7-17-2019

Non-communicable Diseases and Depression: Evidence from South Africa

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Abstract
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Keywords
non-communicable diseases, depression, South Africa, primary health care

Disciplines
Diseases | Mental and Social Health | Other Mental and Social Health | Social and Behavioral Sciences

Edited 17 July 2019

Non-communicable Diseases and Depression: Evidence from South Africa[1]

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ABSTRACT

Although there are numerous studies of depression and its linkages with non-communicable diseases (NCDs), most rely on a single cross-section or a single wave of the National Income Dynamics Study (SA-NIDS) for South Africa, which does not allow for incorporation of individual unobservable effects. Such effects are potentially significant as it is frequently observed that there is considerable variation in depressive symptoms even when an old person suffers from common NCDs. We use correlated random effects probit model on the first 5 waves of SA-NIDS panel data collected every two years between 2008-2016/17 to examine the *reverse* association from Depression to selected NCDs, controlling for socio-economic and demographic characteristics. The analysis yields useful insights into the complex relationships between NCDs and depression. Policy options that focus on biological and behavioural links in the co-occurrence of NCDs and depression are examined. Of particular importance is integration of depression and NCD care in primary health care with a view to increasing prevention, screening, self-management, treatment and rehabilitation in order to achieve equitable, efficient and quality health services in South Africa.

Key Words: Non-communicable diseases, Depression, South Africa, Primary Health Care.

JEL Codes: I100, I120, I150, I180, I190

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[1] We are grateful to Irma Elo, Jere Behrman, G. van Zyl, S. Saxena, Katsushi Imai, K. L. Krishna, and Anil S. Deolalikar for valuable advice. Neha Pandey's help in carrying out the detailed analysis is greatly appreciated. All authors contributed equally in the design, implementation of the econometric analysis and interpretation of the results. The views are personal. There is no conflict of interest as the study was self-financed.

Non-communicable Diseases and Depression: Evidence from South Africa

1. Introduction

South Africa faces a quadruple disease burden, including poverty-related diseases, non-communicable diseases, injuries and HIV/AIDS. Poverty, violence, rapid social and economic changes, lack of education, inadequate services and urbanization contribute as much to increasing cases of non-communicable diseases as they do to HIV, tuberculosis, and other communicable diseases (Puoane, Bradley and Hughes, 2005).

Population ageing is the major driver of projected increases in disease burden, most evident in low income and middle-income countries and for strongly age-dependent disorders (dementia, stroke, chronic obstructive pulmonary disease, and diabetes). These are also the disorders for which chronic disability makes a substantial contribution (Prince et al., 2015). The phenomenon of aging is clearly visible in South Africa. The percentage of the population aged 60 years and above (referred to as aged or elderly) rose from 2.4 million to 3.1 million between 1996 - 2011 (Stats SA, 2017). Moreover, the population of aged South Africans is growing at nearly double the rate of overall population growth rate and its share is projected to almost double during 2000–2030, because of (i) a marked decline in fertility in the past few decades; (ii) the HIV and AIDS pandemic, with a higher mortality of young adults, especially women of reproductive age; and (iii) a rise in life expectancy to 62 years between 2005-2013-– a staggering increase of 8.5 years (Bloom et al. 2015).

In South Africa, ageing Black Africans have worse health outcomes than ageing populations from other racial groups; and the gap in health outcomes is even wider among old Black Africans living in rural areas (Stats SA, 2017). The aggravation of these problems is attributed to isolation, poor housing, low income, poor access to healthcare facilities, and the political and economic marginalization that resulted from apartheid policies (Case and Deaton, 2005). Evidence shows that four in ten elderly persons in South Africa are poor. More than a third make an average living, and the rich constitute about 27%. Provincial variations show that rural provinces have higher proportions of poor elderly persons compared to urban provinces. Racial differences show that elderly Whites and

Indians/Asians/Others occupy a higher socio-economic status than Black Africans and Coloureds (Stats SA, 2017).

Pandey et al. (2018) offers a comprehensive analysis of factors associated with depression among the old (60+ years) in South Africa, using the first four waves of the same panel data source (NIDS) for 2008, 2010, 2012 and 2014. This study unravels the factors underlying depression among the old over the period 2008-2014, and finds that NCDs (including multi-morbidities) and disabilities are positively associated with (alternative measures of) depression, and the associations are robust. Recent evidence also points to *reverse* association from depression to NCDs. A few examples suffice: Both cancer and pain are common in older patients, and depression is a frequent co-morbid condition (Spiegel & Giese-Davis, 2003). Depression can precede a diagnosis of cancer, notably lung and pancreatic cancer, and high rates of depression are seen in breast cancer and head and neck tumours (Raison & Miller, 2003).

Despite numerous research studies on the linkages between depression and NCDs and between disabilities and depression, most rely on a single cross-section or a single wave of the *National Income Dynamics Study (SA-NIDS)* for South Africa, which does not allow incorporation of individual unobservable effects. Such effects are potentially significant as it is frequently observed that there is considerable variation in depressive symptoms even when old persons suffer from common NCDs and disabilities. Thus, a better understanding of associations between depression and NCDs through unobservable individual effects and control for socio-economic factors could lead to important policy insights. The present study aims to fill this gap by examining the *reverse* association from depression to NCDs in South Africa. It uses state-of-art panel models using the five waves of the National Income Dynamics Study (NIDS) panel survey data for South African adults (30 years and above) for the years 2008, 2010, 2012, 2014, and 2016/17. We believe that this is the first study of its kind in the South African context.

The next section discusses the links between NCDs, and depression and more broadly mental health. Section 3 is devoted to salient features of the NIDS panel data and variables. Section 4 discusses the

methodology, followed by a distillation of the results in Section 5. The main findings are discussed from a broader policy perspective in Section 6. Concluding observations are given in Section 7.

2. Links Between NCDs and Depression

Depression and cancer commonly co-occur. The prevalence of depression among cancer patients increases with disease severity and symptoms such as pain and fatigue. The evidence on depression as a predictor of cancer incidence is mixed, although chronic and severe depression may be associated with elevated cancer risk. Psychophysiological mechanisms linking depression and cancer progression include dysregulation of the hypothalamic-pituitary-adrenal axis, especially diurnal variation in cortisol and melatonin. Depression also affects components of immune function that may affect cancer surveillance (Spiegel & Giese-Davis, 2003)**.** Besides, there is increasing appreciation of the possibility that behavioural alterations in cancer patients may represent a "sickness syndrome" that results from activation of the inflammatory cytokine network. This sickness syndrome includes symptoms that overlap with those seen in major depression (Raison & Miller, 2003).

Recent research has found that not only is depression more common in cardiac patients than in the general population, but depression is also a risk factor for cardiac morbidity and mortality, independent of traditional risk factors (Padhy et al. 2015). This link between depression and cardiac morbidity likely involves both physiologic and behavioural effects of depression. These include negative impact on multiple aspects of the course of cardiovascular illness, including physical functioning, quality of life, health care utilization, rehospitalization, and mortality (Huffman et al. 2013).

A meta-analysis of 27 studies found a statistically significant association between depression and hyperglycemia in both type 1 and type 2 diabetes (de Groot et al. 2001). Chronic hyperglycemia is a well-established predictor of the onset and exacerbation of diabetes complications in both type 1 and type 2 diabetes. If depression is associated with hyperglycemia and the latter is associated with diabetes complications, it follows that depression may also be associated with diabetes complications. Type 1 and type 2 diabetes are etiologically distinct diseases, with differing ages of onset, courses of

illness, and treatment regimens. This consistency suggests that there may be common pathways that support the association between depression and type 1 and type 2 diabetes. As all these studies rely on cross-sectional correlation, de Groot et al. (2001) is emphatic that well-designed, longitudinal studies are needed to pinpoint depression and complication trajectories and the mechanisms that link these diseases.

Based on an application of syndemic theory to multimorbidities in low-income and middle-income countries, Mendenhall et al. (2017) focuses on diabetes as an exemplar and discuss its comorbidity with HIV in Kenya, tuberculosis in India, and depression in South Africa. Syndemic involves the clustering of two or more diseases within a population that contributes to, and results from, persistent social and economic inequalities. Specifically, multiple health problems interact, often biologically, with each other and the sociocultural, economic, and physical environment.

Depression and diabetes share biological origins, particularly the activation of innate immunity that leads to a cytokine-mediated inflammatory response, alterations in glucose transport, and potentially through dysregulation of the hypothalamic-pituitary-adrenal axis, as well as behavioural patterns, including consumption of high-caloric foods, low engagement in physical activity, and use of antidepressants that enhance weight gain, and social factors that promote stress, eating, and reduced physical activity.

