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Exploring the relationship between non-communicable diseases and depression

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SHARE Acknowledgement

The analyses presented here are based on data from the Survey of Health, Ageing and Retirement in Europe (SHARE). SHARE is a unique panel database of microdata covering most countries in the European Union and Israel (Börsch-Supan et al., 2013[1]). See Börsch-Supan et al. for methodological details (2013[1]) and Bergmann, M. *et al.,* for response and retention rates (Bergmann et al., 2019[2]).

This paper uses data from SHARE Waves 1, 2, 4, 5 and 6 (DOIs: 10.6103/SHARE.w1.800, 10.6103/SHARE.w2.800, 10.6103/SHARE.w4.800, 10.6103/SHARE.w5.800, 10.6103/SHARE.w6.800,) see Börsch-Supan et al. (2013[1]) *for methodological details.(1) The SHARE data collection has been funded by the European Commission, DG RTD through FP5 (QLK6-CT-2001-00360), FP6 (SHARE-I3: RII-CT-2006-062193, COMPARE: CIT5-CT-2005-028857, SHARELIFE: CIT4-CT-2006-028812), FP7 (SHARE-PREP: GA N°211909, SHARE-LEAP: GA N°227822, SHARE M4: GA N°261982, DASISH: GA N°283646) and Horizon 2020 (SHARE-DEV3: GA N°676536, SHARE-COHESION: GA N°870628, SERISS: GA N°654221, SSHOC: GA N°823782, SHARE-COVID19: GA N°101015924) and by DG Employment, Social Affairs & Inclusion through VS 2015/0195, VS 2016/0135, VS 2018/0285, VS 2019/0332, and VS 2020/0313. Additional funding from the German Ministry of Education and Research, the Max Planck Society for the Advancement of Science, the U.S. National Institute on Aging (U01_AG09740-13S2, P01_AG005842, P01_AG08291, P30_AG12815, R21_AG025169, Y1-AG-4553-01, IAG_BSR06-11, OGHA_04-064, HHSN271201300071C, RAG052527A) and from various national funding sources is gratefully acknowledged (see* www.share-project.org*)*

The SHARE study is subject to continuous ethics review. The continuation of the project was reviewed and approved by the Ethics Council of the Max-Planck-Society. Additionally, the relevant local research ethics committees for each participating country approved SHARE, and written consent was provided by all participants (Lusa and Huebner, 2021[3]).

Abstract

Non communicable diseases (NCDs) such as cancer, heart disease, stroke, chronic lung diseases and diabetes are the leading causes of death across OECD countries and represent a major disability burden among the living. At the same time, there is an increasing awareness of the prevalence and importance of mental ill health in society. In addition to personal suffering, both NCDs and mental ill health are associated with increased economic costs for governments through healthcare costs and lost productivity. As they often co-occur, it is crucial to better understand the relationship between NCDs and mental illnesses in order to develop policies that adequately address both.

The aim of this paper is to better understand the impact of NCDs on depression. SHARE data from 19 countries, collected between 2004 and 2015, was used to explore this relationship. The results suggest that people living with cancer have a 15% increased risk of depression, with heart disease an 18% increased risk, with diabetes an 18% increased risk, with stroke a 23% increased risk and with chronic lung disease a 27% increased risk of depression relative to those without, controlling for age, sex, and baseline depression status among other factors.

In addition, several analyses were conducted to support a causal relationship between NCDs and depression. This paper shows that new cases of depression follow the diagnosis of an NCD, and that the effect persists when using different variables representing mental ill health, and when adjusting for other variables that are known to also influence mental ill health. Additionally, analyses confirmed that the risk of depression increases with increasing numbers of NCDs, suggesting a dose-response effect.

This research underscores the importance of addressing the mental health and well-being of people living with NCDs. Furthermore, the findings suggest that strategies which aim to reduce the burden of NCDs could bring additional mental health co-benefits to society.

Résumé

Les maladies non transmissible (MNT) telles que le cancer, les maladies cardiaques, les accidents vasculaires cérébraux (AVC), les maladies pulmonaires chroniques et le diabète, sont les principales causes de décès dans les pays de l'OCDE et représentent un fardeau majeur en termes de handicap pour les personnes atteintes. Parallèlement, une prise de conscience émerge au sein de la société quant à la prévalence et l'importance des troubles mentaux. Au-delà des souffrances qu'ils causent chez les personnes touchées, les MNT et les troubles mentaux sont associés à des coûts économiques accrus pour les gouvernements, en raison des dépenses de santé et de la perte de productivité qu'ils entraînent. Puisqu'ils coexistent fréquemment, il est essentiel de mieux comprendre leur relation afin d'élaborer des politiques adaptées.

L'objectif de cet article est de mieux comprendre l'impact des MNT sur la dépression. Des données provenant de 19 pays, collectées entre 2004 et 2015, ont été utilisées pour explorer cette relation. Les résultats suggèrent que les personnes vivant avec un cancer présentent un risque accru de dépression de 15%, par rapport à la population générale, en contrôlant pour l'âge, le sexe, et le statut initial de dépression, parmi d'autres facteurs. Le risque de dépression augmente également pour d'autres maladies : de 18% chez les personnes souffrant de maladies cardiaques ou atteintes de diabète, de 23% chez celles ayant eu un AVC, et de 27% chez les personnes souffrant de maladies pulmonaires chroniques.

De plus, plusieurs analyses ont été réalisées pour soutenir un lien de causalité entre les MNT et la dépression. Ce document met en évidence la survenue de nouveaux cas de dépression associés au diagnostic de MNT, et montre que cet effet persiste malgré l'ajustement pour diverses variables représentant les troubles mentaux ainsi que d'autres facteurs connus pour influencer la santé mentale. De plus, les analyses confirment un risque accru de dépression concomitant à l'augmentation du nombre de cas de MNT, suggérant une relation dose-effet.

Cette recherche souligne l'importance de prendre en compte la santé mentale et le bien-être des personnes vivant avec des MNT. De plus, les résultats suggèrent que des stratégies visant à réduire le fardeau des MNT pourraient apporter des co-bénéfices supplémentaires en matière de santé mentale pour la société.

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List of acronyms

BMI	Body Mass Index
CI	Confidence Interval
COPD	Chronic obstructive pulmonary disease
NCDs	Non-Communicable Diseases
OECD	Organisation for Economic Co-operation and Development
OR	Odds ratio
RR	Relative Risk
SES	Socio-economic status
SHARE	Survey of Health, Ageing and Retirement in Europe
SPHEP	Strategic Public Health Planning
WHO	World Health Organization

In Brief

Non communicable diseases (NCDs) such as cancer, heart disease, stroke, chronic lung diseases and diabetes are the leading causes of death across OECD countries and represent a major disability burden among the living. At the same time, there is an increasing awareness of the prevalence and impact of mental ill health in society, particularly in the wake of the covid pandemic.

While NCDs and depression frequently occur together as there are environmental and behavioural factors that can commonly contribute to both, it is important to better understand whether NCDs are a direct cause of depression. If the relationship is causal, then policies should be developed to address the impact of NCDs on people's mental health, such as measures for early detection and support for mental ill health among people diagnosed with NCDs. In addition, it would mean that reducing the burden of NCDs would also reduce the burden of depression in society.

OECD analysis of SHARE data shows that NCDs increase the risk of experiencing depression. Having cancer is associated with a 15% increased risk of depression, people living with heart disease have an 18% increased risk, with diabetes an 18% increased risk, with stroke a 23% increased risk and with chronic lung disease a 27% increased risk of depression relative to those without.

Having one or more NCDs increases the risk of depression in a dose-responsive manner. One NCD increases the risk of depression by 21%, two by 42% and three or more by 50%. This dose-response relationship between the number of NCDs and risk of depression suggests that there is a causal relationship between NCDs and depression.

The relationship between NCDs and depression is consistent, even when different measures of depression are taken, strengthening the argument for causality. For example, people with one NCD had a 31% higher risk of taking medicines for anxiety or depression; those with two have a 61% higher risk, and those with three or more have a 77% higher risk.

The increase in depression with NCDs applies to all people in this study, regardless of gender or socioeconomic status. Women and people in financial difficulties are more likely to experience depression, regardless of the number of NCDs. Gender and socioeconomic gaps in depression risk persist, even as the overall risk of depression rises with increased NCDs.

There are several biological, psychological and social factors that drive the relationship between NCDs and depression. Psychologically and socially, loss of sense of self, social isolation from fatigue and lack of energy that drive loss of pursuit of normal activities, limitations to mobility, activities of daily living and chronic pain have all been associated. Fear and uncertainty of the incurable and unpredictable nature of certain NCDs contribute, as do beliefs about their NCDs and ability to self-manage their NCD. Biologically, neurodegeneration associated with certain NCDs and side effects of treatments associated with others play a role. Although bidirectionality and reverse causality cannot be ruled out, there is evidence that some shared risk factors drive both conditions via different mechanisms. At the same time, health promotion activities that address these shared risk factors such as exercise and smoking

cessation can subsequently improve both physical and mental health. Some of the risk factors specific to NCDs are also modifiable and when actioned upon can improve mental health, such as improved self-care and training in self-management of NCDs.

There are also important economic implications for the increased rates of depression among people with NCDs. Both NCDs and depression are individually associated with increased treatment costs and decreased productivity. However, healthcare costs are even greater when depression and NCD coexist. For example, studies have shown that having both diabetes and depression almost doubles individual healthcare costs, more than triples the number of hospitalisations for complications of diabetes and doubles the risk of multiple hospital admissions compared to having diabetes alone. Depression can also accelerate the disease course of NCDs due to a variety of factors such as reduced self-care, reduced adherence to treatments and less healthy life choices. The increased burden of depression among people with NCDs demands that mental health forms an integral part of policy planning and action on NCDs, from a primary, secondary and tertiary prevention standpoint. Health promotion actions could be evaluated and prioritised in light of their combined contribution to both physical and mental health. This compounding benefit should be factored into the cost-benefit analysis of exercise promotion programmes in NCD action plans.

