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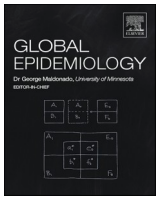

Adult mortality from non-communicable diseases in Fiji's major ethnic groups 2013–17

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ABSTRACT

Background: Sustainable Development Goal 3.4.1 (SDG3.4.1) targets a one-third reduction in non-communicable disease (NCD) mortality in ages 30–69-years by 2030 (relative to 2015). Directing interventions to achieve this aim requires reliable estimates of underlying cause of death (UCoD). This may be problematic when both cardiovascular diseases (CVD) and diabetes are present due to a lack of consistency in certification of such deaths. We estimate empirically 2013–17 NCD mortality in Fiji, by sex and ethnicity, from CVD, diabetes, cancer, and chronic lower respiratory diseases (CRD), and aggregated as NCD4.

Methods: UCoD was determined from Medical Certificates of Cause-of-Death (MCCD) from the Fiji Ministry of Health after pre-processing of mortality data where diabetes and/or hypertension were present in order to generate internationally comparable UCoD. If no potentially fatal complications from diabetes or hypertension accompanied these causes in Part I (direct cause) of the MCCD, these conditions were re-assigned to Part II (contributory cause). The probability of a 30-year-old dying before reaching age 70-years ($PoD_{30–70}$), by cause, was calculated.

Findings: The $PoD_{30–70}$ from NCD4 over 2013–17 differed by sex and ethnicity: in women, it was 36% (95%CI 35–37%) in i-Taukei and 27% (26–28%) in Fijians of Indian descent (FID); in men, it was 41% (40–42%) in both i-Taukei and FID.

$PoD_{30–70}$ from CVD, diabetes, cancer and CRD in women was: 18%, 10%, 13% and 1·0% in i-Taukei; 13%, 10%, 5·6% and 1·1% in FID; in men was: 28%, 8.4%, 7·6% and 2·2% in i-Taukei; 31%, 8.3%, 3.5% and 3·1% in FID.

Interpretation: To achieve SDG3.4.1 goals in Fiji by 2030, effective population wide and ethnic-specific interventions targeting multiple NCDs are required to reduce $PoD_{30–70}$ from NCD4: from 36% to 24% in i-Taukei, and 27% to 18% in FID women; and from 41% to 27% in i-Taukei and FID men.

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Research in context

Evidence before this study

For Fiji in 2015, WHO Global Health Observatory published estimates of the probability of dying between the age 30 and exact age 70 years ($PoD_{30–70}$) due to the four main non-communicable diseases (NCD4) were 34% for women and 43% for men; no estimates of $PoD_{30–70}$ by Fiji's main ethnic groupings are reported by global agencies.

International comparisons of underlying cause of death (UCoD) are problematic when cardiovascular diseases (CVD) and diabetes are present, particularly since physicians of different medical specialties and from different countries often lack consistency in certification of deaths. In particular, reporting diabetes without potentially fatal complications in Part I of the MCCD may artefactually inflate estimates of diabetes mortality and correspondingly reduce estimates of CVD mortality, biasing estimates of the contribution of major NCD causes of death to premature mortality.

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Added value of this study

Pre-processing of cause-of-death (CoD) data where diabetes and hypertension, without potentially fatal complications recorded, are moved from Part I (direct cause) to Part II (contributory cause) of the MCCD to generate alternate CoD sequencing, has the potential to produce mortality estimates less biased by these differing approaches to, and errors in, certification. This study produces the first empirically derived estimates of $PoD_{30–70}$ from NCDs for Fiji's main ethnic groups that account for such variations in death certification.

In Fiji over 2013–17, the contributions of the four NCD causes of death to premature mortality differs significantly between the sexes and by ethnicity in the 30–69-year age group. In women, $PoD_{30–70}$ from CVD was 18% for i-Taukei and 13% for FID. For men, this was 28% for i-Taukei and 31% for FID. $PoD_{30–70}$ from diabetes was 10% in women of both ethnicities, and 8% for men of both ethnicities. $PoD_{30–70}$ from cancer was 9·6% for women and 5·8% for men. Total cancer-related mortality was highest in i-Taukei women with $PoD_{30–70}$ of 13%, approximately double that of FID women at 5·6%.

To reach SDG 3.4.1 targets in Fiji by 2030, the probability of dying between the ages of 30 and 70 years from NCD4 would need to be reduced from 36% to 24% in i-Taukei women, from 27 to 18% in FID women. For men, the reduction target is from 41% to 27% for both ethnicities, but with differences in the proportions of deaths due to the main causes contributing to total mortality. A combination of population wide and targeted, ethnic specific, interventions are required to reduce mortality equitably in Fiji.

Implications of all the available evidence

The intensity, coverage and content of primary and secondary prevention, and diagnosis and treatment, of NCD illness will need to be more effectively targeted if the SDG 3.4.1 goal of reducing NCD4 mortality by one-third by 2030 relative to 2015 levels is to be achieved, particularly with limited health resources. Improvements in death certification, or pre-processing MCCD data in their stead, potentially will produce mortality estimates that more accurately reflect the disease burden of the population and allow more effective targeting of interventions to areas of greatest need. In the Fijian context, NCD mortality differences by ethnicity present a challenge that requires consideration in order to achieve more equitable health outcomes.

Background

Most non-communicable disease (NCD) mortality stems from four main causes; cardiovascular disease (CVD), diabetes mellitus (diabetes), cancer and chronic lower respiratory disease (CRD), referred collectively herein as NCD4 [1]. In Oceania (excluding Australia and New Zealand), the probability of dying from NCD4 between ages 30 and 69 years ($PoD_{30–70}$) was estimated in 2010 and 2019 as 37%, over double the 2019 world average of 18% [2]. Sustainable Development Goal 3.4.1 (SDG3.4.1) targets a one-third reduction in NCD4 mortality by 2030 relative to 2015 levels for those aged 30 to exactly 70 years, through prevention and treatment [3]. Due to the low quality of available vital registration data, the WHO Global Health Observatory reported modelled estimates for Fiji of $PoD_{30–70}$ from NCD4 for 2000 as 38% in women and 48% in men, and for 2015 as 34% in women and 43% in men [4]. No estimates of $PoD_{30–70}$ for Fiji's two principal ethnic groups, indigenous Fijians (i-Taukei) and Fijians of Indian descent (FID), are reported by global agencies.

Fiji is a Pacific Island country in Oceania, whose population at the 2017 census was 884,887, with over 95% residing on the two main islands of Viti Levu (81%) and Vanua Levu (15%) [5]. Fiji's ethnic composition, based on Fiji Bureau of Statistics (FBoS) projections for 2017, were estimated as 62% i-Taukei and 31% FID [6], with the remaining 7% comprising other Pacific Islanders, Asians, Europeans and others; these estimates were corrected to 63% i-Taukei, 33% FID and 4% others with the release of ethnic specific 2017 census counts in 2024 [7]. In 2017, 43% of the population was aged 30–69 years [5].

After decades of political unrest, fuelled in part by racial tensions, the Constitution of Fiji was changed in 2013 declaring all citizens of Fiji to be Fijians, a term previously reserved for i-Taukei [8]. Legally all Fijians are equal under the constitution, but from a disease burden and mortality perspective differences are evident by sex and ethnicity [6,9]. In 2014–17, female LE was estimated as 67·0 years for i-Taukei and 68·2 years for FID; male LE was estimated as 64·9 years for i-Taukei and 63·5 years for FID [6]. Accurately determining the causes of death contributing to adult mortality can inform public health interventions and contribute to improving life expectancy in Fiji.

