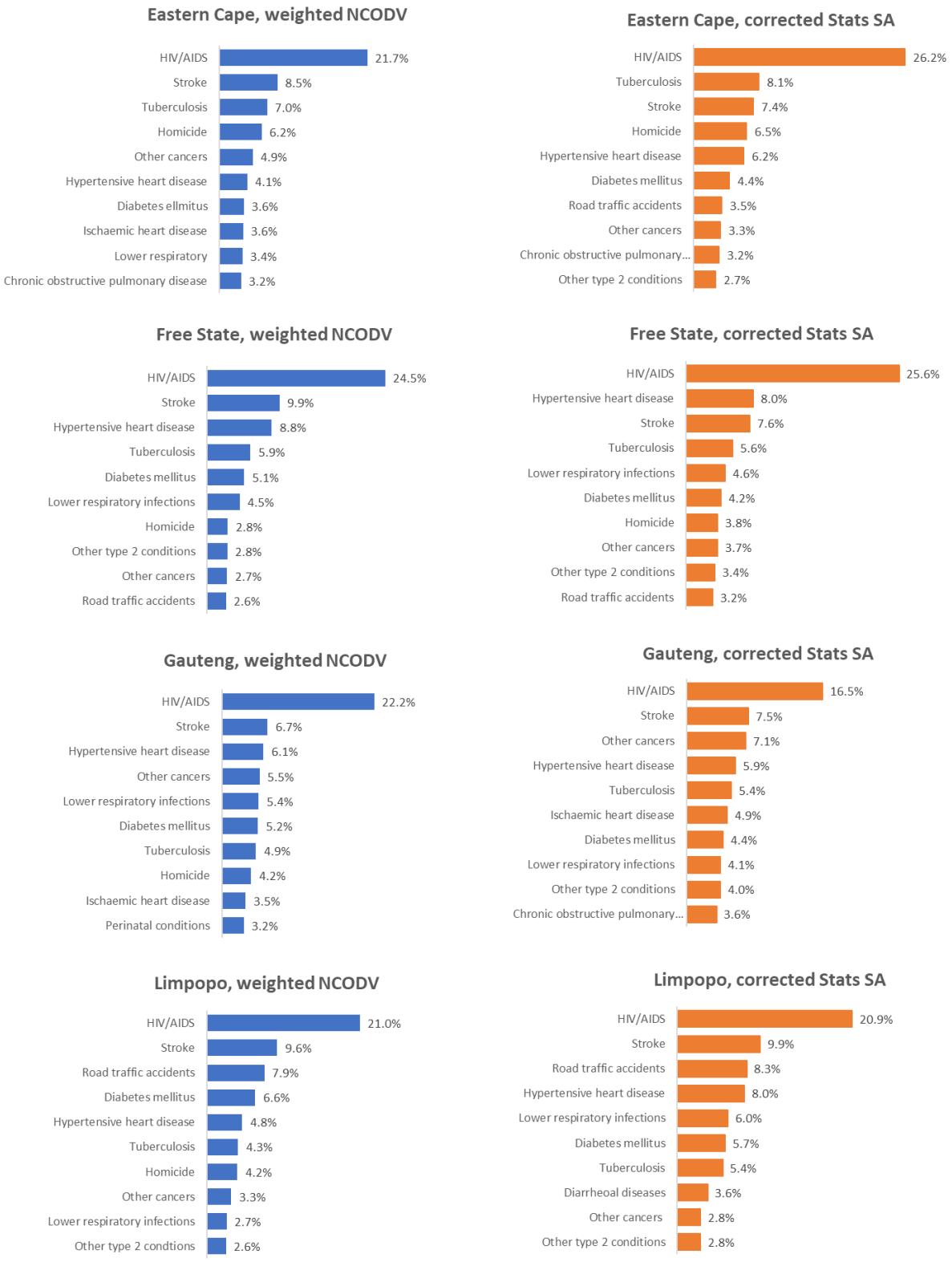


Other type 1 conditions combines less common infectious diseases (Table A3)

Other type 2 conditions combines less common non-communicable conditions (Table A3)

Figure A6: Provincial cause of death profile, Stats SA 2017/18.