In terms of tertiary prevention, improving self-management abilities of patients for their NCDs have been shown to slow progression, reduce costly hospitalisations and improve mental wellbeing. These outcomes should be considered when weighing up the resource costs and benefits of programmes, infrastructure and care delivery models designed to support self-management. Additionally, identifying and treating depression could help improve treatment adherence and participation in self-care and health promotion activities in certain cases. The consequent benefits to society from improved population productivity and reduced treatment costs warrant inclusion in NCD action plans.

The results in this paper will be incorporated into the OECD Strategic Public Health Planning (SPHeP) NCDs model so that depression can be systematically included in analysis on NCD prevention, allowing for a more comprehensive analysis of policy with mental health as a core component.

*Countries included in this analysis from the SHARE database: Austria, Belgium, Czechia, Denmark, Estonia, France, Germany, Greece, Hungary, Israel, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovenia, Spain, Sweden, Switzerland

1 Background

1. Non communicable diseases (NCDs), including cancer, diabetes, chronic lung diseases, stroke and heart disease contribute significantly to ill-health worldwide. NCDs are the leading causes of ill health globally, making up seven out of ten deaths worldwide (Bennett et al., 2018[4]) and 89% of deaths in OECD countries in 2019 (Murray et al., 2020[5]). NCDs accounted for 330 million disability adjusted life years (DALYs) in OECD countries in 2019, a 15% increase from an already high figure of 280 million in 2000 (Murray et al., 2020[5]). That increase alone is more than the entire burden of DALYs from all causes in 2019 in France and Germany combined. DALYs refer to the years of life lost due to premature mortality and the years lived with disability (Murray et al., 2012[6]).

2. Depression is one of the most common comorbidities of many NCDs (Gold et al., 2020[7]). Studies show rates of depression of up to 41% among certain NCDs (Berk et al., 2023[8]), 15-30% among patients with heart disease (Vaccarino et al., 2020[9]) and 17-24% among patients with cancer (Krebber et al., 2013[10]).

3. There are several factors that can explain how NCDs could cause depression that touch on the biological, psychological, and social aspects of the conditions.

- From a biological standpoint, the biological mechanisms of certain NCDs, such as neurodegeneration or brain lesions in stroke, Parkinson's and multiple sclerosis can impact emotional regulation and contribute to depression (Gold et al., 2020[7]). Medications and other treatments related to certain medical diseases can also play a role (Gold et al., 2020[7]; Lang and Borgwardt, 2013[11]).
- Psychological and social factors can majorly contribute. A meta-analysis and qualitative synthesis on patient experiences of depression and anxiety with chronic disease found in a majority of papers patients tended to experience depression as a consequence of being diagnosed with an NCD, with multiple factors such as uncertainty about the future, loss of sense of self, loss of relationships and social isolation and feelings of guilt contributing (DeJean et al., 2013[12]).
- From a symptom standpoint, limitations to mobility, activities of daily living and chronic pain have all been associated with depression among people with NCDs (Feng et al., 2023[13]; Jiang, Zhu and Qin, 2020[14]). Some patients find that fatigue and lack of energy keep them from pursuing their normal activities, and limitations in activities of daily living lead to feelings of frustration and sadness (DeJean et al., 2013[12]).
- Beliefs people hold about their disease and coping style can play a role (Ziarko et al., 2014[15]; Read et al., 2017[16]). Some patients report sudden episodes of panic waking up at night and being unable to sleep due to worrying about their NCD while others have a more constant feeling of uncertainty, attributed to the incurable nature of their disease, an unpredictable disease course or fears about death (DeJean et al., 2013[12]).

4. People living with NCDs as well as depression have poorer health outcomes and quality of life than people with only NCDs. Comorbidity of an NCD and depression worsens health more than any combination of NCDs without depression (Moussavi et al., 2007[17]). Adults with comorbid diabetes and

depression have been shown to be three times more likely to be hospitalised for complications of diabetes (McDaid and Park, 2014[18]; Subramaniam et al., 2009[19]), and to have double the risk of multiple hospital admissions compared to people with diabetes alone (Vamos et al., 2009[20]; McDaid and Park, 2014[18]). Depression has also been identified as an independent risk factor for both short- and long-term readmissions for acute exacerbation of chronic obstructive pulmonary disease (COPD) (Iyer et al., 2016[21])

5. In addition to the increased health burden, the co-occurrence of NCDs and depression also increases healthcare costs. In the United Kingdom, depression was found to be the most important cost-increasing condition among adults with NCDs, not only because it is the biggest contributor to comorbidity related expenses across all ages, but also because depression is highly prevalent (McDaid and Park, 2014[18]; Brilleman et al., 2013[22]). In the United States, healthcare costs for patients with diabetes and depression were almost USD 20 000 compared to USD 11 000 for people with only diabetes (McDaid and Park, 2014[18]; Le et al., 2011[23]). In France, a study by Cortaredona and Ventelous (2017[24]) found based on 2014 French data that major depression among people with at least one NCD increased healthcare expenditure from an additional EUR 1 246 (+/- EUR 555) for men aged 18-39 up to EUR 4 054 (+/- EUR 1 064) for women aged 85-89.

6. As NCDs and depression commonly co-occur, it is important to better understand the relationship between them. If NCDs increase the risk of depression, policies need to be developed to address the impact of NCDs on people's mental health. One way of doing this is through early detection and treatment of depression among people with NCDs. This could help to both improve overall wellbeing and additionally mitigate some of increased costs associated with having depression as a comorbidity. For example, psychosocial interventions can improve self-care behaviours and well-being, encouraging healthier lifestyles and better adherence to treatments, ultimately reducing hospitalisation and cost. There is significant overlap between well-being and NCD self-management, whereby learning self-management skills is associated with reduced depression (Campbell et al., 2022[25]), and where improved wellbeing can lead to better self-care and healthier lifestyle choices . Bundling psychological support with chronic disease management in an integrated care model also reflects and reinforces a patient centred approach with health promotion and well-being at its core.

7. In addition, it would mean that reducing the burden of NCDs would also reduce the burden of depression in society. In this case, the burden of depression should be taken into account when designing, implementing and evaluating the health and economic outcomes of public health policy that addresses NCDs.

8. This paper aims to increase our understanding of whether and to what extent NCDs play a role in determining the mental ill health of our societies, by evaluating and quantifying a potential causal relationship between NCDs and depression. It also contributes to more accurate modelling of public health policy, by including the impact of NCD prevention on mental well-being. Incorporating relative risks between NCDs and depression is one piece of the puzzle along with population dynamics, risk factor and NCD prevalences, labour market links and trajectory modelling that can allow us to better model the economic impacts of NCD linked depression, performed through the OECD SPHeP (Strategic Public Health Planning) model. These results will consequently help inform the development of the OECD SPHeP NCDs model (OECD, 2020[26]).

2 Methodology

9. As the relationship between NCDs and depression is complex, with many confounders and reverse causality, this study focused on establishing whether there is evidence to help support a causal relationship, in which NCDs lead to depression, and quantifying the strength of this relationship. The approach taken centred on causation principles described by Bradford Hill (1965[27]) among others, detailed further in Annex A.

2.1. Data used in this study

10. For this study data was used from the Survey of Health, Ageing and Retirement in Europe (SHARE) release version 8.0.0. SHARE is an ongoing project which began in 2004 that aims to collect information about sociodemographic characteristics, physical and mental health, health-related behaviours, economic status, and social networks from individuals aged 50 and older with further details on methodology described in Börsh-Supan *et al.* (2013[1]). The first wave of the SHARE survey took place in 2004. Subsequent waves were conducted every two years on average, with data collection in each country taking approximately a year, except during the COVID-19 pandemic. The study completed wave eight in 2022. New participants (refreshment samples) are added in each wave (Lusa and Huebner, 2021[3]). See Bergmann, M. *et al.,* (2019[2]) for response and retention rates. The number of countries involved has expanded from the first wave to now include 28 European Countries[1] and Israel (European Health Information Portal, 2022[28])[2] .

11. SHARE data was used as it offers significant advantages compared to alternative options. First, SHARE provides comparable information across multiple OECD countries. Additionally, being a longitudinal study, it allows for the study of temporality (exposure prior to outcome) which was a key requirement for this analysis. Finally, the SHARE dataset is focused on individuals aged 50 or older, which is particularly valuable given that NCDs become prevalent in this population group.

2.2. Variables used in this study

12. Depression, the main outcome variable, was treated as binary (yes/no), based on a cut off value of four from the EURO-D scale. The EURO-D is a 12-point scale based on questions regarding depressive symptoms experienced over the past month (see Annex B for the questions in more detail and for comparisons with clinical and other survey measures). The maximum score of 12 corresponds to 'very depressed' while the minimum score is zero which corresponds to 'not depressed' (Mehrbrodt, Gruber and Wagner, 2019[29]). Although there are many ways to measure depression, each with their own advantages, limitations and differing prevalence estimates (see Annex B), the SHARE symptom measure was used as it offered validated, internationally comparable and longitudinal microlevel data on depression that is linked to the other variables of interest for this study. Although prevalence estimates vary greatly depending on the study, method employed, and severity thresholds used, a meta-analysis by Cai *et al.*, (2023[30]) shows that about one third of older adults have depression, which aligns with the 30-40% prevalence estimates found in SHARE, depending on the wave pair, using EURO-D with a cut-off of four. Prevalence estimates would be lower if a higher cut off score of five for example was used, however a cut off of four was most

consistent with the literature (Mehrbrodt, Gruber and Wagner, 2019[29]; Marques et al., 2021[31]; Lusa and Huebner, 2021[3]; Kucera, Wolfová and Cermakova, 2020[32]; Han et al., 2021[33]) and so was selected.

13. The other variables used in the study included the NCDs heart disease, stroke, diabetes, cancer and chronic lung disease (see Annex C for details). This group of NCDs was selected because they represent the majority of the burden of NCDs across OECD countries and because they have highest policy relevance, given they reflect the 5x5 NCDs prioritised in the most recent UN High level Meeting on NCDs (2018[34]). NCD variables were binary, based on the participant reporting that they did or did not have a particular NCD. Variables used to adjust for confounding include sex, age, country of residence; socioeconomic status; alcohol consumption and smoking status, with further details on how these questions were asked in SHARE are detailed in Annex C. Smoking status was binary based on the participant self-reporting whether they had ever smoked daily for a period of at least one year, and alcohol consumption was binary based on the participant reporting that they drank alcohol daily. Socioeconomic status was classified into four categories based on the financial distress variable asking self-reported ability to make ends meet. These variables were adjusted for to try isolate the link between NCDs and depression and address confounding, as they are shared risk factors for both.