Determination of underlying cause of death (UCoD) is based on placement and sequencing of diseases mentioned on the Medical Certificate of Cause of Death (MCCD), according to the coding rules defined in the International Classification of Disease (ICD) [10]. The cause-of-death (CoD) sequence, as recorded in Part I of the MCCD, represents the medical opinion of the certifying physician, which can vary according to individual physicians' training and speciality [11], their level of knowledge of the deceased persons medical history, and access to diagnostic information. The validity of the UCoD is undermined by errors in certification, particularly placement of contributory causes, normally recorded in Part II of the MCCD, erroneously in Part I. Another source of error arises from not recording causes in a valid sequence, from the immediate (usually listed first in Part I) and intermediate causes to the underlying cause (usually listed last in Part I).

Diabetes may cause death by acute conditions, such as by hyperglycaemic or ketoacidotic states, or by chronic processes, such as diabetic nephropathy or diabetic sepsis with an infected foot ulcer, or more rarely diabetic cardiomyopathy [12]. When a person with known diabetes dies, studies using case scenarios have demonstrated considerable variation by medical specialty in the recording of diabetes on the MCCD [11], and by country of death [13,14]. A person with diabetes who dies from diabetic ketoacidosis, diabetic nephropathy or from sepsis due to a diabetic foot ulcer are widely (and validly) accepted as having diabetes as the UCoD [11,12]. For those with recorded diabetic and CVD causes, approaches to certification vary, producing mortality statistics that may not be consistent or internationally comparable when applying ICD-10 rules to determine UCoD.

A systematic literature review covering 2007–17 found CVDs affected approximately 32% of all persons globally with diabetes [15] and accounted for around half of the deaths of people with diabetes [16,17]. The complex links between CVD and diabetes, along with suboptimal certification practices, potentially contributes to errors in UCoD assignment. Lu et al [13] compared certification practices for diabetes-related mortality between Taiwan, Sweden and Australia and showed that higher age-standardised mortality rates reported from diabetes in Taiwan were due to physicians' greater propensity to record diabetes in Part I rather than Part II of the MCCD, compared to physicians in the other countries. When diabetes is reported in Part I of the MCCD, it is more likely to be selected as the UCoD when following ICD-10 coding rules than when recorded in Part II of the MCCD [13]. Examination of time trends in UCoD due to CVD and diabetes in Mauritius and Fiji suggest a similar certification issue, specifically related to changes in coding rules for CVD and diabetes from ICD-9 to ICD-10. These changes have resulted in potential underestimation of CVD mortality and overestimation of diabetes in official mortality statistics for these two countries [18], making comparison of NCD cause specific mortality rates and their trends between countries problematic.

The aims of this study of mortality in Fiji are to: (1) determine internationally comparable baseline measures of $PoD_{30–70}$ from each component of NCD4, and for NCD4 overall, and establish changes required in these to reach the 2030 SDG 3.4.1 goal of a one-third reduction in NCD4 mortality relative to 2015 levels, by sex and ethnicity; 2) examine the extent of differences in CVD and diabetes

mortality when uncomplicated diabetes and hypertension originally recorded in Part I of the MCCD are retained there, compared to when these are moved to Part II (contributory causes section) of the MCCD.

Methods

Study design

This study is a cross-sectional CoD analysis for the period 2013–17, using unit record MCCD data to: (i) derive the UCoD according to ICD-10 rules; and (ii) with re-assignment of ICD-10 CoD codes for hypertension or diabetes to part II of the MCCD (contributory cause) where those causes are recorded in Part I without potentially lethal complications.

Deaths

All deaths ($n = 35{,}455$) occurring in Fiji between January 2013 and December 2017, and reported to the Fiji Ministry of Health and Medical Services (MHMS), were analysed in this study. Mortality data were recorded on the MCCD at the time of death and entered into the mortality module in the electronic Patient Information System (PatisPlus) by the central Health Information Unit (HIU) of the MHMS. De-identified unit records, extracted from PatisPlus, included text-recorded CoD for direct and contributory causes, with corresponding ICD-10 codes assigned by MHMS, along with date of birth (DoB), date of death, ethnicity, and place of death. Medical histories of decedents were not available to compare with CoD details. The mortality module was added to PatisPlus during 2012, with 2013 being the first year of full mortality recording in the system. Nine mortality records with sex recorded as indeterminate were excluded from further analysis.

Coding cause-of-death

MHMS uses the automated IRIS coding system to assign ICD-10 codes to text causes of death recorded on the MCCD. MHMS reported that IRIS successfully codes 50–60% of MCCD's on the first pass; spelling corrections are then applied before re-running through IRIS, with any remaining records coded manually by MHMS. IRIS is open-source software available at https://www.bfarm.de/EN/Code-systems/Collaboration-and-projects/Iris-Institute/_node.html. IRIS is also used by the Australian Bureau of Statistics and the Office for National Statistics (UK), among others.

For the present study, 4% of unit records extracted from PatisPlus did not have ICD-10 codes assigned for CoD sequences. These were manually coded according to ICD-10 rules by the first author (CD). Simple coding errors were corrected when identified. For example, 20% of cervical cancer CoD in 2013 had been coded to ICD-10 code C76·0, malignant neoplasm of head, face and neck. Where the text CoD was cervical cancer, the code was corrected to C53·9, malignant neoplasm of cervix uteri.

IRIS Version 5·6·0, in code entry mode, was used for coding UCoD in this study.

Population

Populations for each year, by sex and five-year age group, from 0 to 4 years to ≥75 years for 2013–16 were estimated by interpolation between census years 2007 and 2017. Populations counts by ethnicity from the 2017 census were released in early 2024[7] and were used as population denominators in calculations. Prior to this, ethnic populations for 2017 had been estimated [6] based on previously published FBoS projections of population by ethnicity.

Identification and reassignment of possible inappropriate diabetes and hypertension CoD

For MCCDs with diabetes or hypertension recorded in Part I, including type 1 diabetes (ICD-10 codes E10·x, where $0 \leq x \leq 9$), type 2 diabetes (E11·x), unspecified diabetes (E14·x), or hypertension (I10), CoD were either retained in Part I as a direct cause or relocated to Part II of the MCCD as a contributory cause. These instances were captured using an algorithm (written in SAS 9·4) to pre-process the MCCD data according to lethality of diabetes and hypertension complications. After reassignment of individual causes, the UCoD for the alternate causal sequence was determined using IRIS. Diabetes was retained in Part I if:

(i) specific fatal diabetes complications were present, including metabolic complications ($x = 0$ or 1), renal complications ($x = 2$), peripheral circulatory complications ($x = 5$) or diabetic sepsis ($x = 6$),
(ii) causes also listed in Part I are potentially due to diabetes, including renal disease (N08·3, N18, N19), chronic ulcer of the lower limb or decubitus ulcer (L97 and L899), sepsis (A410 and A419) and hypoglycaemia (E16·0, E16·2 and E16·2),
(iii) in the absence of known causes of cardiomyopathy, dilated cardiomyopathy (I42·0), unspecified cardiomyopathy (I42·9) or heart failure (I50) is also listed in Part I.

Otherwise, diabetes was relocated to Part II of the MCCD. Essential hypertension (I10) was retained in Part I if potentially fatal complications were also listed, including renal disease (N08·3, N18, N19) and heart failure (I50); otherwise, it was relocated to Part II.

Analysis

Cause-specific estimates of proportional mortality (PM) (%) and probability of dying (%) between ages 30 and exactly 70 years ($_{30}q_{40}$ or $PoD_{30–70}$) due to each NCD cause, and total for NCD4 overall, are calculated for the age range of highest NCD prevalence. $PoD_{30–70}$ mortality estimates are independent of population age structure, rendering them comparable across populations and time periods.

All mortality measures are tabulated by sex and by ethnicity. NCD cause-specific groupings were neoplasms (ICD-10 codes C00-D48), circulatory diseases (I00-I99), with sub-categories ischaemic heart diseases (IHD) (I20-I25) and cerebrovascular diseases (I60-I69); diabetes (E10-E14); and chronic lower respiratory diseases (J40-J47).

