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Alcohol Drinking and Population Health: Evidence from China's Older Adults

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Abstract

Background: Results of research into the effects of alcohol drinking on population health are inconsistent. Some studies suggest that light to moderate alcohol consumption can have a protective effect on morbidity and mortality. But others challenge this view and claim that alcohol use could lead to health loss regardless of the amount. We contribute evidence to this debate by investigating the association between alcohol drinking and all-cause mortality among older adults in China.

Methods: We use nationally representative samples from the Chinese Longitudinal Healthy Longevity Survey and the China Health and Retirement Longitudinal Study. Cox regressions compare ever drinkers who had been exposed to alcohol at some time and lifelong abstainers. We then subdivide ever drinkers into former drinkers who had stopped drinking and current drinkers who were still consuming alcohol. Cox results are supplemented with the interpolated Markov chain approach to calculate total and disability-free life expectancy.

Results: Among older males, ever drinkers seemed to have similar mortality risks to lifelong abstainers. Compared to abstinence, mortality was elevated for former male drinkers, although the effects were generally insignificant. Current male drinkers aged between 65 and 85 had a significantly lower risk of death. With the adjustment for socioeconomic status, an average current male drinker at age 65 could expect to live 1.65 years longer in total and 1.84 years longer without disability than lifelong abstainers. However, we can't reliably estimate alcohol effects on older Chinese females.

Conclusions: Since there is little doubt that heavy drinking is detrimental to health, our results provide evidence supporting an association between light to moderate alcohol consumption and reduced mortality. The recommendation of zero alcohol consumption might not be well-justified in the contemporary Chinese context. The importance of alcohol intake in evaluating population health should be taken into account when predicting future health care burdens.

Keywords: Alcohol drinking; All-cause mortality; IMaCh; Life expectancy

Introduction

A substantial body of literature has demonstrated a J-shaped relationship between alcohol drinking and adverse health outcomes, where light to moderate drinkers are physically and mentally healthier than abstainers, but heavy drinkers fare the worst (see, for example, El-Guebaly, 2007; Fuchs et al., 1995; Klatsky and Udaltsova, 2007; Plunk et al., 2014; San Jose et al., 1999). There is little doubt that heavy alcohol consumption is related to adverse health outcomes. Leon et al. (2007) show that hazardous drinking probably accounts for nearly half of all deaths in working-age men in a typical Russian city. In a meta-analysis of 1.7 million participants, Stringhini et al. (2017) further conclude that heavy alcohol intake is associated with 0.5 years of life lost for those aged between 40 and 85. However, the influence of light to moderate drinking on health is more complex and still under lots of debate. GBD 2016 Alcohol Collaborators (2018) identify drinking alcohol as a leading risk factor for death and disability, so that the safest drinking level should be zero. Similarly, many recent studies have called into question the protective effects of moderate alcohol consumption (see, for example, Goulden, 2016; Topiwala et al., 2017; García-Esquinas et al., 2018; Millwood et al., 2019).

In order to gain more insights into the health implications of alcohol drinking, this paper evaluates the relationships between alcohol consumption and all-cause mortality in a large developing country. We carry out survival analyses using nationally representative samples of older Chinese adults. The longitudinal data come from the Chinese Longitudinal Healthy Longevity Survey (CLHLS). We include a cohort of elderly aged 65 and over interviewed in the 2002 wave and followed up to the latest 2018 wave. To double-check the reliability of any estimation results, we also draw upon data from the China Health and Retirement Longitudinal Study (CHARLS) and conduct similar analyses. CHARLS followed up a sample of community residents aged 45 years or older from 2011 to 2018.

As pointed out in Abat et al. (2019), alternative classifications among different drinking categories may partially account for the mixed results in previous studies. To avoid any classification confusion, we compare mortality between lifelong abstainers and ever drinkers. If drinking alcohol could lead to health loss regardless of the quantity consumed, there would be an increased mortality risk among ever drinkers who have once been exposed to alcohol at some time during their lifetime. After adjusting socioeconomic factors and calendar effects, we estimate age-specific mortality hazards associated with ever drinking using Cox regression models stratified by gender.

The mortality differences between lifelong abstainers and ever drinkers were generally insignificant among older males. If we assume heavy drinking is detrimental to health, no influence of alcohol exposure as a whole might imply beneficial effects of light to moderate drinking. Given the elevated mortality risks among former drinkers found in previous studies (Fillmore et al., 2006; Rehm et al., 2008), we then subdivide ever drinkers into those who had stopped drinking and those who were still consuming alcohol. In our analyses, however, the increased mortality rates among former male drinkers were not precisely estimated overall. Nevertheless, current drinking was associated with reduced mortality compared with abstinence among males aged 65 to 85. No consistent patterns emerged in both CLHLS and CHARLS datasets for females.

Current drinkers seemed to live longer than lifelong abstainers among males over 65 years old. But Cox regressions provide little direct information on life expectancy and pay no attention to the quality of remaining life. Therefore, we supplement survival analyses with the interpolated Markov chain (IMaCh) approach to calculate total and disability-free life expectancy. To understand the dynamic forces underlying mortality results, for each drinking status, we first estimate age-specific rates of onset and recovery from disability, as well as death rates for the disabled and nondisabled. Among older males, current drinkers were less likely to die from a healthy state compared with lifelong abstainers. They were also more likely to recover from disability. We then evaluate the effects of alcohol drinking on life expectancy and disability-free life expectancy. After we account for socioeconomic factors, total life expectancy (disability-free life expectancy) at age 65 was significantly longer in current male drinkers by 1.65 (1.84) years than lifelong abstainers.

To the best of our knowledge, this is among the first studies to combine the impacts of drinking on mortality and on the presence of disability. Analyzing data from nationally representative samples, our estimation results can be readily generalized to China's elderly population. Although one should be cautious about making causal inferences in an observational study, our findings suggest that the recommendation of abandoning light to moderate drinking altogether might not be well-justified. This study highlights the importance of alcohol intake in evaluating population health and provides useful inputs into predicting future health care burdens for commercial insurers and social security designers.

Data and Methodology

Chinese Longitudinal Health Longevity Study

Our primary analyses utilize data from the Chinese Longitudinal Health Longevity Study (CLHLS), a prospective longitudinal study with first-wave data collected in 1998 and follow-up surveys in 2000, 2002, 2005, 2008, 2011, 2014, and 2018. CLHLS randomly selected half of the counties and cities in 22 of the 31 provinces, covering about 85% of China's total population. The first two waves in 1998 and 2000 focused on the oldest-old aged over 80 years, whereas the 2002 wave extended the age range of the sampled elderly to include those aged 65 to 80 (Zeng et al., 2008). Therefore, the current study uses a sample of participants who were interviewed in 2002 and followed up to the latest available wave in 2018.

In-person interviews were conducted to obtain data on demographic characteristics, socioeconomic factors, lifestyle, and health status. Information on the date of death was collected by interviewing close family members. We assess alcohol consumption using the questions: 'Do you drink alcohol at present?' and 'Did you drink alcohol in the past?'. We categorize participants as lifelong abstainers and ever drinkers, then subdivide the latter into former drinkers and current drinkers. We don't go further to distinguish drinkers based on drinking quantities or patterns for the following reasons. Firstly, self-reported alcohol consumption may have systematic errors and bias (Midanik, 1982; Poikolainen, 1985), leading to potential misclassification, especially in a retrospective study of older adults. Secondly, alcohol consumption was measured only at each survey wave. Compared with whether to drink or not, drinking amount and frequency were more likely to change between interviews, which would not be captured by the survey assessments. Thirdly, a complex categorization of drinking behaviors might limit its applicability (Plunk et al., 2014). A relatively simple classification could also provide useful insights for health care designers.

We include the following socioeconomic factors as covariates: educational level, marital status, living arrangement, whether receiving pension income, household per capita income quintiles calculated within each survey wave, and region of residence. Separate analyses were conducted for males and females, given the reported gender differences in mortality, drinking, and their relationship (Bagnardi et al., 2004; Di Castelnuovo et al., 2006; Frezza et al., 1990). Besides, all analyses are weighted using individual sampling weights to get nationally representative results.

In calculating disability-free life expectancy, we consider both physical and cognitive function (Zeng et al., 2017). We define disability in this study as having functional limitation or cognitive impairment. Functional limitation is measured by having difficulty in performing at least one of the six activities of daily living (ADL): bathing, dressing, going to the toilet, indoor transfer, continence, and eating. CLHLS measured cognitive function using a Chinese version of the Mini-Mental State Examination (MMSE), which captures several dimensions, including orientation, calculation, memory, and language abilities. Following Lei and Bai (2020), we construct an MMSE score ranging from 0 to 30 and define cognitive impairment for those scoring less than 18.

China Health and Retirement Longitudinal Study

The China Health and Retirement Longitudinal Study (CHARLS) is a nationally representative longitudinal survey of Chinese community-residents aged 45 years or older and their spouses. It was designed to examine health and economic adjustments to the rapidly aging population in China (Zhao et al., 2014). In 2011, the national baseline survey was fielded using a stratified multistage sampling design and face-to-face visits, including 17708 individuals from 450 villages or urban committees in 28 provinces (Zhao et al., 2013). We use a sample of CHARLS participants aged no less than 45 years, who were interviewed in the 2011 baseline and provided information on key variables. They were followed up in 2013, 2015, and the latest available wave in 2018.