Research shows that depression may actually increase the risk of stroke and of dying from that stroke (Pan et al., 2011). Their meta-review includes 28 studies of more than 300,000 people. During a follow-up period that ranges from 2 to 29 years, there are 8,478 strokes. Depressed people turn out to be 45% more likely to experience any type of stroke than those who are not depressed. They are also at a 55% increased risk of dying from that stroke.

The same inflammation markers in the bloodstream that set the stage for stroke may also play a role in causing depression. Besides, antidepressants have been associated with stroke risk.

Behavioural aspects matter too. Those depressed tend to eat less healthily and get less exercise. They may also smoke and engage in other unhealthy behaviours that induce strokes. People who are

depressed are also less likely to take their medication as prescribed. This may include blood pressure or cholesterol-lowering drugs. Both high blood pressure and high cholesterol levels are risk factors for stroke.

3. Data and Descriptive Statistics

3.1 Data

The data used in the present study are drawn from the 5 waves of the nationally representative South African National Income Dynamics Study (SA-NIDS) collected every two years between 2008-2016/17 (SA-NIDS; 2018a, b, c, d, e). These waves constitute a rich panel data conducted every two years since its first wave in 2008. NIDS employs stratified sampling procedures (Chinhema et al. (2016), De Villiers et al. (2013), Brown et al. (2013)), and is currently the sole nationally representative panel data source in South Africa. The survey is designed with the key objective to analyze various dimensions of the well-being of South Africans over time. SA-NIDS waves collect data on household wealth, individual and household demographics, health, and other socio-economic characteristics.

Our analysis is confined to adults ≥30 years old. This allows us to examine the shift of the NCD burden from the middle-aged to the old during the period 2008-16.

3.1.1. Outcome variables

SA-NIDS collects information on non-communicable diseases such as diabetes, high blood pressure, heart problems, stroke and cancer through a set of three consecutive questions. For instance, to capture information on diabetes, SA-NIDS questionnaire asks: 1. have you ever been told by a doctor, nurse or health care professional that you have diabetes or high blood sugar?, 2. are you currently taking medication for diabetes or high blood sugar?**,** and 3. do you still have diabetes or high blood sugar?. We use all of these responses to create initial year non-communicable disease conditions as well as continuation of their occurrence across waves. Even though the responses provided by individuals are not medically verified, these are not based entirely on individual's perception either.

Based on these responses, each of these non-communicable diseases is measured on a binary scale (=1 if a particular disease prevails, 0 otherwise). In order to capture non-communicable diseases broadly, we also construct a variable: any NCDs as a binary variable (1 if diabetes, high blood pressure, heart problems, stroke or cancer occur, 0 if free from all of these). These measures are our key outcome variables.

3.1.2. Key explanatory variables

In this study, our key explanatory variable is depression and related mental health conditions. SA-NIDS captures depression in terms of its duration in a week by asking: 'please state how often you have felt depressed during the past week' with responses as rarely or none of the time (less than 1 day), some or little of the time (1-2 days), occasionally or a moderate amount of time (3-4 days), and all of the time (5-7 days) in a week. Based on the responses, we construct a categorical depression variable that classifies a person $\geq$30 years as in mild, moderate or severe depression conditions if he/she was depressed for less than 2 days, 3-4 days, and 5-7 days in a week, respectively. In order to simplify interpretation, we call moderate and severe depression conditions as depression only.

Next, following Tomita and Burns (2013) but with some variation, two new indices of mental health are constructed, based on the self-reported 10-item version scale of the Centre for Epidemiologic Studies Depression (CES-D) available in the adult questionnaire of SA-NIDS. These 10 items include if a respondent is unusually bothered (item 1), has trouble keeping his/her mind on what he/she is doing (item 2), feel depressed (item 3), feel that everything is an effort (item 4), feel hopeful about the future (item 5), feel fearful (item 6), sleep is restless (item 7), is happy (item 8), feels lonely (item 9), and could not get going (item 10). The rating scales for two items, I feel hopeful about the future (item 5), and I am happy (item 8), are reversed in line with others so that higher values reflect greater hopelessness and greater unhappiness. Cronbach's alpha (Cronbach, 1951) is computed to assess the reliability of a summative rating (Likert, 1932) scale composed of the 10 items specified above. Cronbach's alpha scores are 0.79, 0.77, 0.74, 0.69 and 0.73 for the survey years 2008, 2010, 2012, 2014 and 2016, respectively. Cronbach's alpha score for the pooled sample is 0.73. Following Nunnally and Bernstein (1994), a modest reliability score is enough to combine these

10 item scores by adding them together and dividing by 10. We use this average score to measure mental health. We further classify mental health variable into three categories: good mental health if average score less than 3, moderate if 3-4, weak if 5-7. Because of data constraints, we create a mental health dummy that takes the value 1 if mental health is weak and moderate, and 0 if mental health is good.

3.1.3. Control variables

While examining associations from depression to NCDs, we control for socio-economic characteristics. These include gender and ethnicity as time invariant individual characteristics, and age, education, marital status, exercise, household size, whether a death occurred in the family in the last 24 months, social trust, whether a pensioner, and wealth (asset) quartiles as time varying characteristics. Although consumption of alcohol and smoking vary with time, in order to circumvent their endogeneity, these are treated as initial conditions. Details are given in Table 1.

3.2. Descriptive Statistics

3.2.1 Prevalence of NCDs and depression

A broad-brush treatment of prevalence of NCDs including depression by age-group and over time is given below (Fig.1).

While prevalence of depression falls in each age-group (30-44, 45-59, 60-74 years) between 2008-16, it rises slightly in the oldest group (≥75 years) from under 18% to nearly 19%. Although highest prevalence occurs among 45-59 years old in 2008 (20%), it shifts to the oldest in 2016 (19%). But there is no clear shift of the prevalence from the middle-aged to the oldest.

Prevalence of NCDs by age-group presents a contrast. In each age-group, except the oldest, it declines over time. The oldest experience a rise, from about 49% to 54%. Besides, the prevalence rises from the middle- aged to the old in both 2008 and 2016-more so, in the more recent year. Thus, the old become more vulnerable to NCDs in 2016.

Selected NCDs exhibit a varied pattern. Prevalence of diabetes falls in each age-group except among 60 -75 years old over time. The latter record a rise (from under 11% to about 12.5%). There is also a marked progression from the middle –aged to the old in both 2008 and 2016, especially in 2016.

High BP declines among both 30-44 years and 45 -60 years but it surges among the older age groups between 2008-16. Among the oldest, for example, the prevalence rises from nearly 38% to nearly 52%. Thus, the old-especially the oldest-become more vulnerable to high blood pressure.

Prevalence of heart disease declines in each age-group except the oldest over time. The oldest record a rise, from about 9% to just under 12%. The prevalence rises from the middle-aged to the oldest in both 2008 and 2016. Thus, the oldest become more vulnerable to heart disease in 2016.

Cancer affects low segments of the sample population. The lowest prevalence is observed among the middle-aged (0.7%) and highest among 60-74 years old (2.7%) in 2008. It declines or increases among different age-groups except the oldest. The latter see a marked increase between 2008 and 2016, from under 2% to slightly over 4%. However, there is no progression from the middle-aged to the old in either year.

Small fractions of the sample population suffer strokes in both years. However, the prevalence varies with age in both years, more so in 2016. Among the oldest, the prevalence rises from less than 2% to 2.5%, rendering them more vulnerable to strokes.

In sum, in most cases, the oldest are most vulnerable to NCDs –including depression-which also rises over time.

3.2.2 Transition probabilities

Transition probability estimates for NCDs by depression conditions are provided in Table 2. These transition probabilities are defined as probabilities of a specific status in the final period conditional upon occurrence status in initial period, which are estimated by counting transitions from initial values in 2008 to final values in year 2016. For instance, each year from 2008 to 2016, under 96.3% of the depressed non-diabetic persons in 2008 remained non-diabetic in 2016; the remaining 3.7%

became diabetic. For depressed diabetic persons in 2008, while there is 29.8% chance of returning to non-diabetic states, they had 70.2% chance to continue with diabetes. This suggests that depression when interacted with diabetic condition increases the probabilities of continuation with diabetes. A similar pattern can be observed for people with high blood pressure and cancer. However, the relationship is reversed in the case of stroke, heart diseases and any of the NCDs where transition probabilities to remain in the same condition is slightly higher for not-depressed group.