Adult (age 30–69 years) mortality for the original and alternate CoD sequences, calculated from the sum of mortality rates (m_x) in each 5-year age group (n_x) over the broader age interval (cumulative rate), was used to derive the cumulative rate and risk [19]:

$$\textit{Cumulative rate} = \sum_{x=\textit{first age group}}^{\textit{last age group}} (m_x n_x)$$

With the PoD in the specified age interval (cumulative risk) specified as [19]:

$$\textit{Cumulative risk} = 1 - e^{(\textit{cumulative rate})}.$$

95% confidence intervals (CIs) (normal approximation of the binomial) were calculated using a publicly available Microsoft Excel calculation [20].

The SDG3.4.1 targets of one-third reduction in NCD4 mortality by 2030 are estimated as ($PoD_{30–70}$) * 0·667.

To examine the relative contribution of NCD4 causes to premature mortality in Fiji in 2013–17 by sex, cause-specific proportional mortality (PM, the number of cause specific deaths divided by the total number of deaths as a percentage) using original CoD and reassigned (alternate)

CoD sequences, was also calculated, by sex and age group (0–4, 5–29, 30–69 and ≥ 70 years). Exact binomial (Clopper-Pearson) 95% confidence intervals were calculated for PM.

$$\text{PM by cause} = (\text{number of deaths by cause}/\text{total number deaths})^{*}\ 100$$

PM due to each NCD cause and NCD4 between the ages of 30 and exactly 70 years (ages 30–69 years) in Fiji in 2013–17, by sex by ethnicity was also calculated, as:

$$\text{PM for ages 30–69 – years by cause} = PM_{30–70} = \left(\text{Number of deaths by cause}_{30–69\ \text{years}}/\text{total deaths}_{30–69\ \text{years}}\right)^{*}100$$

Results

The 30–69-year age group accounted for 54% (8595) of female deaths and 60% (11,711) of male deaths in Fiji over 2013–17. Across the full mortality data set, an average of around three causes were recorded per MCCD.

Proportional mortality (PM) attributed to CVD, diabetes, neoplasms and CRD accounted for 75% of female and 72% of male deaths in the 30–69-year age group from the alternate CoD sequences (Appendix 1: Table A1). As would be expected, this is very similar to that from the original CoD sequences (77% and 73% respectively). Following reassignment of CoD, $PM_{30–70}$ for women from CVD increased from 27% (original CoD sequence) to 32% (alternate CoD sequence) while $PM_{30–70}$ due to diabetes correspondingly decreased from 26% to 19%. Similarly for men, CVD $PM_{30–70}$ after reassignment increased from 42 to 48%, and diabetes $PM_{30–70}$ decreased from 19 to 12%.

Diabetes (ICD-10 codes E11 or E14) was recorded as a direct and/or contributory cause on the MCCD for 6138 (30%) decedents aged 30–69 years. When E11 or E14 was recorded anywhere on the MCCD: from the original CoD sequence, IRIS selected diabetes as the UCoD for 4478 (73%) and CVD for 817 (13%) of these deaths; from the alternate CoD sequence, IRIS selected diabetes as the UCoD for 3026 (49%) and CVD for 2027 (33%) of these deaths.

Probability of dying from NCD cause 2013–17

After CoD reassignment, the $PoD_{30–70}$ due to NCD4 was estimated as 36% (95% CI 35–37%) for i-Taukei women and 27% (26–28%) for FID women. In men, $PoD_{30–70}$ due to NCD4 was 41% (40–42%) for i-Taukei and FID. The leading UCoD in all groups was CVD (Table 1). Reassignment primarily changes the proportion of deaths with CVD and diabetes UCoD; only minor variations are seen in $PoD_{30–70}$ from other causes when comparing the original and alternate CoD sequences (included in Table 1 for comparison).

From the original CoD sequence, $PoD_{30–70}$ due to CVD was 27% (26–28%) in FID men and 26% (25–27%) in i-Taukei men; in i-Taukei women this was 16% (16–17%), and in FID women was 10% (9–11%). After CoD reassignment, in FID men the $PoD_{30–70}$ due to CVD was 31% (30–32%), higher than in i-Taukei men at 28% (27–29); i-Taukei women were higher at 18% (17–19%) compared to FID women at 13% (12–14%).

CVD mortality is primarily attributable to IHD (I20-I25), and $PoD_{30–70}$ due to IHD was 24% in FID men and 17% in i-Taukei men; IHD $PoD_{30–70}$ was 6·9% in i-Taukei women and 7.3% in FID women.

For Fijian women aged 30–69-years overall, $PoD_{30–70}$ estimates for diabetes and neoplasm were similar (9·6%). $PoD_{30–70}$ due to diabetes was higher in women at 9.6% (9.1–10.0%) and the lower in men at 8.3% (7·8–8.8%).

$PoD_{30–70}$ due to cancer are significantly higher for i-Taukei women at 12.5% (12–13%) and i-Taukei men at 7·6% (7.0–8.1%), compared to FID women at 5·6% (5·1–6.1%) and FID men at 3.5% (3·0–3.9%). High $PoD_{30–70}$ due to breast (2·9%), cervical (2·4%) and ovarian (0·8%) cancers contribute to significantly higher cancer mortality in women overall at 9·6% (9·1–10·0%) compared to men at 5·8% (5·5–6·2%).

$PoD_{30–70}$ due to CRD is significantly higher in FID men at 3·1% (2.6–3.6%) than for any other group, and nearly four times that in i-Taukei women at 1·0% (0·8–1·2%).

To reach SDG 3.4.1 targets in Fiji by 2030, NCD4 $PoD_{30–70}$ would need to be reduced from 36% to 24% in i-Taukei women, from 27 to 18% in FID women, from 41 to 27% in iTaukei and FID men (Table 1).

Proportional mortality between ages 30 and 70 years ($PM_{30–70}$) by ethnicity

For i-Taukei women $PM_{30–70}$ from CVD (29%) was higher than FID women (24%) before reassignment of non-fatal diabetes and hypertension CoD, but $PM_{30–70}$ was 32% for women of both ethnicities from the alternate CoD sequences (Table 2). CVD $PM_{30–70}$ for i-Taukei men was slightly higher after reassignment (42% to 45%) and diabetes $PM_{30–70}$ decreased from 17% to 12%. For FID men, CVD $PM_{30–70}$ was higher after reassignment (44% to 53%) and diabetes $PM_{30–70}$ decreased from 22% to 12% (Table 3).

From the alternate CoD sequence, IHD accounted for 36% of CVD deaths in i-Taukei women, over 50% in FID women and i-Taukei men and 75% of CVD deaths in FID men. Cerebrovascular diseases account for 31% of CVD deaths in i-Taukei women, 22% in FID women, 17% in i-Taukei men and 13% of CVD deaths in FID men (Tables 2 and 3).

$PM_{30–70}$ from neoplasms was approximately double in i-Taukei women (25%) and men (11%) compared to FID women (14%) and men (5%). $PM_{30–70}$ from all neoplasms in women (22%) was more than double that in men (8·5%); however, after removing major reproductive cancers (breast, cervical, ovarian and prostate cancers), $PM_{30–70}$ from neoplasms was 8% for both women and men.

Discussion

In this analysis of empirical mortality data from the Fiji MHMS for 2013–17, around three-quarters of deaths in the 30–69-year age group were recorded with an NCD4 UCoD. The estimated probability of a 30-year-old dying due to NCD4 before reaching their seventieth birthday ($PoD_{30–70}$) ranged from 27% for FID women and 36% for i-Taukei women to 41% for i-Taukei and FID men. $PoD_{30–70}$ due to NCD4 in Fiji was high compared to the average for upper middle-income countries, which in 2017 was 13% for women and 22% for men [4]. Variation in

Table 1
Probability of dying between ages 30–69 years from non-communicable diseases using original and alternate CoD sequences, by sex and ethnicity, Fiji 2013–17.