Vital status was reported by household members, but CHARLS provides dates of death only for those who died before the 2013 follow-up. When the date of death is unknown, we assume that death occurred at the midpoint of the two survey waves. We categorize participants as lifelong abstainers, former drinkers, or current drinkers based on the questions: 'Did you drink any alcoholic beverages, such as beer, wine, or liquor, in the last year?' and 'Did you ever drink alcoholic beverages in the past?'. The same covariates are constructed as those in CLHLS, except for the following adjustments. Educational level is divided into more detailed groups to accommodate a younger and more educated cohort. Since the youngest CHARLS participants were 45 years old, we further account for the labor market working status. We use household per capita expenditure quintiles instead of income because expenditure is a robust indicator of available resources in a low-income context as China (Strauss et al., 2010), but CLHLS only provides income information.

Estimation results from the CLHLS data are compared to and supplemented with those using CHARLS. Therefore, we can cautiously derive implications only from patterns similarly emerging across different survey studies, cohorts, and follow-up periods. Also, we check if drinking behaviors could start affecting mortality way earlier before age 65, which might imply a survival bias in the CLHLS results.

Cox Proportional Hazards Models

Cox proportional hazards models are used to estimate the association between alcohol use and all-cause mortality. Lifetime abstainers serve as the reference group to evaluate the effects of alcohol drinking. Independent variables are measured at each survey wave as time-variant. To put similar subjects in the risk set together and allow a completely non-parametric age effect, we follow the suggestion of Kom et al. (1997) and use age as the time-scale. We relax the proportional hazards assumption by including interaction terms between each independent variable and age, in addition to their main effects. Thus, we are estimating age-specific hazard ratios associated with drinking behaviors.

Calendar time is also important in determining mortality, especially when we accrue many years of follow-up. For instance, someone who was 80 years old in 2002 might be different from those who were 80 in 2018, probably because of socioeconomic and medical changes. To account for calendar effects, we stratify the model by birth year. In this way, the baseline hazard function was allowed to vary across different birth cohorts. We use robust standard errors in all analyses, and results are judged significant if the p-value is less than 0.05.

Life Expectancy

We employ the interpolated Markov chain (IMaCh) approach detailed in Lievre et al. (2003) to estimate total and disability-free life expectancy. IMaCh describes the age-specific probability of transitions between disability-free (state 1), disabled (state 2), and death (absorbing state 3): onset of disability, recovery from disability, and death from the disability-free or disabled state (Figure 1). The transition probabilities are parameterized using the following multinomial logistic regressions:

$$Ln(\frac{{}_hP_x^{ij}}{{}_hP_x^{ii}}) = \beta_{0ij} + \beta_{1ij}Age + \beta_{2ij}Drink + \beta_{3ij}Age \times Drink + \beta_{4ij}SES + \beta_{5ij}Age \times SES,\ i \neq j. \quad (1)$$

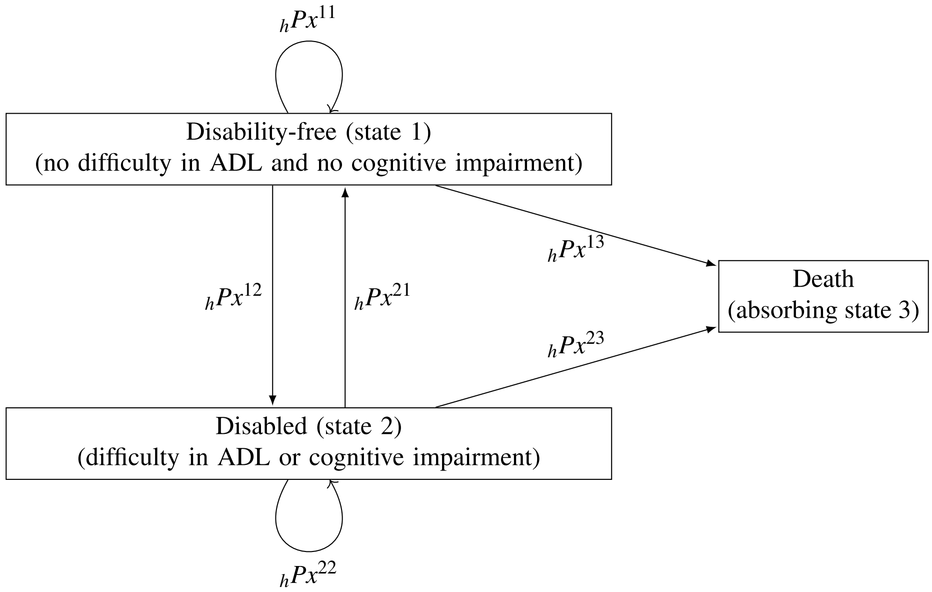


Figure 1: Model of transitions between disability-free, disabled, and death states.

$_hP_x^{ij} = Pr(State(x+h) = j|State(x) = i)$ is the probability that the state of an individual aged $x+h$ is j conditional on his state at age x is i, where $i = 1,2$ and $j = 1,2,3$. h is set to be one month so that we are modeling the monthly transition probabilities. *Drink* represents indicators for alternative drinking status, where lifelong abstainers serve as the reference group. *SES* is our control of socioeconomic status, which will be detailed later. The effects of drinking and socioeconomic status are allowed to vary with age. β's are parameters to be estimated by the method of maximum likelihood.

With estimated parameters, one can calculate the probability that an individual will be in state j at age $x+y$ given that he is in state i at age x as $_yp_x^{ij} = Pr(State(x+y) = j|State(x) = i)$. Then, the expected subsequent time spent in state j by an individual who is in state i at age x can be expressed as $e_x^{ij} = \sum_{y=1}^{\infty} {}_yp_x^{ij}$. Expected subsequent time spent in state j irrespective of the initial state are weighted averages of e_x^{1j} and e_x^{2j}: $e_x^{\cdot j} = \pi_x^1 e_x^{1j} + \pi_x^2 e_x^{2j}$, where weights π_x^1, $\pi_x^2 = 1 - \pi_x^1$ are proportions of the population aged x in states 1 and 2, respectively. Here, we use the stable prevalence of each state among survivors at age x to calculate π_x^1 and π_x^2. The state prevalence is obtained by assuming that a cohort were exposed to the age-specific transition rates estimated in the model from the beginning and the forces of transitions will not change. Total life expectancy is $e_x^{\cdot\cdot} = e_x^{\cdot 1} + e_x^{\cdot 2}$. See Lievre et al. (2003) for more technical details.

Crimmins et al. (2009) summarize several advantages of using the IMaCh approach. IMaCh allows for the possibility that individuals may traverse back and forth between disability-free and disabled states, and the mortality might vary according to disability status. Also, IMaCh naturally handles survey intervals that differ in length and incorporates cases with missing data. Most importantly, IMaCh provides standard errors for the estimated life expectancies so that we can assess whether group differences are statistically meaningful. We take advantage of the approach's capability to include time-varying covariates because both drinking behaviors and socioeconomic status are updated during the survey follow-up.

IMaCh only generates expectancy estimates for a specified combination of covariate values, which might lead to an operational difficulty in our application here. It would be difficult to estimate the life expectancy for an average lifelong abstainer at age 65, for instance, because all our socioeconomic factors are dummy variables, and it is hard to say which combination of these dummies can represent 'the average'. Therefore, we use the structural equation modeling approach to summarize multiple socioeconomic dummy variables into a one-dimensional continuous summary measure using a single-factor measurement model. A detailed description is given in the Supplementary Materials. The constructed socioeconomic status (SES) index is standardized to have a mean of zero and a standard deviation of one among lifelong abstainers at the baseline survey wave. We report estimated transition probabilities and life expectancies while keeping the SES index constant at zero. Thus, we compare outcomes across different drinking groups, assuming they all have the same socioeconomic status as an average lifelong abstainer at the baseline.

Results

Descriptive Statistics

Table 1 summarizes vital status throughout the 16-year follow-up period by baseline drinking status for CLHLS male participants. In total, we include 6767 males interviewed in 2002, among which 49.0% died before the last survey wave. 36.1% were lost to follow-up so that their vital status in 2018 was unknown. The prevalence of lifelong abstainers, former drinkers, and current drinkers at baseline was 41.9%, 19.4%, and 38.7%, respectively. Former drinkers had the highest proportion of deaths, while abstainers were more likely to become lost.

Table S2 in the Supplementary Materials presents vital status for CHARLS male participants. A total of 8315 males participated in the baseline survey and provided information on key variables. Because of the younger cohort and a shorter follow-up period, a lower proportion of CHARLS participants were dead or lost to follow-up than those in CLHLS. Ever drinkers constituted 68.1% of CHARLS males, most of which were current drinkers. Similar to what we have observed in the CLHLS data, former drinkers in CHARLS were also most likely to die.

