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An instrumental variables approach

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Research Summary

Why was the research done?

Mental health disorders and addictive behaviours are two public health issues that are estimated to impose significant socio-economic costs to the global economy. Individuals with mental health disorders disproportionally engage in more addictive behaviours such as smoking, drinking, gambling, or using illicit drugs. Addictive behaviours are difficult to manage and even more so for people with mental health problems. To optimize public health interventions and medical treatments it is important to understand whether mental health disorders cause addictive behaviours. The reciprocal relationship between psychiatric and substance use disorders is well-known, yet it remains largely unknown whether mental health morbidity causally leads to addictive behaviours.

What were the key findings?

We find that mental distress significantly increases the prevalence and intensity of either cigarette or alcohol consumption. Further analysis reveals that mental distress also substantially increases household monetary expenditures on either tobacco or alcohol. The impact is greater for lower educated individuals or children of smokers, and is slightly higher for males.

What does this mean for policy and practice?

Our finding of a strong association between life stress events and depression provides an argument for public initiatives that support vulnerable groups to cope with negative psychological events. Such policies may not only reduce the overall prevalence and impact of mental distress but also discourage mental distress-attributable addictive behaviours and hence alleviate their associated socio-economic costs, following our finding of a measurable impact of mental distress on increasing addictive behaviours. Overall, our findings, together with others, highlight the role of mental health screening and treatment programs, especially among lower educated individuals or children of smokers, to assist in the prevention of addictive activities which are costly to both the individual, and to broader society.

Citation

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The causal impact of mental health on tobacco and alcohol consumption - An instrumental variables approach

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The reciprocal relationship between psychiatric and substance use disorders is well-known, yet it remains largely unknown whether mental health morbidity causally leads to addictive behaviours. This paper utilises a fixed effects instrumental variables model, which is identified by time-varying sources of plausibly exogenous variations in mental health, and a nationally representative panel dataset from Australia to present robust evidence on the causal impact of mental distress on cigarette smoking and alcohol drinking behaviours. We find that mental distress significantly increases the prevalence and intensity of either cigarette or alcohol consumption. Further analysis reveals that mental distress also substantially increases household monetary expenditures on either tobacco or alcohol. The impact is greater for lower educated individuals or children of smokers, and is slightly higher for males. Our findings highlight the importance of mental health screening and treatment programs, especially among lower educated individuals or children of smokers, to assist in the prevention of addictive activities.

Keywords: Mental Health; Depression; Smoking; Drinking; Alcohol Addiction; Instrumental Variables.

JEL codes: C26; I10; I12; I14.

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1. Introduction

Mental health disorders and addictive behaviours[1] are two public health issues that are estimated to impose significant socio-economic costs to the global economy (OECD 2014; Chisholm *et al.* 2016; Prochaska *et al.* 2017; WHO 2017). Individuals with mental health disorders disproportionally engage in more addictive behaviours such as smoking, drinking, gambling, or using illicit drugs (Lawrence *et al.* 2009; Moylan *et al.* 2012; Lalanne *et al.* 2016). Addictive behaviours are difficult to manage and even more so for people with mental health problems (Nunes & Levin 2004; Kalman *et al.* 2005). To optimize public health interventions and medical treatments it is important to understand whether mental health disorders cause addictive behaviours.

The bi-directional relationship between mental health disorders and addictive behaviours is contended, with inconclusive evidence from different studies using data from various countries and methods (Fluharty *et al.* 2017). Furthermore, it remains challenging to determine the causal impact of mental health disorders on addictive behaviours due to issues of individual unobservable factors, reverse causality and measurement errors. In particular, omitted variables, such as genetic factors, may influence both mental health and addictive behaviours (Volkow & Li 2005). Reverse causality may be an issue as individuals with mental health problems are more likely to smoke or drink (Khantzian 1987) but consumption of addictive substances may worsen health, including mental health (Volkow *et al.* 2014). Measurement error would be another problem because researchers typically rely on information reported by respondents when using survey data, and this can be subject to participant recall bias and interpretation error in relation to collection instruments. These self-reported addictive

[1] We follow previous studies (Frijters *et al.* 2014; Nguyen & Connelly 2018; Yang & Zikos 2022) which use the same dataset and similar "mental health" measures to adopt the term "mental health" in this paper. Moreover, we employ the terms "mental health disorders", "mental distress", "mental illness" or "mental health issues" interchangeably in this paper, mainly because there is no commonly agreed practice on which term to use (Fluharty *et al.* 2017). Furthermore, cigarette smoking and alcohol drinking have been identified as "addictive behaviours" (Grant *et al.* 2010).

behaviours may be influenced by participant mental health status, causing a bias in the estimate of the contribution of mental health to addictive behaviours. Studies in the current literature have not been successful in addressing all three issues at the same time (see Section 2 for a literature review), resulting in uncertainty around the interpretation of casual estimates of mental health on addictive behaviours.

In this paper, we employ a fixed effects instrumental variables (FE-IV) model, which is identified by time-varying sources of plausibly exogenous variations in mental health, to estimate the causal impact of mental health on addictive behaviours. We apply this FE-IV model to 18 waves of high-quality Australian longitudinal data to simultaneously tackle the above three research challenges.

Specifically, we employ the death of a close friend as an instrument in mental health equations. This instrument influences many individuals in our data, varies significantly over time for the same individuals and displays a strong causal relationship with subsequent mental health. Moreover, results from a series of robustness tests indicate that this instrument is empirically strong. This study thus improves on most previous research by employing an individual FE-IV model approach to address the endogeneity of mental health and provides more robust evidence on the causal impact of mental health on consumption of alcohol and tobacco.

Our study produces three main results. First, we show that mental distress leads to a measurable increase in the consumption of either cigarettes or alcohol. Second, in line with the mental distress-induced impact on cigarette or alcohol consumption, our results indicate that mental distress also considerably raises household monetary expenditures on tobacco and/or alcohol. Third, the mental distress-attributable impact on smoking and drinking is greater for persons with lower levels of education or those whose parents were smokers, and somewhat higher for males.

This paper proceeds as follows: Section 2 briefly reviews the related literature, while Section 3 discusses the data. Section 4 details our empirical framework, and Section 5 presents the empirical results. Section 6 reports results for various sub-groups and Section 7 concludes the paper.

2. Literature review

This paper explores the impact of mental health on addictive behaviours, relating itself to a very rich literature on the connection between mental health and addictive behaviours.[2] This literature has documented a strong positive association between mental distress and substance use disorders (Lawrence *et al.* 2009; Moylan *et al.* 2012; Lalanne *et al.* 2016). Longitudinal studies in this literature have also explored the bi-directional comorbidity between mental health disorders and addictive behaviours.[3] Evidence so far suggests positive associations in both directions: some studies found substance use disorders were associated with subsequent anxiety disorders (Johnson *et al.* 2000; Klungsøyr *et al.* 2006; Marsden *et al.* 2019) while other studies reported mental distress was associated with later substance use (Zubrick *et al.* 2012; Katz *et al.* 2013; Kim-Mozeleski *et al.* 2020). Some studies go further to establish a bi-directional relationship between mental health and substance use disorders (Kendler *et al.* 1993; Breslau *et al.* 1998; Needham 2007; Leung *et al.* 2012; Ranjit *et al.* 2019).

[2] This paper is also related to the economic literature on addictive behaviours. See, for example, Sloan and Wang (2008) for a review on economic theory and evidence on smoking behaviours and Lillard (2020) on the economics of nicotine consumption.

[3] Potentially due to availability of cigarette smoking information in datasets used and the apparent socio-economic costs of smoking, studies in this literature usually focus on the relationship between cigarette smoking and mental health. See, for instance, Fluharty *et al.* (2017) for a recent review on this relationship. A related line of research focuses on the change in mental health after smoking cessation. The dominant evidence from this line of studies suggests that smoking cessation is associated with reduced depression, anxiety, and stress (Taylor *et al.* 2014b). Establishing the causal link between mental disorders and addictive behaviours conclusively would require evidence from randomised trials, which is hard to achieve in modern times due to the understandable ethical constraints that surround designs involving human subjects. Following this direction, studies have employed experiments on animals. For instance, Iñiguez *et al.* (2009) experimented with varying nicotine exposure to rats to find that nicotine exposure during adolescence causes a depression-like status in adulthood.

Although panel studies can establish the reciprocal association between substance use disorders and mental health problems, their findings can be confounded by unobservable characteristics, such as genetic factors or personal traits, that are associated with both substance use and mental disorders (Wooldridge 2010). To address the issue of unobservable individual heterogeneity, some studies have employed an individual fixed effects (FE) model (Boden *et al.* 2010; Fergusson *et al.* 2011; Horwood *et al.* 2012). The FE results appear to confirm the bi-directional link between mental health disorders and substance use. While the individual FE model can help address the unobservable individual heterogeneity issue, it cannot deal with the reverse causality and measurement error issues, preventing these longitudinal studies from drawing a definitive conclusion about the causality of any link between substance use and depression.

To provide causal evidence on the impact of substance use, which is dominantly measured by cigarette smoking, on depression, some studies have employed an instrumental variables (IV) method. In particular, Mojtabai and Crum (2013) used state-level cigarette taxes and public perceptions toward smoking as instruments for smoking behaviours to show that smoking regularly increases the risk for developing mood and anxiety disorders. Furthermore, an increasing number of studies have employed a Mendelian randomization method, using a genotype known to affect tobacco consumption as an instrument for cigarette smoking, to examine the causal impact of smoking in anxiety and depression. Evidence from these studies commonly suggests that smoking does not lead to mental health issues (Lewis *et al.* 2011; Bjørngaard *et al.* 2013; Taylor *et al.* 2014a; Skov-Ettrup *et al.* 2016).

Overall, our review of the literature indicates that while several efforts have been made to examine a causal bi-directional link between mental health disorders and substance use, the current literature has not successfully established the causal impact of mental health on addictive behaviours given limitations of the methods used. We extend on these studies to

combine both individual FE and IV methods in a unified framework to provide a more rigorous investigation into the causal effects of mental health on the consumption of alcohol and tobacco.

3. Data and sample

3.1. Data

Our data source is from waves 2 to 19 (year 2002 to 2019) of the Household Income and Labour Dynamics in Australia (HILDA) survey.[4] HILDA is a nationally representative annual panel survey from Australia (Summerfield *et al.* 2019). It began in 2001 with a sample of 7,682 households and 13,969 individuals. In each wave, interviews are conducted with all household members who are 15 years of age or older at the survey time. Interviews are administered in-person and by telephone, with supplemental questionnaires collected via mail. The data contain comprehensive information at the individual and household level, including information on mental health and addictive behaviours of surveyed individuals (see Appendix Table A1 for details on variable description and summary statistics).

3.2. Mental health measures

Our main measure of mental health is derived from the Mental Health Inventory (MHI-5), a subscale of the 36-Item Short Form Health Survey (SF-36) (Ware *et al.* 1994). This subscale is constructed from responses to five questions asking the respondents about how often during the past four weeks that they have (1) "been a nervous person", (2) "felt so down in the dumps nothing could cheer you up", (3) "felt calm and peaceful", (4) "felt down", and (5) "been a happy person". The respondent could select one of six responses that range from "all of the time" (1) to "none of the time" (6). We construct a mental health index by summing scored responses to these five questions, with reverse coded responses for the first four questions. We

[4] We do not use wave 1 of HILDA because information to construct our instrument is only available from wave 2 onwards.

then standardize this index to have a mean of zero and a standard deviation of one. By construction, a greater value of this index indicates a higher level of psychological distress, which is associated with poorer mental health. To differentiate with the original MHI-5 index, we name our mental health indicator as "standardized reversed MHI-5" index.

This index is strongly correlated (with the magnitude of 0.81 and the correlation is statistically significant at the 1% level – see Appendix Table A2) with the commonly used Kessler Psychological Distress Scale (K10) score, which has been collected biennially since wave 7 of HILDA.[5] This index is also highly associated with a clinically diagnosed depression or anxiety indicator which was collected in waves 9, 13 and 17 of HILDA: the correlation is 0.41 and statistically significant at the 1% level (see Appendix Table A2). This measure has been employed extensively in Australia (Frijters *et al.* 2014; Nguyen & Connelly 2018; LaMontagne *et al.* 2020; Yang & Zikos 2022) and internationally (Ware *et al.* 2000). We employ this standardized reversed MHI-5 subscale in the main analysis for two reasons: (1) it is available in all waves of HILDA, enabling us to have a sufficiently large sample to implement some sub-group analyses and (2) as demonstrated above, this subscale has been proven to be a psychometrically sound measure of mental health (Berwick *et al.* 1991; Ware *et al.* 2000). In subsection 5.3 we will test the sensitivity of the results by employing other mental health measures available in the data such as K10 and some variations of mental health measures constructed from SF-36.

