EHESP

Master of Public Health

Master de Santé Publique

Exploring the links between cancer and self-reported mental health using SHARE survey data.

< Cormac EVERARD >

Class and year of the Master:
MPH Candidate, Year 2
Biostatistics concentration

Location of the practicum:
Organisation for Economic Cooperation and Development (OECD)

Professional advisor:
Aliénor Lerouge, OECD

Academic Advisor:
Professor Mary Beth Terry, Columbia University, New York.

Contents

Acknowledgements: 3

List of Abbreviations: 3

Abstract: 4

Résumé 5

Introduction: 6

Methods: 8

Data Source, population, collection, and sampling method: 8

Study population for current study 8

Ethical Statement: 9

Figure 1. Study Flow Diagram 10

Dependent variable – Depression Category 11

Independent Variables 12

New Diagnosis of Cancer 12

Other Covariates 12

Descriptive Analysis 14

Choice of Model 16

Results: 17

Descriptive analysis 17

Table 1. Baseline Population Characteristics 17

Logistic Regression results: 19

Effect of new cancer diagnosis on likelihood of depression: 19

Effect of other covariates 22

Discussion: 24

New cancer diagnosis increases likelihood of depression. 24

Female Sex is associated with a higher likelihood of depression category 25

Increasing age is associated with depression and attenuates impact of new cancer diagnosis 26

Previous Depression is a very important indicator of current depression category 26

Higher education is associated with reduced depression score, however effects plateau after upper secondary education 27

Country of origin plays a role in likelihood of being in depression category with new cancer diagnosis 28

Limitations 28

Conclusion/Recommendations/Implications 30

References: 31

Appendix 1. Question Items in Euro D. 36

Acknowledgements:

I would like to express my sincere gratitude to my professional advisor, Aliénor Lerouge, for giving me the opportunity to delve into this project and truly develop my analytical, reflexive and python programming skills. I extend my appreciation to all the members of the public health team in the OECD for their encouragement and insights.

I would also like to thank my academic supervisor Professor Mary Beth Terry for her insight, input, and advice both during this internship and in her teaching during the school term.

Furthermore, I would like to acknowledge the help of the EHESP faculty for their support. I am equally grateful to the faculty of the Andalusian School of Public Health and in particular Dr Alberto Fernandez for a wonderful year of learning and growth. I am also very grateful for the camaraderie and support of my fellow students at EHESP and the Europubhealth+ programme.

Finally, I would like to acknowledge my family and friends for their encouragement, support, and advice over the past two years of the programme.

List of Abbreviations:

OECD/OCDE: Organisation for Economic Cooperation and Development

ELS/HD: Directorate for Employment, Labour, and Skills. Health Division.

SHARE: Survey of Health, Ageing and Retirement in Europe

Abstract:

Background

The prevalence of cancer has been rising globally. Cancer can cause a significant burden for individuals, their caregivers and health care systems. However, less is known about the impact of a new cancer diagnosis on mental health and its association with age from fifty and above, where cancer is most prevalent.

Methods

Data across three wave pairs on 66,717 individuals from the Survey of Health, Ageing and Retirement in Europe (SHARE) were used to analyse the association between having a new cancer diagnosis in one survey wave compared to the preceding wave and likelihood of depression as defined by the survey instrument. Logistic Regression was the model of choice, and the regressions were adjusted for sex, age, education code, depression category in the previous wave and country.

Results

A new cancer diagnosis increased likelihood of being in the depression category (unadjusted OR 1.9 (1.43, 2.52) in wave pair 1-2, OR 2.15, CI (1.8, 2.6) in wave pair 4-5 and OR 1.92, CI (1.6, 2.3) in wave pair 5-6). The effect was stronger in the final adjusted model (OR 6.3 (2.5, 16.0) in wave pair 1-2. OR 3.6 (2.1, 6.2) in wave pair 4-5 and OR 2.6 (1.5, 4.5) in wave pair 5-6). More education decreased likelihood of being in the depression category relative to less, with the benefits increasing up to upper secondary education. Increasing age was associated with a higher likelihood of depression. However, an interaction with older age and new diagnosis showed being older at time of cancer diagnosis seemed to attenuate some of its negative impact on mental health. Female sex was associated with a higher likelihood of depression.

Conclusion

Our results indicate that new cancer diagnosis is associated with an increased likelihood of depression. They add to the evidence base on cancer and mental health, which can be used to help better account for address the psycho-social needs of patients with a new cancer diagnosis, particularly at the population level.

Key Words

Cancer; ageing; mental health; depression; SHARE.

Résumé

Titre

Une exploration des liens entre un nouveau diagnostic de cancer et la santé mentale par auto-évaluation en utilisant les données de l'enquête SHARE.

Introduction

La prévalence du cancer et l'espérance de vie augmentent partout dans le monde. Le cancer peut représenter un lourd fardeau pour les individus affectés, ainsi que leurs soignants et les systèmes de santé. Il peut également engendrer des conséquences économiques significatives. Cependant, l'impact d'un nouveau diagnostic de cancer sur la santé mentale chez les personnes plus âgées reste incertain.

Méthodologie

Une exploration des données de trois paires de vagues de l'enquête SHARE (Enquête sur la santé, le vieillissement et la retraite en Europe) a été réalisée afin d'analyser l'association entre un nouveau diagnostic de cancer dans une vague de l'étude et la santé mentale. Une régression logistique a été employée et les régressions ont été ajustées selon le sexe, l'âge, le niveau d'éducation, l'ancienne catégorie de santé mentale et le pays.

Résultats

Les résultats obtenus sur l'impact d'un nouveau diagnostic de cancer sur la santé mentale demeurent constants pour les trois paires de vagues : un nouveau diagnostic a été associé à un risque accru d'être dans la catégorie de dépression de l'enquête. Ces résultats sont significatifs pour tous les modèles statistiques, ajustés ou non. L'éducation représenterait un facteur protecteur contre le risque d'être dans la catégorie de dépression, et ce de manière croissante jusqu'à l'enseignement secondaire supérieur, par rapport aux personnes sans éducation. L'augmentation de l'âge a également été associée à un risque plus important d'être dans la catégorie de dépression. Pourtant, être plus âgé au temps du diagnostic de cancer réduit légèrement l'impact négatif d'un diagnostic sur la santé mentale. De plus, une régression quantile a été réalisée en tant qu'analyse supplémentaire, et montre un risque accru d'être dans la catégorie de dépression ; l'effet augmente avec chaque quantile.

Conclusion

Les résultats indiquent qu'un nouveau diagnostic de cancer est associé à un risque accru de dépression, ceux-ci demeurant significatifs quand on prend en compte le sexe, l'âge, les antécédents de santé mentale, l'éducation et le pays. Ces résultats s'ajoutent aux bases de connaissances sur le cancer et la santé mentale, et peuvent contribuer à une meilleure prise en compte et prise en compte des besoins psychosociaux des patients souffrant d'un cancer, notamment au niveau de la population.

Mots-Clés: Cancer; le vieillissement; santé mentale; dépression ; SHARE.

Introduction:

Cancer represents an important and increasing proportion of the global burden of disease (Sung *et al.,* 2021). This increasing incidence of cancer is partially attributed to our ageing societies. Additionally, cancer survival rates are improving (Arnold *et al.,* 2019) alongside increasing incidence, meaning more of our society are living with and are affected by cancer. Cancer diagnosis, in addition to its physical and socioeconomic implications, has been shown to impact mental ill health. Studies have demonstrated higher levels of anxiety and depression post diagnosis those diagnosed with cancer (Linden *et al.,* 2012). However, less is known about the mental health impact of cancer diagnosis in older age. Similarly, we have less insight on how the self-reporting of mental ill health changes prior to and post cancer diagnosis for the same people.

Mental ill-health is increasingly a priority subject on public health agendas worldwide. Indeed, the slogan 'No health without mental health' by Prince *et al.* 2007 in the Lancet has been echoed by many including the World Health Organization (WHO, 2023). Additionally, there is a clear economic argument for governments in addressing mental ill-health. For example, mental ill health has been associated with increased absenteeism, decreased likelihood of employment and increased intention to retire early (OECD, 2021). In the current context of societal shifts in working patterns which include later retirement, the economic implications of the mental health of older adults is brought into sharp relief.