Table S3 and Table S4 give information for females. As one may expect, women were much more likely than men to be lifelong abstainers. They also had a smaller proportion of deaths. There was no noticeable difference in death rate between former and current drinkers among CLHLS females. In the CHARLS female sample, former drinkers only made up 4.1%, which may limit the statistical power to detect an effect of previously drinking.

Table 2 lists baseline characteristics by baseline drinking status for CLHLS males. Age distribution was similar across alternative drinking groups. Compared to lifelong abstainers, current drinkers were less likely to receive a pension, less likely to be in the top quintile of household per capita income, and less likely to live in the richest coastal urban region. As a result, the summary SES index indicates a generally lower socioeconomic status among current drinkers than lifelong abstainers. In contrast, former male drinkers were very similar to abstainers in these baseline char-

Table 1: Percentage distribution of vital status by baseline drinking status, males

	Total	Lifelong abstainers	Ever drinkers	Former drinkers	Current drinkers
Alive	14.9	12.6	16.5	17.4	16.0
Dead	49.0	48.2	49.6	51.2	48.8
Lost to follow-up	36.1	39.1	33.9	31.4	35.2
Number of participants	6767	3101	3666	1471	2195
Percentage		41.9	58.1	19.4	38.7

Notes: This table summarizes vital status throughout the follow-up period by baseline drinking status with percentage numbers listed. Percentage statistics are weighted using individual sampling weights. Data source: CLHLS.

acteristics.

Table S5 reports summary statistics for CHARLS males, where current drinkers were on average younger than abstainers, but former drinkers were on average older. Table S6 presents baseline characteristics for CLHLS females. Contrary to CLHLS males, former female drinkers seemed to have a lower socioeconomic status than both abstainers and current drinkers. It might imply different reasons for males and females to stop drinking. Summary statistics for CHARLS females are in Table S7.

Table 2: Baseline characteristics by baseline drinking status, males

	Lifelong abstainers	Ever drinkers	Former drinkers	Current drinkers
Age	72.7	72.1	72.5	71.8
	(5.7)	(5.6)	(5.8)	(5.5)
Education: literate	0.723	0.752	0.732	0.762
Married	0.698	0.727	0.684	0.749
Living with family	0.883	0.881	0.858	0.893
Receiving pension	0.355	0.328	0.369	0.307
Household per capita income: lowest 20th	0.209	0.176	0.172	0.178
Household per capita income: 20th - 40th	0.182	0.209	0.208	0.210
Household per capita income: 40th - 60th	0.183	0.219	0.190	0.234
Household per capita income: 60th - 80th	0.165	0.166	0.172	0.163
Household per capita income: highest 20th	0.260	0.229	0.259	0.215
Region of residence: western rural	0.183	0.217	0.156	0.248
Region of residence: central rural	0.169	0.171	0.201	0.156
Region of residence: coastal rural	0.276	0.272	0.270	0.273
Region of residence: western urban	0.071	0.079	0.083	0.077
Region of residence: central urban	0.082	0.083	0.090	0.080
Region of residence: coastal urban	0.219	0.177	0.199	0.166
SES index	0	-0.069	0.017	-0.112
	(1)	(0.954)	(0.969)	(0.944)
Number of participants	3101	3666	1471	2195

Notes: This table summarizes means or proportions. Standard deviations for continuous variables are in parentheses. Means and standard deviations are weighted using individual sampling weights. Data source: CLHLS.

Cox Proportional Hazards Models

Cox regression results are shown in Table 3 for CLHLS males, and in Table S8 for CHARLS males. Hazard ratios and 95% confidence intervals are presented. In the top panel, we estimate the hazard ratio associated with ever drinking compared with lifelong abstainers. Column (1) reports results with the ever drinking indicator as the only independent variable. Ever drinking is associated with a reduced mortality rate among CHARLS males aged no less than 45. But once people had reached age 65 in CLHLS, we find little effect of ever drinking on all-cause mortality.

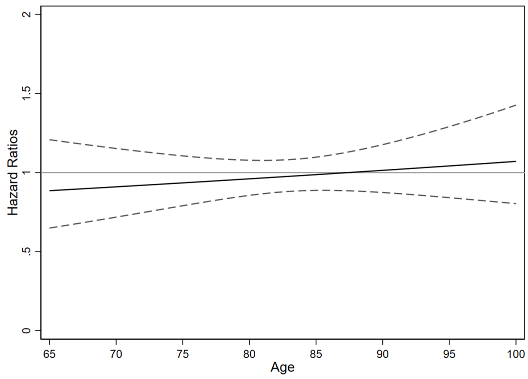
Column (2) allows the effects of drinking to vary with age, where we interact the drinking indicator with age minus 65 in CLHLS (or 45 CHARLS). Therefore, the hazard ratio of ever drinking in this specification indicates the effect of drinking at age 65 (or 45), and the hazard ratio of the interaction term gives the change associated with one year older. For instance, Column (2) of Table 3 shows that ever drinkers had 0.881 times the mortality rate compared with lifetime abstainers, while the corresponding figure at age 80 is $0.935 = 0.881 \times 1.004^{80-65}$. However, the coefficients in Column (2) are not precisely estimated.

Column (3) adds the age-varying effects of socioeconomic covariates. The relationship appears to be attenuated with the adjustment for confounders, but our conclusion barely changes. Our most comprehensive specification in Column (4) further allows for different baseline functions across individuals born in different years. In Table 3, ever drinkers had lower total mortality at age 65, but the benefit associated with drinking decreased steadily with age. Figure 2 visualizes the Cox results from Specification (4) for males. (A1) and (B1) in the top panel summarize ever drinkers' hazard ratios compared with abstainers at each age. In general, the mortality differences between ever drinkers and lifelong abstainers were not significant. The claim that any alcohol exposure could cause health damage is not supported by the CLHLS or CHARLS male sample.

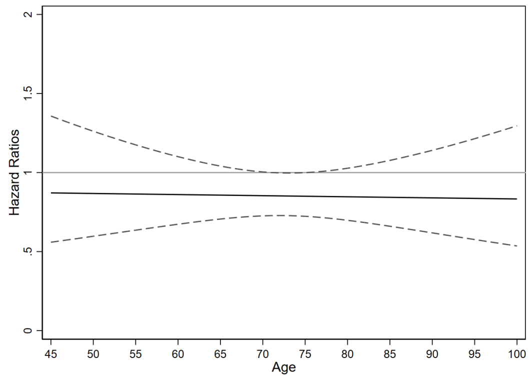
In the bottom panels of Table 3 and Table S8, we subdivide ever drinkers into those who stopped drinking and those who were still consuming alcohol. When age-specific hazard ratios are not allowed in Column (1), former male drinkers had the highest risk of death, and current drinking significantly reduced mortality. This general pattern remains while we move to more sophisticated specifications, where age and birth year effects did not substantially change the results. The middle panel of Figure 2 depicts hazard ratios of previously drinking as a function of age. (A2) compares former drinkers and lifelong abstainers aged no less than 65 in CLHLS. Former drinkers were associated with an increase in mortality rates, and the effects were decreasing with age. But these survival disadvantages were not statistically significant overall. For CHARLS males in (B2), former drinkers' hazard ratios were very close to one across all ages.

(A3) and (B3) in the bottom panel of Figure 2 plot the hazard differences between current male drinkers and abstainers using CLHLS and CHARLS data, respectively. For CLHLS males, current alcohol consumption was associated with reduced mortality compared with abstainers. But these survival benefits appear primarily confined to those aged between 65 and 85. Results from CHARLS confirm these findings. In (B3), currently drinking was associated with significant reductions in overall mortality for males aged from 63 to 93. Since the mortality effects of drinking behaviors were not significant before age 65 in general, the survival bias of analyses conditional on living up to 65 might not be severe.

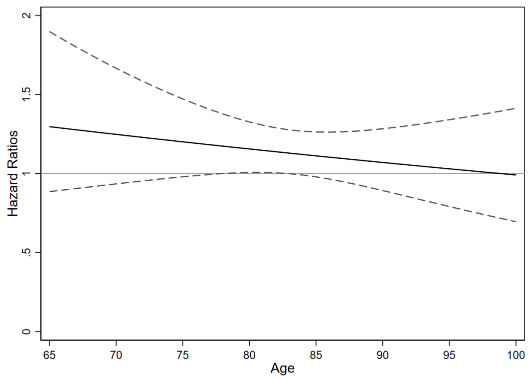
In summary, we find in both datasets that current male drinkers aged 65 to 85 had a significantly reduced mortality risk relative to lifelong abstainers, while the mortality difference between former male drinkers and abstainers was not precisely estimated. Cox regression results for females are listed in Table S9 and Table S10, with a graphic representation in Figure S2. Using CLHLS data, both former and current female drinkers were at a decreased risk of mortality. In contrast, the 95% confidence intervals for CHARLS females were wide. Since the proportion of drinkers and the likelihood of deaths were low for this group, the estimation reliability might be limited. Therefore, we are not as confident about the effects of alcohol drinking on females' all-cause mortality without similar patterns emerging in different datasets.