[5] Specifically, K10 is constructed using responses to a set of 10 questions with the preamble "The following questions are about your feelings in the past 4 weeks. In the last four weeks, about how often did you feel: (1) depressed, (2) everything was an effort, (3) so nervous that nothing could calm you down, (4) so restless that you could not sit still, (5) hopeless, (6) nervous, (7) restless or fidgety, (8) so sad that nothing could cheer you up, (9) tired out for no good reasons, and (10) worthless?". Responses to each question are recorded in a five-point scale, ranging from "all of the time" (1) to "none of the time" (5). As has been done with the MHI-5 subscale, we construct our K10 index by summing scored responses to the 10 questions and standardize it to have a zero mean and a standard deviation of one. Similar to the MHI-5 index, a higher value of our K10 index also indicates a poorer mental health status.

3.3. Addictive behaviour measures

We consider two types of addictive behaviours: tobacco smoking and consumption of alcohol. For smoking behaviours, we use three self-reported measures. The first measure is a dummy variable called "smoker" indicating whether the individual smoked cigarettes or used any other tobacco products at the time of the survey. The second measure denoted by "daily smoker" is an indicator describing whether the individual smoked daily at the time. We further employ the "weekly number of cigarettes" the individual usually smoked each week as the third measure of smoking.

We also employ three self-reported measures to capture drinking behaviours. We first use a dummy variable (referred as "drinker" thereafter) to indicate whether the individual drank alcohol at the survey time. Moreover, we employ an indicator called "daily drinker" which describes whether an individual drank alcohol every day to capture their drinking frequency. Given evidence on potential health benefits associated with low-moderate alcohol consumption (Mukamal *et al.* 2003; Knott *et al.* 2015), it is uncertain whether "drinker" or "daily drinker" variable captures potentially harmful drinking. To further gauge drinking intensity, we use the Australian standard gender-based benchmark for potentially harmful drinking (NHMRC 2009) to construct a variable denoted by "excessive drinker" to describe whether the individual usually drank 5 or more (for females) or 7 or more (for males) standard drinks per day.[6] Thus,

[6] We do not use the current NHMRC alcohol consumption benchmark which was introduced in December 2020 because this new guideline was not available to individuals surveyed during our study period (i.e., 2001 – 2019). Nevertheless, using this new and more restrictive benchmark which suggests "no more than 10 standard drinks a week and no more than 4 standard drinks on any one day" for healthy men and women (NHMRC 2020) does not change our findings. We do not use the number of standard drinks per day as an outcome because responses to a question asking about this are recorded in bands (e.g., "1 to 2 standard drinks" or "3 to 4 standard drinks") and top-coded (i.e., "13 or more standard drinks"). Our data also show that the six measures of addictive behaviours used in this paper are positively and highly statistically correlated (at the 1% level) with one another. Furthermore, each of these addictive measures is positively and statistically significantly (at the 1% level) associated with an indicator describing whether the individual had ever used any illicit drug (see Appendix Table A2). We do not employ illicit drug use as an additional measure for addictive behaviours because the question about drug use is only asked in wave 17 of HILDA.

by construction (NHMRC 2009), this excessive drinking variable captures high risk drinking behaviour reported by individuals in this study.

3.4. Sample

We restrict the sample to individuals who are observed on at least two occasions during the study period because we mainly use a FE model. We further exclude observations with missing information on any variable that we control for in empirical model. These restrictions result in a final sample, which varies by addictive outcomes, of about 236,500 individual-year observations from roughly 24,700 unique individuals observed over 18 years.

3.5. Descriptive analyses

Summary statistics for main outcomes and other characteristics by mental health status are presented in Table 1. Table 1 indicates that individuals with poorer mental health (i.e., individuals with standardized reversed MHI-5 > median) were appreciably different from those with better mental health. Individuals with poorer mental health were more likely to be female, younger, were less likely to be in a marital relationship, were more likely to be Aboriginal or to have come to Australia from a Non-English Speaking Background (NESB) country or were more likely to have lower education. Table 1 also reveals that individuals with poorer mental health were more likely to engage in smoking or harmful drinking, as measured by excessive drinking. By contrast, individuals with poorer mental health were less likely to engage in more moderate drinking patterns, as represented by drinking or daily drinking. However, it is important to note that these relationships between mental health and addictive behaviours could be driven by unobserved characteristics, reverse causality, and measurement errors. We will address these three issues using FE-IV regressions in the following sections.

4. Empirical framework

We use the following model to estimate the impact of mental health MH_{it} on addictive outcome Y_{it} of individual i at time t:

$$Y_{it} = \alpha + \beta MH_{it} + X_{it}\gamma + \delta_i + \mu_{it} \quad (1)$$

In equation (1), X_{it} is a vector of individual characteristics and μ_{it} is an error term. α, β and γ are parameters to be estimated and β is our interested parameter. We include in X_{it} a parsimonious list of characteristics of the individuals or their households, including gender, age (and its square), marital status, Aboriginal status, migration status, education, and household size. We also control for temporal differences in addictive behaviours by including dummies for years and quarters of survey time in all regressions. We additionally control for differences in local socio-economic environments which may influence the individual behaviours by including a relative socio-economic disadvantage index, regional unemployment rates, a metropolitan dummy and state/territory dummies.

Equation (1) which controls for time-invariant individual unobservable characteristics (δ_i) helps address the issue of unobservable individual heterogeneity (such as genetic endowments or discount rate) which is correlated with both mental health and addictive behaviours. However, it cannot deal with reverse causality and measurement error issues which originate from the likelihood that unobserved time-variant, individual-specific factors (μ_{it}) co-vary with both the mental health and addictive behavioural outcomes. We further tackle the possible endogeneity issue of mental health in equation (1) by employing an instrumental variables approach. In particular, we introduce an auxiliary equation for mental health:

$$MH_{it} = \pi + X_{it}\tau + Z_{it}\sigma + \delta_i + \omega_{it} \quad (2)$$

in which Z_{it} is a $1 * \mathrm{D}$ vector of instruments ($D \geq 1$), ω_{it} is an error term, and τ and σ are vectors of parameters to be estimated. Instrumental variable(s) in Z_{it} must satisfy three conditions (Wooldridge 2010): (i) they must be adequately correlated with MH_{it}; (ii) they must be uncorrelated with Y_{it} except through MH_{it}; and (iii) they cannot be associated with individual time-varying unobservable factors in the addictive behaviour equation.

We propose to use the death of a close friend as an instrument for the mental health variable in equation (2). This instrument has been successfully employed in previous studies to investigate the causal effects of mental health on labour supply (Frijters *et al.* 2014), educational attainment (Johnston *et al.* 2014), physical health (Yang & Zikos 2022) or children's developmental outcomes (Le & Nguyen 2017, 2018). We thus adopt death of a close friend as the instrument to examine the impact of mental health on addictive behaviours in this paper. As discussed in previous studies (Frijters *et al.* 2014; Johnston *et al.* 2014), the death of a close friend is likely to satisfy the above mentioned three requirements to be a good instrument.[7] Specifically, the death of a close friend has been found to worsen mental health (Frijters *et al.* 2014; Johnston *et al.* 2014). This instrument is also theoretically sound: the plausibly exogenous[8] death of a close friend directly affects the individual's mental health, but only indirectly affects their addictive behaviours through the mental health channel. As has been done in previous studies, we will empirically test the strength of this instrument against the criterium (iii) by controlling for numerous time-variant variables, including physical health, which are likely correlated with our instrument in subsection 5.3.

We apply an IV model to panel data in an FE-IV model to control for both time-invariant and time-variant unobserved factors. To estimate Equation (1), we employ an Ordinary Least Squares (OLS) method. We model all outcomes as linear.[9] Furthermore, method to estimate

[7] In HILDA, individuals are asked "Did any of these happen to you in the past 12 months?". We use the statement about "Death of a close friend" to construct the instrument. We purposely do not use the death of family members or close relatives as an instrument because these deaths may signal genetic risks, lead to windfall income (in form of inheritance from deceased relatives) or directly influence the addictive behaviours of other household members or relatives.

[8] Our empirical framework is akin to that in a recent study by Friedman (2020). In particular, Friedman (2020) finds that life stressful events such as death of a non-family member statistically significantly increases subsequent initiation and intensity of smoking among adolescents in the US. The empirical model applied by Friedman (2020) to explore the impact of these life stressful events on subsequent smoking behaviours is similar to a reduced form of our empirical model in which a similar life stressful event is employed as an instrument for mental health in the first stage regression (Angrist & Pischke 2008).

[9] We also employed a Probit model for all binary outcome variables. Appendix Table A3 indicate that pooled Probit results are largely similar to the pooled OLS results (reported in Table 2) in terms of the magnitude and statistical significance level, suggesting that our results are not driven by the linearity assumption.

equation (1) and a Two-Staged Least-Squares (2SLS) method to estimate the system of equations (1) and (2). In all regressions, robust standard errors are clustered at the individual level to account for serial correlation.

5. Empirical results

5.1. Main results

Estimates of mental health as measured by standardized reversed MHI-5 on various addictive outcomes are reported in Table 2. In Table 2 we report estimates and relevant statistics from four alternative specifications: (i) "Pooled OLS" results estimated from a model similar to equation (1) without controlling for individual heterogeneity, (ii) "FE" results estimated from equation (1), (iii) "Pooled-IV" results estimated from equations (1) and (2) without controlling for individual heterogeneity, and (iv) "FE-IV" results estimated from equations (1) and (2). We report pooled results to compare with those presented in most of the prior literature which does not account for individual FEs.

Pooled OLS results (reported in columns 1, 5 and 9 of Table 2) show strong associations (with the estimates are all statistically significant at least at the 5% level) between mental distress and all six addictive outcomes considered. Furthermore, while mental distress is negatively associated with the probability of drinking, it is positively associated with other five addictive behavioural outcomes. These results suggest that individuals with poorer mental health are less likely to drink. By contrast though, they are more likely to smoke, smoke more frequently (as measured by smoking daily or smoking more cigarettes per week) or engage in potentially dangerous drinking (as represented by drinking daily or drinking excessively). Our pooled OLS results are thus in line with those reported in the previous cross-sectional studies which consistently show that individuals experiencing mental distress disproportionally engage in smoking or harmful drinking (Lawrence *et al.* 2009; Moylan *et al.* 2012).

FE estimates (reported in columns 2, 6 and 10 in Table 2) show that controlling for the individual FE changes the results considerably. For instance, accounting for individual heterogeneity reduces the magnitude of the mental distress estimates for all three smoking outcomes and the excessive drinking indicator, with the reduction ranging from 28% (as in the estimate on excessive drinking) to 86% (daily smoking). Controlling for the individual confounders also turns the estimate of mental distress on drinking from negative and highly statistically significant to positive and statistically insignificant.

The above comparisons between pooled OLS and FE estimates suggest that failing to account for individual unobserved characteristics may result in over-reporting the positive association between mental distress and addictive behaviours. One of the unobserved characteristics would be discount rates as individuals with a higher discount rate, who value current consumption more than future consumption, typically tolerate higher risk lifestyles and invest less in their current health (Grossman 1972). Another unobserved characteristic could be some generic factors that are correlated with both mental health and addictive behaviours (Wang *et al.* 2012; Pasman *et al.* 2018; Lillard 2020). Therefore, the simple regression which does not control for such unobserved characteristics over-estimates the positive effect of mental distress on addictive behaviours. The same pattern is also observed in other studies employing an individual FE model to document the bi-directional relationship between mental health and substance use disorders (Needham 2007; Leung *et al.* 2012; Ranjit *et al.* 2019). As discussed above, while the FE estimator helps control for time-invariant individual characteristics, it cannot deal with issues associated with reverse causality and measurement errors. We next turn to results obtained from the FE-IV estimator, which simultaneously addresses all three issues.

FE-IV estimates are represented in columns 4, 8 and 12 of Table 2.[10] The lowest first-stage F statistic is 74, rejecting the null hypothesis of a weak instrument (Stock & Yogo 2005).[11] Table 2 also shows that, as compared to a FE-IV model, employing a FE model alone greatly under-estimates the impact of mental distress on all three smoking outcomes and the excessive drinking outcome. In particular, the estimate of mental distress is about 18 (as in the case of excessive drinking) to 28 (as in the case of smoking) times greater in the FE-IV estimator than in the FE estimator while being statistically significant at least at the 5% level in both estimators. In terms of magnitude, the FE-IV estimates indicate that a one-standard-deviation increase in mental distress increases the probability of (i) smoking by 28 percentage points (pp) (corresponding to 105% of the sample mean), (ii) smoking daily by 12 pp (75% of the sample mean), and (iii) drinking excessively by 18 pp (155% of the sample mean). Similarly, a one-standard-deviation increase in mental distress is found to raise the number of cigarettes smoked per week by 11 (equivalent to 75% of the sample mean).

