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An observational study of intergenerational sex differences in mortality in Aotearoa New Zealand

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ABSTRACT

Internationally, there are observable sex differentials in mortality in many countries, most notably in affluent countries, with women living longer than men. To understand if this is also the case in Aotearoa New Zealand (NZ), we visualise the precise nature and evolution of sex differentials in mortality by age over time, within a wider context of increasing life expectancy and falling mortality. This allows us to determine if NZ mirrors other affluent countries in having a male/female inequality in mortality, and how the inequality has evolved over several generations in NZ.

We use newly available single-year mortality data by sex in NZ to visualise and analyse the sex differentials in mortality using an observational study design. Sex and age-specific mortality data were obtained from the human mortality database from 1948 to 2021 for NZ. The data were then processed to create a smoothed data series using a geometric mean of those two years older and younger as well as aggregating the single-year age groups over 90 into a single category due to small numbers. The processed data was then visualised using a lexis diagram.

There are clear patterns of elevated mortality ratios at younger ages (18–30) for males compared to females. The relative difference in mortality inequality between the sexes grew between 1950 and 1980 in NZ, before converging between 2000 and 2020. There is a consistent gap of at least 3 years in life expectancy across the study period by sex.

Particularly striking is the longstanding nature of this inequality in mortality by sex in NZ and the relative lack of focus from policymakers. This focus on one country, NZ, allows examination of this specific context to understand how policy changes may have exacerbated or ameliorated trends in male/female mortality inequality.

1. Introduction

Internationally, mortality inequalities exist within and between various sub-groups of the population (Baxter et al., 2017; Crengle et al., 2022; Disney et al., 2017; Marie-Pier et al., 2022; Rigby and Dorling, 2007; Sandiford, 2009), with men, particularly younger men, experiencing relatively higher mortality rates. Here, we focus on sex differentials in mortality that exist between men and women in high-income countries (Rigby and Dorling, 2007), examining the differences in mortality ratios across the lifespan in Aotearoa New Zealand (NZ). Men's health remains of concern to policymakers worldwide (Baker et al., 2023). This is due to both their biology which puts men at higher risk of particular diseases or conditions compared to women, for example cardiovascular disease, as well as due to global gender relations and cultures of masculinity, meaning men are less likely to use health care, are more likely to work in high-risk occupations and to take more risks than other genders (Baker and Shand, 2017; Sandiford, 2009).

Major causes of disease and death for males in NZ have evolved over time due to important changes in lifestyle, healthcare, as well as changing gender relations and socio-political health determinants (Braveman and Gottlieb, 2014). For instance, causes of mortality among men in the past century, have moved from the primary causes being

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infectious diseases such as tuberculosis (O'Toole, 2019), to other causes such as obesity-related diseases (Ministry of Health, 2004), substance abuse (Allik et al., 2020; Hoopsick et al., 2021), and suicide (Campbell et al., 2015a; Ministry of Health, 2015); often with an elevated mortality rate for men in comparison to women. A significant life expectancy gap between males and females remains (Barford et al., 2006; Luy and Gast, 2013) alongside shifts in the causes of mortality.

There is evidence that young males, 15–40, have death rates three times that of females, but, this age group is a small contributor to the overall sex differences in life expectancy (Zarulli et al., 2021). Moreover, others have found that in multiple contexts, including NZ, that younger ages have had declining contributions to the sex gap in life expectancy since the 1970s, whilst the older ages groups, those 50 or more, were the leading contributors to sex gaps in life expectancy (Zarulli et al., 2020). More specifically, eighty-four percent of all fatal accidents are male; males are more likely to die from injury than females at all ages and almost 100 % of occupational deaths are male (Cullen et al., 2021; Johnson et al., 2008; Stergiou-Kita et al., 2015). Despite falling mortality rates and increasing life expectancy since the 1950s in NZ, there is a longstanding difference in mortality rates by sex.