Additionally, while patterns of mental health and illness change across the lifespan (Westerhof *et al.,* 2010), less is known about how certain factors such as cancer influence mental ill health in older age. Furthermore, there is a need to better understand the sex specific impacts through disaggregated data analysis. A better understanding of these mental health determinants and their impact can contribute to more informed public health strategies and policies.

Furthermore, although there is increasing public health focus on mental health and healthcare providers are increasingly attentive to mental health needs, there remains uncertainty with regards the role of screening for mental health in cancer patients. For example, a Cochrane systematic review found low-certainty evidence that did not support the role of screening psychosocial care needs in patients with cancer, (Schouten *et al.,* 2019). This sheds light on

the need to better identify and understand the impact of cancer on mental health to help make more informed decisions.

This study aims to identify how participant self-reported mental health changes following a new diagnosis of cancer in an older population. Specifically, it aims to identify in a longitudinal setting those study participants who responded to a self-reported questionnaire on mental health both prior to and following the diagnosis of cancer, to see how the new diagnosis of cancer changed their mental health score. The study also aims to consider how other factors such as age, sex, country, and socioeconomic factors influence the relationship between new cancer diagnosis and mental health, and test whether the associations were the same across subgroups by testing for interactions between these factors and new cancer diagnosis. Additionally, the study aimed to examine how the association between new cancer diagnosis and mental health changed depending on which wave pair was used. A broader aim is to contribute to the literature around cancer diagnosis and mental health, to better inform how we should address the burden of mental ill health in our society.

Work was carried out during my time as full-time intern with the public health team of the health division of the OECD. My contribution to this project was under the guidance of the professional and academic supervisor and regular review of the team, to merge the datasets, identify and select appropriate variables, perform the descriptive and inferential statistics, analyse, and interpret the results with the advice and guidance of my professional and academic supervisors.

Methods:

Data Source, population, collection, and sampling method:

The Study of Health, Ageing and Retirement in Europe (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 fifty and older (Börsch-Sup, 2022). The survey gathers information via face-to-face interviews which take place at home with digital support (Börsch-Supan et al., 2013). The first wave of the SHARE survey took place in 2004. Thereafter, further waves followed periodically, typically every two years (Börsch-Supan et al., 2013), with data collection by country taking approximately a year, though with some disruption during COVID-19. The study completed wave 8 in 2022. New participants (as refreshment samples) are added in each wave (Lusa & Huebner, 2021; Börsch-Supan et al., 2013). The number of countries involved has expanded from the first wave to now include 29 European Countries and Israel (Börsch-Supan et al., 2013; Börsch-Sup, 2022).

The survey employs probability-based sampling combined with a sampling protocol to provide an accurate definition of the target population to ensure representativeness of the sample from each country and facilitate international comparability. To be eligible for SHARE, participants had to be 50 years or older. Furthermore, current partners living in the same household were also interviewed, without age restriction (Börsch-Supan et al., 2013). Household response rate varied depending on country and wave, though averaged 55% for wave 1 (country range 35-74%), 54.5% for wave 2 (36-78%), 50.7% for wave 4 (39-63%), 44.5% for wave 5 (33-60%), and 47.5% for wave 6 (36-63%) (Bergmann M. *et al.,* 2017). Sample sizes are shown in figure 1. Overall sample size was 15,061 for wave 1-2 pair, 23,791 for wave 4-5 pair, and 27,865 for wave 5-6 pair. Further details of SHARE methodology are described elsewhere (Börsch-Supa, 2022).

Study population for current study

The inclusion criteria for this current study were participants aged fifty and older who participated in two consecutive survey waves in any of the following three wave pairs: wave one and two, wave four and five, or wave five and six. Wave three was excluded from this study as this wave focuses more on retrospective life history and so the questions were different from those asked in the waves considered for this study (Börshc-Supan, 2022; Schroder, 2011), limiting comparability. Wave seven was also excluded, given a very high proportion of missing data for the mental health module. This is primarily as those participants in wave seven who had not participated in wave 3 were asked the retrospective life history

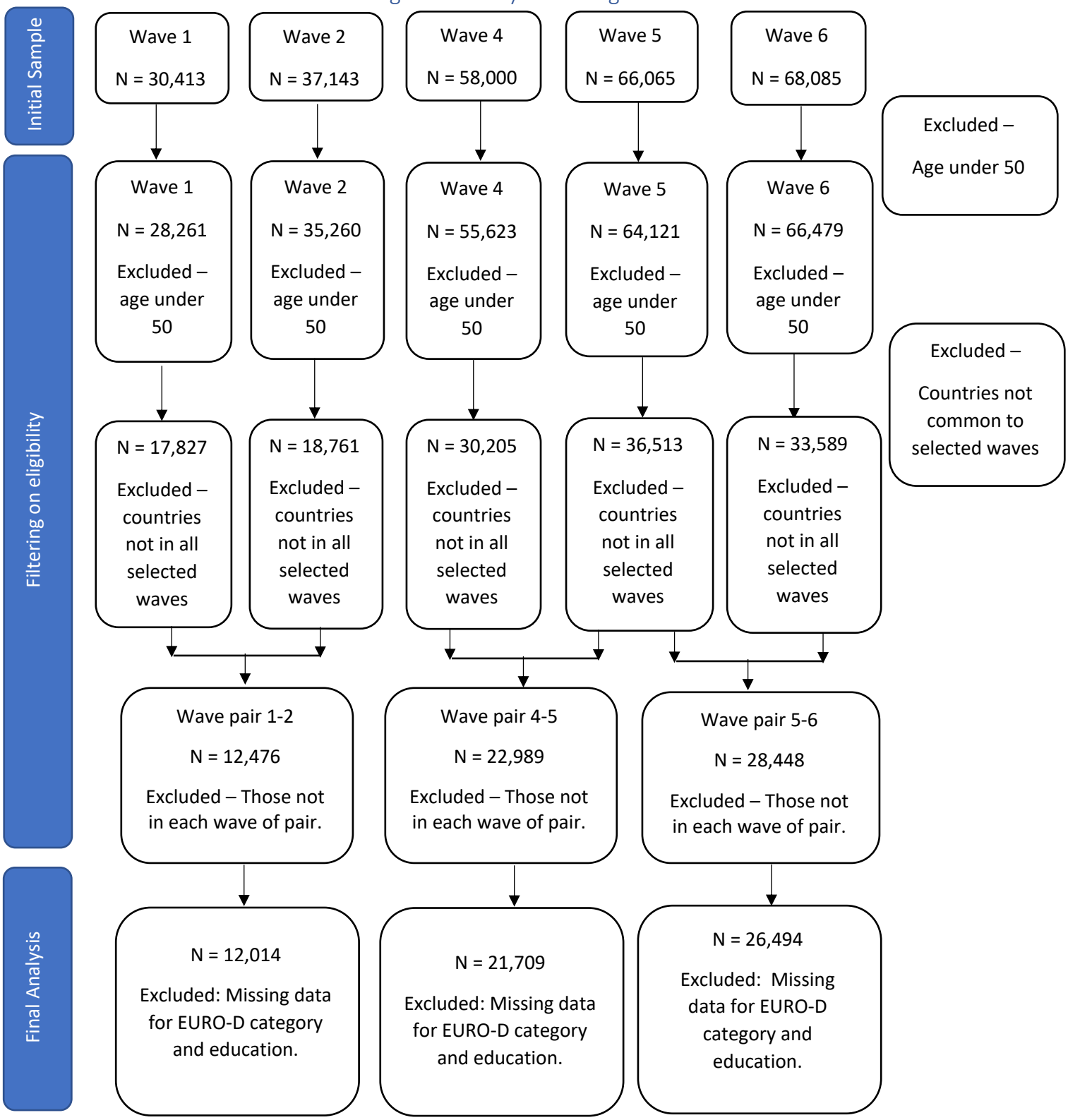
questions that were in wave three, and this comprised the majority of wave 7. Consequently, those same participants received a condensed set of questions from the usual survey questionnaire (Bergmann, Scherpezeel and Börsch-Supan, 2019), and this excluded the questions which made up the EURO-D depression scale. Wave eight took place during the COVID pandemic (Bergmann and Börsch-Supan, 2021). Given its independent impact on mental health it was not included. Moreover, the three wave pairs: wave one and two, wave four and five, and wave five and six were felt optimal for examining the effect of a new cancer diagnosis on mental health in a more comparable way.

