Intersecting gender, racial, and socioeconomic inequalities in multimorbid life expectancy in South Africa: a multistate modelling approach

Anastasia Lam[1,2], Katherine Keenan[1], Mikko Myrskylä[2], Hill Kulu[1]

[1] School of Geography and Sustainable Development, University of St Andrews, UK

[2] Max Planck Institute for Demographic Research, Germany

ABSTRACT

The burden of multimorbidity is expected to increase globally, particularly with ageing populations. The effect of multimorbidity on life expectancy is less clear, as is how it varies by gender, race, and socioeconomic factors, particularly in a middle-income country like South Africa. South Africa's apartheid history adds further complexity to the roles of gender, race, and socioeconomic inequalities in society. This underlines the importance of taking an intersectional perspective when trying to understand the interplay of these factors and how they influence health and mortality. We estimated life expectancy and the time spent living with multimorbidity from age 20 using a discrete-time multistate modelling approach. Women had higher average life expectancy than men (51.0 years vs 48.3 years) but spent more time with multimorbidity. Africans and the lowest educated had the lowest average life expectancy, and Asians/Whites and the most educated had the highest. African men with some secondary school education or less lost more years of life as they accumulated disease compared to any other group. By quantifying the impact of gender, race, and socioeconomic inequalities on time spent with multimorbidity and total life expectancy, our findings highlight the need for interventions and policies to account for these disparities.

INTRODUCTION

Multimorbidity, often defined as the co-occurrence of two or more chronic conditions (Johnston et al., 2019), is associated with poorer health outcomes, decreased quality of life, and increased healthcare utilisation (Academy of Medical Sciences, 2018, Alaba and Chola, 2013). As populations age and the prevalence of non-communicable disease (NCD) risk factors (e.g. obesity, physical inactivity) continue to rise globally, the burden of multimorbidity is expected to increase (Academy of Medical Sciences, 2018). This has implications for individuals and health systems worldwide, but particularly in low- and middle-income countries (LMICs) where the burden of multimorbidity is increasing in settings where about 80% of NCD-related deaths already occur (Hunter and Reddy, 2013). Existing research on multimorbidity has been highly concentrated in high-income countries (HICs), but the literature on multimorbidity in LMICs is expanding, with several studies, reviews, and review protocols recently published (Khorrami et al., 2020, Roomaney et al., 2020, Abebe et al., 2020, Keetile et al., 2020, Hurst et al., 2020, Oladimeji et al., 2020, Chang et al., 2019, Sharman and Bachmann, 2019, Eyowas et al., 2019).

It is important to understand multimorbidity specifically in LMICs because the presentation of multimorbidity and its potential risk factors may differ compared to HICs. One major difference is that many LMICs are undergoing a protracted epidemiological transition, which is the concept that the infectious disease and NCD stages of an epidemiological transition overlap, creating a dual burden of disease and a different pattern of multimorbidity (Frenk et al., 1989, Oni et al., 2015). This dual burden also contributes to the distribution of multimorbidity shifting to a younger age group due to the average age of people with infectious diseases like HIV and tuberculosis being lower compared to those with only NCDs (Afshar et al., 2017, Oni et al., 2014, Oni et al., 2015).

Earlier multimorbidity onset results in people spending more of their life with multimorbidity. A German study identified that multimorbidity occurred earlier in life and there was a faster gain in years with multimorbidity compared to total life expectancy, supporting the idea of an expansion of morbidity (Tetzlaff et al., 2017). Another study projected life expectancy and years lived with multimorbidity at age 65 in England from 2015-2035 (Kingston et al., 2018).

The authors found that as life expectancy increases over time, so do the years spent living with multimorbidity, again supporting the idea of an expansion of morbidity. To our knowledge, this notion has yet to be quantified in an LMIC, but we expect the morbidity expansion idea will hold based on the protracted epidemiological transition state that most LMICs are in.

South Africa is a prime example of a country undergoing a protracted epidemiological transition, with established NCD and infectious disease co-existence (Godongwana et al., 2021, Modjadji, 2021, Oni et al., 2015, Peltzer, 2018, Sharman and Bachmann, 2019, Wong et al., 2021). Although longitudinal evidence on multimorbidity in South Africa is lacking, cross-sectional prevalence estimates vary widely, from 2.7%-70% (Alaba and Chola, 2013, Chang et al., 2019, Oni et al., 2015, Weimann et al., 2016). Life expectancy in South Africa has made great strides in recent years, much of which can be attributed to substantial uptake of antiretroviral therapy, but living longer also increases susceptibility to developing NCDs (Oni et al., 2014, Oni et al., 2015). Further, South Africa's Apartheid legacy has resulted in persistent inequalities across gender, race, and socioeconomic strata (Chopra and Sanders, 2004). The intersection of these factors is likely to result in a disparate spread of multimorbidity, life expectancy, and cumulative disadvantage across these groups.

This study aims to understand the extent to which gender, race, and socioeconomic status (SES) may impact life expectancy and the time spent living with multimorbidity in South Africa. To illustrate this, we first provide an overview of the literature in terms of gender, race, and educational attainment, their impact on multimorbidity, and their role in the South African context. We present results using an intersectionality framework and use the idea of cumulative disadvantage to conceptualise the interactions.

BACKGROUND

Gender

It is well-established that gender differences exist within health and mortality, with males tending to have shorter, but healthier lives compared to females. This phenomenon is known as the morbidity-mortality paradox or the male-female health-survival paradox. Males are generally more susceptible to fatal diseases earlier in life, whereas females have more nonfatal

diseases later in life (Rieker and Bird, 2005). Females are also more likely to have multimorbidity than males (Abebe et al., 2020, Garin et al., 2016, Xu et al., 2017). This may be due to females being more likely to seek care and thus be diagnosed with disease but could also be attributable to physiological factors such as obesity or hormonal differences (Afshar et al., 2017, Weimann et al., 2016). There are also social, cultural, and environmental factors that impact the health and mortality of males and females, such as males being more likely to partake in risky behaviours (Oksuzyan et al., 2010, Mateos et al., 2020).

In southern Africa, females face a triple burden of duties – reproductive, household, and community – which has influenced their rates of fertility, mortality, and literacy. When this is combined with the HIV epidemic, which disproportionately affected Black African females (Mabaso et al., 2019), it resulted in female life expectancy declining at a greater rate than male life expectancy from 1980-2008 (Jusrut and Kalipeni, 2010). With improvements in maternal health and education, there is now a growing divergence in the gender gap, with greater increases in female life expectancy relative to male life expectancy (Medalia and Chang, 2011). However, as LMICs move towards more gender equality, then the trend may become more similar to that in many high-income countries, where the gender gap has been gradually narrowing (Oksuzyan et al., 2010, Medalia and Chang, 2011).

Race

Race is a complex, socially constructed concept which can have differential effects on health and mortality, but this will vary widely depending on cultural, political, and country-specific factors. For example, in the United States, racial and ethnic minorities consistently have poorer health and higher rates of mortality compared to their White counterparts (National Academies of Sciences, 2017). In South Africa, the systemic racial discrimination during apartheid had a detrimental impact on how different racial groups were treated. Racial classification provided the basis for the function of society during apartheid, with individuals being declared as either “White”, “Asian”, “Coloured”, or “Native” (Posel, 2001b). Being “coloured” indicated that someone was of mixed-race and “native” was the label for Black Africans. Based on this racial classification, apartheid policies to improve health and economy during most of the 20th

century focused on the White population, leaving the rest of the country to deal with inferior healthcare and deteriorating living conditions (Benatar, 2013). Although there have been improvements since 1994 when apartheid ended, disparities remain entrenched and widespread. These racial categorisations are also ingrained in South African society, with the younger generations who did not directly experience apartheid still self-identifying in one of these four groups. Thus, these four racial groups are what will be used throughout the paper when we talk about race. We also acknowledge and race and ethnicity are separate concepts, and that South Africa is home to a variety of ethnic groups, but for the purposes of this paper we will refer only to race.

Most of what we know about the relationship between race and multimorbidity comes from high-income countries. In the United States, Blacks and Hispanics consistently have a higher risk of multimorbidity compared to their White counterparts (Gebregziabher et al., 2018, Johnson-Lawrence et al., 2017, Quiñones et al., 2019, Quiñones et al., 2021, Rocca et al., 2014). In the Netherlands, ethnic minorities had higher prevalence of multimorbidity compared to Dutch participants (Verest et al., 2019). There is a lack of evidence on racial differences in multimorbidity in South Africa. One study showed that Asian/Indian participants had over two times the prevalence of cardiometabolic multimorbidity compared to African and Coloured participants (Sewpaul et al., 2021). Another study revealed that Coloured and Asian/Indian participants had the highest odds of multimorbidity, but the direct association between multimorbidity and race is difficult to disentangle due to the inextricable link between race and socioeconomic status (SES) under apartheid (Weimann et al., 2016).