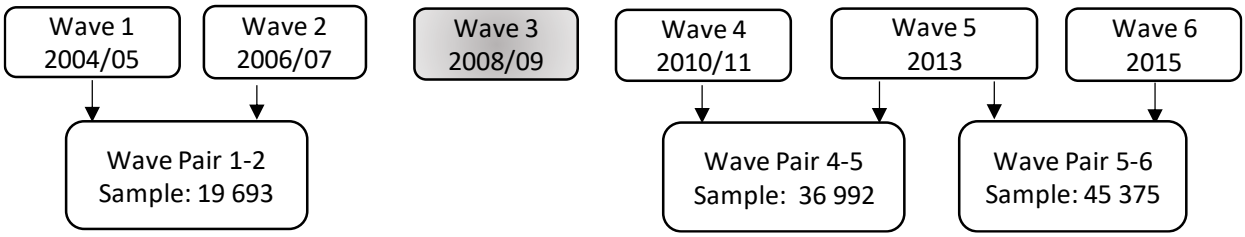
2.3. Data cleaning and wave pair construction

14. Data from survey waves 1 through 6 were used for this analysis, with the exception of wave 3 which was a retrospective life history wave and different to the other waves of SHARE. Cross sectional analysis was performed on survey wave 5, which was the most recent wave with all relevant predictive variables asked in the most comparable manner.

15. For longitudinal analysis, survey waves were analysed as wave pairs with an average of two years between waves. Three wave pairs were formed: wave pair 1-2, wave pair 4-5 and wave pair 5-6 (Figure 2.1). Only participants who participated in both the initial and follow up wave of the wave pair were retained. The reason for this was that people with NCDs, and in particular with cancer, are less likely to participate in all of the survey waves due to illness, death or loss to follow up for other reasons, leading to high levels of attrition (drop out) over the course of several waves. Limiting the follow up to pairs of waves rather than across all waves reduced the impact of this higher attrition rate. The datasets for the three wave pairs were filtered to contain countries common to all three, to allow for greater comparability between wave pairs. The 19 countries included were: Austria, Belgium, Czechia, Denmark, Estonia, France, Germany, Greece, Hungary, Israel, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovenia, Spain, Sweden and Switzerland.

16. Missing data was explored for the selected variables (with an imputed variable from SHARE used for SES), and the proportion of missing data was low for the selected variables (mostly below 1% and all below 5%) with no discernible pattern. Observations with missing data for the selected variables were subsequently removed. Data preparation was performed in python using version 3.9.13 using a number of libraries including pandas, numpy and statsmodels.

Figure 2.1. Wave pairs



Note: The above years refers to the years in which the respective waves of the SHARE survey were carried out.
Source: SHARE and Authors analysis of SHARE data.

2.4. Data analysis

17. Descriptive statistics were produced as a preliminary assessment, with findings described further in the results section, and baseline characteristics of the sample described in Annex D. The burden of depression among people with NCDs was examined cross sectionally using data from wave 5. Diseases were considered both individually and grouped into one, two and three or more NCDs (results in section 3.1).Relative risk regressions were performed using modified poisson regression on the wave pair data to measure the increased risk of depression due to NCDs when adjusting for confounders (results in section 3.2). By using longitudinal wave-pairs, this analysis tested the temporality of the association, looking at whether the exposure (NCD) precedes the outcome (depression), supporting a causal relationship. By testing both individual NCDs as well as grouping NCDs into a list of one, two and three or more NCDs, a dose-response effect was explored.

18. To ensure the consistency of the effect across different study designs, regressions were run with and without adjustment for baseline depression, as well as running another regression excluding participants with depression at baseline (results in section 3.3).

19. To assess consistency across outcome measures, a proxy variable for depression was chosen and relative risk regression undertaken (results in section 3.4). This proxy variable was medication for anxiety or depression, which partially captures some of the population who have depression.

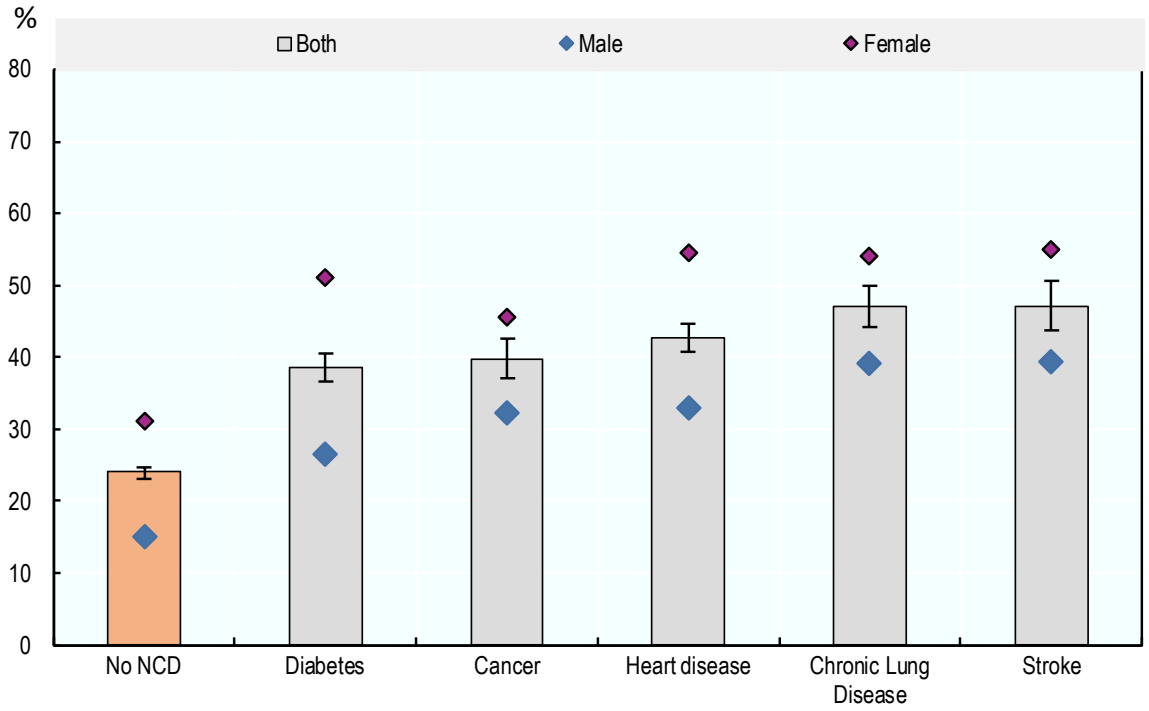
3 Results

3.1. Depression is more common in people with NCDs

20. Cross-sectional analysis shows that depression is more common among participants with cancer, diabetes, heart disease, stroke and chronic lung disease compared to those without. Descriptive analysis of wave 5 shows that for each disease, depression is more common in those with the disease compared to those without NCDs (Figure 3.1). For example, people with cancer have a 16-percentage point increase in depression compared to those without any NCD (40% for cancer vs 24% for people without an NCD), and the effect is even stronger for heart disease, stroke and chronic lung disease.

Figure 3.1. Prevalence of depression among people living with selected NCDs

This figure, based on cross sectional data from SHARE survey wave five using survey weights, shows the proportion with depression with a given NCD compared to without that NCD based on SHARE data, stratified by sex.

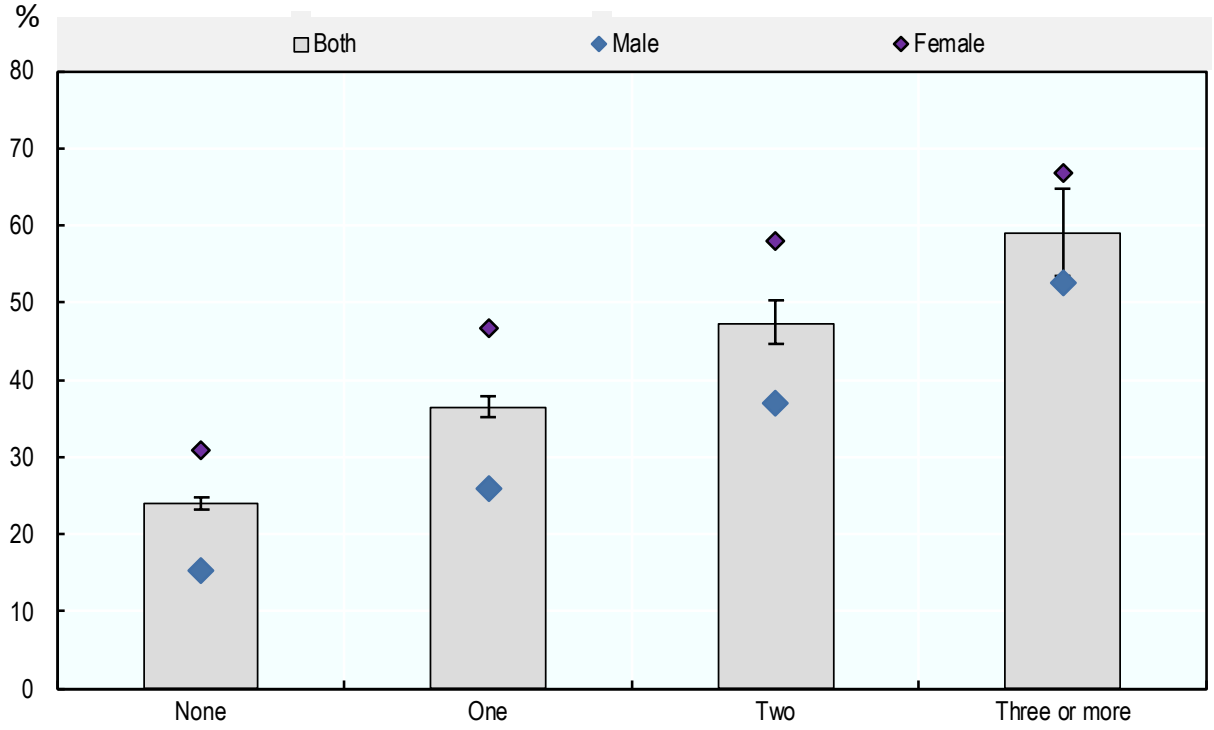


Note: Depression is measured as a binary variable depressed/not depressed based on the EURO-D scale, a validated instrument for measuring depression in people aged over 50. Weighted samples are used, with error bars representing the 95% confidence intervals for the unstratified NCD means.
Source: Authors analysis of SHARE data wave five.