4. Methodology and Estimation

4.1. Model Specifications

We apply and estimate correlated random effects probit model for the binary NCD outcome variables referred to earlier (Arulampalam (1998), Wooldridge (2010) and Greene (2012)). For convenience of exposition, consider the basic model:

$$y_{it}^{*} = \boldsymbol{x}_{it}'\boldsymbol{\beta} + v_{it,}\ i=1,2,...,n \text{ and } t=1,...,T \qquad (1)$$

$$v_{it} = \alpha_i + u_{it} \qquad (2)$$

and $y_{it} = 1\ [y_{it}^{*} > 0]$ and 0 otherwise, y^{*}denotes the unobservable variable, y is the observed outcome, **x** is observable time-varying and time-invariant vector of exogenous characteristics, and initial values of some variables which influence y^{*}, $\boldsymbol{\beta}$ is the vector of coefficients associated with the **x**, α_i denotes the individual specific unobservable effect and u_{it} is a random error. In the case of random effects (RE) probit it is also assumed that $u_{it} \sim IN(0, {\sigma_u}^2)$. For estimation using MLE, it is further assumed that, conditional on the $\boldsymbol{x_{it}}$, $\alpha_i \sim IN(0, {\sigma_\alpha}^2)$ are independent of the u_{it} and the x_{it}. This implies that the correlation between two successive error terms for the same individual is a constant given by,

$$\rho = corr(v_{it}, v_{it-1}) = \frac{\sigma_\alpha^2}{\sigma_\alpha^2 + \sigma_u^2} \qquad (3)$$

The parameters of this model are easily estimated by noting that the distribution of y_{it}^{*} conditional on α_i is independent normal (Wooldridge, 2010). Note that

$$P(y_{it} = 1 | \alpha_i, \boldsymbol{x}_{it}) = P\left(\frac{u_{it}}{\sigma_u} > -\boldsymbol{x}_{it}'\boldsymbol{\beta} - \alpha_i\right) = \Phi(z_{it}) \qquad (4)$$

where

$$z_{it} = -(\boldsymbol{x}_{it}'\boldsymbol{\beta} + \alpha_i)/\sigma_u \quad (5)$$

The assumption $\alpha_i \sim IN(0, {\sigma_\alpha}^2)$ is a very strong assumption. Moreover, it is not enough to assume that α_i and x_i are uncorrelated or even $E(\alpha_i|x_i) = 0$. If x_{it} contains an intercept, the assumption, $E(\alpha_i) = 0$, does not involve loss of generality.

To allow for correlation between α_i and x_i, Chamberlain (1980) assumed a conditional normal distribution with linear expectation and constant variance. A Mundlak (1978) version of Chamberlain's assumption is given as

$$\alpha_i|x_i \sim N(\psi + \bar{x}_\iota\xi, {\sigma_a}^2) \quad (6)$$

where $\bar{x}_\iota$ is the average of $\boldsymbol{x}_{it}$, t=1,…,T and ${\sigma_a}^2$ is the variance of a_i in the equation $\alpha_i = \psi + \bar{\boldsymbol{x}}_\iota\xi + a_i$. That is, ${\sigma_a}^2$ is assumed not to depend on x_i. ${y_{it}}^* = \psi + \boldsymbol{x}_{it}'\boldsymbol{\beta} + \bar{\boldsymbol{x}}_\iota\xi + a_i + u_{it},\ t = 1, \ldots \ldots T$ (7)

4.2. Estimation strategy

While assumption (6) is restrictive in that it specifies a distribution for a_i and x_i, it allows for some dependence between a_i and x_i. We use standard random effects regressions with Mundlak adjustment, also known as correlated random effects probit model, as in equation (7), which is estimated by generalized least squares (GLS)[2]. Briefly, this requires adding group-means of variables. This was proposed as a way to relax the assumption in the random-effects estimator that the observed variables are uncorrelated with the unobserved variables. Unlike the fixed effect logit/probit, the random effect logit/probit models allow use of time-invariant variables. Additionally, the degree of statistical significance of the estimated coefficients on the group means can be used to test whether such assumption holds for individual regressors (Wooldridge, 2016).

[2] Our baseline model was fixed effect logit model. While results for the key depression variables remained robust, we prefer to use correlated random effects probit model over fixed effects model because in the latter model (i) number of observations were dropped drastically due to time-invariant natures of key explanatory variables and (ii) we were also interested in examining some of the time-invariant control variables such as gender and ethnicity. However, the results for fixed effect logit models can be provided upon request.

In estimating our reduced-form models for NCDs, we suspect presence of potential endogeneity due to inclusion of depression, consumption of cigarettes and/or alcohol and income variables in the model. In order to circumvent possibility of endogeneity due to depression, and consumption of cigarettes and/or alcohol, initial conditions at time (t=0) or base line values are used. Wealth quartiles are preferred to income as the former is a more comprehensive measure of economic status of a household. This varies over time. Finally, we estimate the following reduced-form models for NCDs, augmented by time invariant characteristics (e.g. gender, race and other initial conditions):

$$NCD_{it} = \beta_0 + \beta_1 Depress_{it=0} + X_{it}\beta_2 + \overline{X}_i\beta_3 + X_i\beta_{4+}a_i + u_{it} \quad (8)$$

where NCD_{it} is a selected NCD outcome for individual i at time t; $Depress_{it=0}$ is the initial (baseline) depression condition, and X_{it}, a vector of time varying covariates for individual i at time t, and X_i is a vector of time invariant characteristics (e.g., gender, race). In fact, in different specifications, either depression alone or in combination with NCDs are used. $\overline{X}_i$ is the mean of time variant characteristics for individual i over the entire period and a_i is time-invariant unobservable individual characteristic. u_{it} is an idiosyncratic error. In the model, the standard errors are adjusted for clusters in individuals and time dummies are included. A list of set of variables used and their definitions are given in Table 1.

5. Results

The estimated coefficients and marginal effects for the correlated random effects probit models for NCDs are reported in Tables 3-6. Table 3 provides estimation of baseline depression categories. In Table 4, baseline depression condition is interacted with baseline NCDs to understand NCD outcomes. Similarly, Tables 5 and 6 are based on specifications examining associations from mental health to NCDs. Except for a few cases in which a significant coefficient does not have a significant marginal effect/association or vice versa, in all other cases, significant coefficients are accompanied by significant marginal effects/associations. Moreover, comparisons of results with and without controls (adjusted and unadjusted, respectively) are made, but without the details to avoid cluttering the text.

5.1 Baseline NCDs and depression

Without controls, those moderately or severely depressed show higher probabilities of diabetes, high blood pressure, stroke and at least one NCD, relative to those who are not (the omitted group).[3]

For the selected NCDs models with mild, moderate and severe depression (Table 3), the coefficients and marginal effects/associations of baseline moderate and high depressions are positive and significant in most NCDs (the exceptions being diabetes, stroke and cancer). What is striking is that the associations between NCDs and severe depression is strongest, as compared with mild depression.

When we combine baseline individual NCD and moderate/severe depression conditions (Table 4), the associations of baseline NCDs and depression (together or alone) are significant and positive for NCDs in subsequent years. For instance, as compared to those without diabetes and moderate/severe depression conditions in the initial year, the likelihood of diabetes in subsequent years is higher for those who have both or either in the initial year—with slightly larger magnitudes of associations where NCD and moderate/severely depression co-occur.

5.2 Baseline NCDs and Mental Health

When we consider baseline mental health scores in the NCDs models (Table 5), significant and positive associations between individual NCDs and mental health scores are observed (an exception being stroke). As higher mental health score implies a weaker mental health, the positive association suggests that a weaker mental health initially co-occurs with greater vulnerability to NCDs in subsequent years.

When we combine baseline NCD and weak/moderate mental health conditions (Table 6), the associations of occurrence of either or both with NCDs are significant and positive. For instance, as compared to those without diabetes and weak/moderate mental health conditions in the initial year, the likelihoods of diabetes in subsequent years are higher for those having both diabetes and weak/moderate mental health or either in the initial year. The associations are slightly stronger when both NCDs and mental health in the initial year are considered.

5.3. Age

[3] The results are omitted but will be provided upon request.

Going by age-group, as compared to those between 30-44 years of age (the omitted group), those in the age-group 45-59 have significantly higher probabilities of all NCDs, except cancer. Those in the older age group 60-74 years exhibit significantly higher likelihood of diabetes, high blood pressure, and at least of one of the NCDs. However, no significant difference is observed between 30-44 and 60-74 years old in the prevalence of stroke, heart problems and cancer. Among the oldest, ≥75 years, the likelihood of all selected NCDs are significantly higher than in the omitted group, except for stroke and cancer. Mean age groups during the survey period (2008-2016) are highly significant across NCDs, as the prevalence of NCDs significantly varies with age group, relative to the mean age-group of 30-44 years.