Socioeconomic status

SES is often represented by one's education, occupation, and/or income. SES and health tend to have a positive association, with higher SES being associated with better health and lower mortality. This intuitively makes sense as individuals with higher SES likely have better access to health facilities, treatment, and other resources. This relationship is also seen between education and multimorbidity, with higher education generally being associated with a decreased risk of multimorbidity (Pathirana and Jackson, 2018, Afshar et al., 2015, Arokiasamy

et al., 2015). However, the relationship may vary by country and SES indicator. For example, studies from South Africa and China have shown that higher SES is associated with multimorbidity, but the reverse relationship was seen in Ghana (Ataguba, 2013, Kunna et al., 2017). During the time of the studies, South Africa and China were considered upper middle-income and lower middle-income countries, respectively, while Ghana was low-income (World Bank, 2020). The way that SES is associated with health, including with multimorbidity, is likely related to a country's level of economic development. This in turn impacts the availability of and access to healthcare services and influences changes in lifestyles and behaviours (Kunna et al., 2017). In this paper, we will be using an individual's highest level of education as a measure of their SES.

Intersectionality

The aforementioned factors of gender, race, and SES do not act independently upon individuals. They are, in combination with other characteristics such as age, sexuality, and disability, social stratifiers that interact and are shaped by political, religious, cultural, and other social power structures (Hankivsky, 2014). This is the idea of intersectionality. Intersectionality was first coined by Kimberle Crenshaw when she wrote about how being Black and being a woman was a unique experience more complex than that of just being Black or just being a woman (Crenshaw, 1989). Rather than being an additive approach, it describes the multidimensional interaction of various innate and acquired characteristics that shape human experiences (Hankivsky, 2012, Bauer, 2014). Whilst it has mainly been applied in the United States as a way to explain the complexity of gender, race, and class through a feminist lens, it is gaining traction as a framework to understand health disparities and the stigma associated with certain health conditions (Bauer, 2014, Bowleg, 2012, Bowleg, 2021, Jackson-Best and Edwards, 2018, Turan et al., 2019). Qualitative methods have been the primary route for intersectional research because of their ability to elicit a more nuanced interpretation of the impact of individual characteristics, but the use of intersectionality in quantitative analysis is growing (Bauer, 2014, Harari and Lee, 2021, Bowleg, 2012, Bowleg, 2021).

It is logical to use an intersectionality framework in the South African context because of South Africa's legacy of systemic social constructs, especially that between race and class. Race and class became intricately intertwined during apartheid, with Black Africans put into the lowest class and Whites at the top. Intersectionality has been used as a theory to understand race-class interactions (Whitehead, 2013), as well as that of race, class, and gender (Gouws, 2017, Groenmeyer, 2011, Moolman, 2013). There is also the concept of intersectional stigma which has been used both in the United States and in South Africa, commonly as a way to understand the intersecting stigmas associated with HIV, but also with mental illness, physical disability, and incarceration (Abubakari et al., 2021, Jackson-Best and Edwards, 2018, Sangaramoorthy et al., 2017, Woznica et al., 2021).

Cumulative disadvantage

Similar to intersectionality, cumulative disadvantage (or cumulative advantage) describes how individuals' lives are structured by the different risk and protective factors that surround them. However, unlike intersectionality, the main tenant of cumulative disadvantage is the accumulation of these factors over time, resulting in some groups being more disadvantaged (e.g. less educated Black women) and others being more advantaged (e.g. highly educated White men) based on what they have been exposed to throughout life (Pais, 2014, Shuey and Willson, 2008). Over time, this disadvantage (or advantage) tends to grow, resulting in greater inequalities between the advantaged and disadvantaged groups (Dannefer, 2020, Diprete and Eirich, 2006, Seabrook and Avison, 2012, Willson et al., 2007). The original term, cumulative advantage, was derived as a way to describe the accumulation of rewards and advantages for scientists who were successful early in their careers (Merton, 1968, Merton, 1988), and is normally used to discuss achievements. The opposing term, cumulative disadvantage, is more often used when explaining inequalities, especially those of race and health, because the focus of this research tends to be on disadvantaged groups (Diprete and Eirich, 2006). Thus, in this paper we will use the term cumulative disadvantage.

Within our framework of intersectionality, cumulative disadvantage can act as a tool to predict how the intersection of gender, race, and SES can impact multimorbidity and life

expectancy. We use cumulative disadvantage as a concept to describe the synergy between our risk factors: gender, race, and education. This means that the interactions between any disadvantages are greater than the sum of the individual parts, and the same goes for interactions between any advantages. This allows us to hypothesise what the cumulative effects of gender, race, and SES may be. For example, we hypothesise that based on what we know about these risk factors in South Africa, African women with low SES should spend the most time living with multimorbidity while White women with high SES should spend the least.

Like intersectionality, most cumulative disadvantage literature is centred around the United States, with a focus on racial and socioeconomic disparities, particularly across the life course (Dannefer, 2020, Leventhal et al., 2019, Pais, 2014, Seabrook and Avison, 2012, Shuey and Willson, 2008, Willson et al., 2007). To our knowledge, there seems to be no evidence on cumulative disadvantage in South Africa. However, there is potential that research in this area has been done but with the use of different terminology.

Summary

Existing evidence presented above indicates that gender, race, and SES have varying and synergistic effects on multimorbidity and life expectancy. Due to this, we first expect to find that females have higher life expectancy but spend more of their life with multimorbidity. Second, we anticipate that Africans will have the lowest life expectancy and Whites the highest. Third, we expect that there will be a socioeconomic gradient, with higher education being associated with greater life expectancy, but also more time spent living with multimorbidity. Lastly, we foresee that the effect of race will persist regardless of education level, though the gap in life expectancy may narrow with increasing education.

METHODS

Data

Data are from the South African National Income Dynamics Study (NIDS), a nationally representative household panel survey with five waves of data collection from 2008-2017 (Southern Africa Labour and Development Research Unit, 2018a, Southern Africa Labour and

Development Research Unit, 2018b, Southern Africa Labour and Development Research Unit, 2018c, Southern Africa Labour and Development Research Unit, 2018d, Southern Africa Labour and Development Research Unit, 2018e). The baseline sample was collected using a two-stage clustered sampling design and consisted of over 28,000 individuals from more than 7,300 households (Brophy et al., 2018). There were three types of questionnaires: adult, proxy, and household. The questionnaires collected a variety of data, such as self-reported economic, health and well-being, sociodemographic, and household information. The adult questionnaire was the only one that provided detailed health information, since participants were able to take the CES-D-10 to assess depression and have their blood pressure measured. Death was measured through household reports of deaths that occurred in that household within the past 24 months.

Merging data from all five waves resulted in a total sample of N=28,759 participants. We excluded anyone who was only present at one wave and subsequently lost to follow-up (n=8963), anyone with only proxy questionnaires (n=626), anyone younger than age 20 (n=1077), anyone missing at least one wave just prior to their death (n=295), and anyone missing education (n=95). This resulted in a final analytic sample of n=17,776 participants. Each participant had anywhere from one to four transitions between disease states, depending on the number of waves in which they were present, resulting in n=73,876 transitions.

Variables

Multimorbidity was defined as having two or more of the following diseases: Alzheimer's Disease, arthritis, asthma, cancer, depression, diabetes, emphysema, epilepsy, heart problems, HIV, hypertension, kidney problems, and stroke. 'One disease' was defined as having only one of any of the aforementioned diseases throughout follow-up. 'No disease' means having none of the above diseases, which does not necessarily mean being completely disease free. Most diseases were indicated as present if the participant reported ever being told by a doctor, nurse, or healthcare professional that they had the disease. Systolic and diastolic blood pressure were measured twice at each wave and the average of the two measurements were used to indicate whether hypertension was present. The cut-offs for

hypertension were having a systolic blood pressure ≥ 140mmHg and a diastolic blood pressure ≥ 90mmHg, with the difference between the two being ≥ 15mmHg (Cois and Ehrlich, 2018, Unger et al., 2020). A score ≥ 12 on the CES-D-10 indicated depression (Baron et al., 2017).

Age was included as a categorical variable of 5-year age intervals, from age 20 to 85+. Geography was defined as either being urban or rural, with urban indicating any built-up areas and rural indicating both villages under jurisdiction of traditional leaders and farms (Brophy et al., 2018). Participants were asked to identify as being part of one of the following racial groups: African, Asian/Indian, Coloured, or White. Here 'African' is used to describe those of the native Black African group, and 'Coloured' is a uniquely southern African term used to describe someone of mixed race ancestry (Adhikari, 2009), as used in both the NIDS survey and South Africa's census. Due to small sample size in both the Asian/Indian and White groups, we combined those two groups to form the Asian/White category. Education was measured as the highest level of completed education at the baseline visit and split into three categories: some secondary school or less (up to grade 9), completed secondary school (grade 12), and post-secondary school including vocational training.