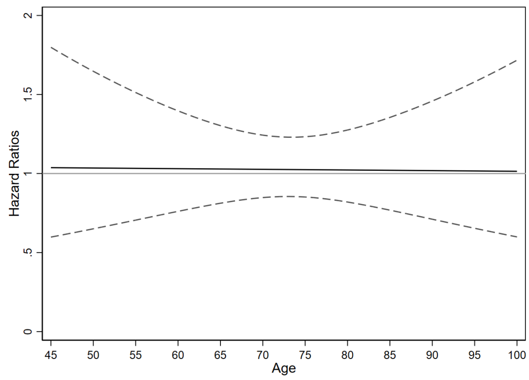
(A1) Ever drinkers vs lifelong abstainers. CLHLS



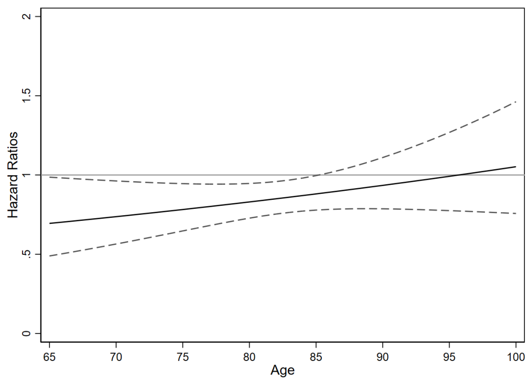
(B1) Ever drinkers vs lifelong abstainers. CHARLS



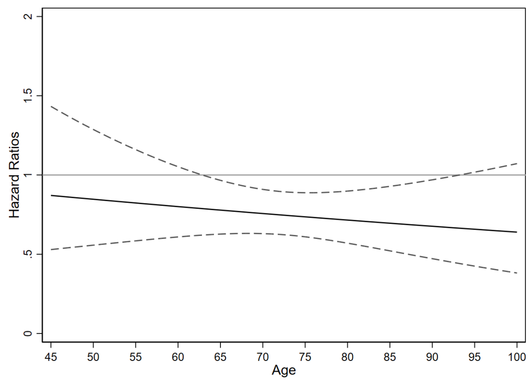
(A2) Former drinkers vs lifelong abstainers. CLHLS



(B2) Former drinkers vs lifelong abstainers. CHARLS



(A3) Current drinkers vs lifelong abstainers. CLHLS



(B3) Current drinkers vs lifelong abstainers. CHARLS

Figure 2: Cox regression results, males. Notes: This figure presents age-specific hazard ratios for each drinking status compared with lifelong abstainers. Results are based on Specification (4) in Table 3 and Table S8. 95% confidence intervals are depicted in dashed lines.

Table 3: Cox regression results, males

	(1)	(2)	(3)	(4)
Ever Drinkers	0.936	0.881	0.936	0.885
	(0.836 - 1.047)	(0.646 - 1.200)	(0.689 - 1.273)	(0.649 - 1.208)
Ever Drinkers × (Age - 65)		1.004	1.001	1.005
		(0.988 - 1.020)	(0.985 - 1.017)	(0.989 - 1.022)
Former drinkers	1.086	1.317	1.398	1.297
	(0.953 - 1.238)	(0.904 - 1.920)	(0.962 - 2.032)	(0.886 - 1.898)
Former drinkers × (Age - 65)		0.988	0.986	0.992
		(0.969 - 1.008)	(0.967 - 1.005)	(0.973 - 1.012)
Current drinkers	0.813**	0.674*	0.716	0.695*
	(0.713 - 0.928)	(0.475 - 0.958)	(0.506 - 1.014)	(0.489 - 0.986)
Current drinkers × (Age - 65)		1.013	1.010	1.012
		(0.994 - 1.031)	(0.992 - 1.028)	(0.994 - 1.031)
SES covariates	No	No	Yes	Yes
SES covariates × (Age - 65)	No	No	Yes	Yes
Birth year as strata	No	No	No	Yes
Number of observations	12340	12340	12340	12340

Notes: This table reports hazard ratios and 95% confidence intervals in parentheses. Confidence intervals are calculated based on robust standard errors. Observations are weighted by individual sampling weights. ** $p < 0.01$, * $p < 0.05$. Data source: CLHLS.

Life Expectancy

Effects of alcohol drinking on the length of total and disability-free life expectancy might be of more interest to policymakers. Given the Cox regression results described above, we focus on comparing lifelong abstainers, former drinkers, and current drinkers among older males aged no less than 65 using CLHLS data in this section. Results on the comparison between male abstainers and ever drinkers are left to the Supplementary Materials. Consistent with the survival analyses, effects of ever exposure to alcohol on life expectancy were generally insignificant. All parallel results for CLHLS females are also reported in the Supplementary Materials for whoever is interested. But we don't infer too much from these analyses since drinking effects on older females cannot be replicated in the CHARLS dataset.

Table 4 presents the distribution of intervals of observation by drinking status at the beginning of the interval for older males. Compared with lifelong abstainers, the prevalence of disability was higher among former drinkers and was lower among current drinkers. Most intervals began and ended disability-free, but there were still substantial transitions over time. Currently (Previously) drinking was associated with decreased (increased) disability onset and increased (decreased) recovery from disability. Not surprisingly, older males were more likely to die from the disabled state, where the disabled former drinkers had the highest death rate.

Table 4: Percentage distribution of intervals by drinking status, males

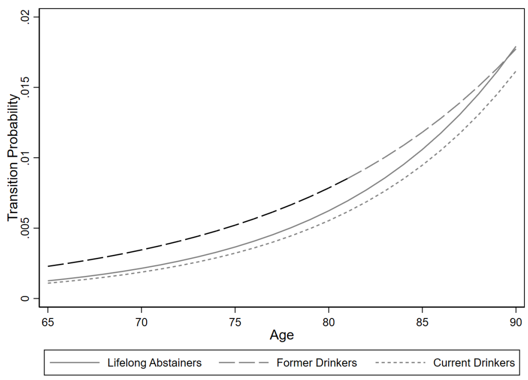
	Lifelong abstainers	Ever drinkers	Former drinkers	Current drinkers
Initial state				
Disability-free	87.7	89.8	84.9	93.2
Disability	12.3	10.2	15.1	6.8
Conditional on initial state = Disability-free				
Disability-free → Disability free	74.9	75.6	69.7	79.4
Disability-free → Disability	9.1	9.0	11.9	7.1
Disability-free → Death	16.0	15.4	18.4	13.5
Conditional on initial state = Disability				
Disability → Disability free	27.2	27.0	21.2	36.0
Disability → Disability	26.5	23.3	24.2	21.8
Disability → Death	46.3	49.7	54.5	42.1
Number of intervals	4795	7409	3119	4290

Notes: This table provides the distribution of intervals of observation by drinking status at the beginning of the interval. Percentage numbers listed are weighted using individual sampling weights. Data source: CLHLS.

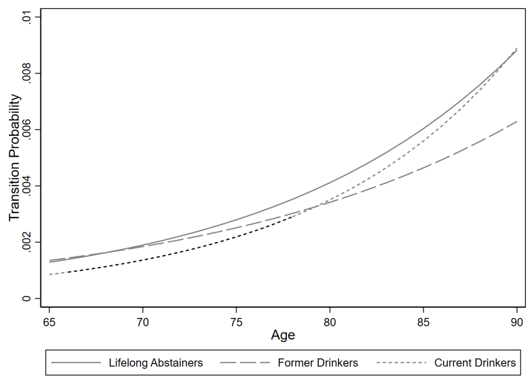
Figure 3 depicts monthly transition probabilities as a function of age by drinking status. These probabilities are calculated based on the estimated IMaCh parameters reported in Table S13. The value of the SES index is kept constant at zero so that we are assuming drinkers to have the same overall socioeconomic status as abstainers. We evaluate the marginal effects of each drinking indicator in Equation (1) to determine whether the group differences were statistically meaningful.

(A1) of Figure 3 gives the probability of disability onset. The age pattern indicates that older males were more likely than younger ones to become disabled. Up to age 81, the likelihood of becoming disabled was significantly higher among former drinkers than abstainers. (A2) presents the death rate from the disability-free state. Healthy current drinkers were less likely to die than lifelong abstainers at an age younger than 78. Age-specific disability recovery rates are in (B1). The probability of recovering from disability was higher at younger ages than at older ages. The recovery rate was significantly higher among current drinkers aged between 72 and 80. Conditional on being in the disabled state as shown in (B2), the death rate did not differ noticeably between current drinkers and abstainers, while disabled former drinkers were much more likely to die in the next month.

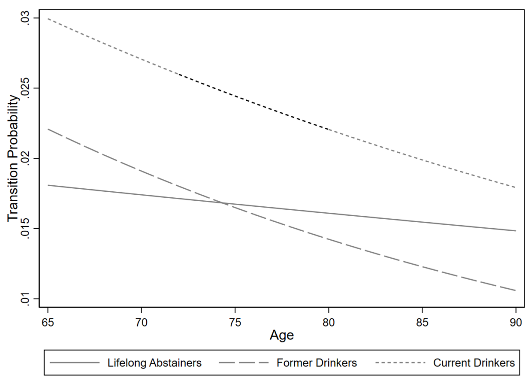
These transition probabilities indicate the dynamic forces underlying mortality and life expectancy results for older males. In summary, former drinkers might expect a shorter life expectancy than abstainers because they were more likely to become disabled and were more likely to die conditional on the disabled state. On the contrary, current drinkers might live longer because they had a higher recovery rate from disability and a lower death rate given the healthy state.