Datasets for each wave of the wave pair were merged based on individual merge id and filtered for those present in both waves using the sex variable. Consequently, participants who undertook one survey wave but not the other in the wave pair were excluded. These wave pairs were selected to allow comparison of mental health reporting for the same participants prior to and following a cancer diagnosis. Among the three wave pairs, subjects with missing values for EURO-D for either wave of the wave pair were excluded from the study. To enhance comparability across the study wave pairs, only participants from countries that were represented in all wave pairs were included. The sample sizes are shown in the study flow diagram (Figure 1).

Ethical Statement:

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 (Lusa & Huebner, 2021). Additionally, the relevant local research ethics committees for each participating country approved SHARE, and written consent was provided by all participants (Lusa & Huebner, 2021).

Figure 1. Study Flow Diagram.



Dependent variable – Depression Category

The outcome variable was a binary variable of depression category (depressed or not depressed) based on a cut off value of four from the EURO-D depressive symptom scale.

The EURO-D scale was developed originally with the aim of deriving a common scale for assessing depression symptoms from various instruments on late-life depression used in various European countries (Prince et al., 1999; Mehrbrodt et al., 2019). The EURO-D-score has been validated in several European settings such as in a Spanish study by Larraga *et al.* 2006. Research by Guerra *et al.,* 2015 also found evidence for cross-cultural validity of the EURO-D scale at Latin American and Indian settings.

In the survey, there are sixteen items which evaluate a variety of depressive symptoms. Participants answer on whether they have experienced the symptom over the past month for each of the sixteen items. The results are condensed and used to generate a scale consisting of twelve variables: depression, pessimism, suicidality, guilt, sleep, interest, irritability, appetite, fatigue, concentration (on reading or entertainment), enjoyment, and tearfulness (Mehrbrodt et al., 2019). The maximum attainable score is 12 and this corresponds to 'very depressed' while the minimum score is zero which corresponds to 'not depressed). (Mehrbrodt et al., 2019). The questions asked in the mental health module are shown in the annex 1.

Within SHARE and in other studies, a participant is classified as being in the depression category based on having a EURO-D score of 4 or higher. This value was chosen as literature regarding the scales and multi-item indicators used in SHARE classified a score of 4 or higher on the scale as a 'case of depression', and a scale score below for as 'not depressed' (Mehrbrodt et al., 2019). Other studies in the literature have also used this cut off score (Marques et al., 2021; Lusa & Huebner, 2021).

Independent Variables

New Diagnosis of Cancer

Our primary independent variable in the study is a new diagnosis of cancer. This variable was created by identifying those participants in the first wave of the wave pair who did not report a diagnosis of cancer when asked, who then reported a diagnosis of cancer in the subsequent wave. In particular, the question asked in the survey was,

'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…

10. Cancer or malignant tumour, including leukaemia or lymphoma, but excluding minor skin cancers'

Participants who reported a cancer diagnosis in the second wave of the wave pair, who did not report a cancer diagnosis in the initial wave were coded as 1, with other participants coded as zero.

Other Covariates

Sex

The variable sex was added to our regression models to better understand the sex specific impacts of a new cancer diagnosis. Sex in the selected SHARE waves was classified as a binary male or female. Female was chosen as the reference for the model and sex was evaluated both alone and as an interaction term with new cancer diagnosis in the models.

Age

Age was added as a predictor variable, both alone and as an interaction term with new cancer diagnosis. To give more meaning to the interpretation of age in the regression output, age was cantered around the mean age. For wave pair 5-6 the mean age was 68 at the time of interview in survey wave 6; for wave pair 4-5 participants also had a mean age of 68 at the time of interview in wave 5; in wave pair 1-2 participants had a mean age of 67 at the time of wave two interview. For consistency, age 68 was the centred age for the three wave pairs.

Education

Education was also used as a predictor variable. The education variable is based on the international standard classification of Education (ISCED) code. This was calculated and inputted by SHARE, with methodology described elsewhere (Mehrbrodt et al., 2019). This education code gives a standardized way of measuring education across countries. It is coded from levels 0 to 6. Level 0 corresponds to pre-primary education; level 1 to primary education or first stage of basic education; level 2 to lower secondary or second stage of basic education; level 3 to upper secondary education; level 4 to post-secondary non-tertiary education; level 5 to first stage of tertiary education; and level 6 to second stage of tertiary education. Further details on each level are described in the UNESCO guidebook (UNESCO, 2006).

Additionally, upon analysis of the effect of education on depression score when controlling for cancer, the effect size increased with each level compared to a level of reference 0 up to level 3. There was then a plateau effect at level 3, such that there was little variation of effect size at level 3,4,5,6 compared to a reference level of 0. This was seen visually during descriptive statistics with the bar plot of education category against depression category (with proportions for depressed/non depressed for each education category) and on an initial regression model. Therefore, education was recategorized to collapse levels 3,4,5,6 (from upper secondary education to second stage of tertiary education) into a combined level.

Country

Country of residence was also examined in the models. The countries which participated changed over the course of the SHARE wave survey. For comparability purposes, country of residence was restricted to those countries which participated in all wave pairs. These were Austria, Belgium, Switzerland, Denmark, Spain, France, Italy, and Sweden. Austria was chosen as the reference country.

Descriptive Analysis

Descriptive Statistics were performed for dependent and independent variables in each wave using python version 3.9.13. Packages used in descriptive and inferential statistics included pandas, numpy, missingno, statsmodels, sklearn, scipy, seaborn and matplotlib. Additionally, a package was written in python to assist in the analysis of this project and help with future analyses. Missing data was displayed in tables for the individual waves and the wave pair datasets.

Overall, missing data was low for most variables. For the dependent variable of depression category ('eurodcat', computed from EURO-D score), there were 343 missing values (2.7 %) for wave 2 and there were 183 missing values (1.5 %) for wave one in wave pair 1-2. There were 486 missing values (2.1 %) in wave 4 and there were 604 missing values (2.6 %) in wave 5 for wave pair 4-5. There were 624 missing values (2.2 %) in wave 5 and there were 1290 missing values (4.55 %) for wave six in wave pair 5-6 for the depression variable.

For the independent variable education code, there were 8 missing observations (0.1%) for wave pair 1-2; 399 (1.7%) missing observations for wave pair 4-5; and 397 missing observations (1.4%) for wave pair 5-6. The independent variables of sex, age and country had no missing values in the final wave pairs. This was due to the initial conditions for filtering the data on age and country and for joining waves to a pair based on sex to arrive at the wave pair dataset.

For cancer, there were 23 missing values (0.2 %) in wave 1 and 25 missing values (0.2 %) in wave 2 for wave pair 1-2. For wave pair 4-5, there were 24 missing values (0.1 %) in wave 4 and 32 missing values (0.1 %) in wave 5. For wave pair 5-6, there were 16 missing values (0.1 %) in wave 5 and 28 missing values (0.1 %) in wave 6. The constructed variable new cancer diagnosis had no missing values, as this variable was computed based on selecting it in the second wave and not selecting it in the first.

To visualize and identify patterns of missingness, a matrix plot, heatmap and dendrograms were performed in python using the missing no package. Visual inspection of dendrogram showed little pattern to missingness among variables with missing observations. Similarly, on heatmap, missingness between the initial wave of EURO-D score and the subsequent wave EURO-D score was low at 0.3 or less in each of the three wave pairs, indicating that missingness of variable was little related to the missingness of the other selected variables.

Given the low percentage of missing data and lack of pattern to missingness, participants who had missing values for the selected variables were removed from the final analysis.

Summary statistics including mean age, education code, sex distribution and country distribution were analysed for each wave pair and are shown in table 1. Change in mean EURO-D score and proportion of participants in the depression category between each wave of the wave pair were also calculated for two groups – one comprising those participants who receive a new diagnosis of cancer in the second wave, and the other for the rest of the participants in the wave pair. This was undertaken prior to the regression analyses.

Choice of Model

Logistic regression was chosen as the model selected for the primary analysis. This was due to the significance of a cut off value of 4 in EURO-D score for approximating clinical depression as described by Mehrbrodt *et al.*, 2019 and used by others such as Marques *et al.*, 2021 and Lusa & Huebner, 2021. For this research question, it was felt to be the most appropriate in evaluating how new cancer diagnosis influences rates of depression.