Statistical analysis

We obtained descriptive statistics of our analytic sample and computed the prevalence of each of the included diseases to identify the most common diseases and multimorbid disease combinations. We then used multinomial logit models to predict the probability of transitioning between different disease states (no disease, one disease, and two or more diseases (multimorbidity) and death. Individuals can begin in any of these three disease states and either remain in the same state, transition to a subsequent state, or die (Figure 1). We did not allow for reverse transitions, in which individuals might become cured of a disease. Death is an absorbing state, meaning that once someone enters that state they cannot leave. All other states are considered transient.

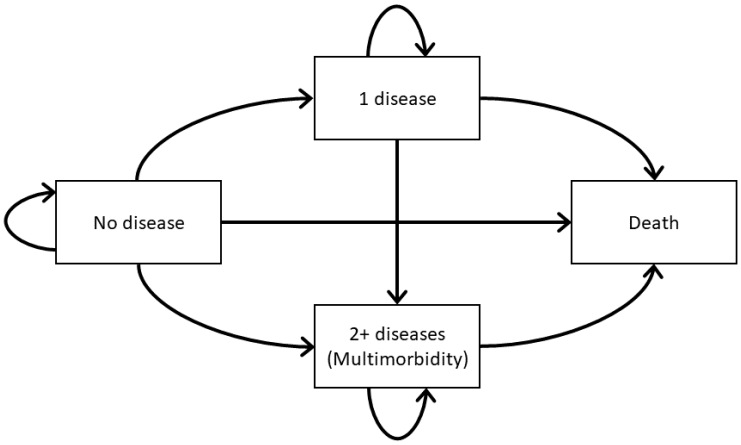


Figure 1. State space of the Markov model

All models were adjusted for age and geography, stratified by gender, and weighted using NIDS design weights which correct for nonresponse. Details of how the weights were calculated can be found elsewhere (Brophy et al., 2018). We then ran additional models stratified by race, education, and the interaction between the two. Confidence intervals were obtained using a bootstrap approach with 1000 iterations. The models take the general form:

$$log\left(\frac{p_{ij}}{p_{iN}}\right) = \alpha_{ij} + \beta_{1,ij}Age + \beta_{2,ij}Geo + \mu_{ij}Cov$$

Where p_{ij} is the probability of transitioning from state *i* to state *j*; *j = N* indicates the reference target state of no disease; α_{ij} is the intercept; *Age* is the individual's age at each interview categorised into 5-year age groups; *Geo* indicates whether an individual lived in an urban or rural area; μ_{ij} is the coefficient for *Cov,* which includes the covariates race, education, and their interaction.

The transition probabilities obtained from these models were input into discrete-time multistate Markov models. These models require evenly spaced time intervals between measurements (Craig and Sendi, 2002, Dudel and Myrskylä, 2020), which in our case was two years. They also take a Markov assumption, meaning that the expectancy estimates are calculated based on the current state and covariate profile of an individual, regardless of their status or duration spent in any prior state (Kemeny and Snell, 1983). They are analysed using a matrix notation, with transition probabilities organised into matrices P = [p_{ij}] for each stratum of race and education, separately for males and females. This resulted in a transition matrix

$$P = \begin{pmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ p_{31} & p_{32} & p_{33} & p_{34} \end{pmatrix}$$

where p_{11} represents the probability of remaining in the first state (no disease), p_{12} the probability of transitioning from no disease to one disease, p_{13} the probability of transitioning from no disease to multimorbidity, p_{14} the probability of transition from no disease to death, and so on.

These transition matrices were used to compute the time spent in each transient state through the fundamental matrix

$$N = (I_n - U)^{-1}$$

where U is a transient-state-only transition matrix; I_n is an $n \times n$ identity matrix; and superscript -1 denotes the inverse. The row sums of N indicate the life expectancy given initial state i. The expected time in target state *j,* given an initial state *i,* is represented by N_{ij}.

Our multistate approach also required the distribution of participants in each state at the starting age, which in our case was the age category 20-24. We obtained these distributions separately for males and females. Since we used five-year age categories, our expectancy outputs were multiplied by five to obtain estimates in years from age 20.

We also performed sensitivity analyses for different definitions of multimorbidity, and for state and life expectancies from age 40. There is debate about whether hypertension is considered a chronic disease or a risk factor for disease, and whether depression is considered chronic based on the way it was measured in this survey. Thus, we estimated state and life expectancies excluding hypertension and/or depression from our multimorbidity definition and instead adjusted for the respective variables in the models. We estimated life expectancy at age 40 because we were interested in whether the patterns of time with multimorbidity and life expectancy would change given an older initial age since multimorbidity is more prevalent in older ages. Analyses were conducted in R version 4.0.3 (R Core Team, 2020) and state and life expectancy estimates were obtained using the *mcwr* package (Schneider et al., 2021).

RESULTS

Table 1 details the sociodemographic characteristics of our sample. The average age was 41.7 years (SD 16.2), with males being younger than females. The majority of the sample (59.9%) was female. Most participants were African (79.7%), followed by Coloured (14.9%), and Asian/White (5.4%). Over half the participants had some secondary school education or less while 34.3% finished secondary school and 12.2% had post-secondary education. More males than females entered the study without any of the included diseases (68.4% vs. 55.7%) whereas more females entered with one disease (29.8% vs. 24.6%) or multimorbidity (14.6% vs. 7.0%). Figure 2 shows the most common diseases, which were by far depression (females: 48.3%, males: 38.5%) and hypertension (females: 46.2%, males: 33.1%). The five most common multimorbid disease combinations were depression/hypertension (19.5%), diabetes/hypertension (7.90%), depression/diabetes/hypertension (4.49%), heart problems/hypertension (2.88%), and diabetes/hypertension/depression (2.83%). Of the 2051 people who had multimorbidity at baseline, 166 (8.09%) had HIV as one of their morbidities. Of these people with HIV multimorbidity, 163 (98.2%) were African and three were Coloured.

Table 1. Baseline sociodemographic characteristics of the analytic sample, by gender and overall

	Male (n=7129)	**Female** (n=10,647)	**Overall** (n=17,776)
Age (years)			
Mean (SD)	40.5 (15.6)	42.5 (16.5)	41.7 (16.2)
Race			
African	5537 (77.7%)	8628 (81.0%)	14,165 (79.7%)
Coloured	1152 (16.2%)	1493 (14.0%)	2645 (14.9%)
Asian/White	440 (6.2%)	526 (4.9%)	966 (5.4%)
Education level			
Some secondary school or less	3661 (51.3%)	5843 (54.9%)	9503 (53.5%)
Completed secondary school	2547 (35.7%)	3552 (33.4%)	6099 (34.3%)
Post-secondary school	921 (12.9%)	1252 (11.8%)	2173 (12.2%)
Initial 'from' state			
0 disease	4874 (68.4%)	5926 (55.7%)	10,800 (60.8%)
1 disease	1754 (24.6%)	3171 (29.8%)	4925 (27.7%)
Multimorbidity	501 (7.0%)	1550 (14.6%)	2051 (11.5%)

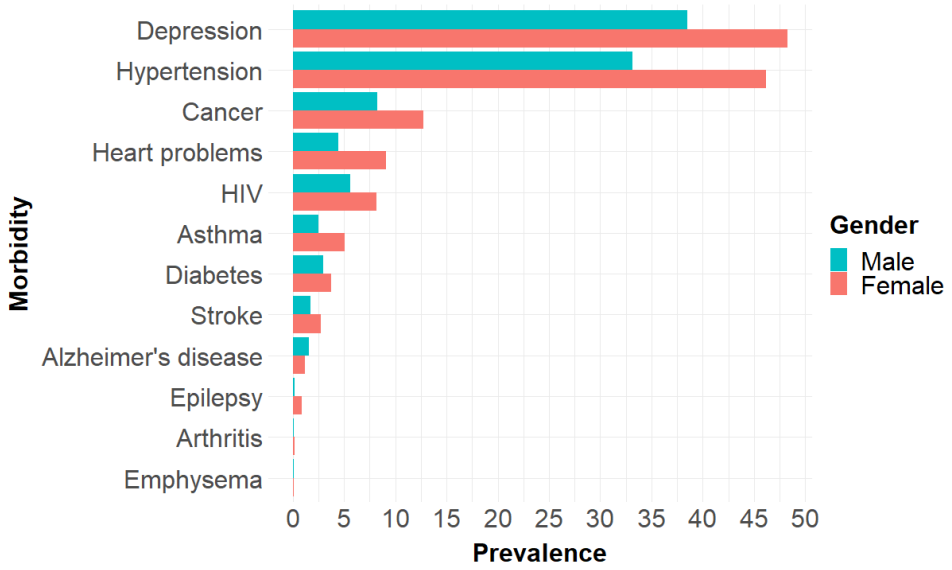


Figure 2. Baseline prevalence of each disease included in our definition of multimorbidity, by gender

Transitions and transition probabilities

Table 2 shows that the majority of people remained in the state they were in when they entered the study (82-95%). The most common transition was from one disease to multimorbidity. Males were more likely to remain with no or one disease and die from all states, while females were more likely to remain with multimorbidity and transition between states. When looking at the breakdown of transitions by 10-year age group, we can see that there is an accumulation of disease with increasing age. From ages 20-49, most of the transitions that take place are to remain with no disease, with a gradual shift to remaining with one disease. From age 50 onwards, the majority of people remain with multimorbidity. There is also an increased percentage of death with age, and from the multimorbid state. We did not find any major differences between males and females when comparing the probability of transitioning between states.