	UCoD from Original CoD Sequences			UCoD from Alternate CoD Sequences		
Underlying cause of death (ICD-10 codes)	iTaukei	FID	All 30–69 years	iTaukei	FID	All 30–69 years
WOMEN	Prob of dying % (95% CI)	Prob of dying % (95% CI)	Prob of dying % (95% CI)	Prob of dying % (95% CI)	Prob of dying % (95% CI)	Prob of dying % (95% CI)
Circulatory diseases (I00-I99)	**16.3 (15.5–17.1)**	**10.0 (9.3–10.7)**	**13·3 (12·8–13·9)**	**17.9 (17.1–18.7)**	**13.1 (12.3–13.9)**	**15·6 (15·0–16·2)**
Ischaemic heart diseases (I20-I25)	6.0 (5.5–6.5)	5.0 (4.5–5.6)	5·5 (5·2–5·9)	6.9 (6.3–7.5)	7.3 (6.7–8.0)	7·1 (6·7–7·5)
Cerebrovascular diseases (I60-I69)	5.6 (5.0–6.1)	2.5 (2.1–2.9)	4·0 (3·7–4·4)	6.3 (5.7–6.8)	3.1 (2.7–3.5)	4·7 (4·4–5·1)
Hypertensive diseases (I10-I14)	3.4 (3.0–3.8)	1.6 (1.3–1.9)	2·5 (2·2–2·8)	3.1 (2.7–3.5)	1.7 (1.4–2.0)	2·4 (2·2–2·7)
ARF and chronic RHD (I00-I09)	0.5 (0.4–0.6)	0.1 (0.0–0.2)	0·3 (0·3–0·4)	0.5 (0.4–0.7)	0.2 (0.1–0.3)	0·4 (0·3–0·5)
Other heart diseases (I30-I51)	1.5 (1.3–1.8)	0.9 (0.7–1.1)	1·2 (1·1–1·4)	2.0 (1.7–2.3)	1.1 (0.9–1.4)	1·6 (1·4–1·8)
Other circulatory diseases	0.4 (0.3–0.6)	0.3 (0.2–0.4)	0·3 (0·3–0·4)	0.4 (0.3–0.6)	0.3 (0.2–0.5)	0·4 (0·3–0·5)
Diabetes (E10-E14)	**12.5 (11.8–13.2)**	**13.8 (12.9–14.6)**	**13·0 (12·4–13·5)**	**9.6 (8.9–10.2)**	**9.8 (9.1–10.5)**	**9·6 (9·1–10·0)**
Neoplasms (C00-D48)	**12.4 (11.7–13.1)**	**5.5 (5.0–6.0)**	**9·5 (9·1–9·9)**	**12.5 (11.9–13.2)**	**5.6 (5.1–6.1)**	**9·6 (9·1–10·0)**
Breast cancer (C50)	3.9 (3.5–4.3)	1.4 (1.2–1.7)	2·9 (2·6–3·1)	3.9 (3.5–4.3)	1.5 (1.2–1.8)	2·9 (2·6–3·1)
Cervical, Uterine cancer (C53-C55)	3.0 (2.7–3.4)	1.2 (0.9–1.5)	2·2 (2·0–2·5)	3.3 (2.9–3.7)	1.3 (1.0–1.6)	2·4 (2·2–2·7)
Ovarian cancer (C56)	1.1 (0.9–1.3)	0.4 (0.3–0.6)	0·8 (0·6–0·9)	1.1 (0.9–1.3)	0.4 (0.3–0.6)	0·8 (0·6–0·9)
Liver cancer (C22)	0.5 (0.4–0.7)	0.2 (0.1–0.3)	0·4 (0·3–0·5)	0.5 (0.4–0.7)	0.2 (0.1–0.3)	0·4 (0·3–0·5)
Lung cancer (C33-C34)	0.5 (0.3–0.6)	0.2 (0.1–0.4)	0·3 (0·2–0·4)	**0.5 (0.3–0.6)**	0.2 (0.1–0.4)	0·3 (0·2–0·4)
Other neoplasm	4.0 (3.6–4.4)	2.2 (1.8–2.5)	3·2 (2·9–3·5)	3.6 (3.2–4.0)	2.1 (1.8–2.5)	3·1 (2·8–3·4)
Chronic lower resp (J40-J47)	**0.9 (0.7–1.1)**	**1.1 (0.8–1.3)**	**1·0 (0·8–1·2)**	**1.0 (0.8–1.2)**	**1.1 (0.9–1.4)**	**1·0 (0·9–1·2)**
Total (all causes) 30–69 yrs	43.8 (42.8–44.7)	34.5 (33.4–35.5)	39·6 (38·9–40·3)	43.8 (42.8–44.7)	34.5 (33.4–35.5)	39·6(38·9–40·3)
NCD4: 2015 baseline	**36.5 (35.5–37.4)**	**27.5 (26.5–28.5)**	**32·4 (31·7–33·1)**	**35.7 (34.8–36.7)**	**26.9 (25.8–27.8)**	**31·7 (31·1–32·4)**
SDG3.4.1 NCD4 PoD target by 2030	**24.3 (Δ = 12.2)**	**18.3 (Δ = 9.2)**	**21·6 (Δ = 10·8)**	**23.6 (Δ = 12.1)**	**17.8 (Δ = 9.1)**	**21·1 (Δ = 10·6)**
MEN						
Circulatory diseases (I00-I99)	**26.2 (25.3–27.1)**	**26.5 (25.5–27.5)**	**25·9 (25·2–26·6)**	**28.2 (27.2–29.1)**	**31.2 (30.1–32.3)**	**29·0 (28·3–29·6)**
Ischaemic heart diseases (I20-I25)	**15.0 (14.2–15.8)**	**19.9 (19.0–20.9)**	16·9 (16·3–17·5)	16.9 (16.1–17.7)	23.9 (22.9–24.9)	19·6 (19·0–20·2)
Cerebrovascular diseases (I60–69)	**5.8 (5.2–6.3)**	**4.2 (3.7–4.7)**	5·0 (4·6–5·4)	6.2 (5.6–6.7)	5.1 (4.5–5.7)	5·6 (5·2–6·0)
Hypertensive diseases (I10-I14)	**4.4 (4.0–4.9)**	**2.0 (1.6–2.4)**	3·3 (3·0–3·6)	3.8 (3.4–4.3)	2.1 (1.8–2.5)	3·0 (2·7–3·3)
ARF and chronic RHD (I00-I09)	**0.3 (0.2–0.4)**	0.2 (0.1–0.4)	0·3 (0·2–0·3)	0.3 (0.2–0.4)	0.2 (0.1–0.4)	0·3 (0·2–0·4)
Other heart diseases (I30-I51)	**2.6 (2.3–3.0)**	**1.6 (1.3–1.9)**	2·2 (1·9–2·4)	3.2 (2.8–3.6)	1.9 (1.6–2.3)	2·6 (2·3–2·9)
Other circulatory diseases	**0.7 (0.5–0.9)**	**0.4 (0.3–0.6)**	0·6 (0·5–0·7)	0.8 (0.6–1.0)	0.5 (0.3–0.7)	0·6 (0·5–0·8)
Diabetes (E10-E14)	**12.2 (11.4–12.9)**	**15.2 (14.3–16.1)**	**13·3 (12·8–13·9)**	**8.4 (7.8–9.0)**	**8.3 (7.6–9.0)**	**8·3 (7·8–8·8)**
Neoplasms (C00-D48)	**7.3 (6.7–7.9)**	**3.4 (3.0–3.9)**	**5·7 (5·3–6·1)**	**7.6 (7.0–8.1)**	**3.5 (3.0–3.9)**	**5·8 (5·5–6·2)**
Liver cancer (C22)	1.3 (1.0–1.5)	0.3 (0.1–0.5)	0·8 (0·7–1·0)	1.3 (1.1–1.6)	0.3 (0.1–0.5)	0·9 (0·7–1·0)
Lung cancer (C33-C34)	0.5 (0.3–0.07)	0.4 (0.2–0.6)	0·5 (0·4–0·6)	0.5 (0.3–0.07)	0.4 (0.2–0.6)	0·5 (0·4–0·6)
Prostate cancer (C61)	0.9 (0.6–1.1)	0.2 (0.1–0.4)	0·6 (0·4–0·7)	0.8 (0.6–1.1)	0.2 (0.1–0.4)	0·6 (0·4–0·7)
Other neoplasm	4.9 (4.4–5.3)	2.5 (2.2–2.9)	3·9 (3·6–4·2)	5.1 (4.6–5.5)	2.6 (2.2–3.0)	4·0 (3·7–4·3)
Chronic lower resp (J40-J47)	**2.2 (1.9–2.6)**	**3.0 (2.5–3.4)**	**2·5 (2·2–2·7)**	**2.2 (1.9–2.6)**	**3.1 (2.6–3.6)**	**2·5 (2·3–2·8)**
Total (all causes) Male 30–69 yrs	51.3 (50.4–52.3)	50.5 (49.4–51.5)	50·5 (49·9–51·2)	51.3 (50.4–52.2)	50.5 (49.4–51.5)	50·5 (49·8–51·2)
NCD4: 2015 baseline	**41.3 (40.3–42.2)**	**41.6 (40.5–42.7)**	**40·9 (40·2–41·6)**	**40.5 (39.6–41.5)**	**41.0 (39.9–42.1)**	**40·2 (39·5–40·9)**
SDG3.4.1 NCD4 PoD target by 2030	**27.5 (Δ = 13·8)**	**27.7 (Δ = 13·9)**	**27·2 (Δ = 13·6)**	**27.0 (Δ = 13·5)**	**27·3 (Δ = 13·7)**	**26·8 (Δ = 13·4)**