21. There is a higher proportion of participants with depression as the number of NCDs increases (Figure 3.2). For example, cross sectional analysis from wave five (shown below) shows that people with three or more NCDs are more than twice as likely to have depression compared to people without NCDs (59% vs 24%). The prevalence of depression increases from 24% among people with no NCDs to 36% among people with one NCD, 47% among people with two NCDs and 59% among people with three or more NCDs. The increase in depression with NCDs is valid for both male and female participants, and there remains a gender gap at every number of NCDs shown, with female participants more commonly experiencing depression than men. Such a dose-response relationship, where greater burden of NCDs translates to higher prevalence of depression, suggests that the relationship between NCDs and depression would be causal.

Figure 3.2. Frequency of depression among people with increasing number of NCDs

This figure, based on cross sectional data from SHARE survey wave five using survey weights, shows the increasing proportion of depression among groups with a greater number of NCDs.



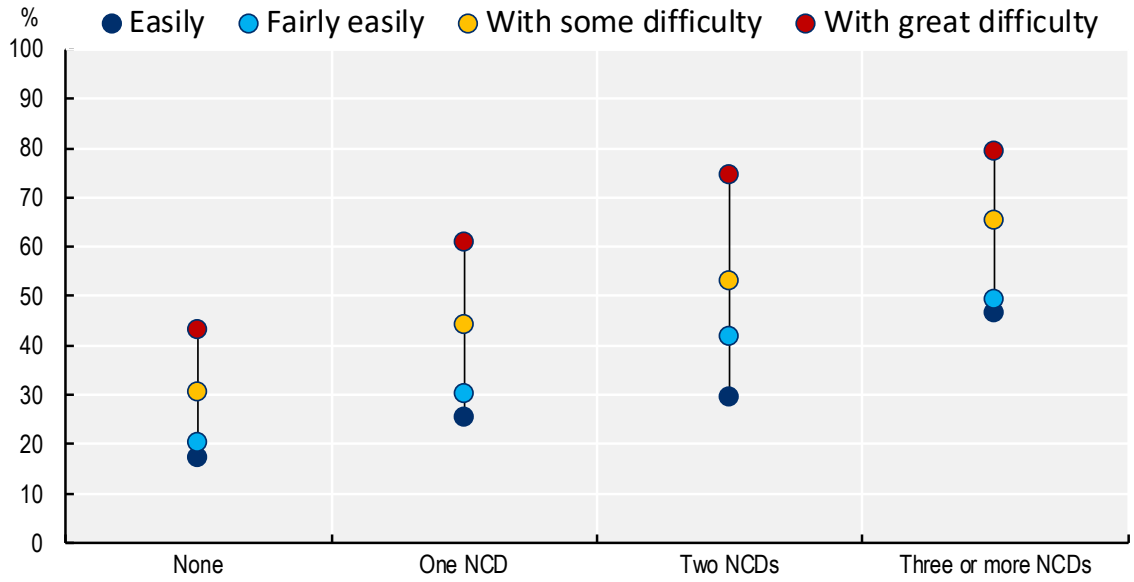
Note: Weighted samples are used, with error bars representing the 95% confidence intervals around the mean for the unstratified analysis.
Source: SHARE survey wave five.

22. The increased risk of depression with increasing NCDs persists across different strata of socio-economic status (SES) (Figure 3.3). In this study, financial distress was used as a proxy measure of SES (see section 2.2 and Annex C for further details), with participants asked about their ability to make ends meet. Responses varied from 'easily' to 'with great difficulty'. For all the SES groups, the risk of depression increased as the number of NCDs increased, and people in the lowest SES were most likely to experience depression in every category of number of NCDs. Although financial hardship was more common among people with the most NCDs (Annex D), higher depression rates among those with more NCDs cannot be attributed solely to higher poverty levels, as all SES strata show increases in depression with more NCDs, as shown in Figure 3.3. This is further supported by the results in sections 3.2, 3.3 and 3.4 which show

that increasing the number of NCDs raises the risk of having depression, even after adjusting for differences in financial hardship.

Figure 3.3. Frequency of depression among people with increasing number of NCDs, stratified by socio-economic status

Socioeconomic status is represented here as ability to make ends meet.



Note: Weighted samples are used, with socio-economic status represented by the variable ability to make ends meet. More information on variables used in this study in Annex C.
Source: Authors analysis of SHARE survey wave five.

3.2. NCDs increase the future risk of depression

23. To quantify the increased risk of depression at follow up due to the presence of NCDs at baseline – thus establishing a temporal effect in support of a causal relationship -, a relative risk regression (Box 3.1) was used on wave-pair data. The regression was performed adjusting for age, sex, socioeconomic status, country, smoking status, and alcohol consumption. The analysis was also adjusted for baseline depression status, to account for fact that people with a history of depression are much more likely (but not certain) to experience depression in future.

Box 3.1. Relative Risk (RR)

Relative risk (RR) is the "ratio of the probability of an event occurring with an exposure versus the probability of the event occurring without the exposure" (Tenny and Hoffman, 2023[35]). Taking cancer and depression as an example, a RR of 1.17 can be interpreted as the risk of experiencing depression being 17% higher in people living with cancer relative to the risk of depression in people who do not have cancer. In other words, people with cancer have a 17% higher risk of also experiencing depression. It is important to note the risks are relative to the baseline, and not absolute increases. Going back to the same example, this means that if on average people had a 10% risk of experiencing depression (baseline risk of 10%), people with cancer but without any other risk factor different from the baseline would have a risk of 11.7% (rather than the baseline 10%) of experiencing depression, due to cancer increasing their increased risk of having depression.

24. Each NCD tested was associated with an increased risk of depression (Table 3.1.). The effect was roughly consistent across wave pairs, and the average increased risk of depression was 15% for people with cancer and diabetes, 17% for heart failure, 25% for chronic lung disease and 21% for stroke. While the increased risk of depression was statistically significant for each NCD compared to not living with that NCD, the differences between which type of NCD lives with has in this analysis did not change the risk to a large extent, given that confidence intervals overlap.

Table 3.1. Relative Risk of depression with individual NCDs

Variables	RR 1-2	CI 1-2	RR 4-5	CI 4-5	RR 5-6	CI 5-6
Cancer initial wave	**1.19**	**(1.1, 1.3)**	**1.15**	**(1.09, 1.22)**	**1.14**	**(1.08, 1.2)**
Diabetes initial wave	**1.17**	**(1.1, 1.25)**	**1.16**	**(1.11, 1.21)**	**1.12**	**(1.08, 1.17)**
Heart Disease initial wave	**1.17**	**(1.11, 1.25)**	**1.17**	**(1.12, 1.21)**	**1.16**	**(1.11, 1.2)**
Lung disease initial wave	**1.27**	**(1.18, 1.38)**	**1.20**	**(1.15, 1.26)**	**1.27**	**(1.21, 1.33)**
Stroke initial wave	**1.21**	**(1.1, 1.34)**	**1.24**	**(1.17, 1.32)**	**1.19**	**(1.12, 1.26)**
Depression initial wave	3.34	(3.16, 3.52)	2.76	(2.67, 2.86)	2.95	(2.85, 3.05)
Age under 60	0.97	(0.92, 1.03)	0.95	(0.91, 0.99)	0.98	(0.94, 1.02)
Age 60-64	0.88	(0.81, 0.95)	0.87	(0.83, 0.92)	0.93	(0.89, 0.98)
Age 75-79	1.23	(1.14, 1.32)	1.15	(1.09, 1.2)	1.11	(1.06, 1.17)
Age over 80	1.44	(1.34, 1.55)	1.31	(1.26, 1.38)	1.34	(1.28, 1.4)
Female Sex	1.41	(1.33, 1.49)	1.47	(1.41, 1.52)	1.43	(1.38, 1.48)
Daily alcohol	0.94	(0.88, 1.0)	1.02	(0.98, 1.07)	0.98	(0.94, 1.03)
Ever smoked daily	1.03	(0.98, 1.08)	1.09	(1.05, 1.13)	0.98	(0.94, 1.03)
Very low SES	1.57	(1.45, 1.7)	1.61	(1.52, 1.7)	1.45	(1.38, 1.53)
Low SES	1.36	(1.27, 1.46)	1.4	(1.33, 1.47)	1.26	(1.21, 1.32)
Average SES	1.14	(1.06, 1.22)	1.15	(1.1, 1.21)	1.1	(1.06, 1.15)

Note: The model has also been adjusted for country of residence (results not shown).
Source: Authors analysis of SHARE data.

25. In addition, the risk of depression increased as the number of NCDs increase (dose-response effect). For each wave pair, the RR of depression increased as the number of NCDs increased. On average across wave pairs, one NCD raises the risk of depression by 21%, two by 42% and three or more by 50%.