State and life expectancy estimates

Conditional on surviving to age 20, males and females are expected to live on average to age 68.3 (95% CI 67.6-69.1) and 71.0 (95% CI 70.5-71.6), respectively. Females who have no or one disease at age 20 are expected to live 3-4 years longer than men with no or one disease, and

Table 2. Percentage of males and females transitioning between 'From' and 'To' states, by 10-year age group

		Males				Females			
		To state				To state			
Age	**From state**	**0 Disease**	**1 disease**	**Multimorbid**	**Dead**	**0 Disease**	**1 disease**	**Multimorbid**	**Dead**
20-29	0 Disease	25.12%	2.19%	0.08%	0.32%	25.72%	2.64%	0.20%	0.26%
	1 Disease	-	13.67%	0.53%	0.27%	-	12.18%	0.98%	0.20%
	Multimorbid	-	-	3.28%	0.14%	-	-	3.07%	0.14%
30-39	0 Disease	26.13%	3.16%	0.38%	0.54%	25.56%	3.95%	0.55%	0.45%
	1 Disease	-	22.03%	2.15%	0.71%	-	19.99%	2.52%	0.27%
	Multimorbid	-	-	10.72%	0.62%	-	-	10.04%	0.36%
40-49	0 Disease	16.55%	2.45%	0.50%	0.37%	16.13%	3.26%	0.58%	0.26%
	1 Disease	-	16.22%	2.55%	0.49%	-	17.15%	3.57%	0.29%
	Multimorbid	-	-	16.10%	0.88%	-	-	17.32%	0.60%
50-59	0 Disease	9.33%	1.95%	0.41%	0.35%	7.92%	2.11%	0.56%	0.15%
	1 Disease	-	15.45%	3.05%	0.60%	-	15.29%	3.70%	0.44%
	Multimorbid	-	-	24.84%	2.18%	-	-	24.78%	0.83%
60-69	0 Disease	4.64%	1.18%	0.24%	0.27%	3.63%	1.08%	0.33%	0.12%
	1 Disease	-	10.20%	2.37%	1.01%	-	9.28%	2.59%	0.44%
	Multimorbid	-	-	20.00%	2.57%	-	-	20.83%	1.39%
70-80	0 Disease	2.02%	0.44%	0.12%	0.22%	2.08%	0.59%	0.21%	0.10%
	1 Disease	-	4.37%	1.32%	0.78%	-	5.51%	1.68%	0.41%
	Multimorbid	-	-	11.40%	2.12%	-	-	12.19%	1.19%
85+	0 Disease	0.61%	0.19%	0.05%	0.19%	0.96%	0.34%	0.13%	0.13%
	1 Disease	-	1.42%	0.40%	0.41%	-	2.21%	0.84%	0.45%
	Multimorbid	-	-	3.62%	1.53%	-	-	6.02%	1.24%
Total	**0 Disease**	**84.76%**	**11.30%**	**1.74%**	**2.20%**	**82.50%**	**13.58%**	**2.48%**	**1.43%**
	1 Disease	**-**	**83.71%**	**12.11%**	**4.18%**	**-**	**81.97%**	**15.57%**	**2.46%**
	Multimorbid	**-**	**-**	**90.04%**	**9.96%**	**-**	**-**	**94.33%**	**5.67%**

females with multimorbidity at age 20 are expected to live 7.7 years longer than similar males (Figure 3). Life expectancy decreases with more disease, particularly for males with multimorbidity, who lose 12.3 years compared to those with no disease. Males also spend longer in states of no or one disease compared to females, while females spend longer living with multimorbidity.

African men and women had the lowest average life expectancy across all racial groups (47.7 years, 95% CI 46.9-48.6 and 50.8 years, 95% CI 50.2-51.3, respectively) while Asian/White men and women had the highest (52.3 years, 95% CI 50.1-54.2 and 53.3 years, 95% CI 51.1,55.3, respectively) (Figure 4). We did not find any major differences in the proportions of time spent in each state. Across education levels, there was a gradient of increasing life expectancy with increasing education for both men and women. Women consistently spent more time living with multimorbidity than men. Time with multimorbidity also tended to decrease with increasing education, but confidence intervals overlapped.

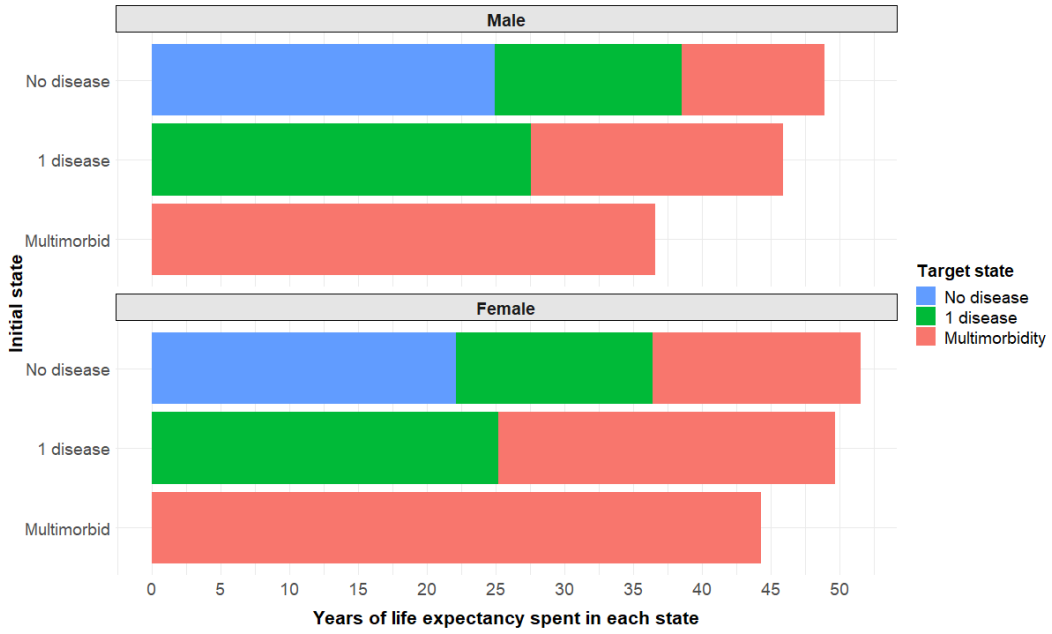


Figure 3. Years of life expectancy spent in each target state, for males and females from different initial disease states at age 20. Length of bar represents total life expectancy.