For the logistic regression, an unadjusted analysis was first performed with a new cancer diagnosis and EURO-D category. Subsequently selected variables were added in sequence. Each variable was first added alone and tested for confounding, and then added as a multiplicative interaction with a new cancer diagnosis. Where the values were significant and meaningful variables were kept in the model. When testing for confounding, a threshold of a 10% change in the effect size of the coefficient of new cancer diagnosis was used. A log-log test was also performed to see if the added variables improved the model. Collinearity testing with variance inflation factor was performed for all variables included in the model and resulted negative.

As a supplementary analysis, a linear model and then a quantile model were tested with the continuous variable EURO-D score as the outcome variable. For the linear model, the distribution of the residuals was tested for normality. Subsequently, a quantile model was tested to examine how the effect size of new cancer diagnosis on EURO-D depression score changes with quantile.

Results:

Descriptive analysis

As described in the study flow diagram, a total of 12,014 individuals in wave pair 1-2, 21,709 individuals in wave pair 4-5 and 26,494 individuals in wave pair 5-6 were included in the final analysis. Characteristics of the study population at baseline for each wave pair are described in table 1. Mean age in the second wave was 67 in wave pair 1-2, 67 in wave pair 4-5 and 68 in wave pair 5-6. There were 45% males and 55% females in wave 1-2, 42% males and 58% females in wave pair 4-5, and 44% males and 56% females in wave pair 5-6. A new cancer diagnosis was reported by 112 (2.1%) of males and 95 (1.4%) of females in wave 1-2, 389 (2.5%) of males and 421 (2%) of females in wave pair 4-5, and 287 (2.4%) of males and 270 (1.8%) of females in wave pair 5-6.

Table 1. Baseline Population Characteristics

Coefficient Name	Male wave 1-2	Female wave 1-2	Male wave 4-5	Female wave 4-5	Male wave 5-6	Female wave 5-6
Sample Size	5434	6580	9845	12763	11828	14980
Proportion by sex	45.20%	54.80%	43.60%	56.50%	44.10%	55.90%
Mean Age First wave	64.48	64.87	65.38	64.93	66.38	65.65
Mean Age Second Wave	66.7	67.11	67.29	66.84	68.29	67.56
Interview Year First Wave	2004.88	2004.87	2011.49	2011.48	2013.47	2013.46
Interview Year Second Wave	2007.12	2007.11	2013.4	2013.41	2015.38	2015.38
Time between Interviews	2.2	2.2	1.9	1.9	1.9	1.9
Cancer first wave	247	422	445	614	529	723
Cancer second wave	213	261	411	472	499	541
New cancer cases	112	95	225	253	287	270
New cancer proportion	2.10%	1.40%	2.30%	2%	2.40%	1.80%
Depressed first wave	879	2172	1743	4070	1938	4570
Depressed Proportion first wave	16%	33%	18%	32%	16%	31%
Depressed second wave	916	2105	1779	4148	2005	4584
Depressed Proportion second wave	17%	32%	18%	33%	17%	31%
Euro-D score first wave	1.8	2.78	1.88	2.74	1.78	2.63
Euro-D score second wave	1.84	2.76	1.88	2.74	1.82	2.65
Education code 1 Proportion	29%	34%	20%	24%	19%	22%
Education code 2 Proportion	16%	18%	13%	16%	15%	17%
Education code 3 Proportion	26%	22%	34%	30%	30%	27%
Education code 4 Proportion	3%	3%	4%	3%	4%	3%
Education code 5 Proportion	20%	16%	23%	20%	24%	23%
Education code 6 Proportion	1%	0%	2%	1%	1%	1%
Education code None Proportion	5%	7%	3%	4%	6%	6%
Education code Other Proportion	1%	1%	1%	1%	0%	1%
Austria Proportion	8%	9%	15%	17%	9%	11%
Belgium Proportion	23%	21%	17%	17%	16%	15%
France Proportion	14%	15%	16%	17%	11%	12%
Switzerland Proportion	6%	5%	13%	12%	10%	9%
Spain Proportion	10%	11%	12%	12%	16%	16%
Italy Proportion	14%	14%	11%	11%	13%	13%
Denmark Proportion	9%	9%	9%	8%	12%	12%
Sweden Proportion	17%	16%	6%	6%	13%	12%

In the above Table 1, proportion by sex refers to the proportion of each sample which is made up of male and female, as asked in a binary way in the survey waves examined. The time between interviews is in years. The decimal represents months adjusted whereby one month is equivalent to 1/12. Cancer first wave refers to those with a diagnosis of cancer in the first wave of the wave pair, while cancer second wave refers to those with a diagnosis of cancer in the second wave of the wave pair. Depressed proportion represents the proportion in percent of respondents who are classified as depressed according to reaching a score of 4 or more on the EURO-D scale. The table also shows the relative proportion of participants from each of the eight countries analyzed.

As seen from the above table, the time between the first and second wave survey in the wave pairs was quite similar across wave pairs with an average of two years, with a range from 1.9 years in wave pair 4-5 and 5-6, to 2.2 years in wave pair 1-2.

From other descriptive analysis, it was found that among those with a new cancer diagnosis in wave pair 1-2, 10% also had a change in EURO-D depression category to depressed. This was 13% for wave pair 4-5 and 13% for wave pair 5-6. In terms of changes in EURO-D depression score, there was a mean increase of 0.73 in the depression score (0.79 among males and 0.65 among females) in wave 12. In wave pair 4-5, this increase was 0.65 (0.74 among males and 0.58 among females). This increase was 0.82 (0.92 among males and 0.72 among females) in wave pair 5-6.

Logistic Regression results:

Effect of new cancer diagnosis on likelihood of depression:

In the unadjusted analysis, a new diagnosis of cancer was shown to be associated with an increased likelihood of being classified as depressed as per survey instrument in each wave pair (OR 1.9 (1.43, 2.52) in wave pair 1-2, OR 2.15, CI (1.8, 2.6) in wave pair 4-5 and OR 1.92, CI (1.6, 2.3) in wave pair 5-6). Of note the effect size was similar in all three wave pairs, with an approximate doubling of the odds ratio. When the model was adjusted for sex (reference female), age (reference mean age 68), previous depression category (reference no previous depression, education code (reference pre-primary education) and country (reference Austria), this association remained statistically significant and consistent across wave pairs as shown in table 2d below (OR 2.21 (1.6, 3.06) in wave pair 1-2, OR 2.39 (1.94, 2.94) in wave pair 4-5 and OR 2.14 (1.76, 2.6) in wave pair 5-6. When interaction terms were added to the model following testing, the overall effect size with the above variables and in addition the interaction terms country and new cancer diagnosis as well as mean age and new cancer diagnosis lead to a stronger effect size which was less consistent across wave pairs compared to the unadjusted or adjusted without interaction terms models. OR 6.33 (2.50, 16.02) in wave pair 1-2, OR 3.66 (2.01, 6.38) in wave pair 4-5, OR 2.61 (1.52, 4.49) in wave pair 5-6.

Table 2a. Logistic Regression Results (Unadjusted) per wave pair.

Coefficient Name	OR 1-2	CI 1-2	OR 4-5	CI 4-5	OR 5-6	CI 5-6
Intercept	0.33	(0.32, 0.35)	0.35	(0.34, 0.36)	0.32	(0.312, 0.33)
New Cancer	1.90	(1.43, 2.52)	2.15	(1.79, 2.59)	1.92	(1.61, 2.278)

Table 2b. Logistic Regression Results Adjusted for Age and Sex per wave pair.

Coefficient Name	OR 1-2	CI 1-2	OR 4-5	CI 4-5	OR 5-6	CI 5-6
Intercept	0.20	(0.18, 0.21)	0.22	(0.2, 0.23)	0.20	(0.19, 0.21)
New Cancer	1.97	(1.48, 2.64)	2.10	(1.74, 2.54)	1.95	(1.64, 2.33)
Female sex	2.33	(2.13, 2.55)	2.23	(2.09, 2.38)	2.22	(2.09, 2.36)
Age centered at mean	1.02	(1.02, 1.03)	1.02	(1.02, 1.03)	1.02	(1.02, 1.02)

Table 2c. Logistic Regression Results for the fully adjusted model without interactions.