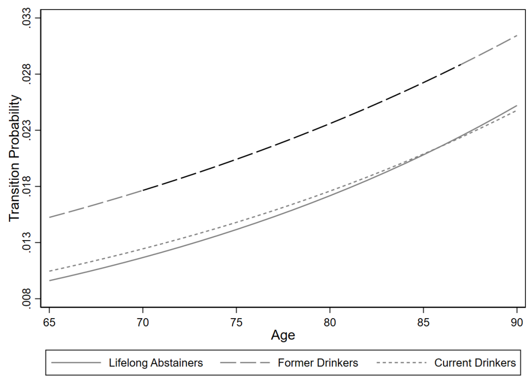
(A1) Disability-free → Disability



(A2) Disability-free → Death



(B1) Disability → Disability-free



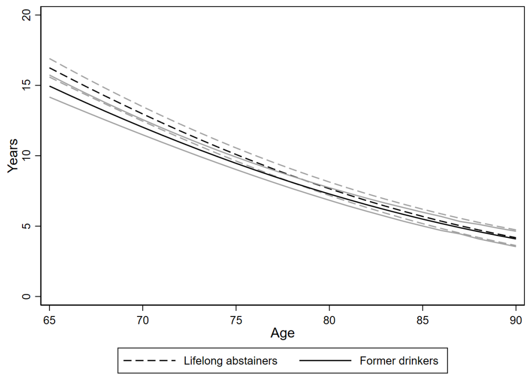
(B2) Disability → Death

Figure 3: Monthly transition probability by drinking status, males. Notes: This figure presents age-specific monthly transition probabilities for each drinking status. Transition probabilities are calculated from the estimated coefficients in Table S13. The value of the SES index is kept constant at zero. Segments with significant differences between drinkers and lifelong abstainers are in bold. We find out significant differences based on the estimated marginal effects of each drinking indicator in the multinomial logistic regressions. Standard errors of the marginal effects are calculated using the delta method. Data source: CLHLS.

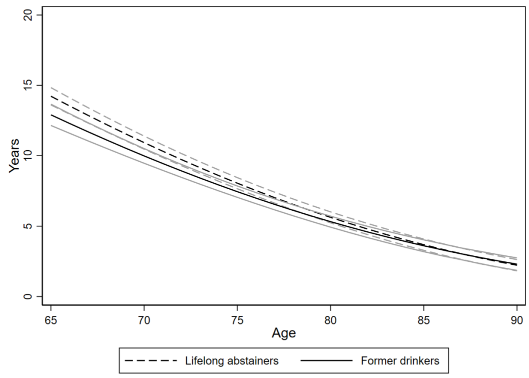
Total and disability-free life expectancy implied by the age-specific transition rates are given in Figure 4, with 95% confidence intervals depicted in grey lines. Table 5 lists some corresponding figures at selected ages. Total life expectancy was estimated to be 16.25 years for an average lifetime abstainer at age 65 and 14.95 years for a former drinker at this age with a similar socioeconomic status. Former drinkers had similar life expectancy to abstainers at older ages, and the differences were generally insignificant as shown by the overlapping confidence intervals in (A1) of Figure 4. In (A2), former drinkers' healthy life expectancy was 1.32 years shorter than abstainers at age 65. This difference was only marginally significant.

(B1) and (B2) compare current drinkers and abstainers. Both total and disability-free life expectancy were longer among current drinkers. At age 65, current drinkers could expect to live 17.90 years, which was significantly longer by 1.65 years than abstainers. Current drinkers at age 80 could expect to live 0.56 years longer, which was not statistically meaningful, though. Disability-free life expectancy was significantly longer among current drinkers at ages up to 78. The difference in healthy life expectancy was 1.84 years at age 65 and was 0.746 years at age 80. At older ages, the proportion of life lived without disability decreased. But the proportion differences across alternative drinking groups were not precisely estimated, as shown in Figure S9.

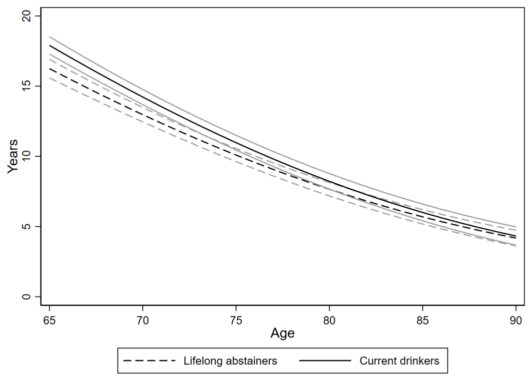
Compared with lifelong abstainers, former male drinkers could expect to live fewer years, while life expectancy was significantly longer for current male drinkers aged up to 73. Given our definition of disability, longer healthy life expectancy among current drinkers seems to be consistent with some previous studies, where light to moderate alcohol consumption is shown to have protective effects against functional limitation (Lee et al., 2009; León-Muñoz et al., 2017) and cognitive decline (Lang et al., 2007; Zhang et al., 2020).



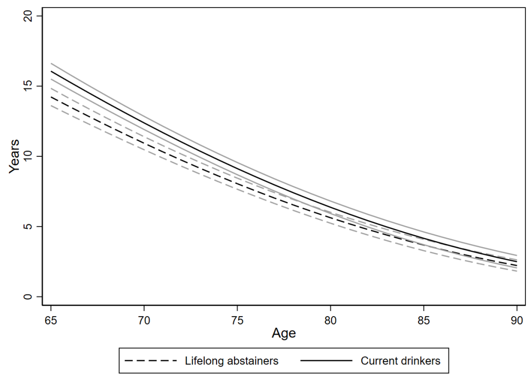
(A1) Total life expectancy: Former drinkers



(A2) Disability-free life expectancy: Former drinkers



(B1) Total life expectancy: Current drinkers



(B2) Disability life expectancy: Current drinkers

Figure 4: Life expectancies by drinking status, males. Notes: This figure presents age-specific total life expectancy and disability-free life expectancy for each drinking status. These results are derived from the estimated interpolated Markov chain model while keeping the value of the SES index constant at zero. 95% confidence intervals are depicted with grey lines. Data source: CLHLS.

Table 5: Life expectancies at selected ages by drinking status, males

Age	TLE	DFLE	DLE	DFLE/TLE
	Lifelong abstainers			
65	16.25	14.23	2.021	0.876
70	12.97	10.94	2.034	0.843
75	10.09	8.051	2.040	0.798
80	7.658	5.625	2.033	0.735
85	5.689	3.682	2.007	0.647
90	4.176	2.222	1.954	0.532
	Former drinkers			
Age	TLE	DFLE	DLE	DFLE/TLE
65	14.95	12.91	2.043	0.863
70	12.03	9.989	2.038	0.831
75	9.462	7.448	2.014	0.787
80	7.283	5.318	1.965	0.730
85	5.497	3.606	1.891	0.656
90	4.089	2.298	1.792	0.562
	Current drinkers			
Age	TLE	DFLE	DLE	DFLE/TLE
65	17.90	16.07	1.836	0.897
70	14.22	12.38	1.843	0.870
75	10.97	9.126	1.847	0.832
80	8.218	6.371	1.847	0.775
85	6.001	4.159	1.842	0.693
90	4.324	2.494	1.830	0.577

Notes: This table reports the estimated total life expectancy (TLE), disability-free life expectancy (DFLE), and life expectancy with disability (DLE) at selected ages. These results are derived from the estimated interpolated Markov chain model while keeping the value of the SES index constant at zero. Data source: CLHLS.

Discussion

Alcohol consumption plays a vital role in population health, although the findings are mixed. Some studies report health benefits associated with light to moderate alcohol consumption, while others suggest that alcohol use leads to health loss regardless of amount. The present study adds to this discussion by evaluating the association between alcohol consumption and all-cause mortality in nationally representative samples of older Chinese adults.

After accounting for a set of socioeconomic factors and calendar effects, we find robust Cox results across datasets that the survival differences between ever drinkers who had been exposed to alcohol at some time and lifelong abstainers were not statistically significant among older males. When we subdivide ever drinkers into former drinkers who stopped drinking and current drinkers who were still consuming alcohol, there were increased risks of death among former male drinkers, although the hazard ratios did not reach statistical significance. Current drinking was related to decreased mortality rates, where the significant association was mainly confined to older males aged 65 to 85. However, the effects of alcohol drinking on older Chinese females cannot be confidently determined using current data.

We then take one step further to assess how alcohol use would affect the length and the quality of life for males aged 65 years and older. The interpolated Markov chain approach is adopted to estimate age-specific total life expectancy and disability-free life expectancy for each drinking group. To incorporate alternative sources of difficulty during the aging process, disability is defined in this study as having functional limitation or cognitive impairment.