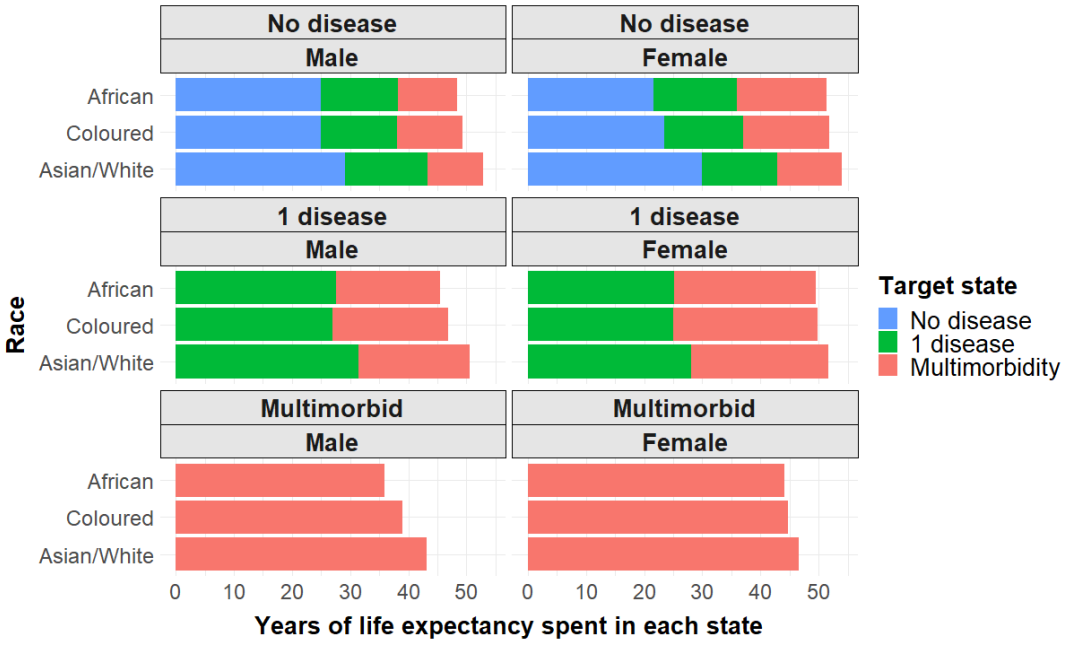


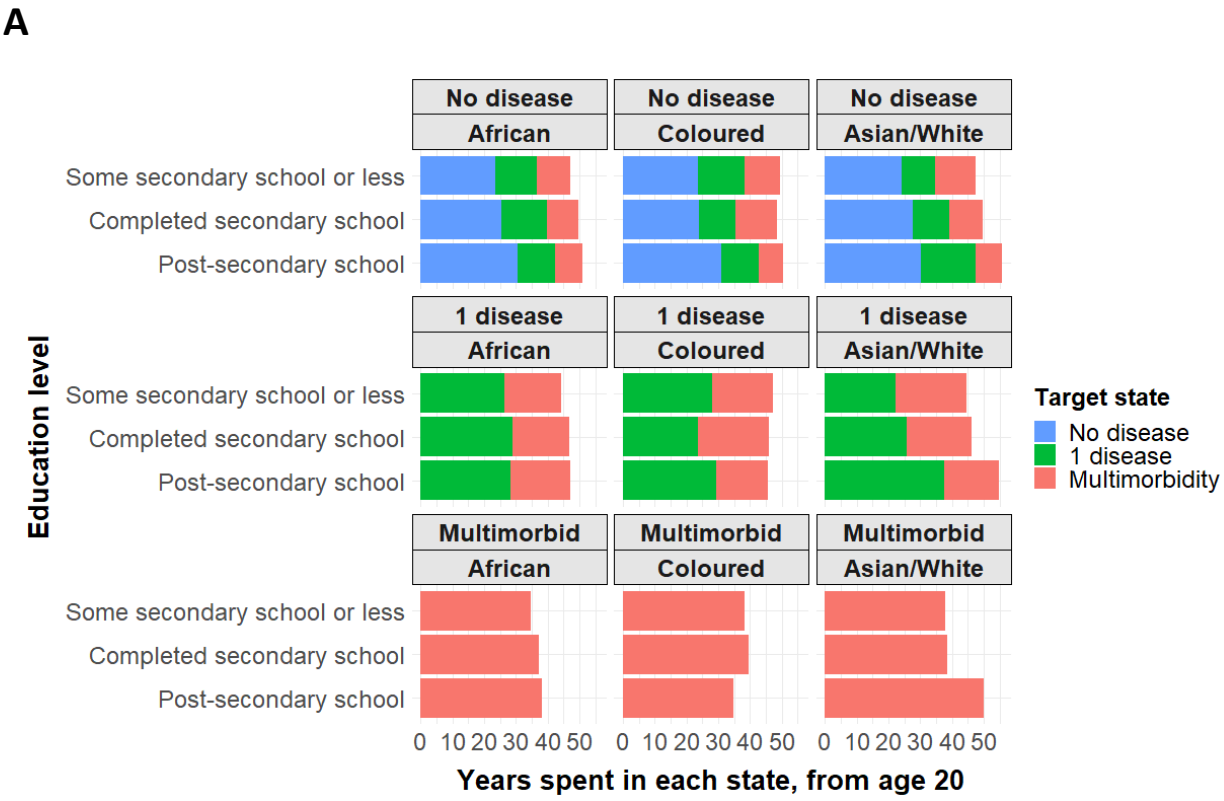
Figure 4. Years of life expectancy spent in each target state, by race and gender, from different initial disease states at age 20. Height of bar represents total life expectancy.

Figure 5 shows state and life expectancies from an initial disease state at age 20 for males (Figure 5A) and females (Figure 5B) by race and education. There are education gradients seen for African and Asian/White men and women, and Coloured women, showing that generally both state and life expectancies increase with more education. We do not notice major differences in the time spent living with multimorbidity, but it is clear that the time spent living with no disease increases as education increases. We also observe that the benefits of education vary by gender and race, thus providing evidence for intersectionality and cumulative disadvantage.

The lowest educated African men are disadvantaged (i.e. they lose more from having a low education) compared to both Coloured and Asian/White men. They lose 12.7 years of life with multimorbidity compared to with no disease, while the lowest educated Coloured and Asian/White men lose 11.1 years and 9.5 years, respectively (Table 3). Amongst the highest educated men, Africans and Coloured are disadvantaged to an even greater degree compared to Asian/Whites who only lose 5.8 years of life compared to 12.8 for Africans and 15.7 for Coloureds. For women, a similar pattern is seen, but with less drastic inequalities.

Sensitivity analyses

Sensitivity analyses showed that excluding hypertension, depression, and both hypertension and depression from the definition of multimorbidity decreased the total life expectancy for people from an initial multimorbid state across all gender, race, and education groups. The greatest decrease was seen for the exclusion of both hypertension and depression. This is likely due to hypertension and depression being generally non-fatal diseases that could be long-lasting and well-managed, resulting in people living longer with multimorbidity that includes these conditions. For our sensitivity analysis increasing the initial age to 40 years, we found that hypertension became the most common disease, but the patterns seen generally stayed the same, indicating that multimorbidity is an important issue for people under age 40 in South Africa.



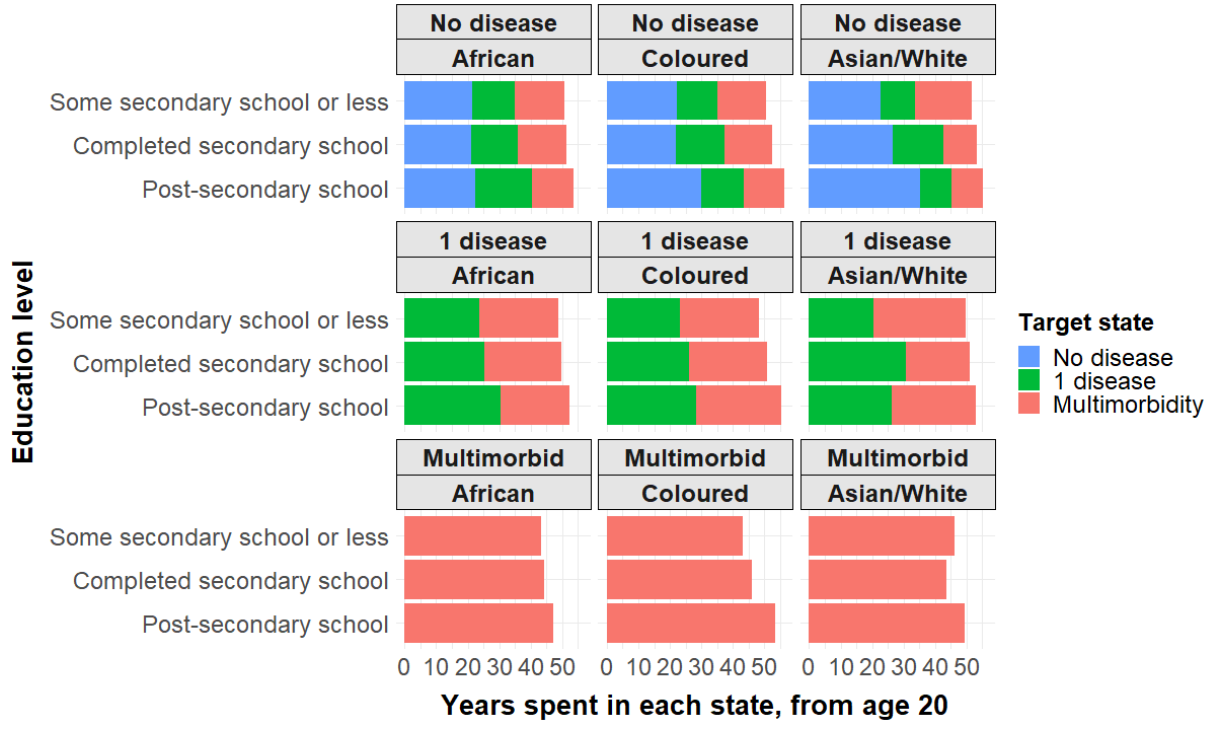


Figure 5. State and life expectancies at age 20 for males (A) and females (B) by initial disease state, race, and education.

