HealthStats NSW

Population attributable fractions (PAFs)

Methods used in HealthStats NSW for applying PAFs from the Australian Burden of Disease Study 2015

INTRODUCTION

Modifiable risk factors contribute significantly to disease, injury and premature death. In 2015, the Australian Institute of Health and Welfare (AIHW) estimated that 38% of disease burden in Australia was due to modifiable risk factors.[1] Population attributable fractions (PAFs) are used to determine the fraction of disease, injury, disability, death and morbidity that can be attributed to each risk factor. These fractions (also known as aetiological fractions) are used to estimate the extent the disease may have been prevented and the potential improvement in population health if the risk factor was reduced or prevented.

HealthStats NSW uses PAFs provided by the AIHW, which are based on the Australian Burden of Disease Study (ABDS) 2015, to report on the mortality and morbidity that is attributable to the risk factors, including but not limited to obesity, alcohol and smoking.

This paper describes the methods used in the 2015 Australian Burden of Disease Study to calculate PAFs, and also provides background and context with respect to burden of disease studies. Generally the risk factors were similar to those used in the ABDS 2011.[2] Methods used in HealthStats NSW to apply the fractions to hospital admissions and deaths data are also described.

WHAT ARE BURDEN OF DISEASE STUDIES?

Burden of disease studies are a systematic, scientific effort to measure the comparative magnitude of health loss due to major disease, injuries and risk factors by age, sex and location.[2] They go beyond singular epidemiological measures of mortality, incidence and prevalence to create measures that incorporate both the prevalence of a given disease or risk factor and the relative harm caused.[2] This allows comparison of diseases across a common framework.

WHY USE BURDEN OF DISEASE STUDIES?

Burden of disease studies provide reliable and comprehensive information on the health status of populations and the effectiveness of prevention strategies that can be used by decision makers in order to set priorities and allocate resources.[1] These studies also serve as a tool for monitoring changes in disease burden patterns across time. For example, the Global Burden of Disease Study (GBDS) has shown that in some countries, as mortality declines from some diseases, disability is becoming increasingly important due to the increasing prevalence of other diseases.[2] The GBDS also provides decision makers with data on how fast a country's health is improving relative to similar countries. This benchmarking is a tool that can provide context for health achievements and help identify areas with greatest potential for improvement.[2] Burden of disease studies provide decision makers with the evidence base to inform health policy and service planning decisions.

WHAT ARE THE BURDEN OF DISEASE MEASURES?

Years of life lost (YLL)

Fatal burden of disease, expressed as years of life lost (YLL), is an estimate of the years of life lost due to premature death summed across the whole population. Specifically, it quantifies the years of life lost between the age at which a person dies and the number of years they could have potentially lived, based on the current life expectancy data about the population. Life expectancy is an estimate of how long, on average, a person is expected to live, based on current age- and sex-specific death rates in the population under consideration. These studies use a reference life table that represents the maximum lifespan of an individual in good health at given ages. For example, a person aged 50 years has the potential to live an additional 35 years (that is, at age 50 years a person could live to be 85 years based on the reference life table). Thus, a death at 50 is a loss of 35 life years.

The ABDS 2015 used the standard reference life expectancy table as used in the GBDS 2010 and 2013 which is based on lowest observed death rates at each age group from multiple countries.[2] The standard reference life table has a life expectancy at birth of 86.0 years. The use of a consistent reference life expectancy table allows comparisons across time and populations.

To calculate YLL, first the total number of deaths by single year of age and disease are tabulated. Within each disease group, each death is weighted according to remaining life expectancy at the age of death based on the reference life table. These "weighted" deaths are then summed to give the total number of years of life lost from all deaths.[1]

> YLL is calculated by summing the number of deaths in each single year of age and is multiplied by the remaining life expectancy at this age according to the reference life table.[1]

Years lived with disability (YLD)

Non-fatal burden of disease, expressed as years lived with disability (YLD), measures the proportion of healthy life lost due to living with a disease or injury in a given year. This measure captures frequency, severity, co-morbidities and the consequence of each disease or injury. It is influenced by the number of people with each disease, how long they spend living with it and the severity of the effects.[1] The calculation of YLD is shown in equation [1].

$$\text{YLD} = \text{point prevalence of disease} * \text{DW} \quad \text{where DW = disability weight} \qquad [1]$$

Point prevalence is the number of people experiencing health loss from the disease or injury on a given day and disability weight provides a measure of the disease severity. The disability weights and health sequelae used in the ABDS 2015 are based on the GBDS 2013.[2] Disability weights were adjusted for comorbidity as well.