5.4. Other control variables

There is a significant gender difference in the prevalence of NCDs with higher likelihoods for females in most NCDs, except stroke.

Relative to individuals with higher education, (i.e. with grades higher than 10), those with below grade 5 education show significantly higher associations with NCDs (e.g., high blood pressure, heart problems or at least one NCD), as also those with middle grades (grades 6 to 10).

There is no significant difference between married or partnered and widowed or divorced individuals in the prevalence of NCDs. However, while unmarried individuals have lower probabilities of NCDs for diabetes and high blood pressure and at least one of the NCDs, the difference is not significant in the case of stroke, heart problems or cancer, relative to married or partnered.

Somewhat surprisingly, baseline consumption of alcohol and smoking show significantly lower likelihood of diabetes but do not have significant associations with any other NCDs. This could be due to patchiness of data on these covariates.

Those living alone do not show significant associations with NCDs, compared with those living in households with 2-4 members (the omitted group). However, when family size is larger than 4 persons, the probabilities of high blood pressure and at least one NCD increase.

Negative events in the family in the last 2 years (e.g. death, major illness) are associated with higher likelihood of diabetes, high blood pressure, heart problems and at least one NCD.

Somewhat surprisingly, physical exercise does not have a significant association with NCDs.

No less surprising is lack of a significant association between social trust and NCDs.

Pensioners are associated with higher risks of diabetes, high blood pressure and at least one NCD, compared with non-pensioners. However, the associations are not significant in the case of stroke, heart diseases and cancer.

As compared to the Africans, the Whites have lower associations with diabetes but greater likelihood of heart problems, cancer and at least one NCD. The Coloureds have higher risks of the selected NCDs, while the Asians and Indians are more vulnerable to diabetes and heart related problems.

As compared to individuals in the 4th asset quartile (the omitted group), those in the first quartile (least wealthy) have lower associations with diabetes, high blood pressure, and strokes; while those in the 2nd quartile have lower risk of stroke. The associations with NCDs do not differ between the third and fourth quartiles. Mean wealth quartiles are statistically significant only in the case of stroke where risks are higher for lower quartiles, as compared to the highest quartile. This suggests that those in lower quartiles have higher likelihood of stroke.

As compared to 2008, likelihood of diabetes rises during subsequent years. For blood pressure and stroke, the risks are significantly lower in 2010 but higher in subsequent years. For heart problems, the risks are lower for 2010 and 2016 but there is no significant difference between 2008 and 2012, and 2014. For cancer, while 2008 and 2010 prevalences are not significantly different, these are higher for 2012, 2014 and 2016. For at least one NCD, 2010 and 2014 show lower prevalences but higher in 2012, and no significant difference is found between 2008 and 2016.

6. Discussion

Drawing upon a selective summary, some observations are made from a broad policy perspective.

WHO estimates show that the burden from NCDs in South Africa is 2-3 times higher than that in developed countries, and similar to that in other sub-Saharan countries and central European countries that appear in the highest burden quintile. These diseases are on the increase in rural communities, and affect disproportionately poor people living in urban settings, and are responsible for a rise in the demand for chronic disease care (Mayosi et al. 2009).

Many NCDs share common risk factors such as tobacco use, physical inactivity, and unhealthy diets that are associated with cardio-vascular diseases (CVDs), diabetes, and cancer. The South African adult population has high levels of these risk factors, and large proportions of the disease burden can be attributed to these modifiable risk factors. Mental disorders increase the risk for all these diseases, which in turn increase the risk for mental disorders.

A policy shift from a singular disease focus to individual patient as one unit is needed. In the South African context, for example, diabetes and depression are separated within the health-care institution so that someone with depressive symptoms during routine diabetes care does not have access to medical attention for the latter (Mendenhall et al. 2017). Our analysis thus acquires greater significance.

Our results show robust associations between NCDs and depression or, more broadly, NCDs and mental health in South Africa. Without controls, those depressed or with poor mental health show greater likelihood of diabetes, high blood pressure, stroke and at least one NCD, relative to those who are not.

With controls for socio-economic factors, the initial conditions of moderate and severe depression are robustly associated with NCDs such as high blood pressure, stroke, heart diseases, cancer, and at least one NCD. This result is also consistent with mental health conditions where poor baseline mental health condition increases the risk of NCDs later. Moreover, the risk of NCDs is higher when severe depression or poor mental health conditions are present—with slightly larger risk when severe mental health conditions co-occur with an NCD in the initial year.

Older persons, relative to 30-44 years old, are more likely to suffer from NCDs (e.g., diabetes, high blood pressure and at least one NCD). The oldest (>75 years) show greater vulnerability to all NCDs except cancer and stroke.

Women are more likely to suffer from most NCDs (except stroke) than men. In fact, there are distinct differences between sexes, with smoking and alcohol use being more common in men and obesity more common in women (Mayosi et al. 2009).

All those with education up to 10 grades show greater vulnerability to NCDs such as high blood pressure, heart diseases and at least one NCD, as compared with those with higher educational attainments.

Relative to the Africans, the Whites are less likely to suffer from diabetes but more vulnerable to heart diseases, cancer and at least one NCD. The Coloureds have higher risks of NCDs while the Asians/ Indians are more vulnerable to diabetes and heart related problems. Mayosi et al. (2009) speculate that, at older ages, the proportion of black Africans is higher than it was previously which might account for the decrease in lung cancer because black Africans have a lower rate of smoking than do White and Coloured people. The South African Indian community is more insulin resistant than other ethnic groups and therefore at greater risk of diabetes type 2 and ischaemic heart disease.

Although there is no evidence of a gradient between NCDs and wealth quartiles, there are a few striking contrasts. Relative to the wealthiest /fourth wealth quartile, the least wealthy/first quartile are less likely to suffer from diabetes, high blood pressure, and stroke, while those in the second quartile show a lower risk of stroke. So, the proposition that NCDs are diseases of affluence has some merit.

Verification of whether there is a residual time trend yields mixed results. Relative to 2008, prevalence of diabetes rises in subsequent years, is higher for cancer in 2012, 2014 and 2016, and lower for heart diseases in 2010 and 2016.

There are, however, a few implausible results (e.g., lack of association between NCDs and smoking and alcohol consumption, and between NCDs and physical exercise). These call for a more detailed scrutiny as the data are patchy.

Some major policy concerns are discussed briefly below.

Primary care is key to a high-quality health system, serving as the main entry point for most concerns and playing a crucial role in coordinating care and ensuring continuity across health system platforms. Uncomplicated non-communicable diseases are well suited for care at the primary level, where providers can more effectively monitor chronic diseases over time and build relationships that make for effective communication and counselling regarding crucial lifestyle modifications. Besides, complications of diabetes such as blindness, kidney failure, and lower limb amputation can be largely averted through high-quality primary care (Huffman et al. 2013). A daunting challenge for South Africa, however, is to strengthen the district-based primary health-care system, to integrate the care of chronic diseases and management of risk factors, to develop a national surveillance system, and to apply interventions of proven cost-effectiveness in the primary and secondary prevention of such diseases within populations and health services (Mayosi et al. 2009).

Behavioural factors matter too in the relationship between depression and NCDs (notably, CVDs, diabetes). Depressed patients are less likely to engage in health promoting behaviours, including maintenance of a healthy diet, regular exercise, adherence to medications, stress reduction, and completion of cardiac rehabilitation programmes following MI. Medication nonadherence and lower physical fitness are associated with an increased risk of cardiovascular events in certain populations, and this additionally suggests that the behavioural changes associated with depression may be associated with the progression of CAD and poor cardiac outcomes in patients with and without established CVD (Huffman et al. 2013). A case in point is the effectiveness of the Tobacco Products Control Act of 1993 in stabilizing or decreasing the death rates of smoking-related cardiovascular and respiratory diseases and cancers. By contrast, alcohol use has remained largely unaffected through taxes (Mayosi et al. 2009).

It seems plausible that higher education and awareness campaigns could lead to healthier diets and life styles.

Evidence suggests that despite aged individuals being in worse health than the younger, they use health services significantly less frequently. These patterns of utilization arise from barriers to access, lack of appropriate services and the prioritization of services towards the old (WHO, 2015). Beard and Bloom (2015), for example, are emphatic that surveillance of health behaviours in ageing population remains imperfect and surmise that substantial benefits may accrue if neglected areas of health promotion and disease prevention in older age are prioritized.