Table 3. Total life expectancy estimates and 95% confidence intervals for males and females from initial disease state at age 20, by race and education

		Racial group		
MALES	**Initial disease state**	**African**	**Coloured**	**Asian/White**
Some secondary school or less	No disease	47.28	49.5	47.34
		(46.2, 48.19)	(46.96, 51.62)	(42.66, 52.86)
	1 disease	44.39	47.16	44.45
		(42.78, 45.79)	(43.68, 50.1)	(37.57, 51.65)
	Multimorbidity	34.63	38.36	37.97
		(30.4, 37.78)	(31.2, 44.52)	(25.73, 49.32)
Completed secondary school	No disease	49.63	48.65	49.76
		(47.97, 51.05)	(44.72, 52.92)	(45.53, 53.66)
	1 disease	46.82	46.14	46.3
		(44.63, 48.75)	(40.64, 51.69)	(40.77, 51.24)
	Multimorbidity	37.1	39.71	38.47
		(32.61, 41.1)	(29.39, 48.87)	(29.97, 46.61)
Post-secondary school	No disease	51.04	50.4	55.82
		(48.14, 53.37)	(43.55, 57.07)	(54.2, 56.84)
	1 disease	47.12	45.81	54.79
		(43.21, 50.7)	(35.77, 56.67)	(52.23, 56.46)
	Multimorbidity	38.26	34.77	50.08
		(31.11, 44.57)	(17.92, 55.72)	(42.21, 54.59)
FEMALES				
Some secondary school or less	No disease	50.74	50.57	51.54
		(49.92, 51.45)	(48.17, 52.61)	(44.74, 56.12)
	1 disease	48.77	48.38	49.69
		(47.68, 49.77)	(45.64, 50.98)	(39.93, 55.75)
	Multimorbidity	43.47	43.05	46.21
		(41, 45.49)	(38.55, 47.14)	(33.28, 54.66)
Completed secondary school	No disease	51.53	52.54	53.27
		(50.32, 52.66)	(49.12, 56.04)	(50.2, 55.67)
	1 disease	49.81	50.95	50.93
		(48.24, 51.28)	(46.34, 55.6)	(46.55, 54.3)
	Multimorbidity	44.41	46	43.76
		(41.48, 47.06)	(37.21, 54.03)	(35.36, 50.47)
Post-secondary school	No disease	53.8	56.28	55.35
		(51.52, 55.46)	(54.76, 57.5)	(52.4, 57.31)
	1 disease	52.47	55.42	52.93
		(49.6, 54.75)	(52.51, 57.5)	(46.85, 57.06)
	Multimorbidity	47.2	53.56	49.52
		(41.8, 51.55)	(44.86, 57.5)	(39.24, 56.74)

DISCUSSION

In this paper, we examined the impact of gender, race, and SES as independent and intersecting factors on total life expectancy and time spent with multimorbidity in South Africa. We used an intersectionality framework to understand how these factors might interact and impact health

and mortality under the lens of cumulative disadvantage. We found that gender, race, and SES all had differential effects on total life expectancy and time spent with multimorbidity. Women lived longer than men but spent more of their lives with multimorbidity. Africans and Coloureds had lower total life expectancy and had greater differences in life expectancy as they accumulated disease compared to Asian/Whites. Life expectancy increased with increasing SES, while time with multimorbidity tended to decrease. Interacting race and SES further amplified these effects, highlighting the differences in the role of SES across different gender and race combinations. Within the lowest SES, African and Coloured men and women were disadvantaged compared to Asian/White men and women, but the inequalities for men were much greater.

The inequalities we observe across gender, race, and SES are the product of myriad systemic differences. One substantial influence in this is apartheid, which constructed deeply rooted social divisions that have consequently had an effect on health and mortality through, for example, the changing of policies, the location and quality of health and social services, and the geographic distribution of households and schools. These factors further amplify the innate biological and behavioural factors which differentiate health and mortality outcomes for men and women. Apartheid was in place from 1948-1994 (Chopra and Sanders, 2004), meaning that much of our study sample spent most of their lives living under apartheid, with some being old enough to experience pre- and post-apartheid society. This likely has differential effects on the life course and lived experiences of individuals, as living situations and available resources differed for people of working age during apartheid versus those of working age after apartheid ended, especially by race and SES.

The accumulation of different experiences across the life course is what results in either cumulative advantage (for Whites) or cumulative disadvantage (for Africans and Coloureds). The discriminatory policies put in place during apartheid against Blacks (i.e. anyone who was not White) were contrasted by beneficial policies for Whites, such as access to jobs, land ownership, and schooling (Posel, 2001a, Posel, 2001b). This led to non-Whites having poorer access to healthcare, worse living conditions, and less opportunities, resulting in poorer health outcomes and higher rates of mortality. This is supported by our findings which show that

Africans and Coloureds tended to be lower educated and consistently had lower life expectancy compared to Asian/Whites.

Soon after apartheid ended, the HIV epidemic began. HIV/AIDS disproportionately affected the impoverished and disadvantaged, so the Black community has faced this double burden of apartheid and HIV/AIDS (Mabaso et al., 2019). HIV/AIDS also had a substantial impact on life expectancy, and potentially acts as a gateway disease for multimorbidity (Kim et al., 2012, Oni et al., 2014, Oni et al., 2015, Wade et al., 2021). The population with HIV tends to be younger and antiretroviral therapy allows HIV to become a chronic disease, so as soon as they are diagnosed with another disease, they have multimorbidity. This was a main reason for why we included participants starting from age 20 in our sample even though multimorbidity usually presents in adults aged 40 years or older. HIV also disproportionately affects women which could contribute to why women spend more time with multimorbidity (Mabaso et al., 2019, Teeraananchai et al., 2017). Although this pattern is also seen in low HIV prevalence settings, the women in our study could have a different constellation of multimorbid diseases compared to women in other countries but investigating this was outside the scope of this paper.

Our female life expectancy estimate at age 20 was comparable to that provided by the WHO (71.0 vs 71.2, respectively), but our estimate for male life expectancy was higher compared to the WHO's estimate (68.3 vs 65.3, respectively) (World Health Organization, 2020). There are a couple potential reasons for this. First, men might be underrepresented in our data. Second, there is likely some survival bias. Since men tend to have higher mortality rates at younger ages, then the men who participated in the survey are potentially healthier than those who did not.

To our knowledge, this is the first paper to use an incidence-based multistate modelling approach to estimate total life expectancy and the time spent living with multimorbidity in South Africa. Using an intersectionality framework and viewing the findings in the context of cumulative disadvantage brings a unique perspective to this topic because we were able to present both independent and combined estimates across the various gender, racial, and socioeconomic strata. However, there are several limitations. First, the disease data is based on

self-report, which makes it prone to recall bias. Second, the NIDS questionnaire only asked about a certain number of diseases, thus limiting what we could include within our definition of multimorbidity. Thus, although we classify people as having “no disease”, they might actually have one or more diseases that were not included in our definition. There is also potential for underdiagnosis of disease, so participants may actually have one or more diseases, but just have not been diagnosed. Both these instances would result in an underestimate of multimorbidity. Third, there were quite small sample sizes in some strata, particularly the Asian/Indian and White groups, requiring us to combine these groups to compute valid confidence intervals. Lastly, 31.2% of the initial study sample were only present at one wave so could not be included in our analysis.

CONCLUSION

In this study, we used a discrete-time multistate modelling approach to estimate total life expectancy and the time spent living with multimorbidity across gender, race, and socioeconomic strata in South Africa. We brought a new perspective to this area of research by interpreting our results based on cumulative disadvantage within an intersectionality framework. We had three main findings from our analyses. First, women had greater total life expectancy and spent more time living with multimorbidity compared to men. Second, Africans and Coloureds were more disadvantaged than Asian/Whites, having both lower total life expectancy and greater differences between no disease and multimorbid states. These patterns were also seen across SES, highlighting the race-class intersection that was constructed during apartheid. Third, by looking at the interaction between race and SES, we identified that Africans and Coloureds of the lowest SES lose more compared to their Asian/White counterparts – underscoring the idea that these groups suffer from cumulative disadvantage.

Future research should investigate other factors that could explain the inequalities observed in multimorbid and total life expectancy, such as health behaviours, health system differences, and spatial disparities. A life course perspective would also be beneficial to understand how childhood adversity might influence the accumulation of both disease and

disadvantage. However, for this to be possible in South Africa or LMICs generally, there needs to be longitudinal data with sufficient health information, which is currently lacking.

Our findings identified the groups most disadvantaged in terms of time spent with multimorbidity and total life expectancy. These groups can benefit from preventive measures targeted at multimorbidity risk factors, but especially from policies aimed at reducing the inequalities across races and socioeconomic classes. The policies should also account for the intersection of gender, race, and SES, as the unique constellation of these factors lead to different presentations of disadvantage across these groups. Thus, applying the idea of proportionate universalism, in which actions should be implemented universally, but the extent to which should be proportional to the level of disadvantage (Marmot and Bell, 2012).

REFERENCES

Abebe, F., Schneider, M., Asrat, B., et al. 2020. Multimorbidity of chronic non-communicable diseases in low- and middle-income countries: A scoping review. *J Comorb,* 10**,** 2235042X20961919.