Coefficient Name	OR 1-2	CI 1-2	OR 4-5	CI 4-5	OR 5-6	CI 5-6
New Cancer	2.21	(1.6, 3.06)	2.39	(1.94, 2.94)	2.14	(1.76, 2.6)
Female sex	1.75	(1.59, 1.93)	1.78	(1.66, 1.91)	1.76	(1.65, 1.88)
Age centered at mean	1.02	(1.01, 1.02)	1.02	(1.01, 1.02)	1.02	(1.01, 1.02)
Education level 1	0.85	(0.7, 1.04)	0.72	(0.61, 0.85)	0.78	(0.68, 0.89)
Education level 2	0.79	(0.63, 0.98)	0.64	(0.54, 0.77)	0.69	(0.6, 0.8)
Education level 3-6	0.63	(0.52, 0.78)	0.52	(0.44, 0.61)	0.62	(0.54, 0.71)
Education - Other	1.13	(0.65, 1.98)	0.57	(0.36, 0.9)	0.67	(0.42, 1.06)
Country Belgium	1.29	(1.06, 1.56)	1.45	(1.28, 1.63)	1.39	(1.23, 1.58)
Country Denmark	0.94	(0.74, 1.2)	1.05	(0.9, 1.23)	0.80	(0.7, 0.93)
Country France	1.33	(1.08, 1.63)	1.70	(1.51, 1.91)	1.44	(1.26, 1.64)
Country Italy	1.68	(1.37, 2.07)	1.91	(1.67, 2.19)	1.38	(1.21, 1.58)
Country Spain	1.20	(0.96, 1.5)	1.22	(1.06, 1.4)	1.00	(0.87, 1.14)
Country Sweden	0.82	(0.67, 1.02)	0.91	(0.76, 1.08)	0.82	(0.71, 0.94)
Country Switzerland	0.67	(0.51, 0.9)	0.98	(0.85, 1.12)	0.81	(0.7, 0.94)

Table 2d. Logistic Regression Results for the fully adjusted model per wave pair.

Coefficient Name	OR 1-2	CI 1-2	OR 4-5	CI 4-5	OR 5-6	CI 5-6
New Cancer	6.33	(2.5, 16.02)	3.57	(2.05, 6.19)	2.61	(1.516, 4.488)
Female sex	1.75	(1.59, 1.93)	1.78	(1.66, 1.91)	1.76	(1.65, 1.881)
Age centered at mean	1.02	(1.01, 1.02)	1.02	(1.01, 1.02)	1.02	(1.013, 1.02)
Centered age New Cancer Interaction	0.97	(0.94, 1.0)	0.97	(0.95, 0.99)	0.98	(0.957, 0.999)
Education level 1	0.86	(0.7, 1.05)	0.72	(0.61, 0.85)	0.78	(0.683, 0.894)
Education level 2	0.79	(0.63, 0.99)	0.64	(0.54, 0.77)	0.69	(0.601, 0.803)
Education level 3-6	0.64	(0.52, 0.78)	0.52	(0.43, 0.61)	0.62	(0.539, 0.71)
Education - Other	1.12	(0.64, 1.97)	0.57	(0.36, 0.9)	0.67	(0.421, 1.06)
Country Belgium	1.32	(1.08, 1.6)	1.46	(1.29, 1.65)	1.41	(1.245, 1.608)
Country Denmark	0.98	(0.77, 1.24)	1.06	(0.91, 1.25)	0.81	(0.697, 0.932)
Country France	1.39	(1.12, 1.71)	1.73	(1.53, 1.95)	1.45	(1.266, 1.661)
Country Italy	1.75	(1.42, 2.16)	1.92	(1.68, 2.2)	1.38	(1.204, 1.58)
Country Spain	1.21	(0.97, 1.51)	1.20	(1.05, 1.39)	1.00	(0.869, 1.141)
Country Sweden	0.86	(0.69, 1.06)	0.93	(0.78, 1.11)	0.82	(0.715, 0.948)
Country Switzerland	0.71	(0.53, 0.95)	1.00	(0.87, 1.15)	0.82	(0.703, 0.957)
Belgium Interaction Cancer	0.60	(0.18, 1.99)	0.69	(0.33, 1.45)	0.62	(0.305, 1.26)
Denmark Interaction Cancer	0.34	(0.09, 1.28)	0.78	(0.3, 2.01)	0.95	(0.415, 2.157)
France Interaction Cancer	0.19	(0.05, 0.66)	0.45	(0.21, 0.94)	0.77	(0.355, 1.668)
Italy Interaction Cancer	0.14	(0.04, 0.56)	0.89	(0.38, 2.1)	1.01	(0.486, 2.117)
Spain Interaction Cancer	1.81	(0.39, 8.34)	1.45	(0.64, 3.3)	1.40	(0.671, 2.93)
Sweden Interaction Cancer	0.32	(0.1, 1.03)	0.58	(0.25, 1.37)	0.73	(0.309, 1.726)
Switzerland Interaction Cancer	0.13	(0.02, 0.91)	0.53	(0.23, 1.21)	0.71	(0.292, 1.721)

In the supplementary quantile regression, in the unadjusted and adjusted analysis there was an increase in the EURO-D depression score at every quantile. For the unadjusted analysis the increase was not statistically significant at the 25th quantile. However, there was an increase of 1.0 (0.927, 1.1) at the median, 1.0 (0.895, 1.11) at the 75th quantile and 2.0 (1.89, 2.1) at the 90th quantile. For the fully adjusted model there was a statically significant increase across the quantiles, with the coefficient increasing at every quantile. In wave 5-6 this was 0.7263 (0.64, 0.82) at the 25th quantile, 0.89 (0.77, 1.03) at the median, 0.96 (0.78, 1.15) at the 75th quantile and 1.14 (0.93, 1.36) at the 90th quantile.

Effect of other covariates

Age was added in the logistic model centred around the mean of 68. It was shown to have a small but statistically significant increase in the likelihood of being in the depressed category for each wave pair when adjusted for the other covariates in the model. For age cantered at the mean the following effect sizes were observed. OR 1.01 (1.01, 1.02) in wave pair 1-2, OR 1.01 (1.01, 1.02) in wave pair 4-5 and OR 1.02 (1.01, 1.02) in wave pair 5-6.

When age was added as an interaction term, it was shown to have a small but statistically significant negative multiplicative interaction with new cancer diagnosis in wave pair 4-5 (OR 0.97 (0.95, 0.99)) and wave pair 5-6 (OR 0.98, CI (0.95, 0.99)), but not so in wave pair 1-2 (OR 0.97 (0.94, 1.01)).

Female sex was also associated with a statistically significant increase in likelihood of depression across all three wave pairs. The OR was 1.75, CI (1.59, 1.93) in wave pair 1-2. OR was 1.77 with CI (1.65, 1.90) in wave pair 4-5 and OR 1.734, CI (1.626, 1.85) in wave pair 5-6. When tested for multiplicative interaction with new cancer diagnosis, there was no statistically significant interaction, and it was not included in the fully adjusted model. When tested for as a confounder, there was a greater than 10% in the beta coefficient for new cancer diagnosis in wave 1-2 (15%), wave 5-6 (13%) and a 9% change in the beta coefficient in wave pair 4-5. Overall, this indicated that sex also confounds the relationship between new cancer diagnosis and mental health.

Depression in the initial wave had the strongest association with the likelihood of depression in the subsequent wave in our model. There was a strong and statistically significant increase in each wave pair (OR 6.52, CI (5.92, 7.18) in wave pair 1-2, OR 6.50, CI (6.06, 6.98) in wave pair 4-5 and OR 5.73, CI (5.38, 6.11) in wave pair 5-6). When tested for confounding, there was a greater than 10% change in the beta coefficient of new cancer diagnosis in wave 4-5 (15%), wave 5-6 (14%), and a 6.5% change in wave pair 1-2. This indicated that previous depression also confounded the relationship. This was adjusted for by keeping previous depression category in the model.

Higher education level when compared to no education was associated with a reduced likelihood of depression when adjusted for the other covariables in the model. The effect was strongest with the grouping of levels 3-6, representing upper secondary school education to university education. The effect sizes for education level 3-6 were OR 0.64, CI (0.52, 0.79) in

wave pair 1-2, OR 0.51 (0.43, 0.60) in wave pair 4-5 and OR 0.61 (0.53, 0.70) in wave pair 5-6.