A larger ethical issue is rationing of aged health care on the notion that health services are scarce and must be allocated to achieve the greatest good for the greatest number of people. WHO (2015) rejects this view on two counterarguments: ageing populations have made the greatest contribution to socioeconomic development that created these services; and they are entitled to live a dignified and healthy life.

Some limitations of the analysis must be noted. Two somewhat glaring omissions are (i) a detailed analysis of the impact of health system and services on prevalence of NCDs; and (ii) the pathways through which depression affects dietary behaviour and its impact on NCDs. We are unable to address these issues because of data constraints. From this perspective, it seems worthwhile to build on the innovative study of pathways between past mental health and current physical health by Ohrnberger et al. (2017).

7. Concluding Observations

Although South Africa faces a quadruple disease burden including poverty –related diseases, non-communicable diseases, injuries and HIV/AIDS, our present analysis is confined to the associations from depression to selected NCDs, with controls for socio-economic and demographic covariates. The robust associations from depression to NCDs raise serious policy concerns that can be addressed cost-effectively through integrated medical services which shift the focus from individual disease to individual patients. Key to this major health sector reform lies in better equipping and reorganisation of primary health care and upgradation of its quality. That quality of health care matters for both health outcomes and mortality is demonstrated conclusively by Kruk et al. (2018). In fact, for a select

list of medical conditions, they report that globally 8 million deaths could be averted with access to high-quality care.

South Africa set about reforming its outdated apartheid –era mental health legislation, and in 2004 the Mental Care Act (No. 17 of 2002) was promulgated. In many ways, it is a landmark legislation as it aims to improve access, make primary health care the first contact of mental health care with the health system, promotes the integration of mental health care into general health services and the development of community- based services. However, implementation of this act has been tardy and unsatisfactory because of insufficient funding and lack of local political accountability (Coovalia et al. 2009, Republic of South Africa, nd).

The National Mental Health Policy Framework and Strategic Plan 2013-2020 (Republic of South Africa, 2017) identifies major lacunae in the health policies and system and offers a bold and compelling but overambitious vision. It is all encompassing and tends to underplay the institutional and financial constraints.

It seeks to redress the lop-sidedness of the integration of mental health care into primary health care focused narrowly on the emergency management and ongoing psychopharmacological care of patients with chronic stabilized mental disorders, with little coverage of adults with depression and anxiety disorders.

Other salient features include empowerment of local communities, especially mental health service users and carers, to participate in promoting mental well-being and recovery within their communities; to establish a monitoring and evaluation system for mental health care; ensuring mental health care users have access to care in close proximity to where they live and work; provide services accessible to all people, regardless of geographical location, economic status, race, gender or social condition; above all, mental health services should have parity with general health services.

Equally daunting is ensuring equitable access to education, employment, housing, and social supports; financing of mental health care on par with other health financing; and protection of people with the catastrophic financial consequences of mental ill-health. A case in point is the National Health

Insurance System that accords parity between mental health services and other health conditions. An Editorial in the *Lancet* (2009) endorses an affordable national health insurance as key to sustainable and equitable access to health services for all.

Routine screening and treatment of physical illness in all consultations for people with mental illness in primary health care will be implemented.

A case could be made for substantially higher investment in primary health-care systems (Mayosi et al. 2009, Prince et al. 2007, Huffman et al. 2013). On the supply side, these investments include greater accountability of services to local communities, enhanced sensitivity of providers to local conditions and beliefs, and provision of care to the needy. On the demand side, effective local services can address complex problems of patient access, offset the financial burden of adult chronic illness, and restrict unnecessary use of expensive private care.

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Table 1

Definitions of variables

Dependent Variables	*Definition*
Diabetes	=1 if diabetes, 0 otherwise
High blood pressure	=1 if high blood pressure, 0 otherwise
Stroke	=1 if stroke, 0 otherwise
Heart problems	=1 if heart problems, 0 otherwise
Cancer	=1 if cancer, 0 otherwise
Any NCDs	=1 if at least one of the NCDs (Diabetes, High blood pressure, Stroke, Heart problems, and Cancer), 0 if none
Key Explanatory Variables	
Depression condition: baseline	
Mild depression: baseline (reference)	=1 if feels depressed for less than 3 days in a week, 0 otherwise
Moderate depression: baseline	=1 if feels depressed for 3-4 days in a week, 0 otherwise
Severe depression: baseline	=1 if feels depressed for 5-7 days in a week, 0 otherwise
Depression: baseline	=1 if feels depressed for 3 or more days in a week, 0 if only for <3 days
NCD and depression condition interactions: baseline	
Diabetes & depression: baseline	=1 if both diabetes and depression in baseline, 0 otherwise
Diabetes or depression: baseline	=1 if either of the diabetes and depression in baseline, 0 otherwise
No diabetes or depression: baseline(reference)	=1 if none of the diabetes and depression in baseline, 0 otherwise
High BP & depression: baseline	=1 if both high blood pressure and depression in baseline, 0 otherwise
High BP or depression: baseline	=1 if either of the high blood pressure and depression in baseline, 0 otherwise
No high BP or depression: baseline (reference)	=1 if none of the high blood pressure and depression in baseline, 0 otherwise
Stroke & depression: baseline	=1 if both stroke and depression in baseline, 0 otherwise
Stroke or depression: baseline	=1 if either of the stroke and depression in baseline, 0 otherwise
No stroke or depression: baseline (reference)	=1 if none of the stroke and depression in baseline, 0 otherwise
Heart & depression: baseline	=1 if both heart problems and depression in baseline, 0 otherwise
Heart or depression: baseline	=1 if either of the heart problems and depression in baseline, 0 otherwise
No heart or depression: baseline (reference)	=1 if none of the heart problems and depression in baseline, 0 otherwise
Cancer & depression: baseline	=1 if both cancer and depression in baseline, 0 otherwise
Cancer or depression: baseline	=1 if either of the cancer and depression in baseline, 0 otherwise
No cancer or depression: baseline (reference)	=1 if none of the cancer and depression in baseline, 0 otherwise
Any NCD & depression: baseline	=1 if both any NCD and depression in baseline, 0 otherwise
Any NCD or depression: baseline	=1 if either of the any NCD and depression in baseline, 0 otherwise
No NCD or depression: baseline (reference)	=1 if none of the any NCD and depression in baseline, 0 otherwise
Mental health Condition	
Mental health score: baseline	=mean score of 10 items on mental health
Good mental health: baseline (reference)	=1 if mental health score<3, 0 otherwise
Poor mental health: baseline	=1 if mental health score is >=3 (weak and moderate), 0 otherwise
NCDs and mental health condition interactions: baseline	
Diabetes & poor MH: baseline	=1 if both diabetes and poor mental health in baseline, 0 otherwise
Diabetes or poor MH: baseline	=1 if either of the diabetes and poor mental health in baseline, 0 otherwise
No diabetes or poor MH: baseline (reference)	=1 if none of the diabetes and poor mental health in baseline, 0 otherwise

High BP & poor MH: baseline	=1 if both high blood pressure and poor mental health in baseline, 0 otherwise
High BP or poor MH: baseline	=1 if either of the high blood pressure and poor mental health in baseline, 0 otherwise
No high BP or poor MH: baseline (reference)	=1 if none of the high blood pressure and poor mental health in baseline, 0 otherwise
Stroke & poor MH: baseline	=1 if both stroke and poor mental health in baseline, 0 otherwise
Stroke or poor MH: baseline	=1 if either of the stroke and poor mental health in baseline, 0 otherwise
No stroke or poor MH: baseline (reference)	=1 if none of the stroke and poor mental health in baseline, 0 otherwise
Heart & poor MH: baseline	=1 if both heart problems and poor mental health in baseline, 0 otherwise
Heart or poor MH: baseline	=1 if either of the heart problems and poor mental health in baseline, 0 otherwise
No heart or poor MH: baseline (reference)	=1 if none of the heart problems and poor mental health in baseline, 0 otherwise
Cancer & poor MH: baseline	=1 if both cancer and poor mental health in baseline, 0 otherwise
Cancer or poor MH: baseline	=1 if either of the cancer and poor mental health in baseline, 0 otherwise
No cancer or poor MH: baseline (reference)	=1 if none of the cancer and poor mental health in baseline, 0 otherwise
Any NCD & poor MH: baseline	=1 if both any NCD and poor mental health in baseline, 0 otherwise
Any NCD or poor MH: baseline	=1 if either of the any NCD and poor mental health in baseline, 0 otherwise
No NCD or poor MH: baseline (reference)	=1 if none of the any NCD and poor mental health in baseline, 0 otherwise
Gender	
Male	=1 if individual is male, 0 if female
Age group	
Age:30-44 (reference)	=1 if age group is 30-44, 0 otherwise
Age:45-59	=1 if age group is 45-59, 0 otherwise
Age:60-74	=1 if age group is 60-74, 0 otherwise
Age:75 and above	=1 if age group is 75 and above, 0 otherwise
Marital status	
Married or partnered (reference)	=1 if married or living with partner, 0 otherwise
Widow/divorced	=1 if widowed or divorced, 0 otherwise
Never married	=1 if never married, 0 otherwise
Education	
Education: up to grade 5	=1 if education up to primary including illiterate, 0 otherwise
Education: grade 6 to grade 10	=1 if education from grade 6 to grade 10, 0 otherwise
Education: grade above 10 (reference)	=1 if higher education grade 11 and above, 0 otherwise
Household size	
Family size: single	=1 if Household size=1, 0 otherwise
Family size: 2-4 (reference)	=1 if Household size>=2 but <=4, 0 otherwise
Family size: 5-7	=1 if Household size>=5 but <=7, 0 otherwise
Family size: 8 or above	=1 if Household size>=8, 0 otherwise
Population group	
Population group: White	=1 if White, 0 otherwise (reference)
Population group: Coloured	=1 if Coloured, 0 otherwise
Population group: African (reference)	=1 if African, 0 otherwise
Population group: Asian/Indian/others	=1 if Asian, Indian and other, 0 otherwise
Exercise	
Exercise	=1 if exercise at least once a week, 0 if never exercise or less than once a week
Wealth quartiles	
Wealth: 1st quartile	Wealth index: 1st quartile
Wealth: 2nd quartile	Wealth index: 2nd quartile
Wealth: 3rd quartile	Wealth index: 3rd quartile