Accounting for comorbidities (that is, a person having more than one disease or injury at the same time) is a particular challenge. The ABDS 2015 addressed comorbidity by using a comorbidity bias adjustment in the calculation of YLD (detailed in the AIHW report Australian Burden of Disease Study 2015: Methods and supplementary material). Adjusting for comorbidity bias in burden of disease estimation has relied on modelling prevalence and disability weights for comorbid conditions. The modelled data are then used to calculate rescaled (comorbidity-adjusted) disability weights for each individual disease. The comorbidity bias adjustment was undertaken separately for each year reported by the AIHW using the prevalence specific to the year. This adjustment ensures that there is not an overestimation of the overall non-fatal burden due to double counting.[2] Within a single disease, a person could have any number of sequelae simultaneously or multiple sequelae from multiple diseases simultaneously. The impact of multiple sequelae are adjusted for in the comorbidity bias adjustment as well.

> YLD is calculated by summing the point prevalence of the disease for each age and sex group multiplied by the disability weight.[1]

Disability-adjusted life year (DALY)

Burden of disease, expressed as DALY, is the main summary measure of the health impact of disease on a population in a given year.[1] DALY is an estimate of the years of healthy life lost either through premature death (YLL) or living with disability (YLD) due to illness or injury in a population. One DALY therefore represents one lost year of healthy life.

A DALY is calculated as per equation [2].

$$\text{DALY} = \text{YLL} + \text{YLD} \qquad [2]$$

This single measure of health loss allows the comparison across diseases, over time and between diverse populations, despite the varied impacts and outcomes of different conditions. The greater the number of DALYs associated with a disease or injury, the greater the burden of that disease in the population.[1,3]

> DALY is calculated by summing the years lived in disability and the years of life lost for each age and sex group.[1]

HOW IS THE CONTRIBUTION OF RISK FACTORS MEASURED?

Burden of disease methods provide a basis to compare and measure change over time of risk factor contribution to disease burden that is amenable to prevention in the population.[4] The disease burden attributable to a specific risk factor represents the disease burden that would not have occurred if exposure to the risk factor had been avoided or had been reduced to its lowest possible level, known as the theoretical minimum risk exposure distribution (TMRED). TMRED represents the risk factor exposure distribution that will lead to the lowest conceivable disease burden.[3] TMRED may be zero in some cases because zero exposure reflects minimum risk. However, for some other risk factors, zero exposure is an inappropriate choice because these are physiologically impossible (e.g. body mass index). In these instances, risk factor exposure that would result in the lowest conceivable disease burden are implemented.

To calculate the attributable disease burden for each risk factor under investigation, the total burden is multiplied by the PAF for each age, sex and relevant disease group.[3]

POPULATION ATTRIBUTABLE FRACTIONS

PAFs are a key component in quantifying the contribution of the risk factor to a disease or death.[1] PAFs integrate both the relative risk ('dangerousness' of a risk factor) and the prevalence of exposure (frequency and level of exposure to the risk factor) in a particular population, allowing for an assessment of what risk factors are most important for population health. When the PAFs are compared across time or between different populations, it is assumed that the causal relationship between the risk factor and the linked conditions are unchanged, but that exposure to the risk factor may either increase or decrease. The change in PAF is expressed as the percentage change in median age-adjusted PAF. A positive change represents either an increase in risk factor exposure or the age at which exposure occurs has changed, resulting in a higher disease burden attributable to the risk factor. A negative change represents a decrease in risk factor exposure or the age of exposure has changed, resulting in a lower fraction of attributable disease burden.[1] The total PAF is the sum of all the PAFs for the risk factor and these will vary between risk factors by the number of diseases that are linked to the risk factor.