From the 1870s to 1940 life expectancy for non-Māori in NZ was the highest in the world (Woodward and Blakely, 2016). However, since the 1980s, NZ has seen a deteriorating relative performance in relation to other high-income nations, notably, Australia (M Campbell, C Bowie et al., 2015). NZ research on sex differentials in mortality has been limited, with studies reporting women generally live significantly longer than men (Sandiford, 2009). Yet, the sex difference in life expectancy in many countries is now narrowing, noting the historical differences in smoking rates or employment practices as important explanations for male disadvantage in earlier cohorts (Blakely et al., 2018). Further research is needed to understand the nature and changes in the inequality over time as has been attempted elsewhere (M Campbell, C Bowie et al., 2015; Rigby and Dorling, 2007); by identifying which age (s), period(s) and cohort(s) of the study population contribute to sex differentials in mortality in NZ.

There is also growing evidence pointing to the complex interplay of factors that shape health inequities and the benefits of de-centering gender in intersectional analyses (Bambra, 2022; Hankivsky, 2012). The intersection of sex and ethnicity is an example, where previous evidence has shown that Māori mortality outcomes are worse due to systematic structural disadvantages, leading to lower income and life expectancy, poorer health measures, stigmatisation and racism within healthcare (Hobbs et al., 2019). Further, men in all ethnic groups die younger than females, with a difference in life expectancy of 4.7 years for Māori and 4.0 years for non-Māori by sex. Strikingly, while many of the differences in mortality are explained by variations in tobacco use, heart disease and all types of cancer, almost a quarter of deaths for men are by accidents and suicide (Allik et al., 2020; Rigby and Dorling, 2007; Stergiou-Kita et al., 2015). It is also important to note that there are a broad range of demographic and socio-economic factors such as age and income that influence health (Blakely et al., 2018; Bowie et al., 2013; Bundy et al., 2023; Mackenbach et al., 2008). Moreover, aspects of the environment and neighbourhood have also been shown to have an impact on health outcomes both in positive and less positive ways (Hobbs et al., 2019; Marek et al., 2020; Pearce et al., 2009). If neighbourhood or environmental influences on health are different between the sexes, this could also give rise to health differences influenced by different neighbourhoods and environments (Rompel et al., 2021). Further, evidence suggests that the residential environment may be more important for women's health, while economic activity is more strongly related to men's health (Stafford et al., 2005). Women's health issues relate mainly to sexual and reproductive health impacting women (Marleen et al., 2015).

Using recent data from the Human Mortality Database (HMD) for NZ on age and sex-specific mortality information, we can now examine in detail the sex differentials in mortality from 1948 up to the period around the COVID-19 pandemic, in 2021. This study aimed to visualise the changes in the sex differential in mortality during the study period covering 1948–2021, highlighting the specific age, period, or cohorts most impacted by inequalities in mortality rates.

2. Materials and methods

2.1. Study design

We use an observational study design in combination with visualisation of the mortality data for NZ in the form of a lexis diagram. This study follows the methodological approach used elsewhere (Campbell et al., 2015b; Rigby and Dorling, 2007) to compare observed mortality rates by groups within or between populations of interest, such as by sex or by country.

2.2. Data

We use data from the Human Mortality Database (HMD) for NZ. The data is mortality (death rates) by single year of age from 0 to 109 and 110 or more aggregated, by sex (Male and Female, noting only 2 sexes were collected) for the years 1948–2021 inclusive. This was the most recent and available data at the time of analysis. The data was then processed to create a smoothed data series using a geometric mean of those two years older and younger as well as aggregating the single-year age groups over 90 into a single category due to small numbers in these age groups. Further, we imputed data that contains no deaths, to allow a rate ratio to be created, and to allow for smoothing the data in the preceding and following 2 years of age. There are 27 female and 13 male observations across the study period containing zero deaths for age and sex specific mortality observations. This smoothing adjusts for the undue influence, for example in early ages, of large numbers in specific calendar years, enabling longer-term trends to become apparent. Processing the raw data was undertaken in the statistical software R and Microsoft Excel, then data was visualised using lexis diagram software.