Wealth: 4th quartile (reference)	Wealth index: 4th quartile
Other household and community variables	
Negative events in family in past 24 months	=1 if there is any negative event in the family in past 24 months, 0 otherwise
Smoke and alcohol: baseline	=1 if smoke cigarette and drink alcohol, 0 otherwise
Any pension	=1 if receiving any pension, 0 otherwise
Social trust	= 1 if very likely that imagine you lost a wallet or purse that contained R200 and it was found by someone who lives close by, 0 if unlikely or somewhat likely
Mean of time-variant variables	
Mean age:30-44 (reference)	Mean of age: 30-44
Mean age:45-59	Mean of age: 45-59
Mean age:60-74	Mean of age: 60-74
Mean age:75 and above	Mean of age: 75 and above
Mean wealth: 1st quartile	Mean of wealth: 1st quartile
Mean wealth: 2nd quartile	Mean of wealth: 2nd quartile
Mean wealth: 3rd quartile	Mean of wealth: 3rd quartile
Mean wealth: 4th quartile (reference)	Mean of wealth: 4th quartile
Wave 1 dummy: 2008 (reference)	=1 if 1st wave, 0 otherwise
Wave 2 dummy: 2010	=1 if 2nd wave, 0 otherwise
Wave 3 dummy: 2012	=1 if 3rd wave, 0 otherwise
Wave 4 dummy: 2014	=1 if 4th wave, 0 otherwise
Wave 5 dummy: 2016	=1 if 5th wave, 0 otherwise

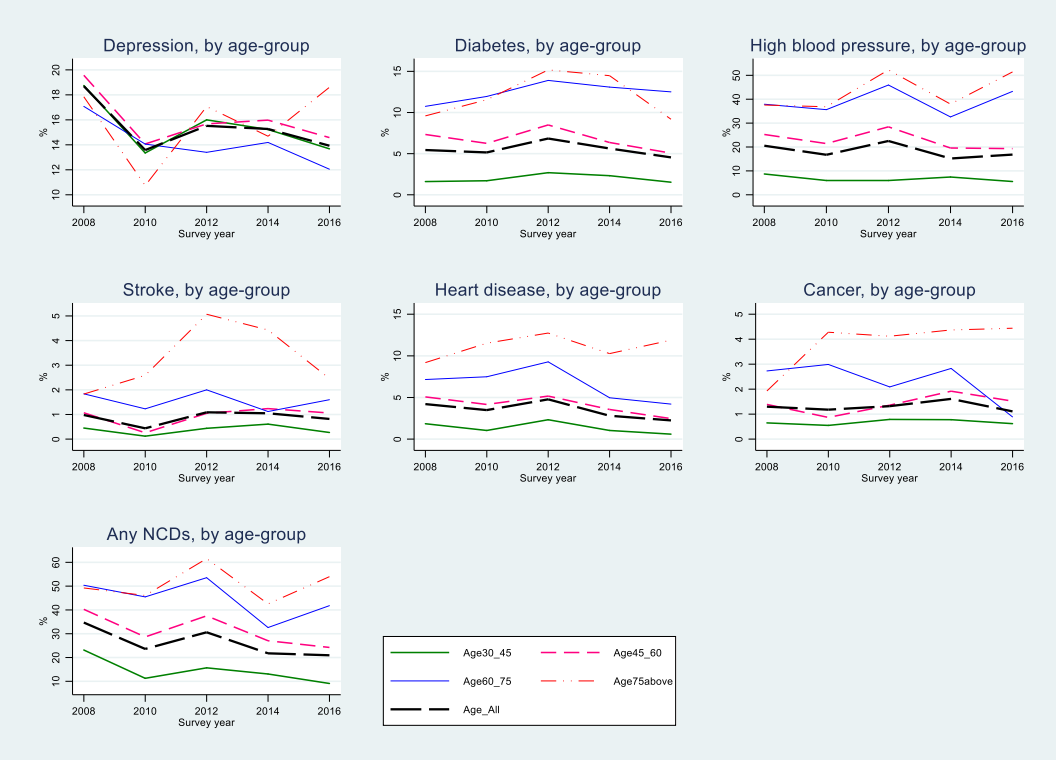

Figure 1: % distribution of population with depression and NCDs by age group, 2008-2016

Table 2

Transition probabilities

	Not depressed				Depressed				All			
	00	**01**	**10**	**11**	**00**	**01**	**10**	**11**	**00**	**01**	**10**	**11**
Diabetes	96.8	3.2	34.8	65.2	96.3	3.7	29.8	70.2	96.6	3.4	34.6	65.4
High BP	89.2	10.8	29.5	70.5	85.9	14.1	26.7	73.3	88.8	11.2	30.1	69.9
Stroke	99.4	0.6	70.4	29.6	99.2	0.8	81.8	18.2	99.2	0.8	63.2	36.8
Heart	98.0	2.0	53.0	47.0	96.2	3.8	55.3	44.7	97.7	2.3	53.5	46.5
Cancer	99.2	0.8	44.8	55.2	99.1	0.9	28.6	71.4	99.1	0.9	53.7	46.3
Any NCD	80.7	19.3	54.3	45.7	73.2	26.8	45.8	54.2	80.0	20.1	51.7	48.3

Note: 00: condition absent in year t, absent in year t+1; **01**: condition absent in year t, present in year t+1; **10**: condition present in year t, absent in year t+1; **11**: condition present in year t, present in year t+1.