Table 3.2. Relative risk of depression by number of NCDs adjusted for baseline depression

Variables	RR 1-2	CI 1-2	RR 4-5	CI 4-5	RR 5-6	CI 5-6
One NCD	**1.27**	**(1.2, 1.34)**	**1.19**	**(1.15, 1.24)**	**1.2**	**(1.16, 1.24)**
Two NCDs	**1.43**	**(1.32, 1.55)**	**1.44**	**(1.37, 1.52)**	**1.4**	**(1.33, 1.48)**
Three or more NCDs	**1.39**	**(1.15, 1.7)**	**1.57**	**(1.43, 1.71)**	**1.48**	**(1.34, 1.62)**
Depression initial wave	3.35	(3.17, 3.53)	2.77	(2.67, 2.87)	2.96	(2.86, 3.06)
Age under 60	0.97	(0.92, 1.03)	0.94	(0.91, 0.99)	0.98	(0.94, 1.02)
Age 60-64	0.88	(0.81, 0.95)	0.87	(0.83, 0.91)	0.93	(0.89, 0.98)
Age 75-79	1.22	(1.13, 1.32)	1.14	(1.09, 1.2)	1.11	(1.06, 1.17)
Age over 80	1.44	(1.34, 1.54)	1.31	(1.26, 1.38)	1.33	(1.28, 1.39)
Female Sex	1.42	(1.34, 1.5)	1.47	(1.41, 1.52)	1.43	(1.38, 1.48)
Daily alcohol	0.94	(0.88, 1.0)	1.02	(0.98, 1.07)	0.99	(0.94, 1.03)
Ever smoked daily	1.04	(0.99, 1.09)	1.09	(1.05, 1.13)	0.99	(0.94, 1.04)
Very low SES	1.57	(1.45, 1.7)	1.61	(1.52, 1.7)	1.45	(1.38, 1.53)
Low SES	1.36	(1.26, 1.46)	1.39	(1.33, 1.46)	1.26	(1.21, 1.31)
Average SES	1.14	(1.06, 1.22)	1.15	(1.1, 1.21)	1.1	(1.06, 1.15)

Note: The model has also been adjusted for country of residence (results not shown). RR 1-2, RR 4-5 and RR 5-6 refer to the relative risk in wave pair 1-2, 4-5 and 5-6 respectively. CI 1-2, 4-5 and 5-6 refer to the 95% confidence interval for wave pairs 1-2, 4-5 and 5-6 respectively.
Source: Authors analysis of SHARE data.

3.3. The risk of depression due to NCDs remains statistically significant when using other study designs

26. The increased risk of depression due to NCDs remains statistically significant when people with depression at baseline are removed from the cohort (Table 3.3), and when baseline depression status is not adjusted for (Table 3.4). When people with depression at baseline as classified from their EURO-D score are removed from the cohort (giving a smaller cohort where no one has depression by this measure at baseline), the increased risk of depression remains statistically significant. Additionally, the size of the effect is even stronger compared to when keeping people with depression at baseline in the cohort but adjusting for this in the regression analysis. When all participants in the cohort (including those with depression at baseline) are kept but baseline depression status as a variable is not adjusted for, the effect of NCDs on depression is also stronger. Overall, adjusting for baseline depression leads to a more conservative but still statistically significant estimate.

Table 3.3. Relative Risk of depression with chronic disease from 'depression free' cohorts in wave pairs 1-2, 4-5, and 5-6

Variables	RR 1-2	CI 1-2	RR 4-5	CI 4-5	RR 5-6	CI 5-6
One NCD	**1.52**	**(1.38, 1.68)**	**1.3**	**(1.22, 1.38)**	**1.26**	**(1.19, 1.34)**
Two NCDs	**1.86**	**(1.55, 2.23)**	**1.79**	**(1.61, 1.98)**	**1.67**	**(1.5, 1.87)**
Three or more NCDs	**2.26**	**(1.4, 3.64)**	**2.24**	**(1.8, 2.78)**	**1.82**	**(1.39, 2.4)**
Age under 60	1.03	(0.93, 1.15)	0.94	(0.88, 1.01)	0.98	(0.91, 1.05)
Age 60-64	0.93	(0.81, 1.06)	0.84	(0.77, 0.92)	0.95	(0.88, 1.03)
Age 75-79	1.4	(1.22, 1.61)	1.17	(1.07, 1.29)	1.2	(1.1, 1.3)
Age over 80	1.74	(1.52, 2.0)	1.5	(1.38, 1.63)	1.68	(1.55, 1.81)
Female Sex	1.7	(1.55, 1.87)	1.75	(1.65, 1.86)	1.67	(1.58, 1.77)
Daily alcohol	0.91	(0.81, 1.01)	1.06	(0.99, 1.15)	0.97	(0.9, 1.04)
Ever smoked daily	1.05	(0.96, 1.14)	1.15	(1.08, 1.23)	0.99	(0.92, 1.08)
Very Low SES	1.85	(1.59, 2.14)	2.09	(1.89, 2.3)	1.84	(1.68, 2.02)
Low SES	1.51	(1.34, 1.71)	1.52	(1.4, 1.65)	1.37	(1.28, 1.48)
Average SES	1.23	(1.1, 1.38)	1.21	(1.13, 1.31)	1.15	(1.07, 1.23)

Source: Authors analysis of SHARE data.

Table 3.4. Relative Risk of Depression by Number of NCDs in usual cohort for three wave pairs, not adjusted for depression status at baseline.

Variables	RR 1-2	CI 1-2	RR 4-5	CI 4-5	RR 5-6	CI 5-6
One NCD	**1.45**	**(1.37, 1.53)**	**1.36**	**(1.31, 1.41)**	**1.36**	**(1.31, 1.41)**
Two NCDs	**1.87**	**(1.72, 2.04)**	**1.75**	**(1.66, 1.85)**	**1.77**	**(1.67, 1.87)**
Three or more NCDs	**2**	**(1.64, 2.44)**	**2.13**	**(1.94, 2.34)**	**2.1**	**(1.9, 2.33)**
Age under 60	0.99	(0.93, 1.05)	0.96	(0.92, 1.01)	1	(0.95, 1.04)
Age 60-64	0.87	(0.8, 0.95)	0.87	(0.82, 0.91)	0.94	(0.89, 0.98)
Age 75-79	1.27	(1.17, 1.38)	1.19	(1.13, 1.26)	1.17	(1.11, 1.23)
Age over 80	1.63	(1.51, 1.76)	1.43	(1.37, 1.5)	1.48	(1.42, 1.55)
Female Sex	1.8	(1.7, 1.91)	1.77	(1.7, 1.84)	1.73	(1.67, 1.8)
Daily alcohol	0.91	(0.85, 0.97)	1.02	(0.98, 1.07)	0.97	(0.93, 1.02)
Ever smoked daily	1.07	(1.01, 1.13)	1.13	(1.09, 1.18)	1.03	(0.98, 1.08)
Very low SES	2.1	(1.93, 2.28)	2.05	(1.93, 2.17)	1.99	(1.89, 2.09)
Low SES	1.58	(1.46, 1.7)	1.6	(1.52, 1.68)	1.5	(1.43, 1.57)
Average SES	1.21	(1.12, 1.3)	1.2	(1.14, 1.26)	1.17	(1.12, 1.23)

Source: Authors analysis of SHARE data.

27. The fact that NCDs increase the risk of depression in a statistically significant manner when using different study designs supports the presence of a causal relationship. For example, regardless of whether in the baseline cohorts there are a mixture of people living with and without depression at baseline or whether in the baseline there are only people not living with depression, there is still a statistically significant risk of people with NCDs experiencing depression at the follow up two years later. This suggests that living with a chronic disease increases the risk of developing depression in those without previous depression, and in experiencing persistent depression or developing another depression episode among people who have experienced it before.

3.4. The increased depression risk due to NCDs persists with a different measure of depression

28. There are different ways to measure depression, as described in Annex B, and in addition to measuring depression diagnosis or symptoms directly, the consumption of antidepressant medications can be used as a proxy measure. Antidepressants are often prescribed as one of the treatments in managing depression. A repeated cross-sectional analysis of 18 countries from SHARE and additional representation from the Health Survey for England (HSE) found that on average 39% of people who were experiencing depression (i.e. scoring four or more in the SHARE EURO-D scale, the same cut off as in this study; or scoring four or more in a similar depressive symptom survey for the participants in HSE) were receiving antidepressants in the 2015-2018 period, up from an average of 25% in 2011-2015, with wide variation among countries including as high as 81% in Austria (Chen et al., 2022[36]).

29. To strengthen the analysis, consumption of medication for depression and anxiety was analysed as a proxy variable for depression, as an alternative to using the EURO-D score, to test the consistency of the association across different outcome measures. Overall, approximately 6% of participants reported taking medication for anxiety or depression. Stratified by symptom score, 15% of participants experiencing depression by EURO-D classification) were taking medication for anxiety or depression compared to only 3% of participants without depression, a fivefold difference.

30. The results of the relative risk regressions showed that living with one or more NCDs was associated with a statistically significant increase in the risk of taking medicines for anxiety or depression (Table 3.5). On weighted average, people with one NCD had a 31% higher risk of taking medicines for anxiety or depression; those with two have a 61% higher risk, and those with three or more have a 77% higher risk.

Table 3.5. Relative Risks of taking medicines for anxiety and/or depression for NCDs

Variables	RR 1-2	CI 1-2	RR 4-5	CI 4-5	RR 5-6	CI 5-6
One NCD	**1.28**	**(1.12, 1.46)**	**1.4**	**(1.28, 1.53)**	**1.24**	**(1.14, 1.35)**
Two NCDs	**1.79**	**(1.46, 2.19)**	**1.57**	**(1.35, 1.82)**	**1.56**	**(1.37, 1.78)**
Three or more NCDs	**2.46**	**(1.64, 3.7)**	**1.68**	**(1.23, 2.29)**	**1.53**	**(1.15, 2.04)**
Depression initial wave	3.3	(2.92, 3.72)	3.17	(2.91, 3.46)	3.03	(2.81, 3.26)
Age under 60	1.06	(0.93, 1.22)	1.13	(1.02, 1.25)	1.12	(1.03, 1.23)
Age 60-64	0.95	(0.8, 1.13)	1.11	(0.99, 1.25)	1.15	(1.04, 1.27)
Age 75-79	0.95	(0.77, 1.16)	0.96	(0.83, 1.1)	0.97	(0.86, 1.1)
Age over 80	0.93	(0.76, 1.14)	0.95	(0.84, 1.09)	0.91	(0.81, 1.03)
Female Sex	1.78	(1.55, 2.04)	1.76	(1.6, 1.93)	1.95	(1.79, 2.13)
Daily alcohol	0.95	(0.82, 1.1)	0.95	(0.85, 1.06)	0.94	(0.85, 1.04)
Ever smoked daily	1.09	(0.97, 1.23)	1.16	(1.06, 1.28)	1.06	(0.96, 1.18)
Very low SES	1.53	(1.26, 1.86)	1.54	(1.34, 1.76)	1.51	(1.34, 1.7)
Low SES	1.36	(1.15, 1.61)	1.33	(1.18, 1.49)	1.41	(1.28, 1.56)
Average SES	1.22	(1.04, 1.43)	1.14	(1.02, 1.27)	1.13	(1.03, 1.25)

Source: Authors analysis of SHARE data.