CALCULATING THE PAFS IN THE ABDS 2015

In the ABDS 2015, PAFs were calculated for 38 risk factor components that combined to 18 individual risk factors and their linked diseases by sex and age group. The linked conditions are diseases or injuries for which there is sufficient evidence that its likelihood is increased by the risk factor.[2] Linked conditions were spread across 15 disease groups. The relevant linked diseases adopted were based on the GBDS 2016 and those AIHW identified via literature reviews.[2]

The calculation of a PAF requires the input of the relative risk (RR) and the prevalence of exposure in the population (P). Details of the methods used in the ABDS 2015 to derive age and sex-specific aetiological fractions can be found in the report *Australian Burden of Disease Study 2015: methods and supplementary information*. This report provides the following overview of the methods (p 111-112):

If PAFs appropriate to the disease and population in question were available from a comprehensive data source (such as a disease register), they were applied directly to the data. If not, PAFs were estimated using the following basic process:

1. Select risk factors
2. Identify linked disease based on best evidence in the literature that risk factor has causal association with increased prevalence or mortality
3. Define the risk factor exposure level not associated with increased risk of disease (i.e. theoretical minimum risk exposure)
4. Estimate the PAFs by comparative risk assessment method
5. Estimate the effect of risk factors on disease outcomes (Relative risks)
6. Estimate the population-level distribution of risk factor exposure
7. Calculate the population attributable fraction. This is done for each risk-outcome pair by sex and age group.

The population attributable fraction combines relative risks and exposure levels as per equation [3].

$$\text{PAF} = \frac{P(RR-1)}{P(RR-1)+1} \times 100 \qquad [3]$$

where RR is relative risk

When the risk factor has multiple categories of relative risks and exposure levels, the equation is generalised as per equation [4].

$$\text{PAF} = \frac{\sum_c P_c(RR_c-1)}{\sum_c P_c(RR_c-1)+1} \times 100 \qquad [4]$$

where:

$\sum_c$ is the sum over all categories
c is the c^{th} category
P is prevalence
RR is relative risk

APPLICATION OF PAFS TO HOSPITAL AND DEATHS DATA

HealthStats NSW used morbidity and mortality PAFs provided by the AIHW from the ABDS 2015 in calculating risk factor attributable hospitalisations and deaths. These files contain PAFs for each risk factor by sex, age group, and condition. The condition classification on this file is specific to the Burden of Disease study with each condition also defined by International Statistical Classification of Diseases and Related Health Problems (ICD-10) codes. This is not necessarily a one-to-one relationship. For example, the condition 'lower respiratory infection' maps to ICD-10 codes J12, J14-J22 or J85-J86. Hospitalisation and death records are coded according to ICD-10-AM and ICD-10 respectively and this code is used to match the AIHW PAF files and the hospitalisation data or the cause of death data files. The NSW Combined Admitted Patient Epidemiology Data (CAPED) records all hospitalisations in terms of an episode of care, with each admission assigned a primary diagnosis code and up to 50 secondary codes. An episode of care ends with the patient ending a period of stay in hospital (by discharge, transfer or death) or by becoming a different 'type' of patient within the same period of stay. A patient can therefore have more than one record within the same period of stay. HealthStats NSW searches CAPED to identify hospitalisations with a condition on the ABDS 2015 list by examining the first three unique ICD-10-AM diagnosis codes and/or the first external cause code of each record. The search commences by looking at the first (principal diagnosis) code. If there is no match on the principal diagnosis ICD code and the ICD code commenced with 'R' or 'Z', then the search moves to