2.3. Analysis

We use descriptive statistics of the age and sex-specific mortality rates as well as lexis diagrams to reveal trends in multi-year mortality data (Figures A1, A2). A lexis diagram is constructed from coloured cells, which are then visualised to represent the underlying single-year sex mortality data. The horizontal axis shows the study period years, from 1948 to 2021 and the vertical axis is each single year of age from 0 to 90 or more. Therefore, we have over 6500 cells in a single diagram, Fig. 2, coloured by the mortality rate ratio of males over females.

3. Results

3.1. Sex differentials in life expectancy

The results show a nuanced insight into the growth and then convergence of sex differences in mortality from 1948 to 2021 in NZ. In absolute terms, life expectancy for the total population in NZ has increased from 68.8 years to 82.3 years between 1948 and 2021 as shown in Fig. 1. This represents an increase of 13.5 years of life expectancy in just over 70 years of the study period. The difference in life expectancy by sex in the same period, 1948 to 2021, shows that female life expectancy increased from 70.8 to 84.0 years, and for male life expectancy, an increase from 66.97 to 80.56 years. This means that life

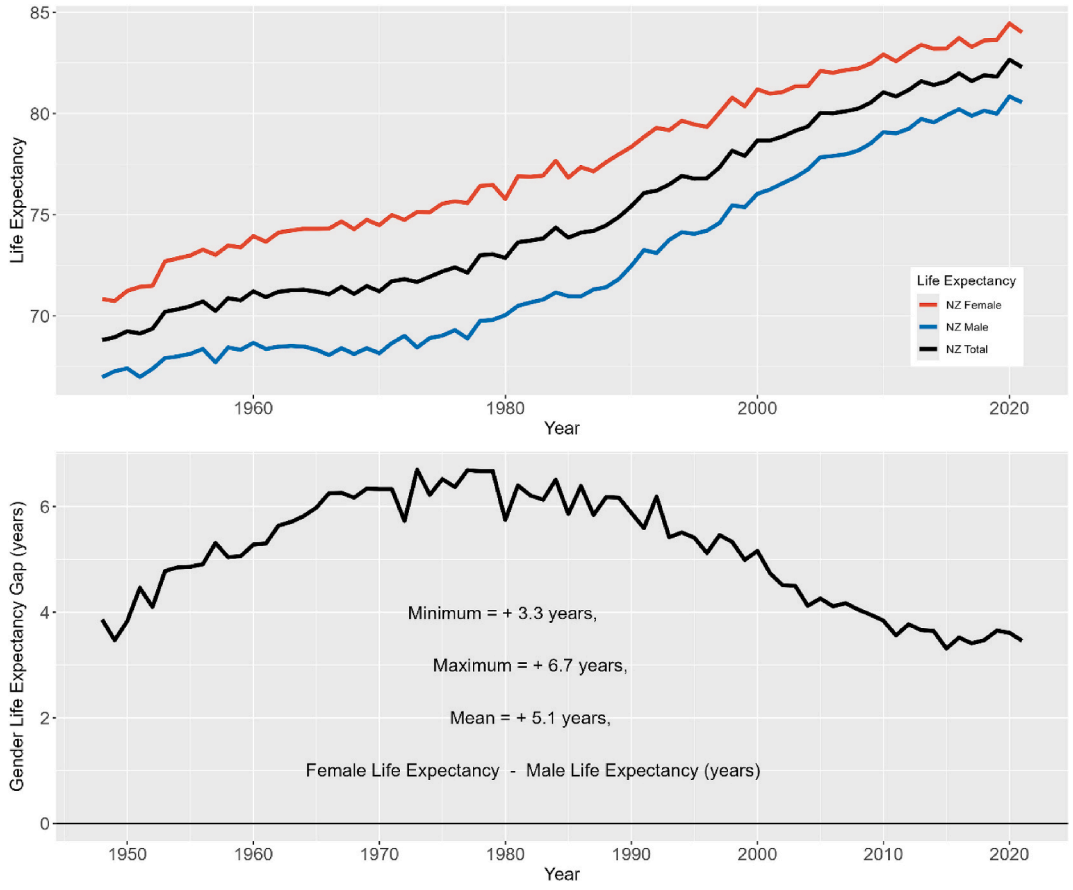

Fig. 1. Sex differentials in Life Expectancy (1948) to 2021.