4 Discussion and key policy messages

4.1. NCDs are independently associated with an increased risk of depression, and the effect increases with multimorbidity

31. The results show that NCDs are independently associated with a statistically significant increased risk of depression. The increased risk was similar across the NCDs included in the analysis, averaging at 15% for cancer and diabetes, 17% for heart failure, 21% for stroke and 25% for chronic lung disease, with confidence intervals overlapping between NCDs. Individuals with multimorbidity have a higher risk of depression than people with one NCD – while people with one NCD have a 21% increase in the risk of depression, this increases with two NCDs to a 42% increase and with three or more NCDs to a 50% increased risk of depression. For each wave pair in this analysis, the increased risk of depression between one and two NCDs is statistically significant, while there is some overlap in confidence intervals between two and three or more NCDs.

32. Evidence of a causal relationship in the direction of living with one or multiple NCDs and subsequently experiencing depression is supported by several factors, drawing on theories of causality described in Annex A. This includes dose-response as evidenced by the increase in size of depression risk with increasing numbers of NCDs. It also includes temporality as seen by relating NCDs at a baseline with depression as a follow up measure two years later. Additionally, it addresses persistence of the effect when other common variables also associated with depression such as sex are taken into consideration. It also includes consistency across measures and methods, where the results show a similarly increased risk of taking medication for anxiety or depression as a proxy measure of depression, and that the burden of depression is higher both temporally and cross-sectionally. Multiple biological, psychological and social factors play a role in the causation narrative, as discussed in the next paragraph.

33. There are strong biological, psychological, and social factors driving the association between having one or more NCDs and experiencing depression. As outlined more extensively in the background of the paper (section 1), biological drivers include neurodegeneration or brain lesions with certain NCDs as well as treatment side effects with other NCDs. Symptoms including fatigue, pain and lack of energy that limit people from pursuing activities of daily living and social activities also contribute. Psychological and social factors include loss of sense of self, feelings of social isolation and guilt, among others. Finally, beliefs people hold about their disease and coping styles also play a role, with some people experiencing difficulty sleeping due to worry about their NCD and others experiencing more constant feelings of uncertainly due to the incurable nature of their disease or its unpredictable course. Understanding the biological, psychological and social factors involved in the association can help to unpick modifiable risk factors and develop policy solutions that can address them. Potential policy responses are described in the next section (4.2).

34. These findings are consistent with literature. For example, Feng *et al.* (2023[13]), also using SHARE data, found that one NCD was associated with a hazard ratio (HR) of 1.33 for depression for younger (age

<65) and 1.44 in older (age > 65) people. A systematic review and meta-analysis found that the relative risk of depressive disorder was three times higher for those with multimorbidity compared to those without any chronic physical condition (RR 2.97 (95% CI 2.06-4.27)) and two times higher for people with multimorbidity compared to those without multimorbidity (RR 2.13 (95% CI 1.62-2.80)) (Read et al., 2017[16]).

35. The results presented in this study are in general more conservative than those seen in the literature, which may be due to the time between survey waves and loss to follow up. The average time of two years between survey waves may mean some participants with more severe disease may be lost to follow up between waves due to death or illness. Participants who have been lost to follow up due to death or illness are more likely to report worse depression, given depression severity has been linked with NCD severity (Read et al., 2017[16]; Østergaard and Foldager, 2011[37]), in particular with cancer severity (Naser et al., 2021[38]).

36. Additionally, the main analysis controlled for baseline depression status. Controlling for a strong predictor of depression at follow-up helps to isolate the impact of NCDs. In sensitivity analysis, producing a 'depression free' cohort at baseline led to a similar trend with a stronger effect size for each of the NCDs. Although each approach has its advantages and limitations, the more conservative method was chosen as the results demonstrate that even when accounting for a person's history of depression, NCDs still exert a statistically significant impact on the risk of future depression.

37. There are several limitations to this study. Although both descriptive and inferential statistics in this study show a consistent link between NCDs and depression, as reflected in the literature, there are other variables that impact risk of depression that are not accounted for in this study. For example, a strong family history of depression or psychiatric illness can influence risk of depression and may not necessarily have the same impact on risk of other NCDs and is not included in this study. Equally, a personal history of abuse and trauma can have a strong influence on the risk of future depression and is not accounted for in this study. However, this is unlikely to eliminate the association between NCDs and depression, and indeed these risk factors could influence both physical and mental health. For example, one study showed that adverse childhood experiences increased the risk of NCDs in young adulthood (Sonu, Post and Feinglass, 2019[39]), and as such might represent a pathway leading to both NCDs and depression rather than a factor which dilutes or eliminates the association. Mental health and well-being should form an integral part of NCD policy development and evaluation.

Although bidirectionality and reverse causality cannot be ruled out, shared risk factors lead to NCDs and depression via distinct biological, psychological and social pathways, and the study sill found significant results after adjusting for confounders

38. Untangling bidirectionality and reverse causality is complex for numerous reasons including the natural history of both groups and a shared vulnerability to common risk factors. Despite this, there are signs that NCDs are still a valid contributor to depression.

- Studying the impact of depression on NCDs is challenging due to episodic nature and underdiagnosis of depression (Faisal-Cury et al., 2022[40]). It is difficult to confirm whether a depressive episode is a true first episode or a recurrence, complicating the timeline between depression onset and NCD development. Depression symptoms can vary over time: a person may experience a single episode that resolves before the NCD diagnosis, ongoing symptoms, or multiple episodes during the study period. In contrast, NCDs like COPD or heart disease are less likely to go undiagnosed or to resolve and reoccur. Although NCD severity may fluctuate and people may experience exacerbations, the NCDs themselves generally persist and rarely resolve, making it easier to study how NCDs lead to depression rather than the reverse.

- NCDs and depression share common risk factors such as smoking, alcohol and physical activity, however the underlying mechanisms driving each condition differ. For example, people with depression may smoke more often as a coping mechanism, increasing their risk for COPD. In contrast, people with COPD who started smoking for other reasons may be at higher risk for depression given the nicotine's impact on dopamine and other brain chemicals (Breslau et al., 1998[41]; Cabello et al., 2017[42]). Similarly, depression can reduce motivation to exercise, raising cardiovascular risk and leading to an NCD. In contrast, NCDs can cause increased physical disability making exercise more challenging, frustrating and leading to despair and loss of personal identity and social connection, which in turn can lead to depression.

39. Although a complete and definitive analysis of reverse causality was not performed given the numerous challenges in achieving this, several steps were taken to try address reverse causality. Shared risk factors of smoking status and alcohol were adjusted for, with the relationship between NCDs and depression remaining statistically significant. Even after adjusting for baseline depression given its episodic nature, NCDs were still linked an increased risk of depression, suggesting they raise the risk of new, persistent and recurrent depression.

4.2. NCD action plans should integrate mental health as a core element to improve population physical health, wellbeing and productivity

40. Action plans on NCDs should integrate mental health as a core component given:

- Depression can play a detrimental role in accelerating NCD progression and driving up costs.
- Several primary and tertiary prevention measures that enhance physical health also improve mental wellbeing. For this reason, any evaluation of these measures should consider their benefits to both physical and mental health, as well as the cost savings they provide.
- People experiencing NCDs are more vulnerable to depression, and given its compounding impact on quality of life, ill-health and costs, due consideration should be given to detection and treatment strategies in these populations.
- Evidence shows that OECD populations are ageing with more NCDs, experiencing worse wellbeing with each additional NCD lived with.
- There is growing interest in integrating mental health into various policies and health programs, as emphasized by the efforts of the UN, WHO and the European Commission.

41. These themes will now be addressed in turn.

Depression can accelerate NCD progression and drive-up costs

42. Poor mental health can worsen physical health, accelerate the progression of NCD disease course and greatly increase treatment costs. Living with an NCD comorbid with depression worsens health more than any combination of NCDs without depression (Moussavi et al., 2007[17]) and people with NCDs and depression have increased hospital admissions and readmissions for exacerbations and complications of the NCD. Depression can also accelerate the disease course of NCDs due to a variety of factors such as reduced self-care, reduced adherence to treatments and less healthy life choices, with patients with mild to moderate kidney failure and more severe depression having almost twice the odds of rapidly declining kidney function relative to those with mild to moderate kidney failure without depressive symptoms (Missikpode et al., 2023[43]). Several NCDs require key healthier lifestyle choices to slow disease progress such as smoking cessation, increasing physical activity and adhering to a healthier diet and treatments, which can be challenging in the context of psychological distress. Together, these factors result in increasing the costs of the NCDs - in France alone, major depression among people with at least one NCD

increased healthcare expenditure from over EUR 1 000 to more than EUR 4 000 on average depending on age and sex (Cortaredona and Ventelous, 2017[24]).

Primary and tertiary prevention activities help to tackle the rising burden of NCDs and reduce complications respectively, while bringing improving mental health and wellbeing co-benefits

43. Interventions targeting the prevention of NCDs may additionally improve mental health as a co-benefit. For example, physical activity, well known to reduce risk of developing several cancers such as colon, breast and stomach cancer by approximately 10-20% (McTiernan et al., 2019[44]) in addition to other NCDs, also reduces depression and improve mental health (OECD, 2022[45]),. Smoking cessation can reduce risk of developing not only cancer but many other NCDs such as cardiovascular disease and chronic lung disease, and is also associated with reduced anxiety and depression compared to people who continue to smoke (Taylor et al., 2021[46]; Taylor et al., 2014[47])

44. Similarly, tertiary prevention interventions aimed at reducing complications among people experiencing NCDs can also bring mental health co-benefits. For example, improving self-management of NCDs, where individuals are empowered in their self-care by developing new behaviours and coping with the emotional impact of their diseases (Ould Brahim et al., 2021[48]), is a key pathway to reduce hospital admissions and improve physical health, and has additionally been shown to reduce depressive symptoms (Cramm and Nieboer, 2012[49]). People living with depression tend to experience reduced capacity to self-manage their NCDs, and consequently have more to gain from self-management training (Jerant et al., 2008[50]). Improved self-care and NCD self-management training has also been shown to both reduce depressive symptoms and reduce hospital admissions and improve physical health (Cramm and Nieboer, 2012[49]; Ould Brahim et al., 2021[48]). For example, a self-management education intervention for patients with type 2 diabetes (T2DM) found both better control of blood glucose and psychological improvement among recipients of the intervention (Chai et al., 2018[51]). Another example is physical activity, which in addition to mental health benefits among people experiencing NCDs, can also reduce all-cause and cancer-specific mortality among those living with certain cancers (McTiernan et al., 2019[44]).