We estimate transition probabilities between disability-free, disabled, and death states. Compared with lifelong abstainers, former male drinkers had a higher likelihood of disability onset and a higher chance of death among the disabled. As a result, the total expected years and years lived without the disability were shorter among former male drinkers than abstainers. In contrast, current drinkers were more likely to recover from the disability. They also had a lower death rate conditional on the disability-free state. After adjustment for socioeconomic status, an average current male drinker at age 65 could expect to live 1.65 years longer than lifelong abstainers. The corresponding difference in disability-free life expectancy at age 65 was 1.84 years, which was statistically meaningful.

In summary, we find elevated mortality and disability risks among former male drinkers, although the effects were generally insignificant. If people stop drinking alcohol due to the onset of health issues (Connor, 2006), a higher risk associated with former drinkers is not surprising. On the other hand, current male drinkers had reduced all-cause mortality and could expect a longer remaining life in general. Therefore, we contribute further evidence supporting an association between light to moderate alcohol consumption and reduced mortality.

These results by no means disprove any potential harm caused by heavy drinking or advocate increased drinking among older people. We observe protective associations between currently drinking and mortality, possibly because most older Chinese male drinkers drank only lightly or moderately. People with a habit of hazardous drinking might die before age 65, but our data are not powerful enough to detect this effect. Nevertheless, our findings challenge the claim that the level of alcohol consumption that minimized harm was zero.

Clarifying the relationship between alcohol consumption and population health for older adults is increasingly important, especially in China's aging society, where people are living longer lives. Individuals and policymakers require rigorous statistical evidence on the health effects of alcohol. Assessment of these effects has vital implications for aged care designers. For example, older adults' alcohol drinking should be taken into account as an important predictor when estimating health insurance premiums or the government's age pension burden.

However, certain limitations should also be acknowledged. Firstly, the relatively small percentage of drinkers among Chinese older females might have reduced the statistical power to detect alcohol effects in this group. Further data are required to provide a reliable estimation. Secondly, we can't fully account for confounding variables in an observational study, and we are not trying to make causal inferences. Thirdly, our paper focuses on the Chinese population, where most people belong to the ethnic group of Han. Since alcohol metabolism could differ across population groups carrying different genes (Agarwal and Goedde, 1992; Jorgenson et al., 2017), the patterns observed in China might be different from those of other countries. Also, what we have found in this paper is based on the current drinking pattern in China. Replication of these findings in different datasets and populations will be important. Finally, the role of alcohol drinking in mortality and disability might be a balance of beneficial and harmful effects. The underlying biological, social, and psychological mechanisms are not clearly understood and need to be examined in future studies.

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Supplementary Materials

Single-Factor Measurement Model

We use the structural equation modeling approach to summarize multiple socioeconomic dummy variables into a one-dimensional continuous summary measure using a single-factor measurement model. The single-factor measurement model consists of a system of equations:

$$y_c = \alpha_c + \beta_c SES + \varepsilon_c. \tag{S1}$$

y_c represents each of the observed socioeconomic characteristics. The model assumes that an unobserved latent variable SES is underlying all observed features. The following socioeconomic characteristics are used as dependent variables: literate, married, living with family, receiving pension income, household per capita income quintiles calculated within each survey wave, and region of residence including western rural, central rural, coastal rural, western urban, central urban, and coastal urban. A graphical representation of our single-factor measurement model is given in Figure S1. The model is estimated using the method of maximum likelihood. To achieve convergence, the linear form is assumed, although the dependent variables used here are binary. Observations are weighted by individual sampling weights, and standard errors are clustered at the individual level.

Theoretically, arbitrary correlations among error terms, ε_1, ε_2, ..., ε_{13}, can be included. However, to be parsimonious, we add correlations between error terms one by one using the following forward inclusion algorithm: (1) Estimate the model with no correlations between the error terms. (2) Calculate the modification index for each possible additional correlation, where the modification index is an approximation to the change in the model's goodness-of-fit Chi-square statistics if the correlation was added. (3) Add into the model the correlation with the largest modification index and re-estimate the measurement model. If the augmented model cannot achieve convergence within 1000 maximum likelihood iterations, omit this correlation and repeat the current step. (4)

Repeat steps (2) and (3) until no additional correlation can improve the model's goodness-of-fit at the 5% significance level.

Estimation results using CLHLS data for males and females are presented in Table S1. The coefficient in the equation of education is normalized to be one. Thus, a higher value of the latent SES variable indicates a better socioeconomic status. We construct the summary SES index for each observation by generating predicted values of the latent variable. We then standardize the index to have a mean of zero and a standard deviation of one among lifelong abstainers at the baseline survey wave. Table S1 also reports two goodness-of-fit measures. A perfect fit corresponds to a standardized root mean squared residual (SRMR) of zero. The Hu and Bentler (1999) threshold of acceptable fit is SRMR ≤ 0.08. The coefficient of determination (CD) is like an R^2 for the whole model, and a value close to one indicates a good fit. It seems that our models have an acceptable fit to the data.

Reference

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Supplementary Tables and Figures

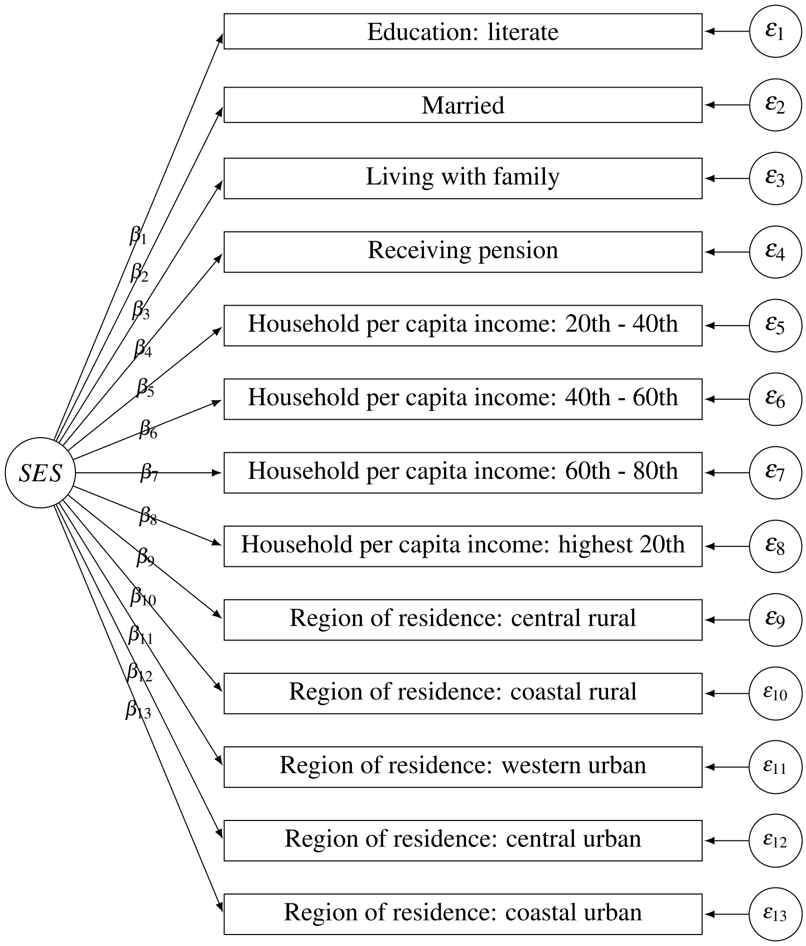


Figure S1: Single-factor measurement model. Notes: Omitted categories are 'lowest 20th' for household per capita income and 'western rural' for region of residence.

Table S1: Results of the single-factor measurement model by gender

	Males	Females
Education: literate	1.000	1.000
	(0.000)	(0.000)
Married	0.674**	0.054
	(0.134)	(0.077)
Living with family	0.159*	0.088**
	(0.070)	(0.033)
Receiving pension	3.838**	1.671**
	(0.356)	(0.106)
Household per capita income: 20th - 40th	-1.289**	-0.420**
	(0.154)	(0.029)
Household per capita income: 40th - 60th	-0.919**	-0.284**
	(0.134)	(0.026)
Household per capita income: 60th - 80th	0.791**	0.244**
	(0.118)	(0.054)
Household per capita income: highest 20th	2.625**	1.071**
	(0.304)	(0.063)
Region of residence: central rural	-0.877**	-0.408**
	(0.109)	(0.031)
Region of residence: coastal rural	-0.441**	-0.425**
	(0.107)	(0.038)
Region of residence: western urban	0.402**	0.263**
	(0.097)	(0.075)
Region of residence: central urban	0.324*	0.293**
	(0.159)	(0.050)
Region of residence: coastal urban	1.703**	0.869**
	(0.212)	(0.072)
Standardized root mean squared residual	0.010	0.014
Coefficient of determination	0.738	0.787
Number of observations	14640	18340

Notes: This table reports coefficients of the latent variable representing one's socioeconomic status on each of the listed observed dependent variables. Observations are weighted by individual sampling weights. Standard errors in parentheses are clustered at the individual level. Omitted categories are 'lowest 20th' for household per capita income and 'western rural' for region of residence. ** $p < 0.01$, * $p < 0.05$. Data source: CLHLS.