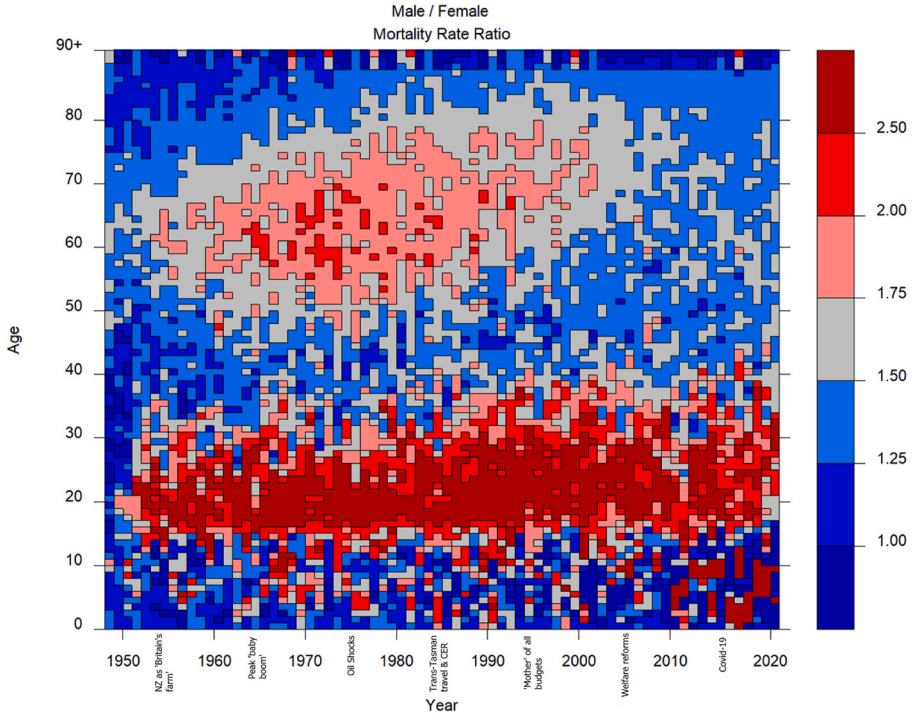

Fig. 2. Sex differentials in mortality rate ratios; 1948–2021.

expectancy increased by 13.2 and 13.6 years for females and males respectively over the study period.

The data (Fig. 1, bottom panel), also shows the differential between male and female life expectancy for the study period, 1948 to 2021. Visualising the difference in life expectancy by sex, there is a fluctuation through the period (Fig. 1, bottom panel) with growth towards a peak in sex differentials for life expectancy in the late 1970s and early 1980s of 6.7 years, between males and females, during a period of economic distress in NZ. However, since the late 1970's, in NZ there has been a steady narrowing of the life expectancy gap between men and women, from 6.5 years in 1975–77 to 4.8 years in 2000–2002 signalling a relatively consistent decline in inequality between male and female life expectancy. The Figure (Fig. 1, bottom panel) shows a consistent male life expectancy penalty, or a female advantage, with an average of 5.1 years across the whole study period, a minimum 3.3 years, into the 2010s showing a pattern of constant change and consistent male disadvantage relative to females.