Abubakari, G. M. R., Dada, D., Nur, J., et al. 2021. Intersectional stigma and its impact on HIV prevention and care among MSM and WSW in sub-Saharan African countries: a protocol for a scoping review. *BMJ Open,* 11**,** e047280.

Academy of Medical Sciences 2018. Multimorbidity: a priority for global health research. London.

Adhikari, M. 2009. Burdened By Race : Coloured Identities in Southern Africa.

Afshar, S., Roderick, P. J., Kowal, P., et al. 2015. Multimorbidity and the inequalities of global ageing: a cross-sectional study of 28 countries using the World Health Surveys. *BMC Public Health,* 15.

Afshar, S., Roderick, P. J., Kowal, P., et al. 2017. Global Patterns of Multimorbidity: A Comparison of 28 Countries Using the World Health Surveys. *In:* HOQUE, M. N., PECOTTE, B. & MCGEHEE, M. A. (eds.) *Applied Demography and Public Health in the 21st Century.* Springer International Publishing.

Alaba, O. & Chola, L. 2013. The social determinants of multimorbidity in South Africa. *Int J Equity Health,* 12**,** 63.

Arokiasamy, P., Uttamacharya, U., Jain, K., et al. 2015. The impact of multimorbidity on adult physical and mental health in low- and middle-income countries: what does the study on global ageing and adult health (SAGE) reveal? *BMC Med,* 13**,** 178.

Ataguba, J. E. 2013. Inequalities in multimorbidity in South Africa. *Int J Equity Health,* 12**,** 64.

Baron, E. C., Davies, T. & Lund, C. 2017. Validation of the 10-item Centre for Epidemiological Studies Depression Scale (CES-D-10) in Zulu, Xhosa and Afrikaans populations in South Africa. *BMC Psychiatry,* 17**,** 6.

Bauer, G. R. 2014. Incorporating intersectionality theory into population health research methodology: Challenges and the potential to advance health equity. *Social Science & Medicine,* 110**,** 10-17.

Benatar, S. R. 2013. The challenges of health disparities in South Africa. *South African Medical Journal,* 103**,** 154.

Bowleg, L. 2012. The problem with the phrase women and minorities: intersectionality-an important theoretical framework for public health. *American journal of public health,* 102**,** 1267-1273.

Bowleg, L. 2021. Evolving Intersectionality Within Public Health: From Analysis to Action. *American Journal of Public Health,* 111**,** 88-90.

Brophy, T., Branson, N., Daniels, R., et al. 2018. National Income Dynamics Study panel user manual. 1 ed. Cape Town: Southern Africa Labour and Development Research Unit.

Chang, A. Y., Gomez-Olive, F. X., Payne, C., et al. 2019. Chronic multimorbidity among older adults in rural South Africa. *BMJ Glob Health,* 4**,** e001386.

Chopra, M. & Sanders, D. 2004. From Apartheid to Globalisation: Health and Social Change in South Africa. *Hygiea Internationalis : An Interdisciplinary Journal for the History of Public Health,* 4**,** 153-174.

Cois, A. & Ehrlich, R. 2018. Antihypertensive treatment and blood pressure trends among South African adults: A repeated cross-sectional analysis of a population panel survey. *PLoS One,* 13**,** e0200606.

Craig, B. A. & Sendi, P. P. 2002. Estimation of the transition matrix of a discrete-time Markov chain. *Health Economics,* 11**,** 33-42.

Crenshaw, K. 1989. Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics. *University of Chicago Legal Forum,* 1989.

Dannefer, D. 2020. Systemic and Reflexive: Foundations of Cumulative Dis/Advantage and Life-Course Processes. *The Journals of Gerontology: Series B,* 75**,** 1249-1263.

Diprete, T. A. & Eirich, G. M. 2006. Cumulative Advantage as a Mechanism for Inequality: A Review of Theoretical and Empirical Developments. *Annual Review of Sociology,* 32**,** 271-297.

Dudel, C. & Myrskylä, M. 2020. Estimating the number and length of episodes in disability using a Markov chain approach. *Population Health Metrics,* 18.

Garin, N., Koyanagi, A., Chatterji, S., et al. 2016. Global Multimorbidity Patterns: A Cross-Sectional, Population-Based, Multi-Country Study. *J Gerontol A Biol Sci Med Sci,* 71**,** 205-14.

Gebregziabher, M., Ward, R. C., Taber, D. J., et al. 2018. Ethnic and geographic variations in multimorbidty: Evidence from three large cohorts. *Social Science & Medicine,* 211**,** 198-206.

Godongwana, M., De Wet-Billings, N. & Milovanovic, M. 2021. The comorbidity of HIV, hypertension and diabetes: a qualitative study exploring the challenges faced by

healthcare providers and patients in selected urban and rural health facilities where the ICDM model is implemented in South Africa. *BMC Health Services Research,* 21.

Gouws, A. 2017. Feminist intersectionality and the matrix of domination in South Africa. *Agenda,* 31**,** 19-27.

Groenmeyer, S. 2011. Intersectionality in Apartheid and Post-apartheid South Africa. *Gender, Technology and Development,* 15**,** 249-274.

Hankivsky, O. 2012. Women's health, men's health, and gender and health: Implications of intersectionality. *Social Science & Medicine,* 74**,** 1712-1720.

Hankivsky, O. 2014. Intersectionality 101. The Institute for Intersectionality Research & Policy, SFU.

Harari, L. & Lee, C. 2021. Intersectionality in quantitative health disparities research: A systematic review of challenges and limitations in empirical studies. *Social Science & Medicine,* 277**,** 113876.

Jackson-Best, F. & Edwards, N. 2018. Stigma and intersectionality: a systematic review of systematic reviews across HIV/AIDS, mental illness, and physical disability. *BMC Public Health,* 18.

Johnson-Lawrence, V., Zajacova, A. & Sneed, R. 2017. Education, race/ethnicity, and multimorbidity among adults aged 30–64 in the National Health Interview Survey. *SSM - Population Health,* 3**,** 366-372.

Johnston, M. C., Crilly, M., Black, C., et al. 2019. Defining and measuring multimorbidity: a systematic review of systematic reviews. *Eur J Public Health,* 29**,** 182-189.

Jusrut, P. & Kalipeni, E. 2010. An analysis of gender-based reversal in life expectancy in southern Africa. *GeoJournal,* 77**,** 541-554.

Kemeny, J. G. & Snell, J. L. 1983. *Finite Markov chains: with a new appendix" Generalization of a fundamental matrix*", Springer.

Kim, D. J., Westfall, A. O., Chamot, E., et al. 2012. Multimorbidity patterns in HIV-infected patients: the role of obesity in chronic disease clustering. *J Acquir Immune Defic Syndr,* 61**,** 600-5.

Kingston, A., Robinson, L., Booth, H., et al. 2018. Projections of multi-morbidity in the older population in England to 2035: estimates from the Population Ageing and Care Simulation (PACSim) model. *Age and Ageing,* 47**,** 374-380.

Kunna, R., San Sebastian, M. & Stewart Williams, J. 2017. Measurement and decomposition of socioeconomic inequality in single and multimorbidity in older adults in China and Ghana: results from the WHO study on global AGEing and adult health (SAGE). *Int J Equity Health,* 16**,** 79.

Leventhal, A. M., Bello, M. S., Galstyan, E., et al. 2019. Association of Cumulative Socioeconomic and Health-Related Disadvantage With Disparities in Smoking Prevalence in the United States, 2008 to 2017. *JAMA Internal Medicine,* 179**,** 777.

Mabaso, M., Makola, L., Naidoo, I., et al. 2019. HIV prevalence in South Africa through gender and racial lenses: results from the 2012 population-based national household survey. *International Journal for Equity in Health,* 18.

Marmot, M. & Bell, R. 2012. Fair society, healthy lives. *Public Health,* 126**,** S4-S10.

Mateos, J. T., Fernández-Sáez, J., Marcos-Marcos, J., et al. 2020. Gender Equality and the Global Gender Gap in Life Expectancy: An Exploratory Analysis of 152 Countries. *International Journal of Health Policy and Management*.

Medalia, C. & Chang, V. W. 2011. Gender equality, development, and cross-national sex gaps in life expectancy. *International Journal of Comparative Sociology,* 52**,** 371-389.

Merton, R. K. 1968. The Matthew Effect in Science. *Science,* 159**,** 56-63.

Merton, R. K. 1988. The Matthew Effect in Science, II: Cumulative Advantage and the Symbolism of Intellectual Property. *Isis,* 79**,** 606-623.

Modjadji, P. 2021. Communicable and non-communicable diseases coexisting in South Africa. *The Lancet Global Health,* 9**,** e889-e890.

Moolman, B. 2013. Rethinking 'masculinities in transition' in South Africa considering the 'intersectionality' of race, class, and sexuality with gender. *African Identities,* 11**,** 93-105.