Table S2: Percentage distribution of vital status by baseline drinking status, males

	Total	Lifelong abstainers	Ever drinkers	Former drinkers	Current drinkers
Alive	69.7	66.7	71.1	64.4	72.6
Dead	12.7	15.2	11.5	21.5	9.4
Lost to follow-up	17.6	18.1	17.3	14.1	18.0
Number of participants	8315	2625	5687	1052	4635
Percentage		31.9	68.1	12.2	55.8

Notes: This table summarizes vital status throughout the follow-up period by baseline drinking status with percentage numbers listed. Percentage statistics are weighted using individual sampling weights. Data source: CHARLS.

Table S3: Percentage distribution of vital status by baseline drinking status, females

	Total	Lifelong abstainers	Ever drinkers	Former drinkers	Current drinkers
Alive	16.1	13.9	26.8	33.8	22.1
Dead	43.0	43.6	39.7	39.7	39.8
Lost to follow-up	41.0	42.5	33.4	26.6	38.1
Number of participants	9030	7107	1923	825	1098
Percentage		83.1	16.9	6.8	10.1

Notes: This table summarizes vital status throughout the follow-up period by baseline drinking status with percentage numbers listed. Percentage statistics are weighted using individual sampling weights. Data source: CLHLS.

Table S4: Percentage distribution of vital status by baseline drinking status, females

	Total	Lifelong abstainers	Ever drinkers	Former drinkers	Current drinkers
Alive	72.8	72.7	73.0	71.4	73.5
Dead	9.7	9.6	10.4	15.1	8.7
Lost to follow-up	17.5	17.7	16.6	13.5	17.7
Number of participants	8733	7309	1422	402	1020
Percentage		84.1	15.8	4.1	11.6

Notes: This table summarizes vital status throughout the follow-up period by baseline drinking status with percentage numbers listed. Percentage statistics are weighted using individual sampling weights. Data source: CHARLS.

Table S5: Baseline characteristics by baseline drinking status, males

	Lifelong abstainers	Ever drinkers	Former drinkers	Current drinkers
Age	61.4	59.4	63.0	58.6
	(10.5)	(9.7)	(10.0)	(9.4)
Education: below elementary school	0.315	0.278	0.350	0.263
Education: elementary school	0.245	0.251	0.249	0.252
Education: middle school	0.253	0.266	0.230	0.274
Education: high school and above	0.187	0.204	0.171	0.211
Married	0.882	0.899	0.861	0.907
Living with family	0.935	0.944	0.941	0.944
Currently working	0.623	0.715	0.549	0.751
Receiving pension	0.297	0.265	0.379	0.240
Household per capita expenditure: lowest 20th	0.199	0.169	0.178	0.167
Household per capita expenditure: 20th - 40th	0.183	0.178	0.178	0.179
Household per capita expenditure: 40th - 60th	0.195	0.186	0.182	0.187
Household per capita expenditure: 60th - 80th	0.215	0.198	0.213	0.195
Household per capita expenditure: highest 20th	0.208	0.268	0.248	0.273
Region of residence: western rural	0.183	0.167	0.199	0.159
Region of residence: central rural	0.150	0.160	0.161	0.159
Region of residence: coastal rural	0.188	0.176	0.152	0.182
Region of residence: western urban	0.124	0.123	0.148	0.118
Region of residence: central urban	0.134	0.150	0.151	0.149
Region of residence: coastal urban	0.221	0.224	0.188	0.232
Number of participants	2625	5687	1052	4635

Notes: This table summarizes means or proportions. Standard deviations for continuous variables are in parentheses. Means and standard deviations are weighted using individual sampling weights. Data source: CHARLS.

Table S6: Baseline characteristics by baseline drinking status, females

	Lifelong abstainers	Ever drinkers	Former drinkers	Current drinkers
Age	73.4	73.8	73.8	73.7
	(6.2)	(6.8)	(7.4)	(6.4)
Education: literate	0.291	0.267	0.248	0.280
Married	0.455	0.427	0.371	0.466
Living with family	0.824	0.832	0.826	0.836
Receiving pension	0.176	0.117	0.089	0.137
Household per capita income: lowest 20th	0.214	0.215	0.224	0.210
Household per capita income: 20th - 40th	0.206	0.243	0.246	0.241
Household per capita income: 40th - 60th	0.199	0.220	0.233	0.211
Household per capita income: 60th - 80th	0.157	0.133	0.120	0.141
Household per capita income: highest 20th	0.224	0.189	0.178	0.197
Region of residence: western rural	0.186	0.271	0.235	0.295
Region of residence: central rural	0.172	0.195	0.229	0.173
Region of residence: coastal rural	0.282	0.243	0.232	0.250
Region of residence: western urban	0.071	0.092	0.103	0.085
Region of residence: central urban	0.084	0.068	0.085	0.057
Region of residence: coastal urban	0.204	0.131	0.116	0.141
SES index	0	-0.160	-0.219	-0.120
	(1)	(0.858)	(0.752)	(0.921)
Number of participants	7107	1923	825	1098

Notes: This table summarizes means or proportions. Standard deviations for continuous variables are in parentheses. Means and standard deviations are weighted using individual sampling weights. Data source: CLHLS.

Table S7: Baseline characteristics by baseline drinking status, females

	Lifelong abstainers	Ever drinkers	Former drinkers	Current drinkers
Age	59.8	59.7	62.5	58.7
	(10.7)	(10.6)	(10.5)	(10.5)
Education: below elementary school	0.562	0.569	0.627	0.548
Education: elementary school	0.164	0.155	0.133	0.163
Education: middle school	0.172	0.115	0.115	0.115
Education: high school and above	0.101	0.162	0.125	0.174
Married	0.813	0.809	0.761	0.827
Living with family	0.935	0.933	0.931	0.934
Currently working	0.531	0.640	0.496	0.691
Receiving pension	0.286	0.289	0.314	0.280
Household per capita expenditure: lowest 20th	0.184	0.175	0.163	0.179
Household per capita expenditure: 20th - 40th	0.183	0.188	0.190	0.187
Household per capita expenditure: 40th - 60th	0.191	0.172	0.204	0.160
Household per capita expenditure: 60th - 80th	0.208	0.215	0.213	0.216
Household per capita expenditure: highest 20th	0.233	0.250	0.230	0.258
Region of residence: western rural	0.168	0.181	0.196	0.176
Region of residence: central rural	0.145	0.179	0.196	0.172
Region of residence: coastal rural	0.177	0.141	0.117	0.149
Region of residence: western urban	0.130	0.137	0.183	0.121
Region of residence: central urban	0.153	0.150	0.174	0.142
Region of residence: coastal urban	0.227	0.212	0.134	0.240
Number of participants	7309	1422	402	1020

Notes: This table summarizes means or proportions. Standard deviations for continuous variables are in parentheses. Means and standard deviations are weighted using individual sampling weights. Data source: CHARLS.

Table S8: Cox regression results, males

	(1)	(2)	(3)	(4)
Ever Drinkers	0.804**	0.837	0.932	0.871
	(0.682 - 0.948)	(0.511 - 1.372)	(0.579 - 1.501)	(0.559 - 1.357)
Ever Drinkers × (Age - 45)		0.999	0.997	0.999
		(0.982 - 1.015)	(0.981 - 1.013)	(0.984 - 1.014)
Former drinkers	1.088	1.143	1.058	1.037
	(0.908 - 1.303)	(0.670 - 1.947)	(0.605 - 1.850)	(0.598 - 1.799)
Former drinkers × (Age - 45)		0.998	0.999	1.000
		(0.980 - 1.016)	(0.980 - 1.018)	(0.981 - 1.018)
Current drinkers	0.669**	0.807	0.936	0.871
	(0.548 - 0.816)	(0.448 - 1.454)	(0.532 - 1.648)	(0.530 - 1.433)
Current drinkers × (Age - 45)		0.993	0.992	0.994
		(0.973 - 1.013)	(0.973 - 1.011)	(0.977 - 1.012)
SES covariates	No	No	Yes	Yes
SES covariates × (Age - 45)	No	No	Yes	Yes
Birth year as strata	No	No	No	Yes
Number of observations	21133	21133	21133	21133

Notes: This table reports hazard ratios and 95% confidence intervals in parentheses. Confidence intervals are calculated based on robust standard errors. Observations are weighted by individual sampling weights. ** $p < 0.01$, * $p < 0.05$. Data source: CHARLS.

Table S9: Cox regression results, females

	(1)	(2)	(3)	(4)
Ever Drinkers	0.725**	0.566**	0.540**	0.565**
	(0.636 - 0.827)	(0.379 - 0.844)	(0.362 - 0.806)	(0.381 - 0.837)
Ever Drinkers × (Age - 65)		1.014	1.016	1.015
		(0.996 - 1.031)	(0.998 - 1.033)	(0.997 - 1.032)
Former drinkers	0.736**	0.596	0.548*	0.617
	(0.619 - 0.875)	(0.331 - 1.073)	(0.305 - 0.984)	(0.352 - 1.082)
Former drinkers × (Age - 65)		1.011	1.015	1.012
		(0.986 - 1.037)	(0.990 - 1.041)	(0.987 - 1.037)
Current drinkers	0.711**	0.538*	0.533*	0.520**
	(0.596 - 0.849)	(0.332 - 0.872)	(0.328 - 0.866)	(0.317 - 0.854)
Current drinkers × (Age - 65)		1.016	1.016	1.017
		(0.995 - 1.037)	(0.995 - 1.037)	(0.995 - 1.039)
SES covariates	No	No	Yes	Yes
SES covariates × (Age - 65)	No	No	Yes	Yes
Birth year as strata	No	No	No	Yes
Number of observations	15400	15400	15400	15400

Notes: This table reports hazard ratios and 95% confidence intervals in parentheses. Confidence intervals are calculated based on robust standard errors. Observations are weighted by individual sampling weights. ** $p < 0.01$, * $p < 0.05$. Data source: CLHLS.