3.2. Sex differentials in mortality

Turning to sex differentials in mortality for the study period, Fig. 2 shows that the sex differential in mortality is not only temporally variable, but there are important age effects in the distribution. Most notably, males transitioning into adulthood, typically between 18 and 25 years of age, experience heightened mortality rates compared to their female counterparts, signalled by the deepest shades of red. Throughout this study period, this age group (males aged 18–25) exhibited 2.5 times the mortality rate of females (Fig. 2). As an example, what this means in practice, is that at the peak of the inequality of mortality in 1986, for every woman dying aged 20, around 4 men, aged 20 died in the same year (Figure A3). In contrast, the darkest blues signify those ages where the differential is the smallest between men and women, or even reversed, for example around age 45 for men and women, during a few periods in the 1990s, or for men in the years 1948–1950 aged under 50. However, the age group from 30 to 40 years old, also sees a deterioration in the rate ratio from equality in the 1950s (in blue shades) to 1.5 times by the end of the study period (in red shades). Beginning in the 1950s though until the 2000s, we can also observe a cohort effect of older men (50 years old or more) experiencing elevated mortality rates in comparison to female peers. However, from approximately the year 2000 onwards, we see a decline in relative inequality in this age group with a move towards greater equality between the sexes.

4. Discussion

The study of sex differentials in mortality is important as it sheds light on how inequalities in mortality may arise by helping to uncover divergence - or convergence – in specific ages, periods or cohorts of the population, illuminating opportunities for intervention in a more targeted manner. Sex differences in mortality rates have significant public health implications, and by more fully understanding why certain subpopulations, specifically men or women, are more vulnerable to premature death, this can inform targeted interventions and healthcare policies to address inequalities. Our study aimed to visualise the changes in the sex differential in mortality during the study period (1948–2021), highlighting the age groups, periods and cohorts most impacted by inequality in mortality by sex. We showed a consistent differential by sex for those aged 18–30 years, persisting through the study period.

With respect to age, period or cohort effects, others have pointed to the dramatic reduction in factors such as the number of traffic-related deaths over successive years, or that the peaks in Coronary Heart Disease (CHD) occurred in the late 1960s (Tobias et al., 2008), with all of the decline resulting from a period effect that likely reflected preventive and therapeutic interventions (Tobias et al., 2006). A particular period effect in New Zealand was during major economic and structural reforms from 1984 to the early 1990s (Blakely et al., 2008), arguably impactful on cohorts born then (Kyriopoulos et al., 2019), with evidence showing that austerity in particular can be harmful to health and increase inequalities (Suhrcke and Stuckler, 2012). Others have argued that this period of economic reform in New Zealand, led to changes in relative mortality rates for subsequent cohorts, compared to Australia (Campbell et al., 2015a). Cohort effects related to smoking and sex show differences of 46 % for those men born 1935–1939, compared to 28 % for those men born 1965–1969 in the UK (Peters et al., 2014). Alongside this, evidence also outlines that smoking may be more harmful to women, with regard to ischaemic heart disease, for example (Prescott et al., 1998), or that there 25 % increased risk for coronary heart disease conferred by cigarette smoking for women compared with men (Huxley and Woodward, 2011).

Internationally, men have a lower life expectancy than women throughout most of the world (Barford et al., 2006; Moon, 2017) and there are limited factors either proven or suspected to cause this difference. Indeed, across high-income countries, men's health is poor according to a wide range of measures, whether life expectancy, mortality or morbidity, with higher mortality for all 15 leading causes of death and an average life expectancy between 5 and 7 years shorter than women (Xiao et al., 2022).

4.1. Social and economic factors

Many social and economic factors contribute to higher mortality rates. Men's poorer survival rates may reflect social and cultural gender norms that play out in employment choices, such as the over-representation of men in outdoor and higher-risk occupations and linked occupational exposure to physical and chemical hazards including in the military, construction, driving and mining. Further issues that may contribute to male mortality disadvantage include economic conditions and hardship that are often cited as more impactful on males compared to females (Rigby and Dorling, 2007). The economic conditions that existed during the 1970s were particularly unfavourable in NZ, driving increasing Trans-Tasman economic migration and corresponding to the peak of the male 'penalty' in NZ, whilst contemporaneously, the rapid divergence between Australia and NZ for mortality began, leading to relatively worse outcomes for mortality in NZ compared to Australia (Campbell et al., 2015b).