Table 2 additionally represents that the FE-IV estimator turns the estimate of drinking from statistically insignificant to statistically significant (at the 1% level). The FE-IV result thus indicates that mental distress leads to drinking and the estimated impact is relatively large in magnitude: a one-standard-deviation increase in mental distress raises the drinking probability by 16 pp (or 20% of the sample mean). Table 2 also shows the considerable changes in the

[10] For comparison purposes, we also report pooled IV regression results in columns 3, 7 and 11 of Table 2. In line with the FE-IV results, the pooled IV results show positive and statistically significant estimates of mental illness on all addictive outcomes except the daily drinking indicator. In our IV approach, pooled IV regressions may provide inaccurate estimates because they don't control for time invariant unobservable factors which may be associated with the instruments and addictive outcomes at the same time.

[11] First-stage regression results from pooled IV and FE-IV estimator are reported in column 1 and 2, respectively, of Appendix Table A4. The results are largely in line with those documented in other studies (Frijters *et al.* 2014; Johnston *et al.* 2014). For instance, the death of a close friend statistically significantly deteriorates mental health. Moreover, age has an inverse U-shape relationship with mental illness and marital breakdown worsens mental health. Appendix Table A5 reports estimation results of remaining variables from second-stage regressions. The results are largely as expected. For example, smoking (either prevalence or intensity) decreases with age. In addition, while drinking and daily drinking increases, at a decreasing rate, with age, excessive drinking decreases, at an increasing rate, with age. While education has no clear relationship with smoking and drinking behaviours, increased household size consistently decreases these two addictive behaviours.

estimates of mental distress on the above addictive measures are in line with results from a Hausman test which suggest mental distress is endogenous when modelling these outcomes. Therefore, the results indicate that failing to adjust for the endogeneity of mental distress would considerably under-estimate the positive impact of mental distress on these addiction measures.

The FE-IV estimate of mental distress on the daily drinking indicator is not statistically significant at any conventional level. This non-significant estimate is consistent with the result from a Hausman test which indicates that we can model the mental health and daily drinking outcome independently. Thus, the results from two Hausman-styled tests[12] support the use of a FE estimator to model the impact of mental distress on the probability of drinking daily. As discussed above, the FE results show that mental distress statistically significantly (at the 1% level) increases the chance of drinking daily, albeit at a rather small magnitude: an increase of one standard deviation of mental distress raises the daily drinking probability by 0.34 pp (or 5% of the sample mean).

5.2. Discussion

In summary, we interpret these results to show that mental distress considerably increases the prevalence and intensity of either cigarette or alcohol consumption. Our finding is in line with the self-medication hypothesis, first introduced by Khantzian (1987), in which individuals engage in these addictive activities to cope with stress. In particular, agonists of nicotinic cholinergic receptors, including nicotine itself, contained in cigarettes can temporarily relieve symptoms of depression and anxiety (Kumari & Postma 2005). Much like the effect of nicotine reward pathways, alcohol consumption can help regulate mood symptoms by supporting the release of endorphins, the naturally occurring feel-good opioids which affect regions of the brain associated with reward processing (Bruijnzeel & Gold 2005). Alcohol is also a central

[12] Specifically, the Hausman-styled test that supports the use of a FE model (over an OLS pooled model) and the one that rejects the endogeneity of mental illness in the FE-IV model.

nervous system depressant, and its long-term use can cause problems with cognition and memory in heavy users (Mukherjee 2013).[13]

However, it has also been hypothesized that smoking or drinking to self-medicate depression is associated with the development of cigarette or alcohol dependence (Sloan & Wang 2008; Dome *et al.* 2010; Crum *et al.* 2013), which in turn entails substantial health and socio-economic consequences. Thus, our finding when viewed with these hypotheses suggest that depressed individuals may rely on cigarette or alcohol consumption to provide some temporary relief of depression, despite significant costs of such addictions. To this end, our findings support existing evidence that individuals living with mental distress may make life choices that might otherwise be considered irrational and not in their best private interests (Kung *et al.* 2018; Bayer *et al.* 2019; Nguyen *et al.* 2021).

5.3. Robustness checks

To assess the robustness of our results, we check whether our main findings are sensitive to: (i) the choice of mental health variables and (ii) the inclusion of additional time-variant variables. The results (detailed analysis is reported in Appendix B) show that our findings are robust to these tests.

5.4. Characterizing the composition of compliers

As with other IV studies, the IV estimates in this study capture a Local Average Treatment Effect (LATE) of mental distress on additive behaviours (Imbens & Angrist 1994). Specifically, the LATE is applicable to individuals who experienced a worsening mental health state because of the death of a close friend ("compliers"). To profile the characteristics of compliers, we use an approach outlined in Angrist and Pischke (2008). Particularly, we calculate the ratio of the instrument coefficient estimated from equation (2) for sub-groups of

[13] Moreover, our finding lends empirical support to a prediction from a rational addiction theory in economics proposed by Becker and Murphy (1988) that anxiety and tensions can cause an addition.

individuals relative to the instrument coefficient estimated for the whole population. This relative likelihood provides indicative evidence suggesting which parts of the population are most likely to be affected by the instrument (i.e., the death of a close friend). To address a heretofore unsolved aggregation issue associated with a continuous treatment (Abadie 2003), we dichotomize our treatment variable by using the suggested cut-off of 68 points or lower for the original MHI-5 index to define if the individual has any depressive symptoms (Yamazaki *et al.* 2005). We focus on specific sub-groups, identified by gender, age, marital status, education level, previous smoking status and previous mental health state.[14]

Table 3 shows the relative likelihood that an individual with a particular characteristic belongs to the compliers in our data. As compared to the overall population, the compliers are more likely to be female, younger, single, or to have lower qualifications. Moreover, consistent with prior evidence of cigarette dependence (Sloan & Wang 2008; Dome *et al.* 2010; Crum *et al.* 2013), we find that individuals with a previous smoking history over-represent among the compliers. Similarly, and in line with prior findings (Zubrick *et al.* 2012; Friedman 2020), individuals with previous mental distress are more responsive to the treatment. The over-representation of individuals with a previous smoking history or previous mental distress among the compliers when viewed with an oft observed pattern of a higher prevalence and intensity of cigarette consumption among these individuals explains some relatively high estimates of mental distress obtained from the IV approach. To this end, our IV estimates may provide an upper bound of the Average Treatment Effect for the overall population (Angrist & Pischke 2008). The notable differences in these observable characteristics between the compliers and the comparison population suggest that our estimates may not be generalized to the general population. Nevertheless, they are particularly informative for some sub-

[14] For brevity purposes, we present results estimated from the regression of "smoker" as an outcome. Results for other outcomes are broadly similar and will be available upon request.

populations, including those with previous mental distress or history of addiction, who are typically of policy interest (AIHW 2017).

5.5. Results on additional outcomes and household expenditure

We next investigate the effects of mental health on other related outcomes. In particular, to capture the potential compounding impact of mental distress on smoking and drinking behaviours (Tauchmann *et al.* 2013; Ren *et al.* 2020), we construct a binary variable describing whether the individual either smoked cigarettes or drank alcohol at the survey time and use it as an additional outcome variable. We also construct a dummy variable which indicates if the individual either smoked daily or drank daily and use it as another dependent variable in the FE-IV model. Results from these experiments, reported in Columns 1 to 4 of Table 4, suggest that mental distress statistically significantly increases the prevalence and intensity of cigarette or alcohol consumption. Specifically, an increase of one standard deviation in mental distress raises the probability of either smoking or drinking by 13 pp (Column 2). The impact of mental distress on the intensity of addictive behaviours is slightly less pronounced since the same increase in mental distress is found to raise the probability of either smoking daily or drinking daily by 11 pp (Column 4).

We further experiment with using household annual monetary expenditures on tobacco, alcohol or both items.[15] As mental distress may affect the household expenditure on items other than tobacco and alcohol, we measure expenditure on tobacco, alcohol or both items in a relative terms, as represented by the share of each of these items in the total household expenditure on

[15] Information on household expenditure is available from Wave 5 onwards and reported by all surveyed members who self-identified that they had responsibility for paying household bills. In cases multiple members of the same household provided response (about a quarter of all surveyed households did so), household expenditure amount is averaged across all individuals providing response. Furthermore, because the preamble of expenditure questions asks: "In a typical week, does this household spend money on", expenditure is calculated at the household level and measured on an annual basis (by multiplying weekly expenditure by 52 (weeks)). Despite some concerns over the quality of expenditure data reported in HILDA (Wilkins & Sun 2010), including the fact that HILDA omits several important spending items, household expenditure measures have been employed in previous studies (Wilkins & Sun 2010; Nguyen *et al.* 2020). These data limitations, including the small sample size and potential measurement errors, should be considered when interpreting the results in this section.

all reported items. Of note, having a mental distress also impacts on other areas of household expenditure.[16] Results from this experiment, reported in Columns 5 to 10 of Table 4, reveal two findings of interest. First, consistent with our earlier findings of an impact of mental distress on rising prevalence and intensity of smoking and drinking, the results in this section also indicate that mental distress statistically significantly increases shares of household expenditure on tobacco or/and alcohol. Second, the estimates are sizable, suggesting that mental distress also causes direct and substantial financial costs to the households of individuals with mental health issues. Particularly, the preferred FE-IV estimate suggests that a one-standard-deviation increase in mental distress raises the share of alcohol expenditure in total household expenditure by 1.65% (or 35% of the sample mean, Column 8). Similarly, the same increase in mental distress raises the proportion of tobacco expenditure in total household expenditure by 0.06% (or 2.1% of the sample mean, according to the preferred FE estimate which is statistically significant at the 1% level, as seen from Column 5). To our knowledge, these significant financial costs to households of addictive behaviours of those with mental distress have not previously been documented in the extant literature.[17]

6. Heterogeneity

To further our understanding of the mental health effects on addictive behaviours, we implement a heterogeneity analysis by running separate regressions on two subsamples of individuals, identified by various characteristics.[18] These variables include gender (i.e., female versus male), age (young versus old, identified relative to the median age of all individuals in the whole sample), marital status (single versus married) and education level (with or without

[16] Unreported results show that mental illness decreases the share of expenditures on Groceries, Clothing and footwear, Private health insurance, Other insurance, and Home repairs. By contrast, mental illness raises the proportion of expenditures on Medicines, Education fees, Public transport, Telephone rent and Electricity bills.
[17] Of note, these household expenditures may be an under-estimate, because our data do not cover all possible addictive substances or behaviours, such as other drugs, gaming or gambling, in sufficient detail.
[18] As discussed in subsection 5.4, this heterogeneity analysis also sheds light on the estimated LATE impact for different subsets of compliers (Angrist & Pischke 2008).

a bachelor or higher degree). For marital status and education level, sub-groups are defined using the value identified at its first appearance in the sample to address a concern that the individuals' mental health and addictive behaviours may influence the way that we assign them to each sub-group. To explore the potential role of genetic or intergenerational factors in explaining our results, we also compare the impact of mental distress by the respondents' parental smoking status during their childhood.[19] For this sub-population investigation, we report results from an FE-IV model if the exogeneity of mental distress is rejected and results from a FE model otherwise.

Estimates on the impact of mental distress by sub-populations for various addictive measures are concisely reported in Figure 1. Figure 1 suggests that mental distress appears to have some differential effects, depending on sub-group characteristics and outcomes being considered. For example, the effect of mental distress on tobacco and alcohol consumption appears to be greater for males because the estimates are always higher (i.e., more positive) or typically more statistically significant for them. By the same reasoning, sub-group results by age groups indicate that the effects of mental distress on all smoking outcomes and being a current alcohol drinker are much more apparent for older individuals. By contrast, the impact of mental distress for younger individuals is more pronounced in regard to the excessive drinking outcome since the estimate is greater (about twice as much) and more statistically significant for them. Moreover, Figure 1 suggests that mental distress appears to have a greater impact on smoking or daily smoking outcomes of married individuals. Conversely, the impact of mental distress tends to be more visible on drinking outcomes for single persons.

[19] Retrospective information on parental smoking behaviour during childhood is constructed from responses to a question asking: "Were any of your parents or guardians smokers at any stage of your childhood?". This question was asked for the first time in wave 9 of HILDA for all respondents and in waves 13 and 17 for new respondents. Consistent with a large literature documenting the intergenerational correlation in risky behaviours, this study also finds that, as compared to children of non-smokers, those of smokers are more likely to engage in smoking and drinking activities (see sub-population mean figures reported below the bars in Figure 1). Unfortunately, there is no retrospective information on parental drinking behaviour in HILDA for us to implement a similar sub-group analysis.