CoD: cause of death; ICD-10: International classification of diseases, 10th revision; All includes iTaukei, FID and others; FID: Fijian of Indian descent; NCD4: Sum of neoplasm, circulatory diseases, diabetes, and chronic lower respiratory diseases; PoD: Probability of dying – cumulative risk from cumulative rate, 95% confidence intervals using normal approx. of binomial; SDG: Sustainable Development Goals; Δ = reduction required in probability of dying from NCD4 in order to meet SDG 3.4.1 target of one third reduction in mortality due to NCD4 in population aged 30–69 years by 2030 relative to 2015 baseline; ARF: acute rheumatic fever; RHD: rheumatic heart diseases.

Table 2
Proportional mortality (%) from non-communicable diseases from original and alternate CoD sequences, women 30–69-years, by ethnicity, Fiji, 2013–17.

Underlying cause of death (ICD-10 codes)	Original CoD sequence						Alternate CoD sequence					
	iTaukei		FID		All 30–69 year		iTaukei		FID		All 30–69 year	
WOMEN	No. Deaths	PM % (95% CI)	No. Deaths	PM % (95% CI)	No. Deaths	PM % (95% CI)	No. Deaths	PM % (95% CI)	No. Deaths	PM % (95% CI)	No. Deaths	PM % (95% CI)
Circulatory diseases (I00-I99)	**1518**	**29 (28–30)**	**727**	**24 (23–26)**	**2330**	**27 (26–28)**	**1668**	**32 (31−33)**	**957**	**32 (31–33)**	**2724**	**32 (31–33)**
Ischaemic heart diseases (I20-I25)	516	9·8 (9.2–10.5)	345	12 (11−13)	906	11 (10−11)	599	11 (11−12)	508	17 (16–18)	1160	13 (13–14)
Cerebrovascular diseases (I60-I69)	465	8·9 (8.2–9.5)	168	5·6 (4.9–6.3)	649	7·6 (7.1–8.0)	518	9·9 (9.2–10.6)	209	7·0 (6.2–7.8)	748	8·7 (8.2–8.9)
Hypertensive diseases (I10-I14)	279	5·3 (4.8–5.8)	109	3·6 (3.1–4.2)	399	4·6 (4.3–5.0)	253	4·8 (4.3–5.3	115	3·8 (3.3–4.4)	378	4·4 (4.0–4.8)
ARF and chronic RHD (I00-I09)	62	1·2 (0.9–1.4)	10	0·3 (0.2–0.5)	77	0·9 (0.7–1.1)	65	1·2 (1.0–1.5)	13	0·4 (0.2–0.6)	83	1·0 (0.8–1.1)
Other heart diseases (I30-I51)	152	2·9 (2.5–3.3)	69	2·3 (1.9–2.8)	227	2·6 (2.4–2.9)	187	3·6 (3.1–4.0)	84	2·8 (2.3–3.3)	278	3·2 (2.9–3.5)
Other circulatory diseases	44	0·8 (0.6–1.0)	26	0·9 (0.6–1.2)	72	0·8 (0.7–1.0)	46	0·9 (0.7–1.1)	28	0·9 (0.7–1.2)	77	0·9 (0.7–1.1)
Diabetes (E10-E14)	**1155**	**22 (21−23)**	**1006**	**34 (32–35)**	**2235**	**26 (25–27)**	**889**	**17 (16–18)**	**710**	**24 (23–25)**	**1655**	**19 (19–20)**
Neoplasms (C00-D48)	**1325**	**25 (24–26)**	**418**	**14 (13–15)**	**1840**	**21 (21−22)**	**1334**	**25 (24–26)**	**425**	**14 (13–15)**	**1854**	**22 (21–22)**
Breast cancer (C50)	426	8·1 (7.5–8.7)	113	3·8 (3.2–4.3)	569	6·6 (6.2–7.1)	426	8·1 (7.5–8.7)	115	3·8 (3.3–4.4)	571	6·6 (6.2–7.1)
Cervical, uterine cancer (C53-C55)	311	5·9 (5.4–6.5)	86	2·9 (2.4–3.4)	422	4·9 (4.5–5.3)	337	6·4 (5.9–7.0)	96	3·2 (2.7–3.7)	460	5·4 (5.0–5.8)
Ovarian cancer (C56)	109	2·1 (1.8–2.4)	30	1·0 (0.7–1.3)	145	1·7 (1.5–1.9)	109	2·1 (1.8–2.4)	30	1·0 (0.7–1.3)	145	1·7 (1.5–1.9)
Liver cancer (C22)	49	0·9 (0.7–1.2)	12	0·4 (0.2–0.6)	68	0·8 (0.6–1.0)	49	0·9 (0.7–1.2)	12	0·4 (0.2–0.6)	68	0·8 (0.6–1.0)
Lung cancer (C33-C34)	38	0·7 (0.5–0.9)	16	0·5 (0.3–0.8)	55	0·6 (0.5–0.8)	38	0·7 (0.5–0.9)	17	0·6 (0.4–0.8)	56	0·7 (0.5–0.8)
Other neoplasm	392	7·5 (6.9–8.1)	161	5·4 (4.7–6.1)	581	6·8 (6.3–7.2)	375	7·1 (6.6–7.7)	155	5·2 (4.5–5.9)	554	6·4 (6.0–6.9)
Chronic lower respiratory (J40-J47)	**90**	**1·7 (1.4–2.0)**	**81**	**2·7 (2.2–3.2)**	**179**	**2·1 (1.8–2.3)**	**96**	**1·8 (1.5–2.1)**	**86**	**2·9 (2.4–3.4)**	**190**	**2·2 (2.0–2.5)**
NCD 4 Total	**4086**	**78 (77–79)**	**2231**	**75 (73–76)**	**6581**	**77 (76–77)**	**3987**	**76 (75–77)**	**2190**	**73 (72–75)**	**6423**	**75 (74–76)**
Ill defined (R00-R99)	61	1·2 (0.9–1.4)	35	1·2 (0.9–1.5)	100	1·2 (1.0–1.4)	61	1·2 (0.9–1.4)	35	1·2 (0.9–1.5)	100	1·2 (1.0–1.4)
Total deaths	**5249**	**100**	**2990**	**100**	**8595**	**100**	**5249**	**100**	**2990**	**100**	**8595**	**100**

CoD: cause of death; PM: proportional mortality; ICD-10: International classification of diseases, 10th revision; MCCD: medical certificate of cause of death; All includes iTaukei, FID and others; FID: Fijian of Indian descent; NCD4: Sum of neoplasm, circulatory diseases, diabetes and chronic lower respiratory diseases; Alternate CoD sequence: UCoD bases on CoD sequence after relocating specific diabetes and hypertension codes from Part I (direct cause) to Part II (contributory cause) of the MCCD; ARF: acute rheumatic fever; RHD: rheumatic heart diseases.