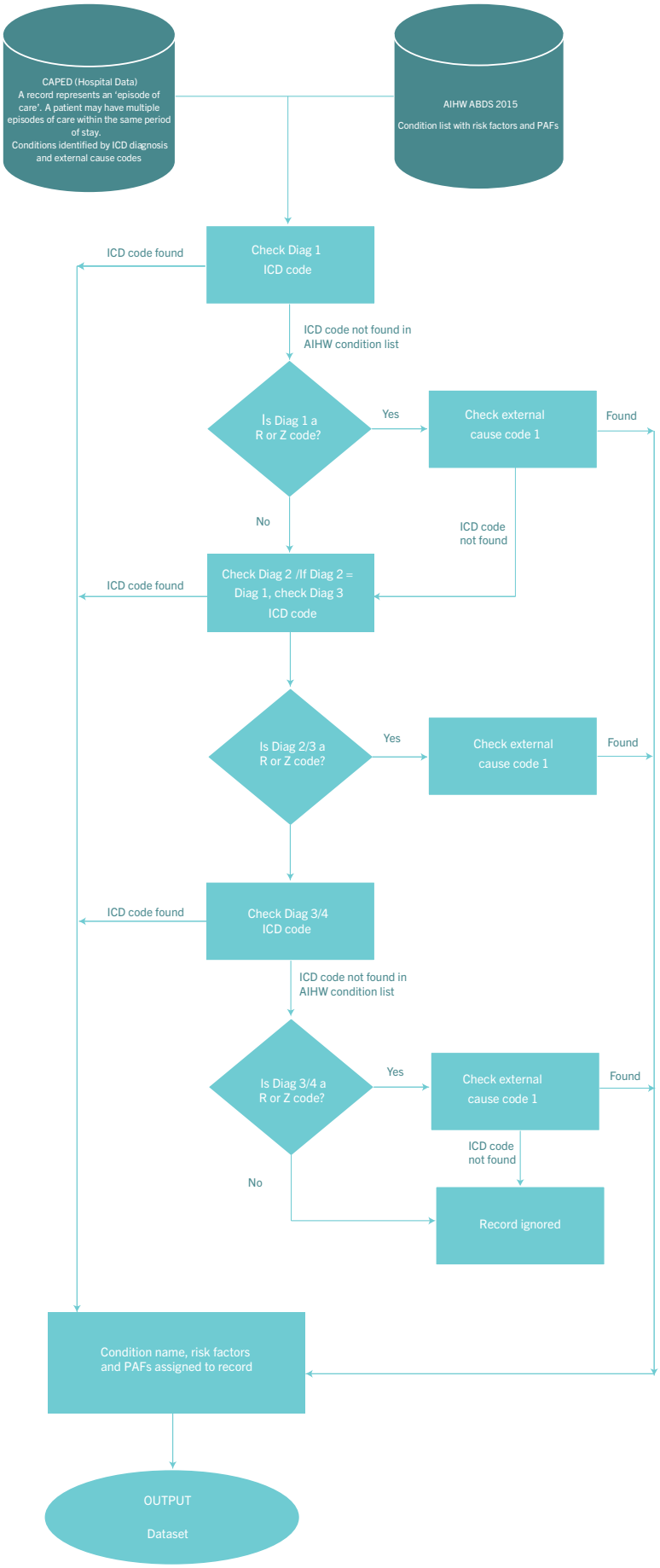
the first external cause code, otherwise the search moves to diagnosis code 2. The process is repeated until an ICD code is identified or the record is discarded after trying to match with up to four diagnosis codes. In the first instance an ICD code is identified, the AIHW condition name, risk factors and morbidity attributable fractions are assigned to that record (Figure 1). At the end of the search the resulting dataset is sorted by year, period of stay, risk factors and their associated attributable fractions. Where a patient has multiple records within a period of stay it is possible that they will have multiple assigned conditions which have the same risk factors. If the same risk factor is assigned within the same period of stay to different records, the record with the highest attributable fraction is retained (Figure 2). This ensures there is not an over estimation of the hospitalisations attributable to a specific risk factor. The fractions for each identified admission are then summed by risk factor, age, sex and year and used to calculate the rate of admissions attributable to each specific risk factor for a given population.

The Cause of Death Unit Record File (CoD URF) provided by the Australian Coordinating Registry is used by HealthStats NSW to identify all deaths due to a condition on the AIHW ABDS 2015 list. Cause of death data is also coded using ICD-10, but only the underlying cause of death code is considered. When a condition is identified, the condition name, risk factors and mortality attributable fractions are applied to the record. The sums of all the attributable fractions are summed in the same way as hospitalisations to calculate the number of deaths attributable to specific risk factors.

HealthStats NSW routinely reports on the hospitalisations and deaths attributable to the risk factors of alcohol, smoking and overweight and obesity. To report hospitalisations and deaths attributable to the risk factors across time the attributable fractions provided by the AIHW for specific reference years (2003, 2011, 2015) are applied to appropriate years either side of the reference year.