Table 3

Correlated Random effects probit regression models for NCDs: Baseline depression

	Diabetes		High Blood Pressure		Stroke		Heart Problems		Cancer		Any NCD	
Variables	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME
Moderate depression: baseline	0.130	0.001	0.250***	0.042***	0.373**	0.000	0.363***	0.004***	0.174	0.000	0.292***	0.062***
	(0.095)	(0.001)	(0.061)	(0.010)	(0.164)	(0.000)	(0.075)	(0.001)	(0.146)	(0.000)	(0.058)	(0.012)
Severe depression: baseline	0.087	0.001	0.401***	0.067***	0.602***	0.000	0.586***	0.006***	0.403*	0.000	0.453***	0.095***
	(0.140)	(0.002)	(0.095)	(0.016)	(0.223)	(0.000)	(0.103)	(0.001)	(0.217)	(0.000)	(0.091)	(0.019)
Male	-0.259***	-0.003***	-0.797***	-0.133***	-0.072	-0.000	-0.385***	-0.004***	-0.337***	-0.0001*	-0.693***	-0.146***
	(0.074)	(0.001)	(0.051)	(0.008)	(0.134)	(0.000)	(0.069)	(0.001)	(0.117)	(0.00007)	(0.048)	(0.010)
Age:45-59	0.453***	0.005***	0.413***	0.069***	0.510**	0.000	0.313***	0.003***	0.224	0.000	0.310***	0.065***
	(0.104)	(0.001)	(0.060)	(0.010)	(0.211)	(0.000)	(0.103)	(0.001)	(0.174)	(0.000)	(0.056)	(0.012)
Age:60-74	0.493***	0.005***	0.508***	0.085***	0.477	0.000	0.187	0.002	0.183	0.000	0.366***	0.077***
	(0.148)	(0.002)	(0.093)	(0.016)	(0.325)	(0.000)	(0.150)	(0.002)	(0.264)	(0.000)	(0.089)	(0.019)
Age:75 and above	0.433**	0.005**	0.455***	0.076***	0.554	0.000	0.353*	0.004*	0.101	0.000	0.415***	0.087***
	(0.197)	(0.002)	(0.136)	(0.023)	(0.410)	(0.000)	(0.196)	(0.002)	(0.362)	(0.000)	(0.132)	(0.028)
Education: up to grade 5	-0.062	-0.001	0.422***	0.070***	-0.014	-0.000	0.362***	0.004***	-0.198	-0.000	0.414***	0.087***
	(0.104)	(0.001)	(0.066)	(0.011)	(0.200)	(0.000)	(0.097)	(0.001)	(0.173)	(0.000)	(0.062)	(0.013)
Education: grade 6 to grade 10	-0.043	-0.000	0.367***	0.061***	0.118	0.000	0.414***	0.004***	-0.137	-0.000	0.342***	0.072***
	(0.090)	(0.001)	(0.056)	(0.009)	(0.160)	(0.000)	(0.081)	(0.001)	(0.134)	(0.000)	(0.052)	(0.011)
Widow/divorced	-0.011	-0.000	-0.045	-0.007	-0.105	-0.000	0.014	0.000	-0.120	-0.000	-0.026	-0.006
	(0.068)	(0.001)	(0.046)	(0.008)	(0.142)	(0.000)	(0.068)	(0.001)	(0.121)	(0.000)	(0.045)	(0.010)
Never married	-0.198**	-0.002**	-0.223***	-0.037***	-0.014	-0.000	-0.006	-0.000	-0.089	-0.000	-0.186***	-0.039***
	(0.078)	(0.001)	(0.047)	(0.008)	(0.136)	(0.000)	(0.069)	(0.001)	(0.126)	(0.000)	(0.044)	(0.009)
Exercise	-0.014	-0.000	0.015	0.002	0.064	0.000	0.077	0.001	0.108	0.000	0.034	0.007
	(0.062)	(0.001)	(0.040)	(0.007)	(0.135)	(0.000)	(0.061)	(0.001)	(0.099)	(0.000)	(0.037)	(0.008)
Smoke and alcohol: baseline	-0.373***	-0.004***	-0.027	-0.005	0.089	0.000	-0.001	-0.000	-0.071	-0.000	-0.059	-0.012
	(0.108)	(0.001)	(0.069)	(0.012)	(0.177)	(0.000)	(0.091)	(0.001)	(0.150)	(0.000)	(0.065)	(0.014)
Family size: single	0.155	0.002	0.030	0.005	-0.191	-0.000	0.091	0.001	0.001	0.000	-0.051	-0.011
	(0.104)	(0.001)	(0.069)	(0.012)	(0.210)	(0.000)	(0.098)	(0.001)	(0.169)	(0.000)	(0.064)	(0.014)
Family size: 5-7	-0.045	-0.000	-0.137***	-0.023***	0.056	0.000	-0.049	-0.001	0.054	0.000	-0.126***	-0.026***
	(0.058)	(0.001)	(0.038)	(0.006)	(0.114)	(0.000)	(0.055)	(0.001)	(0.105)	(0.000)	(0.035)	(0.007)
Family size: 8 or above	0.042	0.000	-0.168***	-0.028***	-0.046	-0.000	-0.033	-0.000	0.143	0.000	-0.160***	-0.034***
	(0.075)	(0.001)	(0.049)	(0.008)	(0.144)	(0.000)	(0.072)	(0.001)	(0.132)	(0.000)	(0.046)	(0.010)
Negative events in family in past 24 months	0.184**	0.002**	0.105**	0.018**	0.208	0.000	0.198**	0.002**	0.175	0.000	0.134***	0.028***
	(0.077)	(0.001)	(0.051)	(0.009)	(0.149)	(0.000)	(0.077)	(0.001)	(0.132)	(0.000)	(0.048)	(0.010)
Social trust	0.048	0.001	-0.045	-0.007	-0.178	-0.000	0.007	0.000	0.005	0.000	-0.005	-0.001
	(0.059)	(0.001)	(0.039)	(0.007)	(0.142)	(0.000)	(0.060)	(0.001)	(0.108)	(0.000)	(0.036)	(0.008)
Any pension	0.136**	0.001**	0.131***	0.022***	0.098	0.000	0.122*	0.001*	0.135	0.000	0.154***	0.032***
	(0.066)	(0.001)	(0.043)	(0.007)	(0.151)	(0.000)	(0.067)	(0.001)	(0.115)	(0.000)	(0.040)	(0.009)
Population group: White	-0.411***	-0.004**	-0.084	-0.014	-0.518	-0.000	0.503***	0.005***	1.345***	0.0005**	0.255***	0.054***
	(0.157)	(0.002)	(0.102)	(0.017)	(0.354)	(0.000)	(0.124)	(0.002)	(0.202)	(0.0002)	(0.094)	(0.020)
Population group: Coloured	0.233**	0.003**	0.480***	0.080***	0.471***	0.000	0.243***	0.003***	0.342**	0.0001*	0.532***	0.112***
	(0.092)	(0.001)	(0.062)	(0.010)	(0.158)	(0.000)	(0.081)	(0.001)	(0.143)	(0.00007)	(0.060)	(0.012)
Population group: Asian/Indian/others	0.949***	0.010***	0.084	0.014	-0.464	-0.000	0.703***	0.007***	0.110	0.000	0.357*	0.075*
	(0.227)	(0.003)	(0.190)	(0.032)	(0.581)	(0.000)	(0.209)	(0.002)	(0.435)	(0.000)	(0.183)	(0.038)
Wealth: 1st quartile	-0.324*	-0.003*	-0.246**	-0.041**	-0.780**	-0.000	-0.127	-0.001	-0.212	-0.000	-0.200*	-0.042*
	(0.173)	(0.002)	(0.112)	(0.019)	(0.359)	(0.000)	(0.171)	(0.002)	(0.316)	(0.000)	(0.105)	(0.022)
Wealth: 2nd quartile	-0.149	-0.002	-0.149*	-0.025*	-0.529*	-0.000	-0.094	-0.001	0.118	0.000	-0.107	-0.023
	(0.132)	(0.001)	(0.089)	(0.015)	(0.296)	(0.000)	(0.135)	(0.001)	(0.250)	(0.000)	(0.083)	(0.018)
Wealth: 3rd quartile	-0.057	-0.001	-0.006	-0.001	-0.106	-0.000	-0.035	-0.000	0.177	0.000	0.022	0.005
	(0.090)	(0.001)	(0.065)	(0.011)	(0.225)	(0.000)	(0.095)	(0.001)	(0.179)	(0.000)	(0.061)	(0.013)
Mean age:45-59	1.134***	0.012***	1.037***	0.173***	0.406*	0.000	0.342***	0.004***	0.340*	0.000	1.089***	0.229***
	(0.135)	(0.002)	(0.079)	(0.013)	(0.230)	(0.000)	(0.116)	(0.001)	(0.202)	(0.000)	(0.073)	(0.015)
Mean age:60-74	1.599***	0.017***	1.605***	0.268***	0.942***	0.000	0.668***	0.007***	0.559**	0.000	1.656***	0.349***
	(0.176)	(0.003)	(0.111)	(0.018)	(0.338)	(0.000)	(0.159)	(0.002)	(0.275)	(0.000)	(0.105)	(0.021)
Mean age:75 and above	1.636***	0.018***	1.692***	0.282***	1.171***	0.000	0.852***	0.009***	0.909**	0.000	1.721***	0.363***
	(0.227)	(0.003)	(0.156)	(0.026)	(0.447)	(0.000)	(0.212)	(0.003)	(0.385)	(0.000)	(0.149)	(0.030)
Mean wealth: 1st quartile	-0.216	-0.002	-0.134	-0.022	0.947**	0.000	-0.200	-0.002	-0.119	-0.000	-0.189*	-0.040*
	(0.169)	(0.002)	(0.110)	(0.018)	(0.379)	(0.000)	(0.170)	(0.002)	(0.326)	(0.000)	(0.104)	(0.022)
Mean wealth: 2nd quartile	-0.144	-0.002	-0.083	-0.014	0.665**	0.000	-0.061	-0.001	-0.324	-0.000	-0.128	-0.027
	(0.128)	(0.001)	(0.087)	(0.014)	(0.306)	(0.000)	(0.130)	(0.001)	(0.248)	(0.000)	(0.082)	(0.017)
Mean wealth: 3rd quartile	-0.083	-0.001	-0.089	-0.015	0.419*	0.000	-0.100	-0.001	-0.212	-0.000	-0.138**	-0.029**
	(0.089)	(0.001)	(0.064)	(0.011)	(0.234)	(0.000)	(0.094)	(0.001)	(0.176)	(0.000)	(0.060)	(0.013)
Wave 2 dummy: 2010	0.136**	0.001**	-0.131***	-0.018***	-0.749***	-0.000	-0.265***	-0.002***	-0.019	-0.000	-0.166***	-0.031***
	(0.061)	(0.000)	(0.039)	(0.005)	(0.171)	(0.000)	(0.060)	(0.001)	(0.121)	(0.000)	(0.036)	(0.007)
Wave 3 dummy: 2012	0.334***	0.003***	0.434***	0.072***	0.259*	0.000	0.076	0.001	0.251**	0.000	0.374***	0.078***
	(0.063)	(0.001)	(0.039)	(0.006)	(0.135)	(0.000)	(0.060)	(0.001)	(0.116)	(0.000)	(0.037)	(0.008)
Wave 4 dummy: 2014	0.417***	0.004***	0.451***	0.075***	0.459***	0.000	-0.012	-0.000	0.623***	0.0003**	0.525***	0.112***
	(0.077)	(0.001)	(0.050)	(0.008)	(0.148)	(0.000)	(0.071)	(0.001)	(0.130)	(0.0001)	(0.045)	(0.009)
Wave 5 dummy: 2016	0.540***	0.006***	0.573***	0.099***	0.371**	0.000	-0.177**	-0.002**	0.488***	0.000	0.567***	0.122***
	(0.083)	(0.001)	(0.052)	(0.009)	(0.169)	(0.000)	(0.082)	(0.001)	(0.152)	(0.000)	(0.049)	(0.010)
Constant	-4.453***		-2.635***		-6.304***		-3.682***		-5.171***		-2.194***	
	(0.170)		(0.084)		(0.487)		(0.149)		(0.364)		(0.075)	
lnsig2u	1.228***		0.865***		1.256***		0.553***		1.030***		0.828***	
	(0.074)		(0.044)		(0.163)		(0.088)		(0.158)		(0.032)	
Observations	33,557		31,690		34,111		33,890		34,195		31,329	
Number of individuals	10,826		10,777		10,830		10,822		10,831		10,759	
Wald Chi-square (34)	527.8***		1905***		101.2***		392.4***		120.3***		2058***	