Sub-group results by education level reported in Figure 1 also indicate the effects of mental distress on all addictive outcomes are much more apparent for individuals with lower qualifications because their estimates are greater or more statistically significant. The finding that mental distress has a more pronounced impact for individuals with lower education is consistent with an oft observed pattern, which is also confirmed in our data (see sample mean figures reported below the bars in Figure 1), that lower educated individuals dispportionaly engage in smoking and risky drinking activities (AIHW 2017). Turning to the sub-group analysis by parental smoking status, we continue to observe that, with an exception of being a current alcohol drinker, where the estimate is about 42% smaller for children of smokers, the effects of mental distress on all other addictive outcomes are much more pronouned for children of smokers.

Figure 1 indicates that the impact of mental distress is not statistically significantly different by all characteristics considered above.[20] However, there are three important exceptions. First, the estimates of mental distress on the number of cigarettes smoked are statistically different (at the 5% level) for males and females, indicating that males statistically significantly smoke more when experiencing negative psychological states. Second, the estimates on daily smoking, drinking and excessive drinking outcomes by education are also statistically different at the 5% level, suggesting that individuals with lower education statistically significantly engage more in these additive activities when facing mental health shocks. Third, the estimates on the probability of daily smoking and the number of cigarettes smoked are statistically different for children of smokers compared with those of non-smokers. To the best of our knowledge, the finding of a much greater impact of mental distress for children of smokers has not been documented the literature. This finding when observed with the observation that children of smokers consume substentially more cigarettes than children of non-smokers (see

[20] Full estimation results are represented in Appendix Table A7.

mean statistics reported below the bars in Figure 1) shows that parental addictive behaviours may not only be transmitted to their children (Mitrou *et al.* 2010) but also influence the way their children respond to mental health shocks.

7. Conclusion

Drawing on a high-quality nationally representative panel dataset we have presented the causal effects of mental health on cigarette smoking and alcohol consumption behaviours of Australians. We find robust evidence that mental distress substantially increases the prevalence and intensity of either cigarette or alcohol consumption. Consistent with this finding, additional analysis reveals substantial monetary costs associated with cigarette and alcohol consumption caused by mental distress. Moreover, the impact is greater for lower educated individuals and children of smokers, and is slightly higher for males.

Our findings on the impact of mental distress on addictive behaviours highlight the importance of controlling for potential endogeneity of mental health when modelling its causal effects on addictive behaviours. Failing to simultaneously address these issues could result in under-estimates of the effect of poor mental health on the increasing prevalence and intensity of either cigarette or alcohol consumption. Our finding of a strong association between life stress events and depression provides an argument for public initiatives that support vulnerable groups to cope with negative psychological events. Such policies may not only reduce the overall prevalence and impact of mental distress but also discourage mental distress-attributable addictive behaviours and hence alleviate their associated socio-economic costs, following our finding of a measurable impact of mental distress on increasing addictive behaviours. Overall, our findings, together with others, highlight the role of mental health screening and treatment programs, especially among lower educated individuals or children of smokers, to assist in the prevention of addictive activities which are costly to both the individual, and to broader society.

References

Abadie, A., 2003. Semiparametric instrumental variable estimation of treatment response models. Journal of Econometrics 113, 231-263

ABS, 1997. 4399.0 - National Health Survey: SF36 Population Norms, Australia, 1995 Australian Bureau of Statistics (Ed.), Canberra

AIHW, 2017. National Drug Strategy Household Survey 2016: detailed findings. Australian Institute of Health Welfare, Canberra

Angrist, J.D., Pischke, J.-S., 2008. Mostly harmless econometrics: An empiricist's companion. Princeton university press.

Bayer, Y.a.M., Shtudiner, Z., Suhorukov, O., Grisaru, N., 2019. Time and risk preferences, and consumption decisions of patients with clinical depression. Journal of Behavioral and Experimental Economics 78, 138-145

Becker, G.S., Murphy, K.M., 1988. A Theory of Rational Addiction. Journal of Political Economy 96, 675-700

Berwick, D.M., Murphy, J.M., Goldman, P.A., Ware, J.E., Jr., Barsky, A.J., Weinstein, M.C., 1991. Performance of a five-item mental health screening test. Med Care 29, 169-76

Bjørngaard, J.H., Gunnell, D., Elvestad, M.B., Smith, G.D., Skorpen, F., Krokan, H., et al., 2013. The causal role of smoking in anxiety and depression: a Mendelian randomization analysis of the HUNT study. Psychological Medicine 43, 711-719

Boden, J.M., Fergusson, D.M., Horwood, L.J., 2010. Cigarette smoking and depression: tests of causal linkages using a longitudinal birth cohort. The British Journal of Psychiatry 196, 440-6

Breslau, N., Peterson, E.L., Schultz, L.R., Chilcoat, H.D., Andreski, P., 1998. Major Depression and Stages of Smoking: A Longitudinal Investigation. Archives of General Psychiatry 55, 161-166

Bruijnzeel, A.W., Gold, M.S., 2005. The role of corticotropin-releasing factor-like peptides in cannabis, nicotine, and alcohol dependence. Brain Research Reviews 49, 505-528

Chisholm, D., Sweeny, K., Sheehan, P., Rasmussen, B., Smit, F., Cuijpers, P., et al., 2016. Scaling-up treatment of depression and anxiety: a global return on investment analysis. The Lancet Psychiatry 3, 415-424

Crum, R.M., Mojtabai, R., Lazareck, S., Bolton, J.M., Robinson, J., Sareen, J., et al., 2013. A Prospective Assessment of Reports of Drinking to Self-medicate Mood Symptoms With the Incidence and Persistence of Alcohol Dependence. JAMA Psychiatry 70, 718-726

Dome, P., Lazary, J., Kalapos, M.P., Rihmer, Z., 2010. Smoking, nicotine and neuropsychiatric disorders. Neuroscience & Biobehavioral Reviews 34, 295-342

Fergusson, D.M., Boden, J.M., Horwood, L.J., 2011. Structural models of the comorbidity of internalizing disorders and substance use disorders in a longitudinal birth cohort. Social Psychiatry and Psychiatric Epidemiology 46, 933-942

Fluharty, M., Taylor, A.E., Grabski, M., Munafò, M.R., 2017. The Association of Cigarette Smoking With Depression and Anxiety: A Systematic Review. Nicotine Tob Res 19, 3-13

Friedman, A.S., 2020. Smoking to cope: Addictive behavior as a response to mental distress. Journal of Health Economics 72, 102323

Frijters, P., Johnston, D.W., Shields, M.A., 2014. The effect of mental health on employment: Evidence from Australian panel data. Health Economics 23, 1058-1071

Grant, J.E., Potenza, M.N., Weinstein, A., Gorelick, D.A., 2010. Introduction to behavioral addictions. The American journal of drug and alcohol abuse 36, 233-241

Grossman, M., 1972. The Demand for Health: A Theoretical and Empirical Investigation. Columbia University Press for National Bureau of Economic Research Books, New York.

Horwood, L.J., Fergusson, D.M., Coffey, C., Patton, G.C., Tait, R., Smart, D., et al., 2012. Cannabis and depression: An integrative data analysis of four Australasian cohorts. Drug and Alcohol Dependence 126, 369-378

Imbens, G.W., Angrist, J.D., 1994. Identification and Estimation of Local Average Treatment Effects. Econometrica 62, 467-475

Iñiguez, S.D., Warren, B.L., Parise, E.M., Alcantara, L.F., Schuh, B., Maffeo, M.L., et al., 2009. Nicotine Exposure during Adolescence Induces a Depression-Like State in Adulthood. Neuropsychopharmacology 34, 1609-1624

Johnson, J.G., Cohen, P., Pine, D.S., Klein, D.F., Kasen, S., Brook, J.S., 2000. Association between cigarette smoking and anxiety disorders during adolescence and early adulthood. JAMA 284, 2348-51

Johnston, D., Propper, C., Pudney, S., Shields, M., 2014. Child mental health and educational attainment: Multiple observers and the measurement error problem. Journal of Applied Econometrics 29, 880-900

Kalman, D., Morissette, S.B., George, T.P., 2005. Co-Morbidity of Smoking in Patients with Psychiatric and Substance Use Disorders. American Journal on Addictions 14, 106-123

Katz, C., El-Gabalawy, R., Keyes, K.M., Martins, S.S., Sareen, J., 2013. Risk factors for incident nonmedical prescription opioid use and abuse and dependence: results from a longitudinal nationally representative sample. Drug and alcohol dependence 132, 107-113

Kendler, K.S., Neale, M.C., MacLean, C.J., Heath, A.C., Eaves, L.J., Kessler, R.C., 1993. Smoking and major depression. A causal analysis. Archives of General Psychiatry 50, 36-43

Khantzian, E.J., 1987. The Self-Medication Hypothesis of Addictive Disorders: Focus on Heroin and Cocaine Dependence. In: Allen DF (ed.) The Cocaine Crisis. Springer US, Boston, MA, pp. 65-74.

Kim-Mozeleski, J.E., Poudel, K.C., Tsoh, J.Y., 2020. Examining Reciprocal Effects of Cigarette Smoking, Food Insecurity, and Psychological Distress in the U.S. Journal of Psychoactive Drugs, 1-8

Klungsøyr, O., Nygård, J.F., Sørensen, T., Sandanger, I., 2006. Cigarette Smoking and Incidence of First Depressive Episode: An 11-Year, Population-based Follow-up Study. American Journal of Epidemiology 163, 421-432

Knott, C., Bell, S., Britton, A., 2015. Alcohol Consumption and the Risk of Type 2 Diabetes: A Systematic Review and Dose-Response Meta-analysis of More Than 1.9 Million Individuals From 38 Observational Studies. Diabetes Care 38, 1804-12

Kumari, V., Postma, P., 2005. Nicotine use in schizophrenia: The self medication hypotheses. Neuroscience & Biobehavioral Reviews 29, 1021-1034

Kung, C.S.J., Johnston, D.W., Shields, M.A., 2018. Mental health and the response to financial incentives: Evidence from a survey incentives experiment. Journal of Health Economics 62, 84-94

Lalanne, L., Lutz, P.-E., Trojak, B., Lang, J.-P., Kieffer, B.L., Bacon, E., 2016. Medications between psychiatric and addictive disorders. Progress in Neuro-Psychopharmacology and Biological Psychiatry 65, 215-223

LaMontagne, A.D., Too, L.S., Punnett, L., Milner, A.J., 2020. Changes in Job Security and Mental Health: An Analysis of 14 Annual Waves of an Australian Working-Population Panel Survey. American Journal of Epidemiology

Lawrence, D., Mitrou, F., Zubrick, S.R., 2009. Smoking and mental illness: results from population surveys in Australia and the United States. BMC public health 9, 1-14

Le, H.T., Nguyen, H.T., 2017. Parental health and children's cognitive and noncognitive development: New evidence from the longitudinal survey of Australian children. Health Economics 26, 1767–1788

Le, H.T., Nguyen, H.T., 2018. The Impact of Maternal Mental Health Shocks on Child Health: Estimates from Fixed Effects Instrumental Variables Models for two Cohorts of Australian Children. American Journal of Health Economics 4, 185-225

Leung, J., Gartner, C., Hall, W., Lucke, J., Dobson, A., 2012. A longitudinal study of the bi-directional relationship between tobacco smoking and psychological distress in a community sample of young Australian women. Psychological Medicine 42, 1273-82

Lewis, S.J., Araya, R., Davey Smith, G., Freathy, R., Gunnell, D., Palmer, T., et al., 2011. Smoking Is Associated with, but Does Not Cause, Depressed Mood in Pregnancy – A Mendelian Randomization Study. Plos One 6, e21689

Lillard, D.R., 2020. The Economics of Nicotine Consumption. In: Zimmermann KF (ed.) Handbook of Labor, Human Resources and Population Economics. Springer International Publishing, Cham, pp. 1-31.