National Academies of Sciences, E., And Medicine; Health and Medicine Division; Board on Population Health and Public Health Practice; Committee on Community-Based Solutions to Promote Health Equity in the United States 2017. The State of Health Disparities in the United States. *In:* BACIU A, NEGUSSIE Y, GELLER A & AL., E. (eds.) *Communities in Action: Pathways to Health Equity.* Washington D.C.: National Academies Press.

Oksuzyan, A., Brønnum-Hansen, H. & Jeune, B. 2010. Gender gap in health expectancy. *European Journal of Ageing,* 7**,** 213-218.

Oni, T., Mcgrath, N., Belue, R., et al. 2014. Chronic diseases and multi-morbidity--a conceptual modification to the WHO ICCC model for countries in health transition. *BMC Public Health,* 14**,** 575.

Oni, T., Youngblood, E., Boulle, A., et al. 2015. Patterns of HIV, TB, and non-communicable disease multi-morbidity in peri-urban South Africa- a cross sectional study. *BMC Infect Dis,* 15**,** 20.

Pais, J. 2014. Cumulative Structural Disadvantage and Racial Health Disparities: The Pathways of Childhood Socioeconomic Influence. *Demography,* 51**,** 1729-1753.

Pathirana, T. I. & Jackson, C. A. 2018. Socioeconomic status and multimorbidity: a systematic review and meta-analysis. *Aust N Z J Public Health,* 42**,** 186-194.

Peltzer, K. 2018. Tuberculosis non-communicable disease comorbidity and multimorbidity in public primary care patients in South Africa. *Afr J Prim Health Care Fam Med,* 10**,** e1-e6.

Posel, D. 2001a. Race as Common Sense: Racial Classification in Twentieth-Century South Africa. *African Studies Review,* 44**,** 87.

Posel, D. 2001b. What's in a name? Racial categorisations under apartheid and their afterlife. *Transformation***,** 50-74.

Quiñones, A. R., Botoseneanu, A., Markwardt, S., et al. 2019. Racial/ethnic differences in multimorbidity development and chronic disease accumulation for middle-aged adults. *PLOS ONE,* 14**,** e0218462.

Quiñones, A. R., Newsom, J. T., Elman, M. R., et al. 2021. Racial and Ethnic Differences in Multimorbidity Changes Over Time. *Medical Care,* 59**,** 402-409.

R Core Team 2020. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

Rieker, P. P. & Bird, C. E. 2005. Rethinking Gender Differences in Health: Why We Need to Integrate Social and Biological Perspectives. *The Journals of Gerontology: Series B,* 60**,** S40-S47.

Rocca, W. A., Boyd, C. M., Grossardt, B. R., et al. 2014. Prevalence of Multimorbidity in a Geographically Defined American Population. *Mayo Clinic Proceedings,* 89**,** 1336-1349.

Sangaramoorthy, T., Jamison, A. & Dyer, T. 2017. Intersectional stigma among midlife and older Black women living with HIV. *Culture, Health & Sexuality,* 19**,** 1329-1343.

Schneider, D., Van Raalte, A. & Myrskylä, M. 2021. mcwr: Markov Chains with Rewards. R Package Version 1.0.0 ed.

Seabrook, J. A. & Avison, W. R. 2012. Socioeconomic Status and Cumulative Disadvantage Processes across the Life Course: Implications for Health Outcomes. *Canadian Review of Sociology/Revue canadienne de sociologie,* 49**,** 50-68.

Sewpaul, R., Mbewu, A. D., Fagbamigbe, A. F., et al. 2021. Prevalence of multimorbidity of cardiometabolic conditions and associated risk factors in a population-based sample of South Africans: A cross-sectional study. *Public Health in Practice,* 2**,** 100193.

Sharman, M. & Bachmann, M. 2019. Prevalence and health effects of communicable and non-communicable disease comorbidity in rural KwaZulu-Natal, South Africa. *Trop Med Int Health,* 24**,** 1198-1207.

Shuey, K. M. & Willson, A. E. 2008. Cumulative Disadvantage and Black-White Disparities in Life-Course Health Trajectories. *Research on Aging,* 30**,** 200-225.

Southern Africa Labour and Development Research Unit 2018a. National Income Dynamics Study 2014-2015, Wave 4 [dataset]. *In:* CAPE TOWN: SOUTHERN AFRICA LABOUR AND DEVELOPMENT RESEARCH UNIT [IMPLEMENTER] (ed.) Version 2.0.0 ed.: Cape Town: DataFirst [distributor].

Southern Africa Labour and Development Research Unit 2018b. National Income Dynamics Study 2017, Wave 5 [dataset]. *In:* CAPE TOWN: SOUTHERN AFRICA LABOUR AND DEVELOPMENT RESEARCH UNIT [IMPLEMENTER] (ed.) Version 1.0.0 ed.: Cape Town: DataFirst [distributor].

Southern Africa Labour and Development Research Unit 2018c. National Income Dynamics Study (NIDS) Wave 1, 2008 [dataset]. *In:* CAPE TOWN: SOUTHERN AFRICA LABOUR AND DEVELOPMENT RESEARCH UNIT [IMPLEMENTER] (ed.) Version 7.0.0 ed. Cape Town: Cape Town: DataFirst [distributor].

Southern Africa Labour and Development Research Unit 2018d. National Income Dynamics Study Wave 2, 2010-2011 [dataset]. *In:* CAPE TOWN: SOUTHERN AFRICA LABOUR AND DEVELOPMENT RESEARCH UNIT [IMPLEMENTER] (ed.) Version 4.0.0 ed.: Cape Town: DataFirst [distributor]

Southern Africa Labour and Development Research Unit 2018e. National Income Dynamics Study Wave 3, 2012 [dataset]. *In:* CAPE TOWN: SOUTHERN AFRICA LABOUR AND DEVELOPMENT RESEARCH UNIT [IMPLEMENTER] (ed.) Version 3.0.0 ed.: Cape Town: DataFirst [distributor].

Teeraananchai, S., Kerr, S., Amin, J., et al. 2017. Life expectancy of HIV-positive people after starting combination antiretroviral therapy: a meta-analysis. *HIV Medicine,* 18**,** 256-266.

Tetzlaff, J., Muschik, D., Epping, J., et al. 2017. Expansion or compression of multimorbidity? 10-year development of life years spent in multimorbidity based on health insurance claims data of Lower Saxony, Germany. *International Journal of Public Health,* 62**,** 679-686.

Turan, J. M., Elafros, M. A., Logie, C. H., et al. 2019. Challenges and opportunities in examining and addressing intersectional stigma and health. *BMC Medicine,* 17.

Unger, T., Borghi, C., Charchar, F., et al. 2020. 2020 International Society of Hypertension Global Hypertension Practice Guidelines. *Hypertension,* 75**,** 1334-1357.

Verest, W. J. G. M., Galenkamp, H., Spek, B., et al. 2019. Do ethnic inequalities in multimorbidity reflect ethnic differences in socioeconomic status? The HELIUS study. *European Journal of Public Health,* 29**,** 687-693.

Wade, A. N., Payne, C. F., Berkman, L., et al. 2021. Multimorbidity and mortality in an older, rural black South African population cohort with high prevalence of HIV findings from the HAALSI Study. *BMJ Open,* 11**,** e047777.

Weimann, A., Dai, D. & Oni, T. 2016. A cross-sectional and spatial analysis of the prevalence of multimorbidity and its association with socioeconomic disadvantage in South Africa: A comparison between 2008 and 2012. *Soc Sci Med,* 163**,** 144-56.

Whitehead, K. A. 2013. Race-Class Intersections as Interactional Resources in Post-Apartheid South Africa. *In:* PASCALE, C. M. (ed.) *Social Inequality and the Politics of Representation: A Global Landscape.* Newbury Park, CA: Sage.

Willson, E., Andrea, Shuey, M., Kim & Elder, J., H., Glen 2007. Cumulative Advantage Processes as Mechanisms of Inequality in Life Course Health. *American Journal of Sociology,* 112**,** 1886-1924.

Wong, E. B., Olivier, S., Gunda, R., et al. 2021. Convergence of infectious and non-communicable disease epidemics in rural South Africa: a cross-sectional, population-based multimorbidity study. *The Lancet Global Health,* 9**,** e967-e976.

World Bank 2020. Historical Classification by Income. http://databank.worldbank.org/data/download/site-content/OGHIST.xls.

World Health Organization 2020. Life tables: Life tables by country South Africa Global Health Observatory.

Woznica, D. M., Ntombela, N., Hoffmann, C. J., et al. 2021. Intersectional Stigma Among People Transitioning From Incarceration to Community-Based HIV Care in Gauteng Province, South Africa. *AIDS Education and Prevention,* 33**,** 202-215.

Xu, X., Mishra, G. D. & Jones, M. 2017. Evidence on multimorbidity from definition to intervention: An overview of systematic reviews. *Ageing Research Reviews,* 37**,** 53-68.