Table 3
Proportional mortality (%) from non-communicable diseases from original and alternate CoD sequences, men 30–69-years, by ethnicity, Fiji, 2013–17.

Underlying cause of death (ICD-10 codes)	Original CoD sequence						Alternate CoD sequence					
	iTaukei		FID		All 30–69 year		iTaukei		FID		All 30–69 year	
MEN	No. Deaths	PM % (95% CI)	No. Deaths	PM % (95% CI)	No. Deaths	PM % (95% CI)	No. Deaths	PM % (95% CI)	No. Deaths	PM % (95% CI)	No. Deaths	PM % (95% CI)
Circulatory diseases (I00-I99)	**2646**	**42 (41–43)**	**2123**	**44 (43–45)**	**4946**	**42 (41–43)**	**2854**	**45 (44–46)**	**2556**	**53 (52–54)**	**5599**	**48 (47–49)**
Ischaemic heart diseases (I20-I25)	1486	23 (23–24)	1581	33 (31–34)	3176	27 (26–28)	1671	26 (25–27)	1916	40 (38–41)	3706	32 (31 –32)
Cerebrovascular diseases (I60-I69)	467	7·4 (6.8–7.9)	260	5·4 (4.8–5.9)	756	6·5 (6.1–6.8)	497	7·8 (7.3–8.4)	324	6·7 (6.1–7.3)	855	7·3 (6.9–7.7)
Hypertensive diseases (I10-I14)	346	5·5 (5.0–5.9)	130	2·7 (2.3–3.1)	491	4·2 (3.9–4.5)	293	4·6 (4.2–5.1)	135	2·8 (2.4–3.2)	439	3·7 (3.5–4.0)
ARF and chronic RHD (I00-I09)	32	0·5 (0.4–0.7)	15	0·3 (0.2–0.5)	51	0·4 (0.3–0.5)	34	0·5 (0.4–0.7)	16	0·3 (0.2–0.5)	54	0·5 (0.4–0.6)
Other heart diseases (I30-I51)	246	3·9 (3.5–4.3)	110	2·3 (1.9–2.6)	370	3·2 (2.9–3.4)	286	4·5 (4.1–4.9)	134	2·8 (2.4–3.2)	435	3·7 (3.4–4.0)
Other circulatory diseases	69	1·1 (0.9–1.3)	27	0·6 (0.4–0.7)	102	0·9 (0.7–1.0)	73	1·2 (0.9–1.4)	31	0·6 (0.5–0.8)	110	0·9 (0.8–1.1)
Diabetes (E10-E14)	**1072**	**17 (16–18)**	**1091**	**22 (22 –23)**	**2253**	**19 (19–20)**	**743**	**12 (11–12)**	**574**	**12 (11–13)**	**1381**	**12 (11–12)**
Neoplasms (C00-D48)	**673**	**11 (10–11)**	**236**	**4·9 (4.4–5.4)**	**968**	**8·3 (7.8–8.7)**	**695**	**11 (10 –12)**	**240**	**4·9 (4.4–5.5)**	**994**	**8·5 (8.1–8.9)**
Liver cancer (C22)	121	1·9 (1.6–2.2)	14	0·3 (0.2–0.4)	144	1·2 (1.1–1.4)	125	2·0 (1.7–2.3)	14	0·3 (0.2–0.4)	148	1·3 (1.1–1.4)
Prostate cancer (C61)	56	0·9 (0.7–1.1)	14	0·3 (0.2–0.4)	71	0·6 (0.5–0.7)	55	0·9 (0.7–1.1)	14	0·3 (0.2–0.4)	70	0·6 (0.5–0.7)
Lung cancer (C33-C34)	39	0·6 (0.5–0.8)	23	0·5 (0.3–0.6)	70	0·6 (0.5–0.7)	40	0·6 (0.5–0.8)	23	0·5 (0.3–0.6)	71	0·6 (0.5–0.7)
Other neoplasm	457	7·2 (6.7–7.7)	185	3·8 (3.4–4.3)	683	5·8 (5.5–6.2)	475	7·5 (7.0–8.0)	189	3·9 (3.4–4.4)	705	6·0 (5.7–6.4)
Chronic lower respiratory (J40-J47)	**195**	**3·1 (2.7–3.4)**	**187**	**3·9 (3.4–4.3)**	**394**	**3·4 (3.1–3.6)**	**196**	**3·1 (2.7–3.5)**	**197**	**4·1 (3.6–4.4)**	**406**	**3·5 (3.2–3.7)**
NCD 4 Total	**4586**	**72 (71–73)**	**3637**	**75 (74–76)**	**8561**	**73 (72–74)**	**4486**	**71 (70–72)**	**3567**	**74 (73–75)**	**8380**	**72 (71–72)**
Ill defined (R00-R99)	123	1·9 (1.7–2.2)	56	1·2 (0.9–1.4)	189	1·6 (1.4–1.8)	123	1·9 (1.7–2.2)	56	1·2 (0.9–1.4)	187	1·6 (1.4–1.8)
Total	**6345**	**100**	**4849**	**100**	**11,711**	**100**	**6345**	**100**	**4849**	**100**	**11,711**	**100**

CoD: cause of death; PM: proportional mortality; ICD-10: International classification of diseases, 10th revision; MCCD: medical certificate of cause of death; All includes iTaukei, FID and others; FID: Fijian of Indian descent; NCD4: Sum of neoplasm, circulatory diseases, diabetes and chronic lower respiratory diseases; Alternate CoD sequence: UCoD bases on CoD sequence after relocating specific diabetes and hypertension codes from Part I (direct cause) to Part II (contributory cause) of the MCCD; ARF: acute rheumatic fever; RHD: rheumatic heart disease.

the specific NCDs contributing to this premature mortality in Fiji are evident by sex and ethnicity. Consequently, health policy and interventions, including primary and secondary prevention, and diagnosis and treatment of NCD illness, will need to be more effectively targeted to the disease burden of each segment of the population if the SDG 3.4.1 goal is to be achieved in Fiji.

Mortality data forms an important component of a population's health profile, and ensuring it provides an accurate picture of disease burden and outcomes is crucial. Diabetes and CVD are common comorbidities [15]. The way these conditions are recorded on the MCCD, and application of ICD-10 coding rules, has been shown to impact UCoD statistics for a population [11,14]. In this study, analysis of MCCD's with diabetes reported anywhere on the certificate suggests an overrepresentation of diabetes as the UCoD in Fiji mortality data. Using the original CoD sequence, diabetes was the UCoD for around 73% and CVD was the UCoD for 13% of deaths in persons with a diabetes CoD on their MCCD, compared to 49% with diabetes and 33% with CVD UCoD after reassignment. In comparison, the literature reports half [15–17] to two-thirds [21] of deaths in patients with diabetes are due to CVD. UCoD statistics for Fiji using the reassigned CoD sequences may provide a more accurate picture of the disease burden in this population.