45. Quantifying the mental health co-benefits brought about by primary and tertiary prevention measures can help to better evaluate the impact and return on investment from health promotion programmes and policies. To this end, the results of this paper will be integrated in the OECD SPHeP NCDs model (OECD, 2020[26]), which is used to evaluate health, economic and societal outcomes of public health policies. This additional output broadens the lens of the impact of health promotion policy, allowing policy makers to understand and assess the impact of policies more fully. Having depression as an output means that quality of life is consistently considered when evaluating public health policy. Moreover, given the additional costs associated with depression, it also allows a better assessment of the economic value of health promotion and disease prevention.

Given greater vulnerability to depression among people living with NCDs, it is important to assess and review identification and treatment policy and strategies

46. Although many of the actions described previously (such as self-management training, smoking cessation and physical activity) can bring important mental health co-benefits for people living with NCDs, it is equally important to consider overall the approaches taken to identify and treat depression among people with NCDs, given their increased vulnerability to it. Various interventions can be employed to treat mental ill-health among people living with NCDs. Research highlights the need for a multidisciplinary (Almeida et al., 2020[52]) and holistic approach that considers all domains of functioning including biological, cognitive, emotional and social (Kemp et al., 2022[53]). Integrating general medical and mental health services is also important (Stein et al., 2019[54]) for more patient centred and coordinated care. Nursing interventions, such as training in emotional regulation, experience sharing and personal reflection

also show promise (Sánchez-Ortega et al., 2022[55]). Digital health interventions also show promise (Sasseville et al., 2021[56]) and may offer a more accessible and affordable service as an adjunct or standalone service. Best practices in mental health will be explored and published in future OECD work.

Implications in light of ageing populations

47. These policies are even more important in the context of an ageing population, since people are living longer with one or more NCDs, reinforced by findings from the recent Patient Reported Indicator Survey (PaRIS) (OECD, 2025[57]). The share of the OECD population between 65 and 85 years old is expected to grow from 18% to 26% in 2060, and PARIS findings indicate that multimorbidity in primary care is becoming the norm, with 8 out of 10 people aged 45 or older who had a primary care consultation in the six months preceding the survey had at least one chronic condition and over half lived with two or more. They also found wellbeing deteriorates with each additional NCD, although higher wellbeing was reported in people who considered their care to be more people centred - a dimension influenced by a variety of factors including usage of care planning for patients with NCDs, self-management support, accessible and effective communication between professionals and patients, continuity of health information throughout the healthcare system, and higher availability of easy-to-use digital tools. This growing burden of NCDs among ageing populations highlights the need for policy that promotes activities with physical and mental health co-benefits. These can help people lead healthier and more productive lives, reducing costs from better controlling risk factors while improving overall wellbeing.

Alignment with Policy Context Internationally

48. The policy implications of this paper align with an international focus on the importance of integrating mental health across policies and, specifically, in actions for NCDs. Some of the most prominent initiatives include:

- The UN High Level Meeting on NCDs in 2025 aims to builds on work and commitments on mental health (WHO, 2024[58]). This includes building on the comprehensive mental health action plan, which advocated for the “inclusion and mainstreaming of mental health issues more explicitly within other priority health programmes” (66th World Health Assembly, 2013[59]). The WHO have also produced a framework on integrating well-being into public health which followed a mandate from the 2022 75th World Health Assembly (WHO, 2022[60]).
- European Commission launched a mental health initiative in 2023 calling for integrating mental health across policies and highlighting the cost of inaction (2023[61]), and also in 2023 the Council of the EU recommendations on mental health were adopted, advocating for action on mental health across multiple levels, sectors and ages (2023[62]). This built on previous recommendations by the Council of the EU which recommended mitigating challenges to wellbeing throughout the life course, including through the promotion of physical activity, healthy nutrition, prevention measures and a range of other measures (2019[63]).

Annex A. Establishing causality

Different strategies have been proposed to demonstrate causality. While many in epidemiology such as Koch's postulates (Falkow, 1988[64]) were initially based around infectious diseases, AB Hill published a paper of nine criteria that could be better applied to NCDs (Hill, 1965[27]). These were:

- **Strength (effect size):** Although a small association does not rule out a causal effect, the larger the association, the more likely it is to be causal.
- **Consistency (reproducibility):** Consistent findings observed by different people in different settings with different sample sizes strengthens the likelihood of a causal effect.
- **Specificity**: Causation is likely if the exposure is associated with the disease under study and no others, and if the disease is associated with the exposure in question and no others. A lack of specificity does not undermine causative relationships under this criterion (Nowinski et al., 2022[65]; Shimonovich et al., 2021[66]). When present, the more specific an association between an exposure and an effect, the higher the probability of a causal relationship. In modern epidemiology, multiple causation (where one exposure may affect many diseases and one disease may be effected by many exposures) there is more limited utility in directly applying specificity in epidemiological practice (Shimonovich et al., 2021[66]). However, we can think of related concepts, such as identifying and adjusting for confounding, to highlight that the association between exposure and outcome is not distorted by another variable or variables.
- **Temporality**: The effect should occur after the exposure, and if there is an expected delay between exposure and effect, then the effect should occur after that delay.
- **Biological gradient** (dose–response relationship): Greater exposure should generally lead to greater incidence of the effect, though this is not always necessary and in some cases the reverse may be the case.
- **Plausibility**: A plausible mechanism between cause and effect can help, though Bradford Hill acknowledged that our understanding of potential mechanisms is limited by current knowledge.
- **Coherence**: Findings should be coherent with observed trends in society. For example, when examining an association between cigarette smoking and lung cancer incidence, increases in both cigarette smoking and lung cancer would be coherent. However, Hill noted that "lack of such [laboratory] evidence cannot nullify the epidemiological effect on associations".
- **Experiment**: Bradford Hill described that evidence deriving from experiment, particularly in epidemiological studies where disease risk declines following an intervention or reduction in exposure – may in fact lead to the strongest support for causal inference (Fedak et al., 2015[67]).
- **Analogy**: Hill implied that when there is strong evidence of a causal relationship between a given agent and a particular disease, researchers should be more accepting of weaker evidence that a similar agent may cause a similar disease (Fedak et al., 2015[67]).

Hill's criteria should be considered as a guide rather than an exhaustive checklist, employed to test the strength of an argument for causation.

Annex B. Measuring depression

There are many ways to measure depression prevalence at a population level. Three different approaches, each with their own strengths, limitations and caveats, are data from medical records with clinically diagnosed depression, patient reported diagnosis of depression via survey and validated symptom questionnaires used in population surveys:

In primary care and clinical settings, depression can be diagnosed and coded from provider patient interactions, bringing potential advances in terms of the clinical richness of the data, although limited by access and vulnerable to under and misdiagnosis. Healthcare providers, depending on the context, can use clinical judgement and/or refer to the diagnostic and statistical manual of Mental Disorders V (DSM V) criteria, the International Classification of Diseases version 11 (ICD 11) or similar to qualify and evaluate the severity of depression. Researchers leveraging this data where it is available and ethically approved have the advantage in theory of clinically diagnosed, potentially well documented and understood depression that in theory could be linked to other medical and social records. However, medical records, particularly those with linked general practice and hospital inpatient and outpatient data are not always available on a larger scale or may be limited to settings with adequate digital health infrastructure. Prevalence estimates based on this data may also underdiagnose and risk not being representative of the full population.

Surveys that ask for respondent self-report of diagnosis of depression from a medical professional in the past year can in theory benefit from a representative population sample and leverage clinically diagnosed data, although responses are subject to recall bias and as with all clinical records can risk underestimating depression prevalence due to the barriers faced in attaining a clinical diagnosis. One known limitation of clinical diagnosis is the underdiagnosis of depression at a population level (Last et al., 2021[68]). Many people living with mental illness do not seek help and could have lived with depression without receiving a formal diagnosis. A person may be undiagnosed for several reasons such as perceived stigma, perceptions of potential treatment effectiveness or side effects, and financial implications. Although healthcare professionals may overcome some of these limitations when faced with a patient in a consultation for a separate presenting complaint through screening or asking about depression in a person more vulnerable to same, both time and resource constraints often limit this opportunity, leading to potential cases being missed. Research from Brazil found that more than half of people living with depression were underdiagnosed (Faisal-Cury et al., 2022[40]) and challenges of under recognition and underdiagnosis are common in many other countries (Cepoiu et al., 2008[69]).

Survey instruments can also ask patients questions regarding their symptoms which are then mapped to a score which can be used to define whether a person is experiencing depression, and in some survey instruments connect this score to clinical depression severity levels. The advantage of this is that capture those participants whose symptoms are consistent with clinical depression but who may not have sought medical attention or may have experienced barriers to access and diagnosis. There are a variety of survey instruments which have been clinically validated including the 8 and 9 item Patient Health Questionnaire survey (PHQ-8 (Kroenke et al., 2009[70]) and PHQ-9 (Costantini et al., 2021[71]) respectively), the Centre for Epidemiologic Studies Depression Scale (CES-D) (Vilagut et al., 2016[72]) and as in the case of this study, the EURO-D scale. For certain survey instruments such as PHQ8, results have been mapped and validated against clinical severity depression levels from mild to severe allowing more granular analysis. Currently there is less research on the mapping of the EURO-D scale against depression severity levels,

however it carries several advantages including validation in a variety of cultural contexts (Guerra et al., 2015[73]).