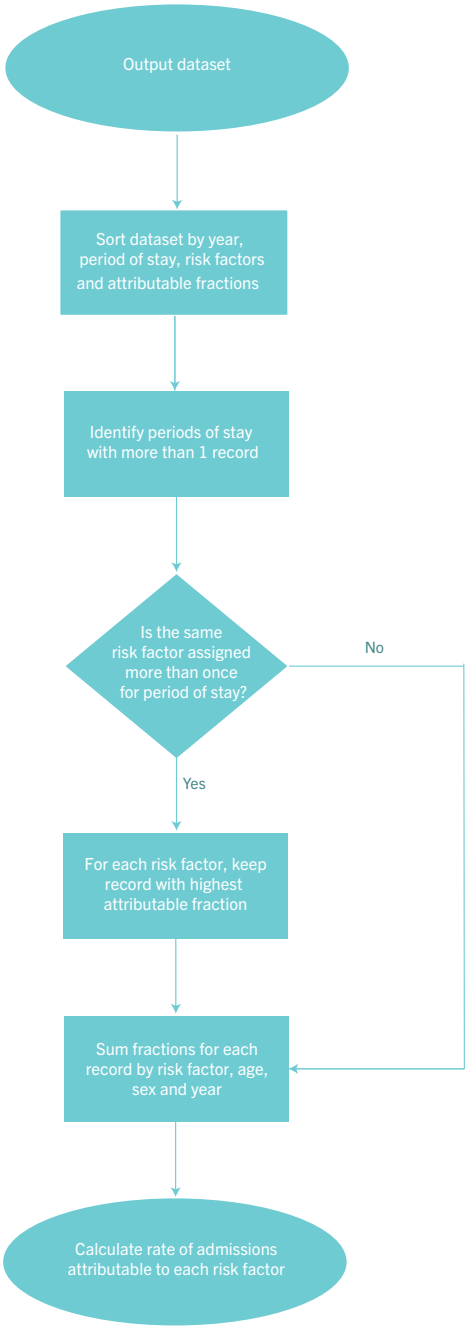
Although the population attributable fractions were designed to quantify the relationship between a risk factor and health loss in the population, they only provide a proxy measure in estimating the impact of specific risk factors on hospitalisations. For some conditions, where hospitalisation is a likely outcome of a disease (e.g. stroke), the hospitalisation data provides a reasonable representation of the overall prevalence of that disease. In these circumstances the PAFs offer a more reliable estimate of the impact of the risk factor on hospitalisation than when a disease's prevalence is not closely aligned with hospitalisations. It should also be noted that these PAFs were calculated at the national level and it is therefore not appropriate to apply these fractions to individual hospitals.

Figure 1. Identification and allocation of population attributable fractions to hospital records



ICD codes commencing with R or Z:
R: Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified
Z: Factors influencing health status and contact with services

Figure 2. Calculation of rate of hospitalisations attributable to risk factors



Morbidity and mortality summarised PAFs used by HealthStats NSW and provided by the AIHW from the ABDS 2015 are available in the Attributable Fractions Spreadsheets.

REFERENCES

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APPENDIX

ABDS 2015 DISEASE LIST BY ICD-10 CODE

ABDS 2015 disease/injury	ICD-10 codes(a)
Cancer and other neoplasms	
Lip and oral cavity cancer(b)	C00–C08
Nasopharyngeal cancer	C11
Other oral cavity and pharynx cancers	C09–C10, C12–C14
Laryngeal cancer	C32
Oesophageal cancer	C15
Stomach cancer	C16
Bowel cancer	C18–C20
Liver cancer	C22
Gallbladder cancer	C23, C24
Pancreatic cancer	C25
Lung cancer	C33, C34
Mesothelioma	C45
Melanoma of the skin	C43
Breast cancer	C50
Cervical cancer	C53
Uterine cancer	C54, C55
Ovarian cancer	C56
Prostate cancer	C61
Bladder cancer	C67
Kidney cancer	C64
Thyroid cancer	C73
Non-Hodgkin lymphoma	C82–C86
Hodgkin lymphoma	C81
Acute myeloid leukaemia (AML)	C92.0, C92.3–C92.6, C92.8, C93.0, C94.0, C94.2, C94.4–C94.5
Chronic myeloid leukaemia (CML)	C92.1
Acute lymphoblastic leukaemia (ALL)	C91.0
Chronic lymphocytic leukaemia (CLL)	C91.1
Other leukaemias	C91.2–C91.9, C92.2, C92.7, C92.9, C93.1–C93.9, C94.1, C94.3, C94.6– C94.7, C95
Myeloma	C90
Cardiovascular diseases	
Coronary heart disease	I20–I25
Stroke	I60–I69
Hypertensive heart disease	I11
Atrial fibrillation and flutter	I48
Inflammatory heart disease	I30–I33, I40–I41
Cardiomyopathy	I42–I43
Aortic aneurysm	I71
Peripheral vascular disease	I70.0–I70.8, I72–I74
Other cardiovascular diseases	G45, I10, I13, I15, I26–I28, I44–I47, I49, I50–I52, I70.9, I77–I84, I86–I89, I95, I97–I99
Endocrine disorders	
Type 2 diabetes mellitus	E11.0–E11.1, E11.3–E11.9, O24.1
Gastrointestinal disorders	
Gastroduodenal disorders	K22.1, K25–K29