Lower secondary education (level 2) was also associated with a reduced likelihood of depression compared to no education, with the result statistically significant in each wave pair. OR 0.79 (0.64, 0.99) in wave pair 1-2, OR 0.63 (0.53, 0.76) in wave pair 4-5 and OR 0.69 (0.59, 0.80) in wave pair 5-6. Primary education had a statistically significant reduced likelihood of depressed compared to no education for wave pairs 4-5 (OR 0.71 (0.60, 0.84) and 5-6 (OR 0.77 (0.67, 0.88)), but not for wave par 1-2 (OR 0.86, CI (0.70, 1.05). When tested for confounding, there was a less than 10% change in the beta coefficient of new cancer diagnosis in all three wave pairs (2% in wave pair 1-2, 5.2% in wave pair 4-5, and 5.7% in wave pair 5-6), suggesting education did not confound the relationship between new cancer diagnosis and mental health.

Finally, country of residence had an impact on likelihood of depression, with the effect varying with every country compared to a reference country of Austria. Belgium, Denmark, France and Italy had statistically significant increased likelihoods of depression compared to Austria. The effect was not statistically significant in any wave for Sweden. When tested for interaction, there was a statistically significant interaction with France in wave 4-5, but this was only significant for this wave pair and not for any other wave pair. No other country had a statistically significant interaction with new cancer diagnosis. The model was tested for goodness of fit with and without the interaction term using the likelihood ratio test. Given a statistically significant improvement in the log likelihood, the interaction term with country was kept in the model.

Discussion:

New cancer diagnosis increases likelihood of depression.

New cancer diagnosis was associated with an increased likelihood of being in the depressed category, as evidenced in both the descriptive statistics with datasets filtered for only those with a new cancer diagnosis in the latter wave of the wave pair, and the logistic regressions including all participants in each wave pair.

In the descriptive statistical analysis, 10% of newly diagnosed cancer patients also transitioned to the depressed category. This figure was 13% for wave 4-5, and 13% for wave 5-6. In the logistic regressions, there was an important and statistically significant increased likelihood of depression with a new diagnosis of cancer in all wave pairs and in both unadjusted and adjusted analysis. In the supplementary adjusted quantile regression analysis, new cancer diagnosis was also associated with an increase in EURO-D depression score, with the diagnosis having the greatest impact on the highest quantiles. The impact of new cancer diagnosis on increased likelihood of depression remained statistically significant when adjusted for age, sex, education code, previous depression score and country, including interaction of country and new cancer diagnosis as well as age and new cancer diagnosis. Effect sizes for the final adjusted models were OR 6.33 (2.50, 16.02) in wave pair 1-2, OR 3.66 (2.01, 6.38) in wave pair 4-5, OR 2.61 (1.52, 4.49) in wave pair 5-6.

These findings were robust to confounding bias for the selected covariables. As variables were added in turn to the model, confounding was tested for, and confounders were taken into account through their inclusion in the final adjusted model. The variables added were also tested for multiplicative interaction, and where the interaction term was statistically significant were kept in the model. In the case of country, although not statistically significant, the interaction term increased the goodness of fit of the model as evidenced by the log likelihoods and so was kept. Misclassification bias is less likely to have influenced these results as those with cancer are more likely to report it and those without cancer are less likely to report that they have it. In terms of potential selection bias, the SHARE survey was conducted by probability-based sampling with a sampling protocol so this is less likely. However, some recipients with a new cancer diagnosis may have been diagnosed and passed away in the time between the first and second wave of the wave pair, and as such this study does not capture those cancers which for certain participants lead to a rapidly fatal outcome. The aggressive nature of those cancers which were potentially missed in this study may have lead

to a larger effect size than seen in our study, given their overwhelming impact on quality of life.

The findings described in this study for new cancer diagnosis and mental health are important for several reasons. Firstly, they are coherent with and add to the existing literature on how new cancer diagnosis impacts mental health. There are several reasons why a cancer diagnosis can negatively impact mental health. As described by Alwhaibi and colleagues, a new diagnosis of cancer is associated with increased rate of depression for multiple reasons including a fear of death, changes in social roles, physical health, life plans and work (Alwhaibi *et al.,* 2017; NCI, 2017). Additionally, it is likely that a proportion of respondents reporting cancer in SHARE were receiving chemotherapy treatment, and there is evidence from the literature of an association between chemotherapy treatment and risk of depression, such as for example among breast cancer patients (Reece *et al.,* 2013; Alwhaibi *et al.,* 2017).

Moreover, this research suggests that re-examining the psychosocial needs of new cancer patients may be warranted, including the role of screening for depression among cancer patients. For example, a 2019 Cochrane systematic review did not support the role of screening psychosocial care needs in patients with cancer, however this was with low-certainty evidence (Schouten *et al.,* 2019.) It follows that additional evidence from studies such as this on the increased burden of mental ill health among newly diagnosed cancer patients with certain subgroups taken into account suggest an updated review may be warranted.

Female Sex is associated with a higher likelihood of depression category

In this study, female sex was associated with a statistically significant higher likelihood of being in the depressed category in all three wave pairs with OR 1.75, CI (1.59, 1.93) in wave pair 1-2, OR 1.77, CI (1.65, 1.90) in wave pair 4-5 and OR 1.73, CI (1.63, 1.85) in wave pair 5-6.

When tested for interaction, there was no statistically significant multiplicative interaction found. When tested for confounding with new cancer diagnosis, there was a greater than ten percent change in the beta of new cancer diagnosis and depression in two of the three wave pairs (and a 9% change in wave pair 4-5) and female sex was kept in the model to adjust for this.

The increased rate of depression among participants of female sex compared to male sex is consistent with the literature. For example, Alwhaibi and colleagues found that women with colorectal cancer had a forty six percent higher risk of newly diagnosed depression compared to men with the same diagnosis (Alwhaibi *et al.,* 2017). Additionally, a systematic review of

age and gender specific depression in later life found consistent evidence for a higher risk of depression among older women compared to men (Luppa *et al.,* 2012). It also suggested that gender differences in symptom reporting may account for some of this difference, as some literature suggests women are more likely to complain about their dysphoric feelings than men (Luppa *et al.,* 2012; Koenig and Blazer, 2007; Sonnenberg et al., 2000)

Increasing age is associated with depression and attenuates impact of new cancer diagnosis

Increasing age was found to be associated with a higher likelihood of being in the depressed category in our study. In all three wave pairs, there was a statistically significant increase. For age cantered at mean, OR was 1.02 (1.01, 1.02) in wave pair 1-2, OR 1.02 (1.01, 1.02) in wave pair 4-5 and OR 1.02I (1.01, 1.02) in wave pair 5-6. When tested for multiplicative interaction, there was statistically significant multiplicative interaction found between increasing age and new cancer diagnosis in wave pair 4-5 (OR 0.97 (0.95, 0.99)) and wave pair 5-6 (OR 0.98, CI (0.95, 0.99)), but not so in wave pair 1-2 (OR 0.97 (0.94, 1.01)).Overall, this suggests that getting a new cancer diagnosis at a later age slightly attenuates the impact of the cancer on likelihood of depression.

The association between increasing age and higher likelihood of depression is consistent with literature findings. For example, a systematic review found that rates of depression among older people increase substantially with age, particularly in the highest age groups such as 85-89 and 90 and above (Luppa *et al.,* 2012). However, less is known about the interaction between a new diagnosis of cancer and its impact on mental ill health in older compared to younger geriatric patients. This research suggests that a new diagnosis of cancer in older geriatric patients may in a small but statistically significant way attenuate the impact of the cancer diagnosis on mental ill health. There are many reasons why this may be the case, one of which may be due to reduced healthy life years at an older relative to a younger age, and with that reduced perception of loss with diagnosis. Such information is important when we consider a systematic review on the relation between mental health, ageing and cancer found diagnosing and assessing depression among older cancer patients particularly challenging (Massa *et al.,* 2021).

Previous Depression is a very important indicator of current depression category

Our findings suggest that the depression score participants had during the first wave of the survey wave pair is strongly associated with the depression category they will be in during the wave in which the new cancer diagnosis is reported. This is consistent with the literature in that previous depression is a strong predictive risk factor of future depression.