4.2. Biological factors

There is evidence across the life course, beginning in infancy, that males have an enhanced probability of mortality and premature birth which are often linked to their greater risk of genetic disorders due to the chromosomal structure (Orzack et al., 2015). Males may be biologically at higher risk of dying of heart disease, perhaps due to having lower oestrogen levels than women (Iorga et al., 2017), but also due to their diet (more cholesterol) and poorer use of health services for hypertension which are more culturally determined behaviours. Moreover, there are sex specific diseases, such as prostate cancer, which, at one point was the most frequently diagnosed cancer in NZ men as well as being the overall 3rd largest contributor to cancer deaths (Matti et al., 2021).

A men's health issue is a disease or condition unique to men, more prevalent in men, more serious among men, for which risk factors are different for men or for which different interventions are required for men (Allik et al., 2020; Möller-Leimkühler, 2003; Xiao et al., 2022). Similarly, women's health has a set of specific issues relating to sexual and reproductive health impacting most on women (Marleen et al., 2015), although this is better recognised in policy as NZ has a women's

health strategy (Ministry of Health, 2023). Further, evidence has suggested that men's health has a smaller evidence base and it is argued that men's health specific interventions are warranted (Johnson et al., 2008; Moon, 2017). Notably, there has been less research specifically on the health of men (Xiao et al., 2022). For instance, a Medline search from 1980 to 1999 found 3667 articles using the keywords 'women's health', compared to 89 using the keywords 'men's health' while a similar search in 2008 yielded 18,249 references for women's health compared with 442 for men's health (Goodyear-Smith and Birks, 2003; Johnson et al., 2008). Whilst medical studies have often defaulted to using male subjects at the expense of females (Melloni et al., 2010), the lesser volume of literature focused on men's health, suggests there is room for a greater research and policy focus on men's health and the resultant inequalities in mortality by sex.

4.3. Cultural, behavioural and risk factors

Although we have described biological and genetic factors above, of course, they are entangled with socio-political and cultural determinants of health. For example, men take more risks, which seems to be linked to slower development of the frontal lobe (which controls judgement and consequences of actions) for young men compared to young women as well as perceived cultural and social expectations for young men to be bold and take risks (Heitzeg et al., 2018). This is reflected in men's higher rates of accidents such as driving, drinking to excess and in the higher rates of death in suicide attempts. This continues through to late childhood and early adulthood when external causes of death, such as suicide, accidents or violence, are much less common for females (Rigby and Dorling, 2007). Moreover, others have found higher external mortality among males aged 30–39, is important, compared to higher smoking-related and cardiovascular disease mortality among males aged 60–69, suggesting each age group needs a different focus to prevent mortality (Zazueta-Borboa et al., 2023). Additionally, research including Australian and NZ based, has highlighted that risky behaviours cluster in young adulthood, especially for males (Hobbs et al., 2018). Men generally have higher rates of admission to hospital (Cameron et al., 2010; Schlichthorst et al., 2016; Yingying et al., 2013) but are more reluctant to access primary care than women (Galdas et al., 2005; Noone and Stephens, 2008). When men see a doctor, they are less likely to report on the symptoms of disease or illness (Johnson et al., 2008; Marmot et al., 2012). Additionally, there are important cultural and social factors impacting on men's healthcare-seeking behaviour; men may view sickness as a form of weakness as well as hold negative views about men who seek medical help including among health care professionals (Hale et al., 2010). Reasons for this are mixed with the complexity of masculine identity and perhaps concerns of health-seeking as a sign of 'weakness'. Such evidence may explain the complex mix of social and cultural factors leading to differences between sexes in health-seeking behaviours and ultimately in mortality outcomes in the longer term. Broadly, men experience poorer mental health which can link to risk of self-harm, suicide and other mortality from other causes. A further factor is social connection, a key protective factor for mental health which is typically lower for men than for women (Kawachi and Berkman, 2001). Turning specifically to NZ, data from 2018 shows the confirmed death rate for suicide in NZ by sex and age was highest among males aged 45–64 years with a 2018 rate of 26.8 per 100,000 contrasted with a rate of either 3.7 per 100,000 in 2009 or 7.1 in 2018 for females aged over 65 (Bellamy, 2022) both of which are substantially lower.