ABDS 2015 disease/injury	ICD-10 codes(a)
Chronic liver disease	B18, I85, K70–K76
Gall bladder and bile duct disease	K80–K83
Pancreatitis	K85, K86
Hearing and vision disorders	
Cataract and other lens disorders	H25–H27
Age-related macular degeneration	H35.3
Infectious diseases	
HIV/AIDS	B20–B24, O98.7
Hepatitis A	B15
Hepatitis B (acute)	B16, B17.0
Hepatitis C (acute)	B17.1, B17.8, B17.9
Otitis media	H65–H68, H70
Lower respiratory infections	J12, J14–J18, J20–J22, J85–J86
Influenza	J09–J11
Injuries (external cause)	
Road traffic injuries: motorcyclists	V20.3–V20.5, V20.9, V21.3–V21.5, V21.9, V22.3–V22.5, V22.9, V23.3–V23.5, V23.9, V24.3–V24.5, V24.9, V25.3–V25.5, V25.9, V26.3–V26.5, V26.9, V27.3–V27.5, V27.9, V28.3–V28.5, V28.9, V29.4–V29.6, V29.8–V29.9
Road traffic injuries: motor vehicle occupants	V30.4–V30.7, V30.9, V31.4–V31.7, V31.9, V32.4– V32.7, V32.9, V33.4–V33.7, V33.9, V34.4–V34.7, V34.9, V35.4–V35.7, V35.9, V36.4–V36.7, V36.9, V37.4–V37.7, V37.9, V38.4–V38.7, V38.9, V39.4–V39.6, V39.8–V39.9, V40.4–V40.7, V40.9, V41.4–V41.7, V41.9, V42.4–V42.7, V42.9, V43.4–V43.7, V43.9, V44.4–V44.7, V44.9, V45.4–V45.7, V45.9, V46.4–V46.7, V46.9, V47.4–V47.7, V47.9, V48.4–V48.7, V48.9, V49.4–V49.6, V49.8–V49.9, V50.4–V50.7, V50.9, V51.4–V51.7, V51.9, V52.4–V52.7, V52.9, V53.4–V53.7, V53.9, V54.4–V54.7, V54.9, V55.4–V55.7, V55.9, V56.4–V56.7, V56.9, V57.4–V57.7, V57.9, V58.4–V58.7, V58.9, V59.4–V59.6, V59.8–V59.9, V60.4–V60.7, V60.9, V61.4–V61.7, V61.9, V62.4–V62.7, V62.9, V63.4–V63.7, V63.9, V64.4–V64.7, V64.9, V65.4–V65.7, V65.9, V66.4–V66.7, V66.9, V67.4–V67.7, V67.9, V68.4–V68.7, V68.9, V69.4–V69.6, V69.8–V69.9, V70.4–V70.7, V70.9, V71.4–V71.7, V71.9, V72.4–V72.7, V72.9, V73.4–V73.7, V73.9, V74.4–V74.7, V74.9, V75.4–V75.7, V75.9, V76.4–V76.7, V76.9, V77.4–V77.7, V77.9, V78.4–V78.7, V78.9, V79.4–V79.6, V79.8–V79.9, V89.2, Y85.0
Road traffic injuries: pedal cyclists	V10.3–V10.5, V10.9, V11.3–V11.5, V11.9, V12.3–V12.5, V12.9, V13.3–V13.5, V13.9, V14.3–V14.5, V14.9, V15.3–V15.5, V15.9, V16.3–V16.5, V16.9, V17.3–V17.5, V17.9, V18.3–V18.5, V18.9, V19.4–V19.6, V19.8–V19.9
Road traffic injuries: pedestrians	V01.1, V01.9, V02.1, V02.9, V03.1, V03.9, V04.1, V04.9, V05.1, V05.9, V06.1, V06.9, V09.2–V09.3, V09.9
Other land transport injuries	V01.0, V02.0, V03.0, V04.0, V05.0, V06.0, V09.0, V09.1, V10.0–V10.2, V11.0–V11.2, V12.0–V12.2, V13.0– V13.2, V14.0–V14.2, V15.0–V15.2, V16.0–V16.2, V17.0–V17.2, V18.0–V18.2, V19.0–V19.3, V20.0–V20.2, V21.0–V21.2, V22.0–V22.2, V23.0–V23.2, V24.0– V24.2, V25.0–V25.2, V26.0–V26.2, V27.0–V27.2, V28.0–V28.2, V29.0–V29.3, V30.0–V30.3, V31.0–V31.3, V32.0–V32.3, V33.0–V33.3, V34.0–V34.3, V35.0–V35.3, V36.0–V36.3, V37.0–V37.3, V38.0–V38.3, V39.0–V39.3, V40.0–V40.3, V41.0–V41.3, V42.0–V42.3, V43.0–V43.3, V44.0–V44.3, V45.0–V45.3, V46.0–V46.3, V47.0–V47.3, V48.0–V48.3, V49.0–V49.3, V50.0–V50.3, V51.0–V51.3, V52.0–V52.3, V53.0–V53.3, V54.0–V54.3, V55.0–V55.3, V56.0–V56.3, V57.0–V57.3, V58.0–V58.3, V59.0–V59.3, V60.0–V60.3, V61.0–V61.3, V62.0–V62.3, V63.0–V63.3, V64.0–V64.3, V65.0–V65.3, V66.0–V66.3, V67.0–V67.3, V68.0–V68.3, V69.0–V69.3, V70.0–V70.3, V71.0–V71.3, V72.0–V72.3, V73.0–V73.3, V74.0–V74.3, V75.0–V75.3, V76.0–V76.3, V77.0–V77.3, V78.0–V78.3, V79.0–V79.3, V80–V86, V88, V89.0, V89.1, V89.3, V89.9, Y85.9, V87.9
Poisoning	X40–X49
Falls	W00–W19
Fire, burns and scalds	X00–X06, X08–X19
Drowning	V90, V92, W65–W74