When tested for confounding, there was a greater than 10% change in the beta coefficient for new cancer diagnosis in wave 4-5 (15%), wave 5-6 (14%), and a 6.5% change in wave pair 1-2. In these cases, the effect size of new cancer diagnosis on likelihood of depression increased when previous depression category was taken into account. This indicates that previous depression is a negative confounder of the relationship between new cancer diagnosis and mental health. When tested for multiplicative interaction, the interaction term was not statistically significant in any of the three wave pairs (coefficient -0.396 (-0.819, 0.027) in wave pair 5-6, coefficient -0.1454 (-0.597, 0.306) in wave pair 4-5 and coefficient -0.4802 (-1.138, 0.178) in wave pair 1-2).

Overall, these findings suggest that previous depression has an important association with current likelihood of depression, and that it negatively confounds the relationship with new cancer diagnosis and mental health and should be adjusted for in the model to better reflect the true relationship between cancer diagnosis and depression likelihood. However, it is also noteworthy that the relationship between new cancer diagnosis and likelihood of depression is still statistically significant even when this negative confounding is not adjusted for in the model.

Higher education is associated with reduced depression score, however effects plateau after upper secondary education

Results suggest that increased education reduces likelihood of being in the depressed category when accounting for the other covariates in the model, compared to a reference of no education. The effect peaked and plateaued at upper secondary education, this level and above were grouped and the following effects produced, with OR 0.64 (0.52, 0.79) in wave pair 1-2, OR 0.51 (0.43, 0.60) in wave pair 4-5 and OR 0.61 (0.53, 0.70) in wave pair 5-6. There was no evidence for education confounding the relationship between new cancer diagnosis and mental health in this study.

Regarding the literature, less is known about how education level influences the mental health impact of a new cancer diagnosis. However, a study from Denmark on men with prostate cancer also found that men with fewer years of education had a higher rate of first depression with cancer diagnosis compared to those with more year of education (Friberg *et al.,* 2019).

Moreover, this suggests that patients with low education levels who have a new diagnosis of cancer may benefit more from screening for identification of depression and psychosocial need. Lower education level has already been associated higher mortality level (Albano *et al.,*

2007) and a recent systematic review and meta-analysis highlighted the critical role of health literacy in effective cancer prevention (Baccolini *et al.,* 2022). Therefore, this result adds an additional case for addressing the needs of patients with lower education level in addition to addressing the underlying social, cultural, and economic barriers to education more broadly.

Country of origin plays a role in likelihood of being in depression category with new cancer diagnosis.

The results suggest that county one lives in plays a role in the likelihood of being in the depression category. For example, we see that Belgium, Denmark, France and Italy had statistically significant increased likelihoods of depression compared to Austria, which was significant in all waves. However, this also raises the question of how the survey item measures are perceived in different countries, and whether this accounts partially for the impact of country on score. For example, although the EURO-D scale has been validated in Europe (Larraga *et al.* 2006), some argue that some countries a different cut off score should be used in different countries or aligned country means should be used (Maskileyson *et al.,* 2021). However, by including the countries as covariates in the model and showing that the increase in likelihood of depression with a new cancer diagnosis remains robust, we hope to demonstrate the impact of new cancer diagnosis on mental ill health in spite of country differences.

Limitations

There are limitations to this study. Firstly, some patients who are diagnosed with cancer following one wave of the study will have passed away prior to the subsequent study wave, and as such this study misses those fatal interval cancers. Given the strong impact of more aggressive rapidly fatal cancers on psychosocial wellbeing, it is likely that those interval cancers would have led to a stronger effect size, and so our study may subsequently underestimate the effect of a new cancer diagnosis on mental health by missing these participants.

Additionally, reflecting on the way the question was asked, some cancer patients who may have been in remission in one wave and answered no, and had a recurrence of cancer in the subsequent wave, would be included as a new cancer diagnosis when this was not the case. It is uncertain how this may bias results. For example, those with recurrences of cancer may have more aggressive forms, in which case it is likely that it would have a greater impact on mental health. If this is the case, our results would overestimate the true effect of a new cancer

diagnosis. Conversely, those with recurrence may have some attenuation of the impact on mental health from cancer secondary to resilience in the face of recurrence. Indeed, a controlled perspective study by Andersen *et al.* (Anderson *et al.,* 2007) found that patient stress in the face of cancer recurrence was 'compartmentalized' and at least in the first few weeks of a diagnosis of cancer recurrence did not result in diffuse emotional distress, underscoring resilience.

Furthermore, there was a paucity of literature on the validation of the self-report of cancer by pathology record or other means. However, it is likely that most people reporting a diagnosis of cancer as told by their doctor were indeed told they had a cancer diagnosis. Moreover, this current did not look at cancer grade and stage at diagnosis as this was not asked, and it is likely that the score would change depending on these features.

Furthermore, although EURO-D is a validated measure of depression in the European population (Prince et al., 1999; Mehrbrodt et al., 2019) and the EURO-D cut off score of 4 has been used in other studies such as Marques *et al.,* 2021, self-reporting measures of depressive symptoms involve a risk of reporting bias, as described by Komulainen *et al.,* 2021. Additionally, a dichotomy of depression vs non depression based on a cut off score doesn't fully capture symptom severity, and there remains a paucity of literature on the use of the EURO-D scale to classify differing severity levels of depression.

Conclusion/Recommendations/Implications

Our findings suggest a new diagnosis of cancer in patients over the age of fifty is associated with a statistically significant and important increase in the likelihood of depression based on the SHARE EURO-D score, and this effect was seen across different wave pairs of the SHARE survey. This increased likelihood remains statistically significant when adjusted for age, sex, education code, previous depression category and country of residence. Furthermore, while increasing age is associated with higher likelihood of being in the depression category, age seems to attenuate to a small extent the negative mental health impact of a cancer diagnosis. Higher education level was found to have a protective effect on likelihood of being depressed, however this effect peaked and plateaued after upper secondary education.

These findings add to the existing literature on cancer diagnosis and mental health. In particular, they invite discussion on the role of education and the interaction of age and new cancer diagnosis on mental ill health. Moreover, our results suggest that a review of the utility of screening for mental ill health among newly diagnosed cancer patients may be warranted in light of new evidence. Indeed, increased focus on patients with a lower education level may be warranted to provide more equitable care and ensure psychological needs are met in patients receiving a diagnosis of cancer. Given global increases in life expectancy and the increasing burden of cancer worldwide, our findings add to the literature which is needed more than ever for evidence-based decision making in the fields of mental health, cancer, and ageing.

References:

Albano JD, Ward E, Jemal A, Anderson R, Cokkinides VE, Murray T, Henley J, Liff J, Thun MJ. Cancer mortality in the United States by education level and race. J Natl Cancer Inst. 2007 Sep 19;99(18):1384-94. doi: 10.1093/jnci/djm127. Epub 2007 Sep 11. PMID: 17848670.

ALWHAIBI, Monira, SAMBAMOORTHI, Usha, MADHAVAN, Suresh, et al. Cancer type and risk of newly diagnosed depression among elderly medicare beneficiaries with incident breast, colorectal, and prostate cancers. Journal of the National Comprehensive Cancer Network, 2017, vol. 15, no 1, p. 46-55.

Andersen, B. L., Shapiro, C. L., Farrar, W. B., Crespin, T., & Wells-DiGregorio, S. (2005). Psychological responses to cancer recurrence: a controlled prospective study. Cancer, 104(7), 1540-1547.

Arnold, M., Rutherford, M. J., Bardot, A., Ferlay, J., Andersson, T. M. L., Myklebust, T. Å., Tervonen, H., Thursfield, V., Ransom, D., Shack, L., Woods, R. R., Turner, D., Leonfellner, S., Ryan, S., Saint-Jacques, N., De, P., McClure, C., Ramanakumar, A. v., Stuart-Panko, H., … Bray, F. (2019). Progress in cancer survival, mortality, and incidence in seven high-income countries 1995–2014 (ICBP SURVMARK-2): a population-based study. The Lancet Oncology, 20(11). https://doi.org/10.1016/S1470-2045(19)30456-5

Baccolini V, Isonne C, Salerno C, Giffi M, Migliara G, Mazzalai E, Turatto F, Sinopoli A, Rosso A, De Vito C, Marzuillo C, Villari P. The association between adherence to cancer screening programs and health literacy: A systematic review and meta-analysis. Prev Med. 2022 Feb;155:106927. doi: 10.1016/j.ypmed.2021.106927. Epub 2021 Dec 23. PMID: 34954244.