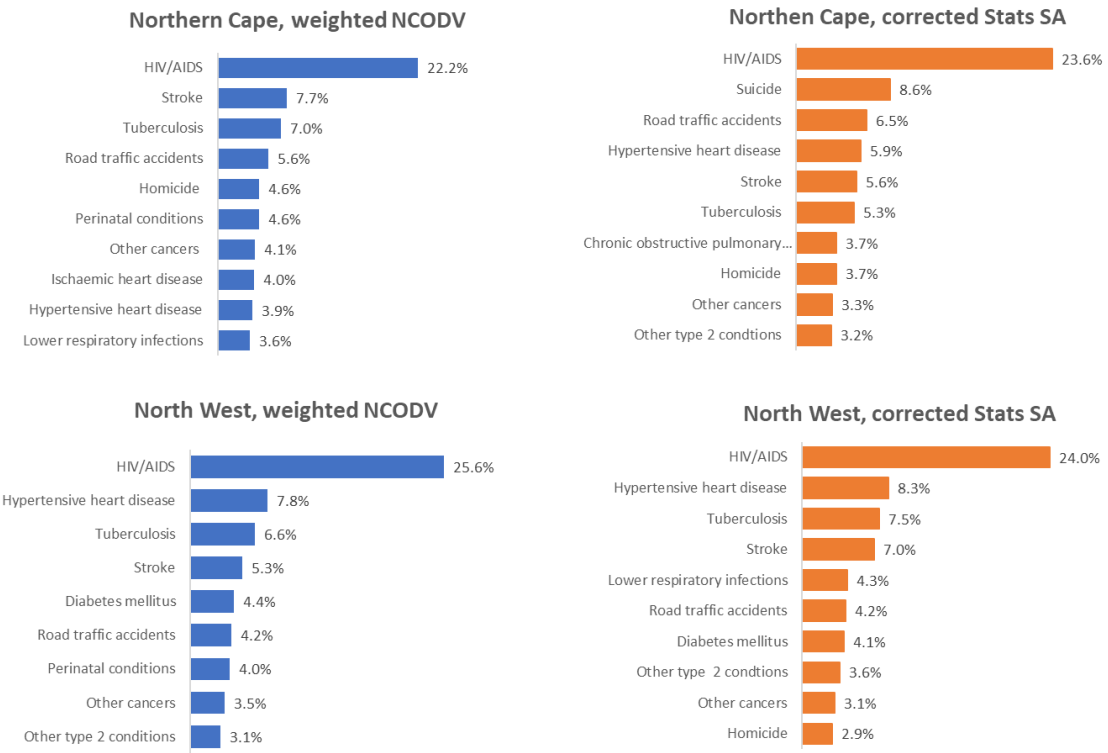
8.7 Leading causes of death by province based on SA NCODV and corrected Stats SA data



Other type 1 conditions combines less common infectious diseases (Table A3)

Other type 2 conditions combines less common non-communicable conditions (Table A3)

Figure A7: Comparison of top ten causes of death based on weighted SA NCODV sample and corrected Stats SA for Eastern Cape, Free State, Gauteng and Limpopo, SA NCODV project 2017/18.



Other type 1 conditions combines less common infectious diseases (Table A3)
Other type 2 conditions combines less common non-communicable conditions (Table A3)

Figure A8: Comparison of top ten causes of death based on weighted SA NCODV sample and corrected Stats SA for Northern Cape and North West, SA NCODV project 2017/18.

8.8 Comparative information from the 2nd Injury Mortality Survey 2017

Figure A9 shows the injury death rates for homicide, transport and suicide by province based on the IMS 2017.[42] This highlights the relative ranking of these causes of death in each province with homicides leading in Eastern Cape, Free State, Gauteng, KwaZulu-Natal and Western Cape while homicides and road traffic were similar in the Northern Cape and road traffic was the leading cause in Limpopo, Mpumalanga and North West.