4.4. Policy implications

There are clear policy implications or future research questions to be addressed given our findings of an enduring mortality disparity above and recent evidence that suggests NZ has not kept pace with international policy promoting men's health (Sagar-Ouriaghli et al., 2019), though previously has demonstrated it can be world-leading, for example in Smokefree legislation (Campbell and Hobbs, 2024). Our findings support previous research and policy which increasingly recognises that the survival disadvantage of men is inequitable and reducing disparity as a legitimate goal for health policy (Sandiford, 2009). Some national policies may have reduced risk-taking behaviour which is typically more prevalent among young men contributing to the convergence of mortality risk between men and women in the 20th century. These policies include penalties for dangerous driving introduced in 1924 and speed limits in 1930s, slower speed limits and seat belt requirements in the 1970's, the requirement for use of cycle helmets in the 1990's (Ministry of Health, 2023) and the increases in driving ages and more strict limits on alcohol use for young drivers in 2011 (Goodyear-Smith and Birks, 2003; Melloni et al., 2010). However, we argue that more serious and targeted interventions to reduce mortality in young men in terms of policy and research are overdue, particularly to reduce risk taking behaviour. This finding is echoed in (Zazueta-Borboa et al., 2023), where intervention focused on improved health behaviours for relatively younger age groups would reduce differences in life expectancy. It could be the case that females have a more rapid uptake of health-promoting actions following policies changes for example. Recognising that men are at risk of markedly increased suicide rates (about 3.5 times female rates, using data for all ages between 2009 and 2013), suggests that a suicide reduction strategy is also likely a key component in reducing inequity between males and females in terms of mortality outcomes (Xiao et al., 2022). Appreciating that there has been little change in help-seeking among men across the past twenty years, there is an urgent need for further research to suggest health services provide men-only health interventions to normalise help-seeking behaviour (Simons et al., 2023). For example, funding a free primary healthcare visit every year from age 18–30 years could support the development of relationships and trust with a provider which supports help-seeking for all types of healthcare (Smith et al., 2006).

4.5. Limitations

A limitation of our analysis is that we have not conducted a specific causes of death analysis, and suggest that future research explores in fine detail the specific causes of death at each age that can be attributed to the sex differentials in mortality examined here. A key limitation is that due to small numbers, we are unable to explore the intersectional factors that contribute to mortality such as age and sex in combination with economic or ethnic-specific inequalities in mortality, which are likely to show even greater variance. For example, Māori specific data were only available until 2008, so we have not used that data here. Also, there are smaller numbers in early childhood, meaning it is difficult to report and make any firm conclusions in the early years of life. Additionally, the data is only available for male and female for all ethnicities combined, so no further analysis can be undertaken beyond this binary categorisation of sex, which may mask even greater inequalities in mortality for nonbinary people (Hughes et al., 2022) and precludes the exploration of mortality inequalities by ethnicity. On balance, there is considerable strength in the comprehensive nature of a national study from 1948 to 2021, with consistent data over time to highlight the origin and evolution of changes over time in sex inequality in mortality.

5. Conclusion

We add to the understanding of sex differentials in mortality by examining the picture in NZ across a more than 70-year span,

demonstrating the longstanding nature and evolution of sex differentials in mortality. The visualisation of relative mortality rates also allows, for the first time, a more specific and detailed understanding of where the divergence, or convergence is occurring across specific age groups, historical periods or cohorts through time. Further, our findings demonstrate consistent sex differentials in mortality from 1948 to 2021 in NZ. Specifically, we show the consistent male disadvantage relative to females; especially for young men aged 18–30 years. Our analysis underlines that this consistent male disadvantage is not static but evolves over time to widen and lessen the relative asymmetry. There are some improvements to the relative mortality differentials for older men through the study period.