Using EURO-D score to measure depression

As discussed in section 2.2, depression in SHARE is measured via a symptom scale, based on sixteen question items with responses condensed into a 12-point scale of depressive symptomatology. The exact questions asked in the survey are listed below:

Questions items in SHARE that formed the EURO-D depression scale:

MH002 In the last month, have you been sad or depressed?
1. Yes
5. No
MH003 What are your hopes for the future?
1. Any hopes mentioned
2. No hopes mentioned
MH004 In the last month, have you felt that you would rather be dead?
1. Any mention of suicidal feelings or wishing to be dead
2. No such feelings
MH005 Do you tend to blame yourself or feel guilty about anything?
1. Obvious excessive guilt or self blame
2. No such feelings
3. Mentions guilt or self blame, but it is unclear if these constitute obvious or excessive guilt or self-blame
MH006 (if MH005 = 3) So, for what do you blame yourself?
1. Example(s) given constitute obvious excessive guilt or self-blame
2. Example(s) do not constitute obvious excessive guilt or self-blame, or it remains unclear if these constitute obvious or excessive guilt or self-blame
MH007 Have you had trouble sleeping recently?
1. Trouble with sleep or recent change in pattern
2. No trouble sleeping
MH008 In the last month, what is your interest in things?
1. Less interest than usual mentioned
2. No mention of loss of interest
3. Non-specific or uncodeable response
MH009 (if MH008 = 3) So, do you keep up your interests?
1. Yes
5. No
MH010 Have you been irritable recently?
1. Yes
5. No
MH011 What has your appetite been like?
1. Diminution in desire for food
2. No diminution in desire for food
3. Non-specific or uncodeable response
MH012 (if MH011 = 3) So, have you been eating more or less than usual?
1. Less
2. More
3. Neither more nor less 37
MH013 In the last month, have you had too little energy to do the things you wanted to do?
1. Yes
5. No
MH014 How is your concentration? For example, can you concentrate on a television programme, film or radio programme?
1. Difficulty in concentrating on entertainment
2. No such difficulty mentioned
MH015 Can you concentrate on something you read?

1. Difficulty in concentrating on reading
2. No such difficulty mentioned

MH016 What have you enjoyed doing recently?
1. Fails to mention any enjoyable activity
2. Mentions ANY enjoyment from activity

MH017 In the last month, have you cried at all?
1. Yes
5. No

An important consideration is to understand what research has been performed to validate the EURO-D scale and map it to common measures of clinical depression. The following are of note:

- Courtin et al. (2015[74]) examined wave 2 data from SHARE where both Centre for Epidemiologic Studies Depression Scale (CES-D) and EURO-D questions were asked of respondents. The authors found that although both scales were strongly correlated ($r=0.6819$, $p<0.000$), agreement between the two scales were moderate. CES-D was shown to capture a more extreme pool of individuals experiencing depression than in EURO-D, and while associations with risk factors were in the same direction, they were often stronger for CES-D compared to EURO-D.
- Guerra et al., (2015[73]) found that based on a sample of almost 18000 respondents from 9 low and middle income countries a cutoff point of 4/5 was optimal for EURO-D against the reference of ICD-10 depressive episode. Sensitivity was 86% or higher in all sites and specificity exceeding 84% in all Latin American and Chinese sites. However, to date, there is insufficient knowledge on how to map severity by score in EURO-D to clinical severity levels in DSM V or ICD.

Overall in the literature, a score of four or more rather than five appears to be the most commonly used (Mehrbrodt, Gruber and Wagner, 2019[29]; Marques et al., 2021[31]; Lusa and Huebner, 2021[3]) and is additionally the cut off used for the generated binary depression eurodcat (for case of depression) in SHARE release version 8.0.0. Consequently, a score of 4 or more was used to classify a respondent experiencing depression in this study.

Annex C. Variables used in this study

The variables used in this study included depression, other NCDs, socioeconomic status, smoking status and alcohol. The study adjusted for the influence of other variables to ensure that the association between depression and NCDs was not confounded by other common factors. In addition to age, sex and country, the study looked at socioeconomic status (based on the ability to make ends meet), alcohol use (frequency of alcohol consumed in last three months) and smoking status (ever smoked, binary variable). The following paragraphs give more information on how these variables were asked.

Participants were assigned certain NCDs (heart disease, stroke, diabetes, chronic lung disease or cancer) based on self-reported diagnoses. NCDs were asked in a section on chronic diseases. Specifically, participants were asked:

''Has a doctor ever told you that you had/Do you currently have any of the conditions on this card?'. With this we mean that a doctor has told you that you have this condition, and that you are either currently being treated for or bothered by this condition…".

This was followed by a list of conditions. For the five NCDs of interest in this paper, the questions were:

- A heart attack including myocardial infarction or coronary thrombosis or any other heart problem including congestive heart failure
- A stroke or cerebral vascular disease
- Diabetes or high blood sugar
- Chronic lung disease such as chronic bronchitis or emphysema
- Cancer or malignant tumour, including leukaemia or lymphoma, but excluding minor skin cancers.

Socioeconomic status (SES) was measured using the variable 'fdistress' in SHARE, which is an imputed variable based on the ability to make ends meet. Specifically, participants were asked:

"Thinking of your household's total monthly income, would you say that your household is able to make ends meet…"

The responses to this question included whether the household able to make ends meet with "great difficulty", with "some difficulty", "fairly easily" or "easily. Socioeconomic status has been associated with both depression and with NCDs, so it was important to adjust for it to better understand the true impact of NCDs on depression.

Smoking status was based on the binary variable br001_ in SHARE which asked:

'Have you ever smoked cigarettes, cigars, cigarillos or a pipe daily for a period of at least one year?'

Smoking has shown mixed results with regards to influence on depression (Fluharty et al., 2017[75]). It was included to out rule that the impact seen with NCDs could be due in part to smoking.

Alcohol consumption was based on the frequency of alcohol consumption in the last three months. Participants were asked:

'During the last 3 months, how often have you drunk any alcoholic beverages, like beer, cider, wine, spirits or cocktails?'

The response categories were merged to give a binary of daily or less than daily alcohol consumption. Of note alcohol was a challenging variable as the questions asked pertaining to alcohol in terms of asking about quantity differed in several waves of the survey. This variable was chosen for its consistency across each of the survey waves used and may be a reasonable measure. However, it may not be the most appropriate way to assess for the impact of alcohol given that some participants may drink a small quantity each day, or others may drink less frequently but binge drink more often. Binge drinking was also tested as a variable in place of daily alcohol consumption and when adjusted for, the impact of NCDs on depression was similar in this analysis.

Annex D. Baseline characteristics of the sample

Descriptive statistics of the sample data were undertaken to show the baseline characteristics among those with and without the NCD of interest and with increasing numbers of NCDs. The tables below describe the baseline characteristics for people with no, one, two and three or more NCDs in wave pair 1-2, 4-5 and 5-6. The regression models adjusted for the variables shown in the tables.

Table A D.1. Baseline Characteristics of participants stratified on number of selected NCDs – wave pair 1-2

Baseline characteristics for the wave pair 1-2

Variable	No NCD	One NCD	Two NCDs	Three or more NCDs
Sample size	14101	4417	1006	169
Sample proportion (%)	72	22	5	1
Mean age	65	69	72	73
Proportion female (%)	57	50	49	46
Proportion male (%)	43	50	51	54
Less than daily alcohol consumption (%)	78	78	79	78
Daily alcohol consumption (%)	22	22	21	22
Ever smoked daily (%)	46	49	54	60
Cancer (%)	0	15	24	44
Chronic Lung Disease (%)	0	13	28	53
Diabetes (%)	0	29	53	73
Heart Disease (%)	0	35	71	88
Stroke (%)	0	8	25	50
Very low SES (%)	10	13	18	24
Low SES (%)	26	28	29	32
Average SES (%)	34	32	33	26
High SES (%)	29	26	20	18

Note: SES is socio-economic status. This is based on the ability to make ends meet. See Annex C for further details on these variables.
Source: Analysis of SHARE data.

Table A D.2. Baseline Characteristics of participants stratified on number of selected NCDs – wave pair 4-5

Baseline characteristics for the wave pair 4-5

Variable	No NCD	One NCD	Two NCDs	Three or more NCDs
Sample size	25394	8880	2224	494
Sample proportion (%)	69	24	6	1
Mean age	66	70	72	73
Proportion female (%)	59	53	51	52

Proportion male (%)	41	47	49	48
Less than daily alcohol consumption (%)	80	82	85	85
Daily alcohol consumption (%)	20	18	15	15
Ever smoked daily (%)	26	29	34	35
Cancer (%)	0	13	23	43
Chronic Lung Disease (%)	0	16	33	57
Diabetes (%)	0	32	53	77
Heart Disease (%)	0	33	67	88
Stroke (%)	0	7	23	49
Very low SES (%)	8	11	14	21
Low SES (%)	24	29	33	34
Average SES (%)	35	34	33	30
High SES (%)	34	26	20	15

Note: SES is socio-economic status. This is based on the ability to make ends meet. See Annex C for further details on these variables.
Source: Analysis of SHARE data.

Table A D.3. Baseline Characteristics of participants stratified on number of selected NCDs – wave pair 5-6

Baseline characteristics for the wave pair 5-6

Variable	No NCD	One NCD	Two NCDs	Three or more NCDs
Sample size	31499	10796	2557	523
Sample proportion (%)	69	24	6	1
Mean age	67	71	73	74
Proportion female (%)	58	52	50	47
Proportion male (%)	42	48	50	53
Less than daily alcohol consumption (%)	83	84	86	86
Daily alcohol consumption (%)	17	16	14	14
Ever smoked daily (%)	14	16	17	18
Cancer (%)	0	14	25	40
Chronic Lung Disease (%)	0	15	29	60
Diabetes (%)	0	36	60	78
Heart Disease (%)	0	28	62	89
Stroke (%)	0	8	23	47
Very low SES (%)	7	10	15	16
Low SES (%)	23	28	29	35
Average SES (%)	30	29	25	24
High SES (%)	39	32	29	23

Note: SES is socio-economic status. This is based on the ability to make ends meet. See Annex C for further details on these variables.
Source: Analysis of SHARE data.

[1] Countries involved in SHARE: By 2022, the following 28 European countries, as well as Israel were involved: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and Switzerland. For the purposes of this research, data was used from 19 countries which were: Austria, Belgium, Czechia, Denmark, Estonia, France, Germany, Greece, Hungary, Israel, Italy, Luxembourg, The Netherlands, Poland, Portugal, Slovenia, Spain, Sweden and Switzerland.

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