Marsden, D.G., Loukas, A., Chen, B., Perry, C.L., Wilkinson, A.V., 2019. Associations between frequency of cigarette and alternative tobacco product use and depressive symptoms: A longitudinal study of young adults. Addictive Behaviors 99, 106078

Mitrou, F., Gaudie, J., Lawrence, D., Silburn, S.R., Stanley, F.J., Zubrick, S.R., 2010. Antecedents of hospital admission for deliberate self-harm from a 14-year follow-up study using data-linkage. BMC psychiatry 10, 1-11

Mojtabai, R., Crum, R.M., 2013. Cigarette smoking and onset of mood and anxiety disorders. American journal of public health 103, 1656-1665

Moylan, S., Jacka, F.N., Pasco, J.A., Berk, M., 2012. Cigarette smoking, nicotine dependence and anxiety disorders: a systematic review of population-based, epidemiological studies. BMC medicine 10, 1-14

Mukamal, K.J., Conigrave, K.M., Mittleman, M.A., Camargo, C.A., Jr., Stampfer, M.J., Willett, W.C., et al., 2003. Roles of drinking pattern and type of alcohol consumed in coronary heart disease in men. N Engl J Med 348, 109-18

Mukherjee, S., 2013. Alcoholism and its effects on the central nervous system. Current neurovascular research 10, 256-262

Needham, B.L., 2007. Gender differences in trajectories of depressive symptomatology and substance use during the transition from adolescence to young adulthood. Social Science & Medicine 65, 1166-1179

Nguyen, H.T., Connelly, L.B., 2018. Out of sight but not out of mind: Home countries' macroeconomic volatilities and immigrants' mental health. Health Economics 27, 189–208

Nguyen, H.T., Le, H.T., Connelly, L.B., 2021. Who's declining the "free lunch"? New evidence from the uptake of public child dental benefits. Health Economics 30, 270-288

Nguyen, H.T., Mitrou, F., Taylor, C., Zubrick, S., 2020. Does Retirement Lead to Life Satisfaction? Causal Evidence from Fixed Effect Instrumental Variable Models. GLO Discussion Paper, No. 536

NHMRC, 2009. Australian Guidelines to Reduce Health Risks from Drinking Alcohol. National Health and Medical Research Council (NHMRC) (Ed.), Canberra

NHMRC, 2020. Australian Guidelines to Reduce Health Risks from Drinking Alcohol. National Health and Medical Research Council (NHMRC) (Ed.), Canberra

Nunes, E.V., Levin, F.R., 2004. Treatment of depression in patients with alcohol or other drug dependence: a meta-analysis. Jama 291, 1887-96

OECD, 2014. Making Mental Health Count: The Social and Economic Costs of Neglecting Mental Health Care. Organisation for Economic Co-operation Development (OECD) Publishing, Paris, France

Pasman, J.A., Verweij, K.J.H., Gerring, Z., Stringer, S., Sanchez-Roige, S., Treur, J.L., et al., 2018. GWAS of lifetime cannabis use reveals new risk loci, genetic overlap with psychiatric traits, and a causal effect of schizophrenia liability. Nature Neuroscience 21, 1161-1170

Prochaska, J.J., Das, S., Young-Wolff, K.C., 2017. Smoking, Mental Illness, and Public Health. Annual Review of Public Health 38, 165-185

Ranjit, A., Korhonen, T., Buchwald, J., Heikkilä, K., Tuulio-Henriksson, A., Rose, R.J., et al., 2019. Testing the reciprocal association between smoking and depressive symptoms from adolescence to adulthood: A longitudinal twin study. Drug and Alcohol Dependence 200, 64-70

Ren, Y., Castro Campos, B., Loy, J.-P., 2020. Drink and smoke; drink or smoke? The interdependence between alcohol and cigarette consumption for men in China. Empirical Economics 58, 921-955

Skov-Ettrup, L.S., Nordestgaard, B.G., Petersen, C.B., Tolstrup, J.S., 2016. Does High Tobacco Consumption Cause Psychological Distress? A Mendelian Randomization Study. Nicotine & Tobacco Research 19, 32-38

Sloan, F.A., Wang, Y., 2008. Economic theory and evidence on smoking behavior of adults. Addiction 103, 1777-1785

Stock, J.H., Yogo, M., 2005. Testing for Weak Instruments in Linear IV Regression. In: Andrews DWK (ed.) Identification and Inference for Econometric Models. Identification and Inference for Econometric Models. Cambridge University Press, New York, pp. 80-108.

Summerfield, M., Bright, S., Hahn, M., La, N., Macalalad, N., Watson, N., et al., 2019. HILDA User Manual – Release 18. Melbourne Institute of Applied Economic and Social Research, The University of Melbourne

Tauchmann, H., Lenz, S., Requate, T., Schmidt, C.M., 2013. Tobacco and alcohol: complements or substitutes? Empirical Economics 45, 539-566

Taylor, A.E., Fluharty, M.E., Bjørngaard, J.H., Gabrielsen, M.E., Skorpen, F., Marioni, R.E., et al., 2014a. Investigating the possible causal association of smoking with depression and anxiety using Mendelian randomisation meta-analysis: the CARTA consortium. BMJ Open 4, e006141

Taylor, G., McNeill, A., Girling, A., Farley, A., Lindson-Hawley, N., Aveyard, P., 2014b. Change in mental health after smoking cessation: systematic review and meta-analysis. BMJ : British Medical Journal 348, g1151

Volkow, N., Li, T.-K., 2005. The neuroscience of addiction. Nature Neuroscience 8, 1429-1430

Volkow, N.D., Baler, R.D., Compton, W.M., Weiss, S.R.B., 2014. Adverse health effects of marijuana use. The New England journal of medicine 370, 2219-2227

Wang, J.-C., Kapoor, M., Goate, A.M., 2012. The genetics of substance dependence. Annual review of genomics and human genetics 13, 241-261

Ware, J.E., Kosinski, M., Dewey, J.E., Gandek, B., 2000. SF-36 health survey: manual and interpretation guide. Quality Metric Inc.

Ware, J.E., Kosinski, M., Keller, S., 1994. SF-36 physical and mental health summary scales: a user's manual. Health Assessment Lab., Boston.

WHO, 2017. Depression and other common mental disorders: global health estimates. World Health Organization, Geneva

Wilkins, R., Sun, C., 2010. Assessing the Quality of the Expenditure Data Collected in the Self-Completion Questionnaire HILDA project technical paper series No. 1/10, April 2010, Melbourne Institute of Applied Economic and Social Research, The University of Melbourne

Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data. MIT Press, Cambridge, Mass.

Yamazaki, S., Fukuhara, S., Green, J., 2005. Usefulness of five-item and three-item Mental Health Inventories to screen for depressive symptoms in the general population of Japan. Health and Quality of Life Outcomes 3, 48

Yang, L., Zikos, V., 2022. Healthy mind in healthy body: Identifying the causal effect of mental health on physical health. Economics Letters 213, 110358

Zubrick, S.R., Lawrence, D., Mitrou, F., Christensen, D., Taylor, C.L., 2012. Early mental health morbidity and later smoking at age 17 years. Psychological Medicine 42, 1103-1115

Table 1: Sample means of outcomes and key covariates by mental health condition

	Poorer mental health	Better mental health	Poorer mental health - Better mental health
	(1)	(2)	(3)
Male	0.46	0.51	-0.05***
Age (years)	49.54	51.84	-2.3***
Married/De facto	0.65	0.73	-0.08***
Separated/divorced/widowed	0.18	0.15	0.03***
Aboriginal	0.02	0.01	0.01***
Non-English-Speaking migrant	0.17	0.12	0.04***
English-Speaking migrant	0.10	0.11	-0.01***
Year 12	0.14	0.13	0.01***
Vocational and training qualification	0.36	0.40	-0.04***
Bachelor or higher degree	0.18	0.19	-0.01***
Number of household members	2.68	2.68	0.00
SF36 Mental Component Summary	0.60	-0.66	1.27***
SF36 9-item mental health index	0.75	-0.73	1.48***
K10	0.49	-0.60	1.09***
Smoker	0.20	0.14	0.06***
Daily smoker	0.17	0.12	0.05***
Weekly number of cigarettes	16.96	11.72	5.24***
Drinker	0.79	0.84	-0.05***
Daily drinker	0.07	0.09	-0.01***
Excessive drinker	0.09	0.07	0.02***
Number of observations	117,537	117,841	

Notes: Figures are sample means. Estimated sample from the regression of "smoker" as an outcome. Tests are performed on the significance of the difference between the sample mean for individuals with "poorer mental health" (identified as those with standardized reversed MHI-5 > median of this mental health variable among individuals included in the final sample) and those with "better mental health" (standardized reversed MHI-5 <=median). The symbol *denotes significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Table 2: Impact of mental health on addictive behaviours - results from various models

	Pooled OLS	FE	Pooled IV	FE-IV	Pooled OLS	FE	Pooled IV	FE-IV	Pooled OLS	FE	Pooled IV	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Smoking outcomes	Smoker				Daily smoker				Weekly number of cigarettes			
Stand. rev. MHI-5	3.80***	0.70***	41.84***	19.96***	3.27***	0.47***	32.59***	11.56***	3.58***	0.56***	32.27***	10.97**
	[0.20]	[0.10]	[4.84]	[4.30]	[0.18]	[0.09]	[4.14]	[3.62]	[0.24]	[0.12]	[4.78]	[4.74]
Observations	235,378	235,378	235,378	235,378	235,378	235,378	235,378	235,378	234,604	234,604	234,604	234,604
Individuals	24,678	24,678	24,678	24,678	24,678	24,678	24,678	24,678	24,628	24,628	24,628	24,628
Mean of dep. variable	18.99	18.99	18.99	18.99	15.45	15.45	15.45	15.45	14.69	14.69	14.69	14.69
F-statistic of IV			117.34	76.37			117.34	76.37			113.45	74.31
Hausman test (p value)			0.00	0.00			0.00	0.00			0.00	0.02
Panel B: Drinking outcomes	Drinker				Daily drinker				Excessive drinker			
Stand. rev. MHI-5	-1.29***	0.02	16.42***	16.08***	0.24**	0.34***	0.10	0.13	1.31***	0.94***	22.42***	17.66***
	[0.19]	[0.11]	[3.88]	[4.49]	[0.11]	[0.06]	[2.50]	[3.33]	[0.12]	[0.10]	[3.10]	[4.28]
Observations	235,389	235,389	235,389	235,389	235,389	235,389	235,389	235,389	235,049	235,049	235,049	235,049
Individuals	24,697	24,697	24,697	24,697	24,697	24,697	24,697	24,697	24,665	24,665	24,665	24,665
Mean of dep. variable	81.61	81.61	81.61	81.61	6.92	6.92	6.92	6.92	11.42	11.42	11.42	11.42
F-statistic of IV			115.86	75.53			115.86	75.53			113.63	77.81
Hausman test (p value)			0.00	0.00			0.96	0.95			0.00	0.00

Notes: "Pooled OLS" results are from the regression (1) without controlling for individual FEs while FE results are from the regression (1). Pooled-IV results are from models (1) and (2) without controlling for individual FEs while FE-IV results from models (1) and (2). "F-statistic of IV" denotes the F statistic for the strength of the excluded instrument in the first stage regression. "Hausman test (p value)" denotes p value from a Hausman test for endogeneity of the mental health variable in equation (1). Other explanatory variables include gender, age (and its square), migration status, Aboriginal status, marital status, education, household size, local socio-economic background variables, state/territory dummies, year dummies, and survey quarter dummies. Robust standard errors clustered at the individual level in parentheses. For all binary outcome variables, results (coefficient estimates, standard errors and sample means) are multiplied by 100 for aesthetic purposes. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Table 3: Characterizing the composition of compliers

Characteristic identified by	Calculated likelihood ratio
Gender:	
Female	1.14
Male	0.82
Age:	
Young	1.85
Old	0.54
Marital status:	
Single	1.50
Married	0.63
Education:	
No post-school degree	1.02
Bachelor degree or higher	0.85
Previous smoking status:	
Non-smoker	0.87
Smoker	1.32
Previous mental health status:	
Had no mental illness	0.78
Had mental illness	1.21