In conclusion, we argue that policy and programmes within and beyond the health system should focus on interventions and approaches that address the persistent male disadvantage, linked to both males' greater risk-taking behaviour, to their reduced help-seeking as well as their slower uptake of health-promoting behaviours. Monitoring the inequality between the sexes is important to understand how changes in policy impact longer-term trends in mortality. An urgent research and policy priority is to identify what specific policies could led to a further narrowing or elimination of these inequalities in the shortest timeframe. Research and policy should focus both on reducing deaths among young men, and, on the sex gap at older ages, to reduce sex differentials in mortality. This could be done by targeting early detection of diseases for men, increasing medication adherence, and promoting health education and literacy for all New Zealanders. It could be argued that a suite of policies such as this, could lead to more fulsome adoption of healthy behaviours, reducing sex differentials in mortality.

CRediT authorship contribution statement

M. Campbell: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **M. Hobbs:** Writing – review & editing, Writing – original draft. **K. Mathias:** Writing – review & editing, Writing – original draft. **P. Eggleton:** Writing – review & editing, Writing – original draft.

Ethics statement

Ethics not required.

Fig. A1. Male Age specific mortality rate, 1948–2021.

Fig. A2. Female Age specific mortality rate, 1948–2021.

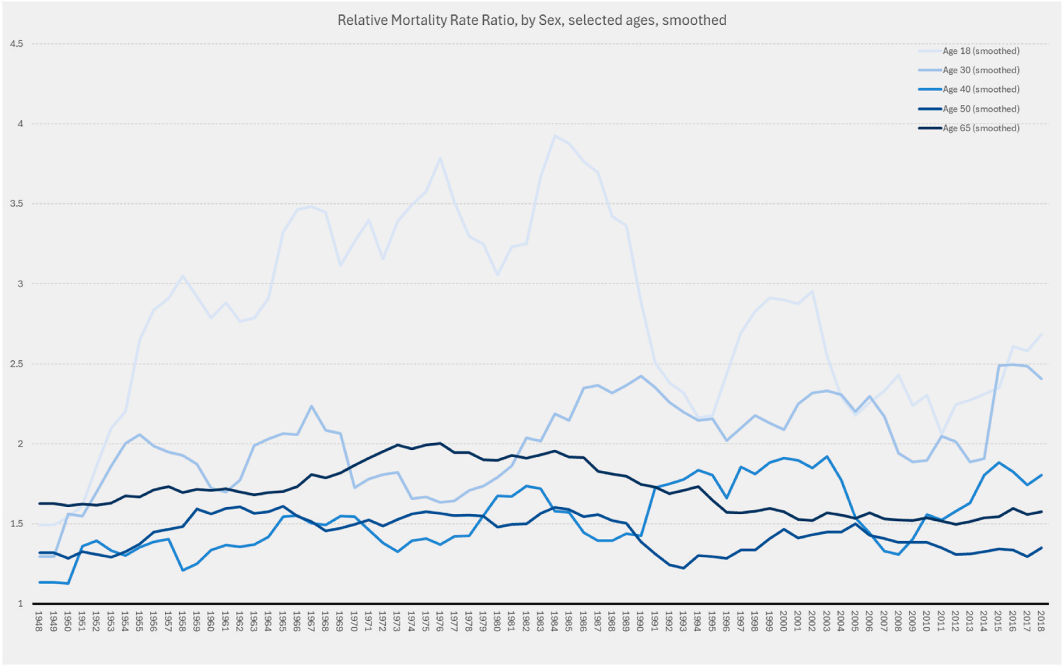

Fig. A3. Relative mortality rate, by sex, selected ages, 1948–2018.

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None.

Declaration of competing interest

None to declare.

Data availability

Data is publicly available.

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