CVD is the largest UCoD contributor to NCD4 mortality in ages 30–69 years in Fiji for both sexes and ethnicities when CoD sequences are reassigned, with $PM_{30–70}$ for females at 32% and for males 45–53%. In FID, both men and women have higher $PM_{30–70}$ from diabetes and IHD than i-Taukei, from both original and alternate CoD sequences. As a consequence, reassigning non-fatal diabetes and hypertension CoD from Part I to Part II of the MCCD results in a larger increase in CVD and decrease in diabetes mortality for FID compared to i-Taukei. As expected, the reassignment algorithm has minimal impact on the proportion of deaths due to other UCoD.

The contributions to premature mortality from various circulatory diseases differs by sex and ethnicity. $PoD_{30–70}$ due to IHD ranges from 7% for i-Taukei and FID women to 24% for FID men. Acute rheumatic fever (ARF) and rheumatic heart disease (RHD) are small but variable contributors to CVD mortality in Fiji. Gaps in the current school-based screening program for prevention and management of ARF and RHD have been reported [22], but data by ethnicity are not available to assess any possible correlations between program delivery gaps and CVD mortality disparities.

Levels of established risk factors for CVD (smoking, diabetes, hypertension and dyslipidaemia) [23,24] vary by sex and ethnicity across the Fijian population. From published survey data for 2011, the prevalence of hypertension in adult Fijians ranged from 33% for FID women to 41% for i-Taukei men [25]. In 2011, the prevalence of diabetes was higher in FID women and men (19·9% and 17·9%) than in i-Taukei women and men (13·6% and 11·1%) [26]. Although empirical survey data in Fijians aged 25–64 years show declines in daily smoking between 1980 and 2000, the prevalence of tobacco smoking in Fijian men of both ethnicities was around 27% in 2011, compared with 10% for i-Taukei women and 1% for FID women [27]. High rates of smoking in men and higher rates of diabetes in FID than i-Taukei may contribute to some of the differences seen in rates of CVD mortality, providing potential for more targeted intervention.

Epidemiological studies have demonstrated differing risk for development of CVD in some populations which requires consideration in targeting NCD reduction interventions in Fiji. People of South Asian origin, including Indians, have been found to be twice as likely to develop coronary artery disease as Caucasians due to pathophysiological and lifestyle related risk factors [15], including higher rates of abdominal obesity, type 2 diabetes and insulin resistance [28].

Diabetes is the second highest UCoD in FID women and in men of both ethnicities in Fiji, with $PoD_{30–70}$ due to diabetes ranging from 8% to 10% across these population segments. Diabetes is a direct cause of death (CoD) but also contributes to premature mortality by increasing the risk of CVD, with observational studies showing a four-fold increased

risk of incident heart failure in women with diabetes and a 2-fold increased risk in men, compared to people without diabetes [29,30]. The most significant modifiable risk factors for development of type 2 diabetes are overweight, abdominal obesity and lack of physical activity [31]. Studies have demonstrated that type 2 diabetes may be prevented by targeting these risk factors through effective diet and lifestyle modifications [32]. The prevalence of obesity was significantly lower for FID than i-Taukei: 26·6% for FID and 52·9% for i-Taukei women; 9·4% for FID and 28·9% for i-Taukei men [26]. A US study of three prospective cohorts diagnosed with diabetes shows that controlling blood glucose (measured as HbA_{1c}), blood pressure and LDL cholesterol at target levels for all three risk factors reduced the risk of CVD events by about 60% compared to those with diabetes not at target levels for these factors [33].

Hyperglycaemia and hyperinsulinemia accelerate atherosclerosis, and poor glycaemic control, common in Fiji [34,35], has been associated with increased risk of heart failure and worse cardiovascular outcomes [36]. Tighter glycaemic control early in the diabetes disease course and prior to development of other CVD risk factors may produce the largest reduction in CVD morbidity and mortality [17,37]. Investigating the factors contributing to poor glycaemic control in the Fijian context may facilitate better targeting of interventions to control diabetes and prevent complications.

Given the significant contribution of CVD and diabetes to total adult mortality in Fiji, population-wide public health policy appropriately targets these two conditions and their risk factors [38]. However, for i-Taukei women aged 30–69-years 25% of deaths are due to cancer, making reduction of cancer mortality for this group imperative if SDG 3.4.1 targets are to be achieved. Examination of empirically derived cancer mortality by ethnicity shows that $PoD_{30–70}$ due to breast cancer, ovarian cancer or all cancers is approximately double in i-Taukei compared to FID women. Moreover, cancer mortality was also higher in i-Taukei women than women of any other country reported in Globocan 2020 [39]. For Fijian women of both ethnicities, the $PoD_{30–70}$ due to cancer (ICD-10 C00-D48) was significantly higher than in Fijian men of matching ethnicity. Globally, cancer mortality is not inherently higher in women aged 30–69 years: in 2020, the estimated $PoD_{30–70}$ due to cancer in women was 6·2% compared to 8·4% in men [39]. Empirically derived $PoD_{30–70}$ from cancer is significantly higher in i-Taukei (7.6%) than FID (3.5%) men.

Higher incidence rates, delayed diagnosis, limited access and non-compliance to treatment are factors that may contribute to higher mortality from cancer [40]. For Fiji, limited published data show incidence rates for breast cancer are very similar in i-Taukei and FID women [41], whereas for cervical cancer, higher age standardised incidence rates in i-Taukei compared to FID women have been reported [42]. Recognising the differences in cancer mortality rates between i-Taukei and FID, and investigating the factors contributing to these differences, should inform cancer-related health policy and identify new pathways to reducing cancer mortality for i-Taukei women and men.

The absence of an organised cervical screening program in Fiji, and difficulties in follow-up of women with oncogenic human papilloma virus (HPV) infection or abnormal cytology when screening does occur [43], suggest a see-and-treat approach to prevention and management of cervical cancer may be appropriate. Acceptability and effectiveness of such programs have been demonstrated in Papua New Guinea [44,45]. Further mitigation of the risk of cervical cancer mortality may be expected following the inclusion of a bivalent HPV vaccine in the school-based national vaccination program in Fiji from 2013 [46]. Near 100% vaccine coverage for the first dose has been reported for the target group of 12-year-old girls over 2013–16, but lower coverage of the second dose [47] may require remedial action.

Consistent with the differing mortality profiles found by sex and ethnicity in this study, the Fiji Islands Health System Review of 2011 [48] noted: “The two major ethnic groups have maintained much of their lifestyle and dietary differences, and consequently, have differing epidemiological profiles.” However, limited data are collected or publicly available with ethnicity reported. The Fiji National Development Plan (NDP) 2017–2036 provides a whole-of-government vision for “Transforming Fiji” for all Fijians with no one left behind, “regardless of geographical location, gender, ethnicity” [49]. The NDP outlines strategies to reduce NCDs, including changes in lifestyle, healthy diets, physical activity, and better health education. The MHMS Strategic Plan 2020–25 [50] details implementation of the NDP related to health, with NCDs more specifically targeted in the Non-communicable Diseases Strategic Plan 2015–2019 [38]. However, none of these plans acknowledge the differing levels and causes of morbidity and mortality experienced by the two main ethnic populations in Fiji. Consequently, health policies need to acknowledge and respond to the differing disease burdens experienced by each segment of the population and provide ethnic-specific strategies to achieve equitable health outcomes.

The strengths of this study include using an essentially complete empirical mortality dataset, including all direct and contributory CoD data as recorded on MCCD's, and using IRIS to standardise UCoD selection. Availability of sex and ethnicity data allowed mortality analysis for each segment of the population, and identification of the significant differences in the disease burden experienced by each group.