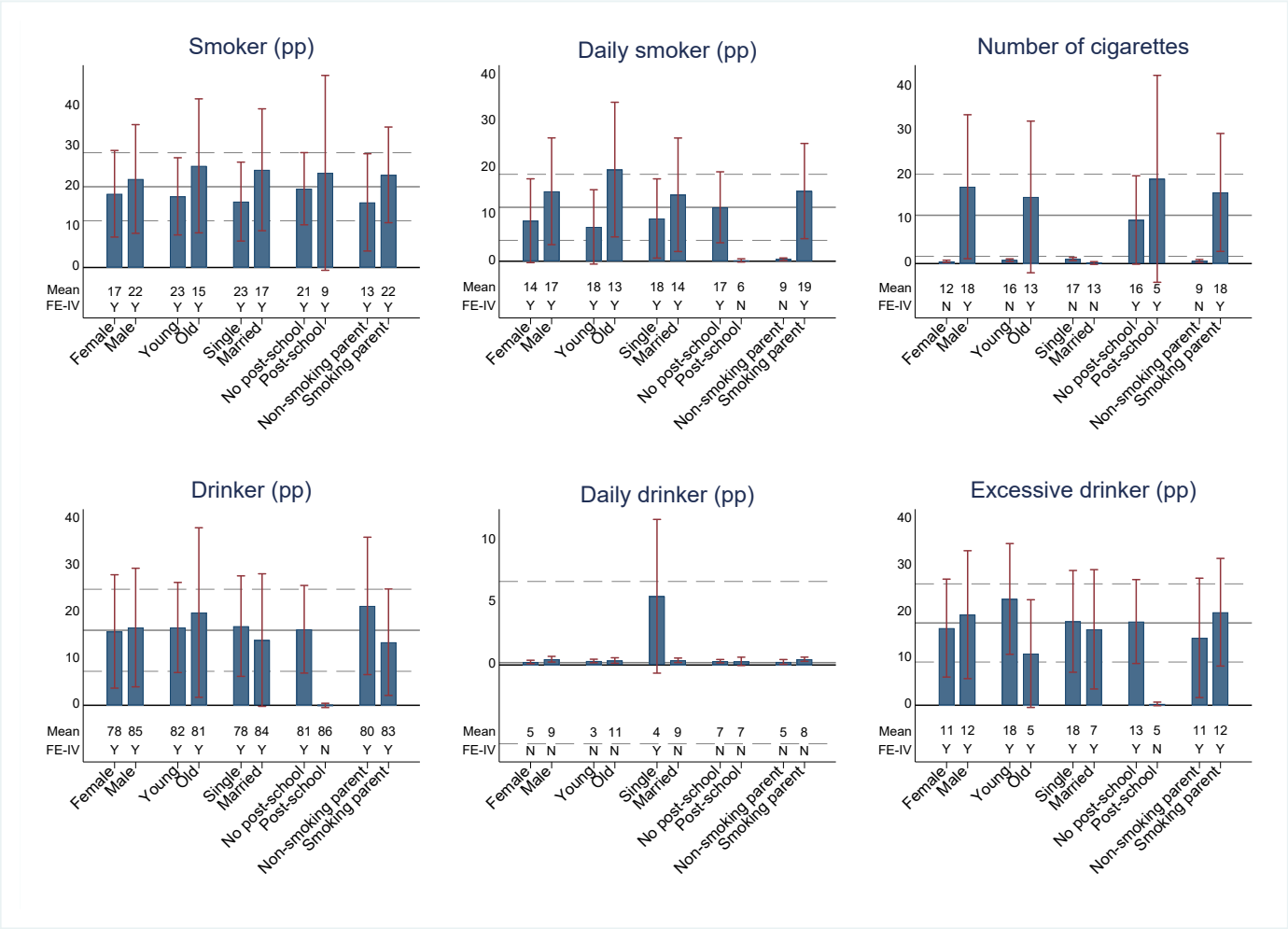
Notes: Statistics are calculated using an estimated sample from the regression of "smoker" as an outcome. "Young" sub-group includes individuals aged equal or below the median of the whole sample while "Old" sub-group consists of remaining individuals. "Previous" smoking (mental illness) status is identified using one-year lag of smoking (mental illness) status. "Mental illness" is identified using the suggested MHI-5 cut-off of 68.

Table 4: Impact of mental health on additional outcomes and household expenditure

	FE	FE-IV	FE	FE-IV	FE	FE-IV	FE	FE-IV	FE	FE-IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Smoking or drinking (Dummy = 1 if yes, = 0 if no)		Daily smoking or daily drinking (Dummy = 1 if yes, = 0 if no)		Share of expenditure on cigarettes and tobacco in total expenditure (%)		Share of expenditure on alcohol in total expenditure (%)		Share of expenditure on cigarettes, tobacco and alcohol in total expenditure (%)	
Stand. rev. MHI-5	0.27***	12.78***	0.63***	11.22**	0.06***	0.54	0.03*	1.65*	0.09***	2.19
	[0.10]	[4.23]	[0.10]	[4.44]	[0.02]	[1.00]	[0.02]	[0.97]	[0.03]	[1.44]
Observations	236,671	236,671	236,671	236,671	179,195	179,195	179,195	179,195	179,195	179,195
Individuals	24,731	24,731	24,731	24,731	21,934	21,934	21,934	21,934	21,934	21,934
Mean of dep. variable	83.56	83.56	20.62	20.62	2.86	2.86	4.77	4.77	7.62	7.62
F-statistic of IV		77.23		77.23		43.76		43.76		43.76
Hausman test (p value)		0.00		0.01		0.63		0.09		0.14

Notes: FE results are from the regression (1) while FE-IV results from regressions (1) and (2). "F-statistic of IV" denotes the F statistic for the strength of the excluded instrument in the first stage regression. "Hausman test (p value)" denotes p value from a Hausman test for endogeneity of the mental health variable in equation (1). Other explanatory variables include age (and its square), marital status, education, household size, local socio-economic background variables, state/territory dummies, year dummies, and survey quarter dummies. Robust standard errors clustered at the individual level in parentheses. For all binary outcome variables, results (coefficient estimates, standard errors and sample means) are multiplied by 100 for aesthetic purposes. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Figure 1: Heterogeneity



Notes: Results for different sub-populations are obtained from separate FE-IV or FE regressions. The model for each sub-population is printed above the sub-population label (Y indicates results from a FE-IV model while N from a FE model). For all binary outcome variables, sample mean, coefficient estimate and its 95% confidence interval are multiplied by 100 for aesthetic purposes. The solid (dash) horizontal line shows the mental health coefficient (95% confidence interval) estimates for the whole population. The sample mean of dependent variable for each sub-population is printed below the bars. Detailed regression results are reported in Appendix Table A7.

Online Appendix

for refereeing purposes and to be published online

Appendix A: Additional results

Appendix B: Robustness checks

Appendix Table A1: Variable description and summary statistics

Variable	Description	Mean	Min	Max	Standard deviations		
					Overall	Between	Within
Male	Dummy variable: = 1 if is a male and 0 otherwise	0.47	0.00	1.00	0.50	0.50	0.00
Age	Age at the survey time (years)	44.93	14.00	101.00	18.46	19.06	4.27
Married/De facto	Dummy variable: = 1 if is married or in De factor relationship at the survey time and 0 otherwise	0.64	0.00	1.00	0.48	0.44	0.23
Separated/divorced/widowed	Dummy variable: = 1 if is separated/divorced/widowed at the survey time and 0 otherwise	0.13	0.00	1.00	0.34	0.30	0.15
Aboriginal	Dummy variable: = 1 if has an Aboriginal and Torres Strait Islanders origin and 0 otherwise	0.02	0.00	1.00	0.15	0.17	0.00
Non-English-Speaking migrant	Dummy: = 1 if immigrant from a Non-English-Speaking Background (NESB) country and 0 otherwise	0.11	0.00	1.00	0.31	0.32	0.00
English-Speaking migrant	Dummy: = 1 if immigrant from an English-Speaking Background (NESB) country and 0 otherwise	0.10	0.00	1.00	0.30	0.29	0.00
Year 12	Dummy: = 1 if complete Year 12 and 0 otherwise	0.15	0.00	1.00	0.36	0.32	0.17
Vocational or training qualification	Dummy: = 1 if has a vocational or training qualification and 0 otherwise	0.36	0.00	1.00	0.48	0.45	0.16
Bachelor or higher degree	Dummy: = 1 if has a bachelor degree or higher and 0 otherwise	0.19	0.00	1.00	0.39	0.36	0.13
Household size	Number of household members	2.87	1.00	17.00	1.46	1.29	0.80
Stand. rev. MHI-5	Mental Health Inventory (MHI-5) index, calculated from 5 items of the 36-Item Short Form Health Survey, standardized: a higher value indicates poorer mental health. See text for details.	-0.01	-1.51	4.24	1.00	0.82	0.62
SF36 MCS	SF36 Mental Component Summary, standardized: a higher value indicates poorer mental health. See text for details.	-0.01	-2.63	4.81	1.00	0.79	0.66
MH-9	Mental Health index, calculated from 9 items of the 36-Item Short Form Health Survey, standardized: a higher value indicates poorer mental health. See text for details.	-0.01	-1.91	3.97	1.00	0.84	0.59
K10	Kessler Psychological Distress Scale (K10) score, standardized: a higher value indicates poorer mental health. See text for details.	-0.01	-0.91	5.09	0.99	0.90	0.53
Smoker	Dummy variable: = 1 if responded "Yes" to the question "Do you smoke cigarettes or any other tobacco products?" and 0 if responded "No, I have never smoked" or "No, I no longer smoke".	0.19	0.00	1.00	0.39	0.36	0.20
Daily smoker	Dummy variable: = 1 if responded "Yes, I smoke daily" to the question "Do you smoke cigarettes or any other tobacco products?" and 0 if otherwise.	0.15	0.00	1.00	0.36	0.33	0.18
Weekly number of cigarettes	Number of cigarettes usually smoked each week, derived from valid responses to the question "How many cigarettes do you usually smoke each week?"	14.66	0.00	1200.00	42.16	36.73	22.91
Drinker	Dummy variable: = 1 if responded "Yes" to the question "Do you drink alcohol?" and 0 if responded "I have never drunk alcohol" or "I no longer drink".	0.82	0.00	1.00	0.39	0.33	0.23
Daily smoker	Dummy variable: = 1 if responded "Yes, I drink alcohol everyday" to the question "Do you drink alcohol?" and 0 otherwise.	0.07	0.00	1.00	0.25	0.19	0.16
Excessive drinker	Dummy variable: = 1 if responses as 5 or more (for females) or 7 or more (for males) to the question "On a day that you have an alcoholic drink, how many standard drinks do you usually have?" and 0 otherwise.	0.11	0.00	1.00	0.32	0.25	0.23
Death of a close friend	Dummy variable: = 1 if responded "Yes" to the event "Death of a close friend" in the question "Did any of these happen to you in the past 12 months?" and 0 otherwise.	0.11	0.00	1.00	0.31	0.17	0.27

Notes: Statistics are calculated using an estimated sample from the regression of “smoker” as an outcome.

Appendix Table A2: Correlation structure among key variables

	Stand. rev. MHI-5	SF36 MCS	MH-9	K10	Clinically diagnosed depression	Smoker	Daily smoker	Weekly number of cigarettes	Drinker	Daily drinker	Excessive drinker	Illicit drug use
Stand. rev. MHI-5	1.00											
SF36 MCS	0.85	1.00										
MH-9	0.93	0.83	1.00									
K10	0.81	0.76	0.78	1.00								
Clinically diagnosed depression	0.41	0.41	0.40	0.43	1.00							
Smoker	0.13	0.13	0.12	0.17	0.12	1.00						
Daily smoker	0.12	0.12	0.12	0.16	0.12	0.89	1.00					
Weekly number of cigarettes	0.11	0.10	0.11	0.14	0.11	0.73	0.79	1.00				
Drinker	-0.06	-0.04	-0.06	-0.08	-0.03	0.08	0.06	0.05	1.00			
Daily drinker	-0.02	-0.03	-0.02	-0.03		0.05	0.06	0.08	0.13	1.00		
Excessive drinker	0.07	0.08	0.05	0.11	0.04	0.21	0.17	0.15	0.17	0.04	1.00	
Illicit drug use	0.08	0.12	0.09	0.09	0.09	0.25	0.21	0.18	0.21	0.02	0.18	1.00

Notes: All listed correlations are statistically significant at the 1% level.
"Clinically diagnosed depression" is a dummy variable taking the value of 1 if the individual was "diagnosed with serious illness - Depression or anxiety" and 0 otherwise. This information is only available in waves 9, 13 and 17 of HILDA.
"Illicit drug use" is a dummy variable taking the value of 1 if the individual had ever used drugs such as cocaine, ecstasy, hallucinogens, inhalants, marijuana/cannabis, meth/amphetamine and other illicit drug and 0 otherwise. This information is only asked in wave 17 of HILDA.