Bergmann, M., A. Scherpenzeel and A. Börsch-Supan (Eds.) (2019). SHARE Wave 7 Methodology: Panel Innovations and Life Histories. Munich: Munich Center for the Economics of Aging (MEA).

Bergmann, M., Kneip, T., De Luca, G., & Scherpenzeel, A. (2017). Survey participation in the survey of health, ageing and retirement in Europe (SHARE), Wave 1-6. Munich: Munich Center for the Economics of Aging.

Bergmann, M. and A. Börsch-Supan (Eds.) (2021). SHARE Wave 8 Methodology: Collecting Cross-National Survey Data in Times of COVID-19. Munich: MEA, Max Planck Institute for Social Law and Social Policy.

Börsch-Supan A, Brandt M, Hunkler C, Kneip T, Korbmacher J, Malter F, et al. Data resource profile: the Survey of Health, Ageing and Retirement in Europe (SHARE). Int J Epidemiol. 2013;42:992–1001. doi:10.6103/ SHARE.w7.700.

Börsch-Supan, A. (2022). Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 7. Release version: 8.0.0. SHARE-ERIC. Data set. DOI: 10.6103/SHARE.w7.800

Börsch-Supan, A. (2022). Survey of Health, Ageing and Retirement in Europe (SHARE) Wave 3 – SHARELIFE. Release version: 8.0.0. SHARE-ERIC. Data set. DOI: 10.6103/SHARE.w3.800Schröder, M. (2011).

FRIBERG, Anne Sofie, RASK MOUSTSEN, Ida, BENZON LARSEN, Signe, et al. Educational level and the risk of depression after prostate cancer. Acta oncologica, 2019, vol. 58, no 5, p. 722-729.

Guerra, M., Ferri, C., Llibre, J., Prina, A. M., & Prince, M. (2015). Psychometric properties of EURO-D, a geriatric depression scale: a cross-cultural validation study. BMC psychiatry, 15(1), 1-14.

Guerra, M.; Ferri, C.; Llibre, J.; Prina, A.M.; Prince, M. Psychometric properties of EURO-D, a geriatric depression scale: A cross-cultural validation study. BMC Psychiatry 2015, 15, 1–14. [CrossRef] [PubMed])

JC, Chan YF, Herbert J, et al. Course of depression, mental health service utilization and treatment preferences in women receiving chemotherapy for breast cancer. Gen Hosp Psychiatry. 2013; 35:376–381. [PubMed: 23642440]

Komulainen, K., Gluschkoff, K., Garcia Velazquez, R., Airaksinen, J., Szmulewicz, A., & Jokela, M. (2021). Association of depressive symptoms with health care utilization in older adults: longitudinal evidence from the survey of health, aging, and retirement in Europe. International journal of geriatric psychiatry, 36(4), 521-529.

Koenig, H.G., Blazer, D.G., 2007. Mood Disorders. In: Blazer, D.G., Steffens, D.C., Busse, E.W. (Eds.), Essential of geriatric psychiatry. American Psychiatric Pub, Washington, DC, pp. 145–176.

Larraga L, Saz P, Dewey ME, Marcos G, Lobo A, ZARADEMP Workgroup. Validation of the Spanish version of the EURO-D scale: an instrument for detecting depression in older people. Int J Geriatr Psychiatry 2006; (12): 1199-205.

Linden, W., Vodermaier, A., MacKenzie, R., & Greig, D. (2012). Anxiety and depression after cancer diagnosis: Prevalence rates by cancer type, gender, and age. Journal of Affective Disorders, 141(2–3). https://doi.org/10.1016/j.jad.2012.03.025

Listabarth, Stephan, et al. "Cognitive decline and alcohol consumption in the aging population—A longitudinal analysis of the Survey of Health, Ageing and Retirement in Europe." European Psychiatry 65.1 (2022): e83.

Luppa, Melanie, et al. "Age-and gender-specific prevalence of depression in latest-life–systematic review and meta-analysis." Journal of affective disorders 136.3 (2012): 212-221.

Lusa, L.; Huebner, M Organizing and Analyzing Data from the SHARE Study with an Application to Age and Sex Differences in Depressive Symptoms. Int. J. Environ. Res. Public Health 2021, 18, 9684. https://doi.org/10.3390/ ijerph18189684

Marques, A., Henriques-Neto, D., Peralta, M., Marconcin, P., Gouveia, É. R., Ferrari, G., ... & Ihle, A. (2021). Exploring grip strength as a predictor of depression in middle-aged and older adults. Scientific reports, 11(1), 1-8.

MASSA, Elena, DONISI, Clelia, LISCIA, Nicole, et al. The Difficult Task of Diagnosing Depression in Elderly People with Cancer: A Systematic Review. Clinical Practice and Epidemiology in Mental Health: CP & EMH, 2021, vol. 17, no 1, p. 295.

Maskileyson, D., Seddig, D., & Davidov, E. (2021). The EURO-D measure of depressive symptoms in the aging population: comparability across European countries and Israel. Frontiers in Political Science, 3, 665004.

Mehrbrodt T, Gruber S, Wagner M. Scales and multi-item indicators in the SHARE—Survey of Health, Ageing and Retirement in Europe; SHARE Working Paper Series 45-2019. 2019

National Cancer Institute. Adjustment to Cancer: Anxiety and Distress (PDQ®) – Patient Version. 2015. Available at: http://www.cancer.gov/cancertopics/pdq/supportivecare/adjustment/Patient/page1 Accessed December 5

OECD (2021), Fitter Minds, Fitter Jobs: From Awareness to Change in Integrated Mental Health, Skills and Work Policies, Mental Health and Work, OECD Publishing, Paris, https://doi.org/10.1787/a0815d0f-en.

Prince M, Patel V, Saxena S, et al. No health without mental health. Lancet 2007; 370: 859–77 Indeed the World Health Organisation attest 'there is no health without mental health'. WHO says there is no health without mental health.

Prince, M. J., Reischies, F., Beekman, A. T. F., Fuhrer, R., Jonker, C., Kivela, S. L., Lawlor, B., Lobo A., Magnusson, H., Fichter, M. M., Van Oyen, H., Roelands, M., Skoog, I., Turrina, C. & Copeland, J. R. (1999). Development of the EURO-D scale – a European Union initiative to compare symptoms of depression in 14 European centres. The British Journal of Psychiatry, 174(4), 330-338.

Prince, M.J.; Reischies, F.; Beekman, A.T.; Fuhrer, R.; Jonker, C.; Kivela, S.L.; Lawlor, B.A.; Lobo, A.; Magnusson, H.; Fichter, M.; et al. Development of the EURO–D scale–a European Union initiative to compare symptoms of depression in 14 European centres. Br. J. Psychiatry 1999, 174, 330–338. [CrossRef] [PubMed]

Retrospective data collection in the Survey of Health, Ageing and Retirement in Europe. SHARELIFE methodology. Mannheim: Mannheim Research Institute for the Economics of Aging (MEA).

Schouten, B., Avau, B., Vankrunkelsven, P., Mebis, J., Hellings, J., & Van Hecke, A. (2019). Systematic screening and assessment of psychosocial well-being and care needs of people with cancer. Cochrane Database of Systematic Reviews, (3).

Sonnenberg, C.M., Beekman, A.T., Deeg, D.J., van Tilburg, W., 2000. Sex differences in late-life depression. Acta Psychiatr. Scand. 101, 286–292.

Sung, H., Ferlay, J., Siegel, R. L., Laversanne, M., Soerjomataram, I., Jemal, A., & Bray, F. (2021). Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA: A Cancer Journal for Clinicians, 71(3). https://doi.org/10.3322/caac.21660

UNESCO (2006). International Standard Classification of Education: ISCED 1997. Retrieved from http://www.uis.unesco.org/Library/Documents/isced97-en.pdf

Westerhof, Gerben J., and Corey LM Keyes. "Mental illness and mental health: The two continua model across the lifespan." Journal of adult development 17 (2010): 110-119.

World Health Organisation. Health and Wellbeing. The Global Health Observatory. 2023. Accessed 17/04/2023. Available at: Health and Well-Being (who.int)

Appendix 1. Question Items in Euro D.

MH001_ intro mental health

Earlier we talked about your physical health. Another measure of health is your emotional health or wellbeing -- that is, how you feel about things that happen around you.

1. Continue

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

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