Recording of ill-defined causes or incomplete information in the causal sequence reduces the quality of the mortality data available, as do underlying causes that are not useful from a health policy perspective, including cardiovascular codes that lack diagnostic meaning, such as cardiac arrest (ICD-10: I46) and heart failure (ICD-10: I50) [51]. In Fiji, $PoD_{30–70}$ due to other heart diseases ranges from 1·1% to 3·2% (ICD-10 codes I30 to I51). Some of these deaths potentially could be more appropriately certified as IHD, although reassignment of these deaths to IHD would have little impact on the difference between FID men and the other segments of the population.

Limitations in this study include possible erroneous or incomplete clinical diagnosis contributing to inaccuracy in CoD information recorded on MCCDs [52]. The medical doctor may have had no, or minimal, prior contact with the deceased, and medical records and diagnostic history may be limited when deaths occur in the community. Nearly 60% of deaths in FID in this study are recorded as occurring in a health facility compared with 45% for i-Taukei, potentially contributing to a disparity in the accuracy and completeness of the CoD data. Assessment of the records for deaths occurring at home or in the community may provide insight into the potential impact on mortality analysis. Improvement in certification is required, as well as more effective follow up of issues identified at coding, in order to achieve a more complete and accurate mortality dataset.

Applying ICD-10 coding rules to CoD sequences that have been recorded without respecting ICD-10 standards may produce UCoD other than what was intended by the certifying physician, for example, by recording causes in random rather than sequential order. Death certification including non-fatal diabetes or non-fatal hypertension CoD as a direct cause may lead to UCoD misclassification if the certifier has failed to record details of any complications that may be present. Relocating diabetes to Part II of the MCCD in this circumstance could contribute to an underestimation of diabetes mortality. Conversely, retaining diabetes or hypertension in Part I where kidney disease without non-diabetic origin is also recorded may lead to an overestimation of diabetes with renal complications.

Over the period 2000 to 2015, adult mortality ($PoD_{30–70}$) from all causes was reduced by 4% for women and by 8% for men [6]. Fiji will not achieve the SDG 3.4.1 goal of reducing NCD mortality by one-third without accelerating rates of reduction through more effective targeting of interventions to prevent, diagnose and treat NCDs which contribute a high proportion of mortality in this age group.

Conclusion

Multiple targeted strategies will be required in order to meet SDG

3.4.1 targets in Fiji. Reframing of health and NCD policies to acknowledge, address and monitor the differences in health needs by sex and ethnicity may assist in achieving this.

Ethics approval and consent to participate

Approved by Fiji National Health Research and Ethics Review Committee (2018.72.NW) and by the University of New South Wales Human Research Ethics Committee (iRECS4350).

Consent for publication

Not applicable.

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CRediT authorship contribution statement

Dearie Catherine: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Linhart Christine:** Writing – review & editing, Supervision. **Figueroa Carah:** Writing – review & editing. **Saumaka Varanisese:** Writing – review & editing, Data curation. **Dobbins Timothy:** Writing – review & editing, Supervision. **Morrell Stephen:** Conceptualization. **Taylor Richard:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors have no relevant conflicts of interest to declare.

Data availability

The mortality dataset analysed is not publicly available but may be requested by submission of a Data Request form to the Data Analysis Management Unit (DAMU) of the Ministry of Health and Medical Services, Fiji. The non-confidential information used in this publication, was compiled in accordance with the Information Act of 2018 of the Republic of Fiji but which DAMU has no authority to independently verify. The Data Analysis Management Unit of the Ministry of Health and Medical Services cannot and does not represent that the data was appropriate for this publication or endorse or support any conclusions that may be drawn from the use of the data.

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Appendix A. Appendix

Table A1
Comparison of proportional mortality (%) from non-communicable disease causes of death by original and alternate CoD sequences, by age group and sex, Fiji, 2013–17.

Underlying cause of death (ICD-10 codes)	Original CoD sequence										Alternate CoD sequence									
	Age group (years)										Age group (years)									
	0–4		5–29		30–69		≥70		Total		0–4		5–29		30–69		≥70		Total	
Women	Deaths	%	Deaths	%	Deaths	%	Deaths	%	Deaths	%	Deaths	%	Deaths	%	Deaths	%	Deaths	%	Deaths	%
Circulatory Disease (I00-I99)	20	2·5	103	14	2330	27	2074	35	4527	28	21	2·6	100	14	2724	32	2461	42	5306	33
Ischaemic heart diseases (I20-I25)	0	0	5	0·7	906	11	737	13	1648	10	0	0	5	0·7	1160	13	936	16	2100	13
Cerebrovascular diseases (I60-I69)	2	0·3	15	2·0	649	7·6	690	12	1356	8·5	3	0·4	12	1·6	748	8·7	777	13	1540	9·6
Diabetes (E10-E14)	1	0·1	25	3·4	2235	26	1186	20	3447	22	0	0	25	3·4	1655	19	669	11	2349	15
Neoplasms (C00-D48)	13	1·6	104	14	1840	21	439	7·5	2396	15	12	1·5	104	14	1854	22	451	7·7	2421	15
Chronic lower respiratory (J40-J47)	3	0·4	13	1·8	179	2·1	130	2·2	325	2·0	3	0·4	13	1·8	190	2·2	138	2·4	344	2·2
NCD 4 total	**37**	**4·6**	**245**	**33**	**6581**	**77**	**3829**	**65**	**10,692**	**67**	**36**	**4·5**	**242**	**33**	**6423**	**75**	**3719**	**64**	**10,418**	**65**
All cause total CoD	**799**	**100**	**735**	**100**	**8595**	**100**	**5853**	**100**	**15,982**	**100**	**799**	**100**	**735**	**100**	**8595**	**100**	**5853**	**100**	**15,982**	**100**
Men																				
Circulatory Disease (I00-I99)	30	2·8	127	12	4946	42	2153	38	7256	37	30	2·8	128	12	5599	48	2404	43	8161	42
Ischaemic heart diseases (I20-I25)	2	0·2	23	2·2	3176	27	984	17	4185	21	2	0·2	23	2·2	3706	32	1161	21	4892	25
Cerebrovascular diseases (I60-I69)	8	0·7	16	1·6	756	6·5	564	10	1344	6·9	8	0·7	16	1·6	855	7·3	615	11	1494	7·7
Diabetes (E10-E14)	1	0·1	7	0·7	2253	19	964	17	3225	17	1	0·1	8	0·8	1381	12	568	10	1958	10
Neoplasms (C00-D48)	27	2·5	112	11	968	8·3	409	7·2	1516	7·8	27	2·5	111	11	994	8·5	414	7·3	1546	7·9
Chronic lower respiratory (J40-J47)	4	0·4	26	2·5	394	3·4	302	5·3	726	3·7	4	0·4	25	2·4	406	3·5	321	5·7	756	3·9
NCD 4 Total	**62**	**5·7**	**272**	**26**	**8561**	**73**	**3828**	**68**	**12,726**	**65**	**62**	**5·7**	**272**	**26**	**8378**	**72**	**3706**	**66**	**12,421**	**64**
All cause total CoD	**1077**	**100**	**1031**	**100**	**11,711**	**100**	**5645**	**100**	**19,464**	**100**	**1077**	**100**	**1031**	**100**	**11,711**	**100**	**5645**	**100**	**19,464**	**100**

CoD: cause of death; ICD-10: International classification of diseases, 10th revision; Total includes iTaukei, FID and others; NCD4: Sum of neoplasm, circulatory diseases, diabetes and chronic lower respiratory diseases; Alternate CoD sequence: UCoD bases on CoD sequence after relocating specific diabetes and hypertension codes from Part I (direct cause) to Part II (contributory cause) of the MCCD.

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