Appendix Table A3: Applying a Probit model for binary outcomes

	Smoker		Daily smoker		Drinker		Daily drinker		Excessive drinker	
	Probit	IV Probit	Probit	IV Probit	Probit	IV Probit	Probit	IV Probit	Probit	IV Probit
Stand. rev. MHI-5	3.19***	23.03***	2.70***	20.70***	-1.62***	13.55***	0.16	-0.01	1.14***	19.54***
	[0.17]	[0.93]	[0.16]	[1.25]	[0.17]	[2.97]	[0.11]	[2.00]	[0.11]	[1.40]
Observations	235,378	235,378	235,378	235,378	235,389	235,389	235,389	235,389	235,049	235,049
P value of a Wald test of exogeneity		0.00		0.00		0.00		0.93		0.00

Notes: "Probit" results are from a Probit regression of equation (1) without controlling for individual FEs. "IV Probit" results are from an IV Probit regression of equations (1) and (2) without controlling for individual FEs. Results (coefficient estimates and standard errors) are reported in marginal effects and are multiplied by 100 for aesthetic purposes. Instrument: death of close friend. "P value of a Wald test of exogeneity" denotes p value from a Wald test for exogeneity of the mental health variable in the IV Probit model. Other explanatory variables include gender, age (and its square), migration status, Aboriginal status, marital status, education, household size, local socio-economic background variables, state/territory dummies, year dummies, and survey quarter dummies. Robust standard errors clustered at the individual level in parentheses. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Appendix Table A4: First-stage regression results

Variable	Pooled OLS	FE
	(1)	(2)
Death of a close friend	10.61***	5.36***
	[0.65]	[0.49]
Male	-11.85***	
	[0.41]	
Age (years)	1.26***	0.81***
	[0.06]	[0.09]
Age squared	-0.02***	-0.01***
	[0.00]	[0.00]
Married/De facto[(a)]	-19.30***	-9.36***
	[0.63]	[0.72]
Separated/divorced/widowed[(a)]	1.66**	8.03***
	[0.85]	[1.07]
Aboriginal	19.18***	
	[1.37]	
NESB immigrant[(b)]	13.59***	
	[0.67]	
ESB immigrant[(b)]	-0.01	
	[0.70]	
Year 12[(c)]	-9.86***	-1.53*
	[0.66]	[0.84]
Vocational and Training qualification[(c)]	-10.71***	-5.03***
	[0.53]	[0.85]
Bachelor or higher degree[(c)]	-16.36***	-8.60***
	[0.65]	[1.06]
Household size	-1.13***	0.21
	[0.16]	[0.17]
Observations	235,378	235,378
Individuals		24,678

Notes: Pooled OLS results are from the first stage of pooled IV regression of the "smoking" as an outcome while FE results from the FE-IV regression. Coefficient estimates and standard errors are multiplied by 100 for aesthetic purposes. [(a)], [(b)] and [(c)] denotes being single, native, and having year 11 or below qualification as the base group, respectively. Other included variables: local socio-economic background variables, state/territory dummies, year dummies, and survey quarter dummies. Robust standard errors clustered at the individual level in parentheses. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Appendix Table A5: Second-stage remaining regression results

Variable	Smoker	Daily smoker	Weekly number of cigarettes	Drinker	Daily drinker	Excessive drinker
	(1)	(2)	(3)	(4)	(5)	(6)
Age (years)	-0.86***	-0.33**	-0.36**	0.46**	0.29**	-1.20***
	[0.18]	[0.15]	[0.15]	[0.19]	[0.14]	[0.20]
Age squared	0.00*	-0.00	-0.00***	-0.01***	-0.00***	0.01***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Married/De facto [(a)]	-0.05	0.88*	0.50	-1.58***	-0.21	-7.44***
	[0.60]	[0.52]	[0.60]	[0.57]	[0.32]	[0.63]
Separated/divorced/widowed [(a)]	-0.78	0.34	0.48	-4.54***	-1.70***	-9.18***
	[0.83]	[0.71]	[0.90]	[0.79]	[0.51]	[0.79]
Year 12 [(b)]	7.33***	4.67***	4.02***	30.31***	-0.21	18.66***
	[0.58]	[0.48]	[0.50]	[0.76]	[0.23]	[0.70]
Vocational and Training qualification [(b)]	5.26***	3.63***	2.71***	18.33***	-0.82***	10.10***
	[0.72]	[0.63]	[0.72]	[0.82]	[0.28]	[0.70]
Bachelor or higher degree [(b)]	6.37***	4.36***	3.36***	27.30***	-0.82**	11.01***
	[0.81]	[0.64]	[0.66]	[0.94]	[0.33]	[0.90]
Number of other household members	-1.15***	-0.86***	-0.68***	-0.68***	-0.06	-0.43***
	[0.11]	[0.10]	[0.11]	[0.11]	[0.06]	[0.11]
Observations	235,378	235,378	234,604	235,389	235,389	235,049
Individuals	24,678	24,678	24,628	24,697	24,697	24,665

Notes: Results are from the second stage of FE-IV regression. For all binary outcome variables, results (coefficient estimates and standard errors) are multiplied by 100 for aesthetic purposes. [(a)] and [(b)] denotes being single and having year 11 or below qualification as the base group, respectively. Other included variables: local socio-economic background variables, state/territory dummies, year dummies, and survey quarter dummies. Robust standard errors clustered at the individual level in parentheses. The symbol *denotes significance at the 10% level, **at the 5% level, and ***at the 1% level.

Appendix Table A6: Robustness checks

	Smoker	Daily smoker	Weekly number of cigarettes	Drinker	Daily drinker	Excessive drinker
	(1)	(2)	(3)	(4)	(5)	(6)
A. Baseline						
Stand. rev. MHI-5	19.96***	11.56***	10.97**	16.08***	0.13	17.66***
	[4.30]	[3.62]	[4.74]	[4.49]	[3.33]	[4.28]
Observations	235,378	235,378	234,604	235,389	235,389	235,049
Individuals	24,678	24,678	24,628	24,697	24,697	24,665
F-statistic of IV	76.37	76.37	74.31	75.53	75.53	77.81
Hausman test (p value)	0.00	0.00	0.02	0.00	0.95	0.00
B1. Different mental health measures: SF-36 Mental Component Summary (reversed, standardised)						
SF-36 MCS	20.24***	11.07***	10.79**	15.58***	-0.48	19.71***
	[4.66]	[3.85]	[4.89]	[4.84]	[3.56]	[4.76]
Observations	229,397	229,397	228,673	229,358	229,358	229,099
Individuals	24,440	24,440	24,392	24,455	24,455	24,430
F-statistic of IV	58.27	58.27	57.02	56.52	56.52	59.24
Hausman test (p value)	0.00	0.00	0.03	0.00	0.84	0.00
B2. Different mental health measures: MH-9 of the SF-36 (standardized)						
MH-9	23.97***	13.98***	13.20**	19.17***	-0.58	20.98***
	[5.59]	[4.59]	[5.97]	[5.76]	[4.17]	[5.50]
Observations	230,114	230,114	229,391	230,118	230,118	229,828
Individuals	24,486	24,486	24,437	24,505	24,505	24,476
F-statistic of IV	55.17	55.17	53.45	54.05	54.05	56.31
Hausman test (p value)	0.00	0.00	0.03	0.00	0.82	0.00
B3. Different mental health measures: Depression indicator as defined using MHI-5 cut-off						
Depression	52.31***	30.22***	28.23**	41.78***	0.50	46.48***
	[12.55]	[9.96]	[12.61]	[12.54]	[8.65]	[12.30]
Observations	235,443	235,443	234,669	235,454	235,454	235,114
Individuals	24,685	24,685	24,635	24,704	24,704	24,672
F-statistic of IV	40.90	40.90	40.42	41.07	41.07	41.08
Hausman test (p value)	0.00	0.00	0.02	0.00	1.00	0.00
B4. Different mental health measures: Kessler Psychological Distress Scale (K10) score (standardized)						
K10	32.26***	18.47**	20.27**	1.39	1.15	25.78***
	[10.28]	[7.83]	[9.54]	[8.20]	[6.58]	[9.66]
Observations	93,809	93,809	93,442	93,757	93,757	93,718
Individuals	19,368	19,368	19,333	19,373	19,373	19,355
F-statistic of IV	19.24	19.24	18.56	20.08	20.08	19.85
Hausman test (p value)	0.00	0.01	0.02	0.87	0.91	0.00

Notes: See Table 2.

Appendix Table A6: Robustness checks (continued)

	Smoker	Daily smoker	Weekly number of cigarettes	Drinker	Daily drinker	Excessive drinker
	(1)	(2)	(3)	(4)	(5)	(6)
C. Excluding potentially endogenous variables: Excluding marital status, education and household size						
Stand. rev. MHI-5	20.49***	11.72***	11.10**	17.58***	0.26	19.66***
	[4.30]	[3.60]	[4.70]	[4.56]	[3.30]	[4.38]
Observations	235,443	235,443	234,669	235,454	235,454	235,114
Individuals	24,685	24,685	24,635	24,704	24,704	24,672
F-statistic of IV	77.49	77.49	75.56	76.78	76.78	78.96
Hausman test (p value)	0.00	0.00	0.02	0.00	0.98	0.00
D1. Including additional variables: SF36 Physical Component Summary						
Stand. rev. MHI-5	20.72***	11.38***	11.23**	16.34***	-0.44	20.17***
	[4.66]	[3.88]	[5.01]	[4.86]	[3.62]	[4.75]
Observations	229,397	229,397	228,673	229,358	229,358	229,099
Individuals	24,440	24,440	24,392	24,455	24,455	24,430
F-statistic of IV	66.98	66.98	64.24	64.92	64.92	67.99
Hausman test (p value)	0.00	0.00	0.03	0.00	0.83	0.00
D2. Including additional variables: Disabled condition						
Stand. rev. MHI-5	20.61***	11.93***	11.31**	16.71***	0.25	18.19***
	[4.46]	[3.73]	[4.88]	[4.63]	[3.42]	[4.42]
Observations	235,443	235,443	234,669	235,454	235,454	235,114
Individuals	24,685	24,685	24,635	24,704	24,704	24,672
F-statistic of IV	72.63	72.63	70.64	72.08	72.08	74.11
Hausman test (p value)	0.00	0.00	0.02	0.00	0.98	0.00
D3. Including additional variables: Serious personal injury/illness						
Stand. rev. MHI-5	21.93***	13.01***	12.18**	17.36***	0.14	19.16***
	[4.77]	[3.97]	[5.15]	[4.90]	[3.60]	[4.69]
Observations	234,767	234,767	233,988	234,775	234,775	234,452
Individuals	24,661	24,661	24,611	24,679	24,679	24,649
F-statistic of IV	65.66	65.66	63.99	65.35	65.35	67.86
Hausman test (p value)	0.00	0.00	0.02	0.00	0.95	0.00
D4. Including additional variables: Labour market participation status						
Stand. rev. MHI-5	20.21***	11.69***	11.03**	16.48***	0.20	17.86***
	[4.33]	[3.64]	[4.76]	[4.53]	[3.35]	[4.31]
Observations	235,443	235,443	234,669	235,454	235,454	235,114
Individuals	24,685	24,685	24,635	24,704	24,704	24,672
F-statistic of IV	75.69	75.69	73.64	74.80	74.80	77.13
Hausman test (p value)	0.00	0.00	0.02	0.00	0.97	0.00

See Table 2. "Disabled condition" mentioned in Panel D2 is a dummy variable which indicates whether the individual had a long-term health condition, disability or impairment. "Serious personal injury/illness" mentioned in Panel D3 is a dummy variable indicating whether the individual had any serious personal injury/illness in the last year. "Labour market participation status" variable mentioned in Panel D4 is a dummy variable which indicates whether the individual was in the labour force at the survey time.