ABDS 2015 disease/injury	ICD-10 codes(a)
Suicide and self-inflicted injuries	X60–X84, Y87.0
Homicide and violence	X85–Y09, Y87.1
Other unintentional injuries	V91, V93–V99, W20–W64, W75–W99, X20–X39, X50–X58, Y35, Y36, Y86, Y89.0, Y89.1
Kidney and urinary diseases	
Chronic kidney disease	E10.2, E11.2, E12.2, E13.2, E14.2, I12, N02–N07, N08, N13–N16, N18, N39.1, N39.2, Q61.0–Q61.3
Mental and substance use disorders	
Depressive disorders	F32, F33, F34.1, F34.8, F34.9, F38–F39
Anxiety disorders	F40–F43
Alcohol use disorders	F10
Drug use disorders (excluding alcohol)	F11–F16, F18, F19
Schizophrenia	F20–F25, F28, F29
Musculoskeletal conditions	
Osteoarthritis	M15–M19
Gout	M10
Rheumatoid arthritis	M05, M06, M08
Back pain and problems	M40, M41, M45–M51, M53, M54, M99
Neurological conditions	
Epilepsy	G40, G41
Dementia	F00–F03, G30–G31
Multiple sclerosis	G35
Respiratory diseases	
Asthma	J45, J46
Chronic obstructive pulmonary disease	J40, J44
Interstitial lung disease	J84
Other chronic respiratory diseases	J47, J66–J68, J70, J80–J82, J90–J95, J98–J99
Other unintentional injuries	V91, V93–V99, W20–W64, W75–W99, X20–X39, X50–X58, Y35, Y36, Y86, Y89.0, Y89.1