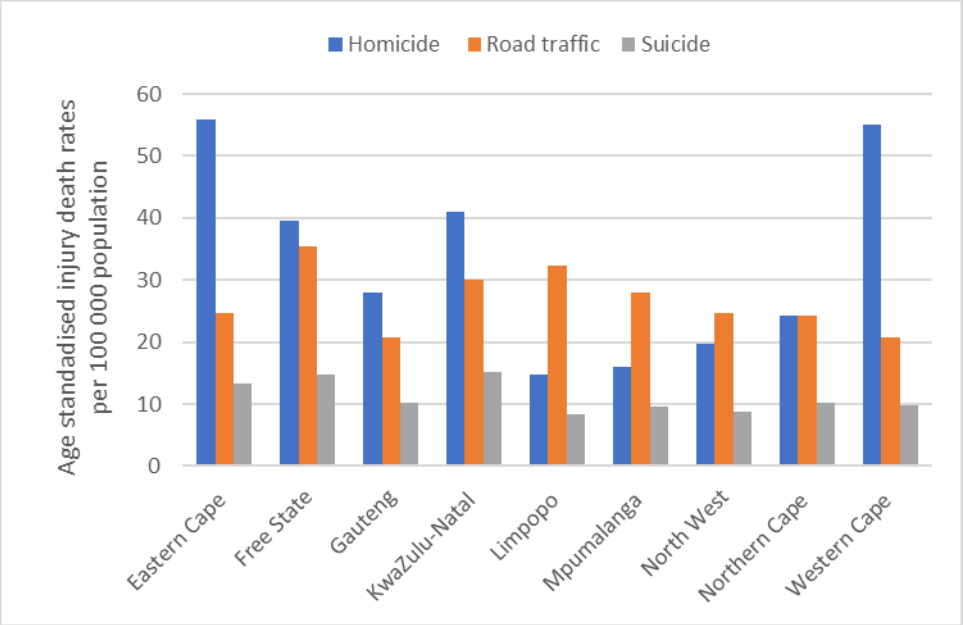


Figure A9: Age standardised injury death rates per 100 000 population by province, IMS 2017.[42]

The homicide: suicide ratios and the homicide: road traffic death ratios are shown in Table A16 based on the frequencies in Stats SA data and the weighted SA NCODV sample as well as the ratio based on the death rates from the IMS. This highlights reasonable similarity in the homicide: road traffic death ratios but considerable difference in the homicide: suicide ratio in the Stats SA data which appears to indicate a systematic under-reporting of suicides to Stats SA which varies by province.

Table A17: Homicide: suicide and homicide: road traffic deaths ratios based on Stats SA, IMS and weighted SA NCODV sample by province.

Source	Median	EC	FS	GT	KZN	LP	MP	NW	NC	WC
Homicide:Suicide Ratio										
Stats SA	37.000	113.000	37.000	69.500	9.333	11.875	32.333	67.000	3.303	58.000
IMS	2.694	4.164	2.694	2.735	2.715	1.771	1.667	2.250	2.373	5.670
SA NCODV (weighted)	2.350	3.859	2.658	2.719	1.272	4.299	1.577	2.350	1.431	1.832
Homicide:Road traffic accidents Ratio										
Stats SA	1.126	2.132	1.360	0.799	1.126	0.497	0.279	3.722	0.657	3.867
IMS	1.115	2.259	1.115	1.341	1.367	0.455	0.573	0.805	0.996	2.657
SA NCODV (weighted)	0.997	2.474	1.078	1.335	1.158	0.997	0.662	0.865	0.721	0.988

8.9 PCVA cause of death for ill-defined MR/FPS records

Table A18: Causes assigned by PCVA where UCOD from MR or FPS was ill-defined natural, (N=108), SA NCODV Project 2017/18.

Underlying cause of death (UCOD) based on PCVA	Number	Percent
1. Tuberculosis	12	11.1%
2. HIV/AIDS	12	11.1%
3. Diarrhoeal diseases	2	1.9%
6. Perinatal conditions	1	0.9%
8. Other type 1 conditions[#]	3	2.8%
10. Trachea/bronchi/lung cancer	1	0.9%
12. Cervix cancer	1	0.9%
13. Prostate cancer	2	1.9%
14. Other cancers	4	3.7%
16. Diabetes mellitus	6	5.6%
17. Epilepsy	2	1.9%
18. Ischaemic heart disease	4	3.7%
19. Stroke	6	5.6%
21. Hypertensive heart disease	8	7.4%
25. Chronic obstructive pulmonary disease	2	1.9%
26. Other chronic respiratory	1	0.9%
27. Peptic ulcer	1	0.9%
29. Other digestive	1	0.9%
30. Nephritis/nephrosis	2	1.9%
31. Other genitourinary conditions	1	0.9%
34. Ill-defined naturals	26	24.1%
35. Road traffic accidents	2	1.9%
36. Falls	2	1.9%
38. Drowning	1	0.9%
40. Other unintentional injuries specified	2	1.9%
42. Undetermined intent	3	2.8%
Total	**108**	**100.0%**

[#] Other type 1 conditions combines less common infectious diseases (Table A3)

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