Appendix Table A6: Robustness checks (continued)

	Smoker	Daily smoker	Weekly number of cigarettes	Drinker	Daily drinker	Excessive drinker
	(1)	(2)	(3)	(4)	(5)	(6)
D5. Including additional variables: Current active member of a club						
Stand. rev. MHI-5	19.22***	10.42***	10.48**	15.07***	-0.51	17.42***
	[4.14]	[3.47]	[4.59]	[4.32]	[3.25]	[4.16]
Observations	233,512	233,512	232,747	233,519	233,519	233,200
Individuals	24,615	24,615	24,564	24,635	24,635	24,602
F-statistic of IV	81.20	81.20	79.20	80.26	80.26	82.52
Hausman test (p value)	0.00	0.00	0.03	0.00	0.79	0.00
D6. Including additional variables: Weekly hours spent on informal caring						
Stand. rev. MHI-5	18.39***	10.76***	10.00**	17.41***	-0.22	19.21***
	[4.48]	[3.83]	[4.88]	[4.90]	[3.61]	[4.66]
Observations	212,369	212,369	211,777	212,323	212,323	212,120
Individuals	24,040	24,040	24,003	24,058	24,058	24,032
F-statistic of IV	67.21	67.21	66.39	65.43	65.43	68.18
Hausman test (p value)	0.00	0.00	0.05	0.00	0.88	0.00
D7. Including additional variables: Frequency to participate in physical activity						
Stand. rev. MHI-5	19.85***	11.59***	10.65**	15.45***	0.37	17.43***
	[4.24]	[3.58]	[4.67]	[4.40]	[3.29]	[4.20]
Observations	235,026	235,026	234,246	235,019	235,019	234,677
Individuals	24,669	24,669	24,619	24,687	24,687	24,657
F-statistic of IV	79.59	79.59	77.81	79.00	79.00	81.77
Hausman test (p value)	0.00	0.00	0.03	0.00	0.98	0.00
D8. Including additional variables: Non-wage income						
Stand. rev. MHI-5	20.07***	11.59***	10.94**	16.13***	0.18	17.65***
	[4.31]	[3.62]	[4.74]	[4.50]	[3.34]	[4.28]
Observations	235,443	235,443	234,669	235,454	235,454	235,114
Individuals	24,685	24,685	24,635	24,704	24,704	24,672
F-statistic of IV	76.15	76.15	74.11	75.31	75.31	77.59
Hausman test (p value)	0.00	0.00	0.02	0.00	0.96	0.00

See Table 2. "Currently an active member" variable mentioned in Panel D5 is constructed from responses to a question "Are you currently an active member of a sporting, hobby or community-based club or association?". "Weekly hours spent on informal caring" variable mentioned in Panel D6 is constructed from responses to a question asking "How much time would you spend on each of the following activities in a typical week?" on "Caring for disabled spouse/relative". "Frequency to participate in physical activity" variable mentioned in Panel D7 is constructed from responses to a question asking "In general, how often do you participate in moderate or intensive physical activity for at least 30 minutes?". "Non-wage income" variable mentioned in Panel D8 is non-wage household income adjusted for household size.

Appendix Table A7: Heterogeneity

	Smoker		Daily smoker		Weekly number of cigarettes		Drinker		Daily drinker		Excessive drinker	
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Separate regression by	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A. Gender (Male = Yes, Female = No)												
Stand. rev. MHI-5	18.34***	22.01***	8.72*	15.05**	0.49***	17.42**	15.89**	16.73**	0.24***	0.47***	16.60***	19.49***
	[5.49]	[6.89]	[4.60]	[5.86]	[0.14]	[8.32]	[6.22]	[6.51]	[0.07]	[0.12]	[5.38]	[7.02]
Observations	125,188	110,255	125,188	110,255	124,867	109,802	125,159	110,295	125,159	110,295	124,848	110,266
Individuals	12,813	11,872	12,813	11,872	12,784	11,851	12,819	11,885	12,819	11,885	12,798	11,874
Mean of dep. variable	16.79	21.51	13.72	17.44	11.78	18.01	78.49	85.16	4.74	9.38	10.84	12.09
F-statistic of IV	46.29	37.70	46.29	37.70		36.93	45.86	37.36			48.41	37.03
Hausman test (p-value)	0.00	0.00	0.07	0.01		0.03	0.01	0.00			0.00	0.00
Regression model	FE-IV	FE-IV	FE-IV	FE-IV	FE	FE-IV	FE-IV	FE-IV	FE	FE	FE-IV	FE-IV
B. Age (Age above the median = Yes, Age equal or below the median = No)												
Stand. rev. MHI-5	17.70***	25.28***	7.39*	19.72***	0.76***	15.10*	16.74***	19.95**	0.32***	0.36***	22.87***	11.11*
	[4.90]	[8.50]	[4.08]	[7.39]	[0.16]	[8.77]	[4.95]	[9.31]	[0.07]	[0.11]	[6.08]	[5.91]
Observations	119,465	115,064	119,465	115,064	119,217	114,481	118,889	114,426	119,328	114,902	118,939	113,981
Individuals	16,153	11,925	16,153	11,925	16,542	11,906	16,134	11,915	16,573	12,391	16,120	11,887
Mean of dep. variable	23.12	14.72	18.04	12.78	16.10	13.16	82.22	81.03	2.97	10.99	17.63	4.96
F-statistic of IV	78.87	22.45	78.87	22.45		22.36	78.24	21.46			78.43	22.86
Hausman test (p-value)	0.00	0.00	0.10	0.00		0.06	0.00	0.01			0.00	0.05
Regression model	FE-IV	FE-IV	FE-IV	FE-IV	FE	FE-IV	FE-IV	FE-IV	FE	FE	FE-IV	FE-IV
C. Marital status (Married/De facto = Yes, Single or Separated/divorced/widowed = No)												
Stand. rev. MHI-5	16.39***	24.30***	9.20**	14.30**	1.04***	0.13	17.03***	14.03*	5.55*	0.38***	18.05***	16.34**
	[5.01]	[7.73]	[4.35]	[6.23]	[0.18]	[0.15]	[5.52]	[7.28]	[3.17]	[0.09]	[5.59]	[6.55]
Observations	93,228	142,215	93,228	142,215	93,811	143,027	93,141	142,313	93,141	150,580	92,972	142,142
Individuals	10,762	13,923	10,762	13,923	10,729	13,906	10,770	13,934	10,770	13,934	10,759	13,913
Mean of dep. variable	22.75	16.53	18.03	13.77	16.54	13.47	77.84	84.09	4.22	8.75	17.61	7.38
F-statistic of IV	66.63	27.11	66.63	27.11			63.87	28.07	63.87		66.62	28.29
Hausman test (p-value)	0.00	0.00	0.05	0.01			0.00	0.03	0.08		0.00	0.01
Regression model	FE-IV	FE-IV	FE-IV	FE-IV	FE	FE	FE-IV	FE-IV	FE-IV	FE	FE-IV	FE-IV

Notes: Results for different sub-populations are obtained from a separate FE or FE-IV regression. For all binary outcome variables, results (coefficient estimates, standard errors and sample means) are multiplied by 100 for aesthetic purposes. Other notes: see Table 2.

Appendix Table A7: Heterogeneity (continued)

	Smoker		Daily smoker		Weekly number of cigarettes		Drinker		Daily drinker		Excessive drinker	
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Separate regression by	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
D. Education (Bachelor or higher degree = Yes, No bachelor or higher degree = No)												
Stand. rev. MHI-5	19.59***	23.54*	11.61***	0.17	9.87*	19.20	16.35***	-0.03	0.31***	0.29*	18.01***	0.29
	[4.58]	[12.36]	[3.89]	[0.18]	[5.11]	[11.97]	[4.81]	[0.24]	[0.07]	[0.17]	[4.61]	[0.19]
Observations	198,817	36,626	198,817	38,399	198,059	36,610	198,924	38,301	210,147	38,301	198,569	38,295
Individuals	21,067	3,618	21,067	3,618	21,015	3,620	21,084	3,620	21,084	3,620	21,053	3,619
Mean of dep. variable	20.82	9.11	17.21	6.31	16.43	5.29	80.81	86.13	7.00	6.93	12.66	4.81
F-statistic of IV	75.19	8.89	75.19		72.39	9.12	74.54				77.23	
Hausman test (p-value)	0.00	0.02	0.00		0.07	0.06	0.00				0.00	
Regression model	FE-IV	FE-IV	FE-IV	FE	FE-IV	FE-IV	FE-IV	FE	FE	FE	FE-IV	FE
E. Parental smoking status (Parent smoked during childhood = Yes, Parent did not smoke during childhood = No)												
Stand. rev. MHI-5	16.19***	23.03***	0.43***	15.10***	0.59***	16.11**	21.39***	13.57**	0.25**	0.46***	14.49**	20.01***
	[6.17]	[6.07]	[0.14]	[5.23]	[0.17]	[6.82]	[7.54]	[5.84]	[0.10]	[0.09]	[6.56]	[5.91]
Observations	84,073	139,452	84,073	139,452	83,920	138,882	83,988	139,507	83,988	139,507	83,970	139,276
Individuals	8,193	12,810	8,193	12,810	8,183	12,790	8,199	12,811	8,199	12,811	8,201	12,804
Mean of dep. variable	12.90	22.28	9.44	18.75	8.54	18.16	79.76	82.87	5.10	7.97	10.72	11.70
F-statistic of IV	33.42	48.13		48.13		47.44	34.81	46.18			33.50	48.37
Hausman test (p-value)	0.00	0.00		0.00		0.02	0.00	0.01			0.02	0.00
Regression model	FE-IV	FE-IV	FE	FE-IV	FE	FE-IV	FE-IV	FE-IV	FE	FE	FE-IV	FE-IV

Appendix B: Robustness checks

This Supplementary Appendix reports results from various sensitivity tests. In particular, to test that our results are not driven by the way we construct the mental health variable, we re-estimate the FE-IV model using the SF-36 Mental Component Summary (MCS) scores as an alternative mental health measure (Ware *et al.* 1994).[21] We subsequently follow Frijters *et al.* (2014) to combine four items assessing vitality with the five items describing emotional wellbeing (i.e., our standardized reversed MHI-5 measure) to construct a variable called MH-9 index and use it in place of the standardized reversed MHI-5 variable in the FE-IV regression.[22] FE-IV estimates of these two additional mental health variables (reported in Panels B1 and B2 of Appendix Table A6) are remarkably similar to the FE-IV estimates of the standardized reversed MHI-5 variable in the baseline regression (reproduced in Panel A of Appendix Table A6). The similarity in the findings using three different SF-36-based mental health measures is mostly likely to be explained by the very high correlations among these measures (i.e., the lowest correlation is 0.83 as can be seen from Appendix Table A2). We then use the suggested cut-off of 68 points or lower for the original MHI-5 index to define if the individual has any depressive symptoms (Yamazaki *et al.* 2005). Panel B3 of Appendix Table A6 reports a similar pattern as found in the baseline analysis which uses the continuous MHI-5 based index as the endogenous independent variable. We further test the sensitivity of our findings by employing another validated measure of mental health status available in our data: K10 score. The FE-IV estimates of K10 (reported in Panel B3 of Appendix Table A6) are broadly similar to those of standardized reversed MHI-5 in terms of the magnitude and statistical

[21] In particular, MCS is composed of 8 multi-item scales assessing physical function (10 items), role limitations due to physical health issues (4 items), bodily pain (2 items), general health (5 items), vitality (4 items), social functioning (2 items), role limitations due to emotional issues (3 items) and emotional well-being (5 items) (Ware *et al.* 1994). We use factor score coefficients suggested for the Australian population to construct MCS (ABS 1997). As has been done with the MHI-5 mental health variable, we use a standardized and reversed MCS index so a higher score of this variable indicates a poorer mental health condition in this study.

[22] Four questions assessing the respondents' vitality in SF-36 ask about the frequency during the last four weeks that they "felt full of life", "had a lot of energy", "felt worn out" and "felt tired". To be consistent with other mental health variables used in this study, this MH-9 variable is constructed in the way that a higher value describes poorer mental health status.

significance level.[23] It is worth noting that this stability in the findings is achieved even though we have a substantially smaller sample size to work with when using K10 as a mental health variable.

We also test whether unobserved time-variant factors may influence the estimates of mental distress on addictive behaviours.[24] We do so by additionally controlling for some important time-variant variables which may co-vary with the instrument and addictive behaviours. Particularly, we alleviate concerns that the recent death of a close friend may also affect physical health of the individuals by directly controlling for each of three variables representing their physical health in the regressions. These variables include SF36 Physical Component Summary scores and two separate indicators capturing whether the individual had any disability condition or any serious personal injury/illness (results are presented in Panels D1, D2 and D3 of Appendix Table A6, respectively). Moreover, we address the concern that the occurrence of this stressful event may cause the individuals to shift their time allocation by additionally controlling for each of four time-use measures, represented by the individual's labour force participation status (results are presented in Panel D4 of Appendix Table A6), whether the individual is an active member of a sporting/community club (Panel D5), the number of weekly hours the individual spent on caring for disable spouse/relatives (Panel D6), and the frequency that the individual participated in physical activity (Panel D7). Furthermore, we deal with a concern that this event might lead to changes in financial situation (such as bequests from deceased friends) by explicitly controlling for non-wage income in the FE-IV regressions (Panel D8). Estimation results reported in Appendix Table A6 show that including all above mentioned variables largely does not affect our results because

[23] An exception is that the estimate on drinking is still positive but statistically insignificant. This insignificant FE-IV estimate is in line with the result from a Hausman test which indicates that mental health is exogenous when modelling the drinking probability. Unreported results from a pooled IV estimator which find the mental health variable endogenous indicate a sizable and statistically significant (at the 1% level) estimate: a one-standard-deviation increase in mental illness raises the drinking probability by 7 pp (or 8% of the sample mean).

[24] Likewise, Panel C in Appendix Table A7 suggests that excluding some potentially endogenous time variant variables such as marital status and household size from the list of explanatory variables does not affect our findings.

estimates of the standardized reversed MHI-5 variable are remarkably similar to those obtained from the baseline regressions.