Note: Robust standard errors in parentheses. Coeff: Coefficients, ME: Marginal effects. *** p<0.01, ** p<0.05, * p<0.1

Table 4

Correlated Random effects probit regression models for NCDs: Baseline NCDs with or without depression

	Diabetes		High Blood Pressure		Stroke		Heart Problems		Cancer		Any NCD	
Variables	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME
Diabetes & depression: baseline	4.261***	0.086***										
	(0.225)	(0.006)										
Diabetes or depression: baseline	1.327***	0.027***										
	(0.077)	(0.003)										
High BP & depression: baseline			2.870***	0.413***								
			(0.091)	(0.010)								
High BP or depression: baseline			1.599***	0.230***								
			(0.044)	(0.005)								
Stroke & depression: baseline					5.057***	0.006***						
					(0.401)	(0.001)						
Stroke or depression: baseline					0.922***	0.001***						
					(0.128)	(0.000)						
Heart & depression: baseline							3.110***	0.064***				
							(0.142)	(0.004)				
Heart or depression: baseline							1.092***	0.022***				
							(0.064)	(0.002)				
Cancer & depression: baseline									4.606***	0.008***		
									(0.383)	(0.002)		
Cancer or depression: baseline									0.719***	0.001***		
									(0.106)	(0.000)		
Any NCD & depression: baseline											2.753***	0.470***
											(0.081)	(0.010)
Any NCD or depression: baseline											1.787***	0.305***
											(0.042)	(0.005)
lnsig2u	0.913***		0.349***		0.780***		0.186**		0.491***		0.249***	
	(0.072)		(0.046)		(0.166)		(0.091)		(0.178)		(0.043)	
Constant	-4.447***		-2.816***		-5.752***		-3.638***		-4.612***		-2.538***	
	(0.164)		(0.078)		(0.400)		(0.136)		(0.305)		(0.070)	
Observations	33,871		31,911		34,470		34,262		34,543		31,137	
Number of individuals	11,036		10,942		11,060		11,060		11,059		10,683	
Wald Chi-square (34)	662.1***		2603***		209.1***		694.2***		184.3***		3096***	

Note: Control variables included in the model are same as used in Table 2, except depression dummies. Full estimates are available upon request. Robust standard errors in parentheses.
Coeff: Coefficients, ME: Marginal effects. *** p<0.01, ** p<0.05, * p<0.1

Table 5

Correlated Random effects probit regression models for NCDs: Baseline Mental health score

	Diabetes		High Blood Pressure		Stroke		Heart Problems		Cancer		Any NCD	
Variables	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME
Mental health score: baseline	0.125*	0.001*	0.249***	0.041***	0.458***	0.000	0.361***	0.004***	0.212**	0.000*	0.279***	0.058***
	(0.066)	(0.001)	(0.045)	(0.007)	(0.114)	(0.000)	(0.055)	(0.001)	(0.090)	(0.000)	(0.042)	(0.009)
lnsig2u	1.226***		0.862***		1.206***		0.545***		0.680***		0.825***	
	(0.075)		(0.044)		(0.161)		(0.088)		(0.130)		(0.042)	
Constant	-4.684***		-3.051***		-6.962***		-4.244***		-4.933***		-2.652***	
	(0.211)		(0.118)		(0.563)		(0.184)		(0.307)		(0.108)	
Observations	33,691		31,835		34,240		34,020		34,327		31,463	
Number of individuals	10,981		10,931		10,985		10,979		10,987		10,913	
Wald Chi-square (33)	521.8***		1900***		108.3***		385.4***		158.8***		2052***	

Control variables included in the model are same as used in Table 2, except depression dummies. Full estimates are available upon request. Robust standard errors in parentheses. Coeff: Coefficients, ME: Marginal effects. *** p<0.01, ** p<0.05, * p<0.1

Table 6

Correlated Random effects probit regression models for NCDs: Baseline NCDs with or without poor mental health

	Diabetes		High Blood Pressure		Stroke		Heart Problems		Cancer		Any NCD	
Variables	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME	Coeff	ME
Diabetes & poor MH: baseline	3.703***	0.107***										
	(0.417)	(0.010)										
Diabetes or poor MH: baseline	2.721***	0.079***										
	(0.123)	(0.004)										
High BP & poor MH: baseline			2.826***	0.334***								
			(0.179)	(0.020)								
High BP or poor MH: baseline			2.372***	0.280***								
			(0.059)	(0.004)								
Stroke & poor MH: baseline					4.543***	0.008***						
					(0.609)	(0.002)						
Stroke or poor MH: baseline					2.143***	0.004***						
					(0.225)	(0.001)						
Heart & depression: baseline							3.049***	0.073***				
							(0.221)	(0.005)				
Heart or depression: baseline							2.009***	0.048***				
							(0.100)	(0.003)				
Cancer & depression: baseline									5.112***	0.012***		
									(0.679)	(0.003)		
Cancer or depression: baseline									2.120***	0.005***		
									(0.219)	(0.001)		
Any NCD & depression: baseline											2.659***	0.370***
											(0.163)	(0.021)
Any NCD or depression: baseline											2.460***	0.343***
											(0.055)	(0.004)
lnsig2u	0.701***		0.004		0.720***		0.057		0.757***		-0.089*	
	(0.088)		(0.057)		(0.200)		(0.112)		(0.194)		(0.053)	
Constant	-4.188***		-2.514***		-5.462***		-3.614***		-5.133***		-2.300***	
	(0.179)		(0.080)		(0.469)		(0.158)		(0.409)		(0.073)	
Observations	24,294		22,975		24,764		24,594		24,785		22,367	
Number of individuals	7,955		7,903		7,977		7,977		7,975		7,704	
Wald Chi-square (34)	632.1***		2380***		140.1***		572.2***		141.7***		2762***	

Note: Control variables included in the model are same as used in Table 2, except depression dummies. Full estimates are available upon request. Robust standard errors in parentheses.
Coeff: Coefficients, ME: Marginal effects. *** p<0.01, ** p<0.05, * p<0.1