Table S10: Cox regression results, females

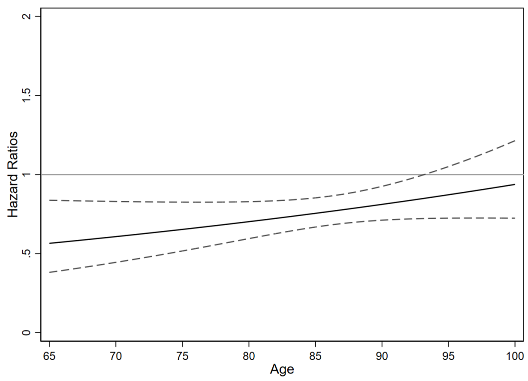
	(1)	(2)	(3)	(4)
Ever Drinkers	1.001	1.107	1.380	1.383
	(0.822 - 1.219)	(0.634 - 1.930)	(0.794 - 2.401)	(0.807 - 2.373)
Ever Drinkers × (Age - 45)		0.997	0.990	0.991
		(0.980 - 1.014)	(0.973 - 1.008)	(0.974 - 1.007)
Former drinkers	1.230	1.403	1.596	1.686
	(0.970 - 1.560)	(0.659 - 2.988)	(0.752 - 3.388)	(0.800 - 3.553)
Former drinkers × (Age - 45)		0.996	0.991	0.990
		(0.973 - 1.019)	(0.969 - 1.015)	(0.968 - 1.013)
Current drinkers	0.831	0.934	1.250	1.202
	(0.627 - 1.102)	(0.449 - 1.940)	(0.609 - 2.563)	(0.592 - 2.439)
Current drinkers × (Age - 45)		0.996	0.988	0.990
		(0.974 - 1.019)	(0.967 - 1.010)	(0.969 - 1.012)
SES covariates	No	No	Yes	Yes
SES covariates × (Age - 45)	No	No	Yes	Yes
Birth year as strata	No	No	No	Yes
Number of observations	22489	22489	22489	22489

Notes: This table reports hazard ratios and 95% confidence intervals in parentheses. Confidence intervals are calculated based on robust standard errors. Observations are weighted by individual sampling weights. ** $p < 0.01$, * $p < 0.05$. Data source: CHARLS.

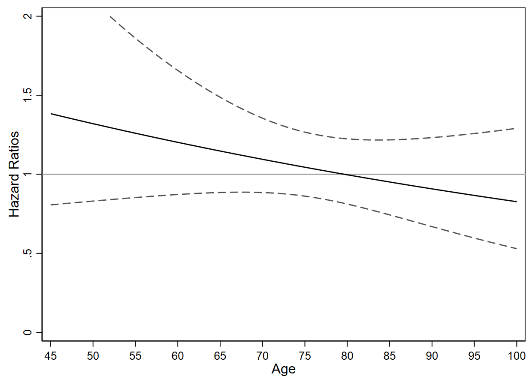
Table S11: Percentage distribution of intervals by drinking status, females

	Lifelong abstainers	Ever drinkers	Former drinkers	Current drinkers
Initial state				
Disability-free	83.1	85.2	84.2	86.2
Disability	16.9	14.8	15.8	13.8
Conditional on initial state = Disability-free				
Disability-free → Disability free	73.4	76.1	74.0	78.2
Disability-free → Disability	13.3	12.2	14.4	10.0
Disability-free → Death	13.3	11.7	11.6	11.8
Conditional on initial state = Disability				
Disability → Disability free	25.9	35.7	28.9	44.0
Disability → Disability	33.5	28.2	27.7	28.8
Disability → Death	40.6	36.1	43.4	27.2
Number of intervals	11535	3726	1689	2037

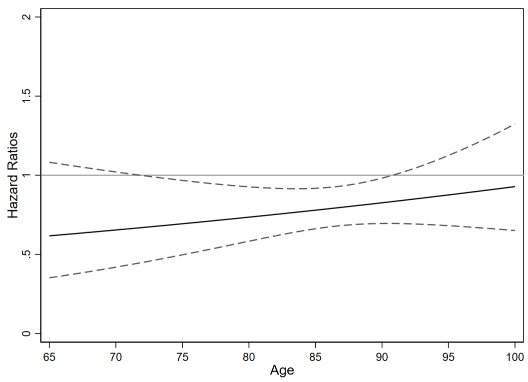
Notes: This table provides the distribution of intervals of observation by drinking status at the beginning of the interval. Percentage numbers listed are weighted using individual sampling weights. Data source: CLHLS.



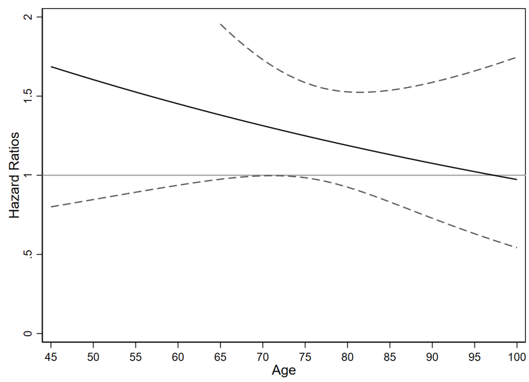
(A1) Ever drinkers vs lifelong abstainers. CLHLS



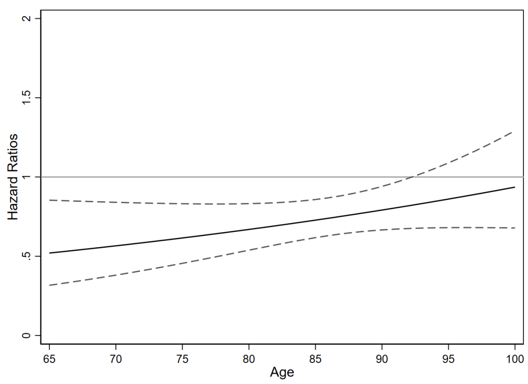
(B1) Ever drinkers vs lifelong abstainers. CHARLS



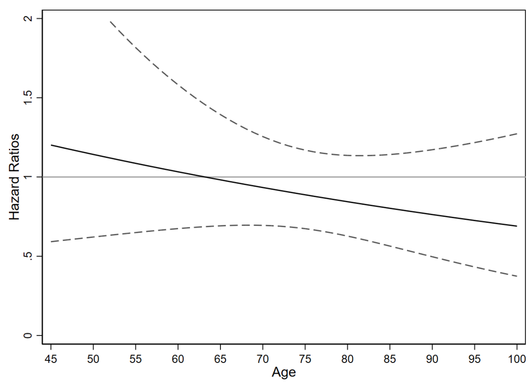
(A2) Former drinkers vs lifelong abstainers. CLHLS



(B2) Former drinkers vs lifelong abstainers. CHARLS



(A3) Current drinkers vs lifelong abstainers. CLHLS



(B3) Current drinkers vs lifelong abstainers. CHARLS

Figure S2: Cox regression results, females. Notes: This figure presents age-specific hazard ratios for each drinking status compared with lifelong abstainers. Results are based on Specification (4) in Table S9 and Table S10. 95% confidence intervals are depicted in dashed lines.

Table S12: Estimated parameters of the interpolated Markov chain model, males

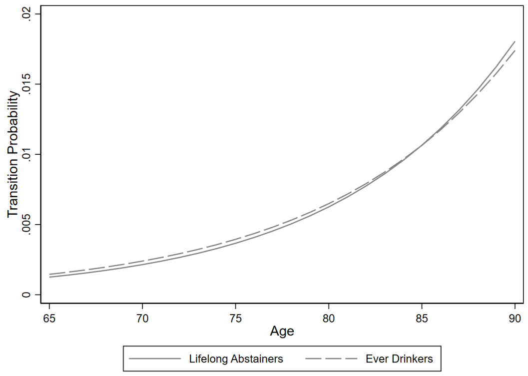
	Disability-free → Disability	Disability-free → Death	Disability → Disability-free	Disability → Death
Age	0.108**	0.078**	-0.005	0.039**
	(0.011)	(0.011)	(0.019)	(0.011)
Ever drinkers	0.634	-0.547	1.745	0.938
	(1.094)	(1.050)	(1.722)	(1.103)
Age × Ever drinkers	-0.007	0.004	-0.021	-0.009
	(0.014)	(0.013)	(0.022)	(0.013)
SES index	-1.403*	-0.325	-2.295*	0.012
	(0.563)	(0.633)	(0.991)	(0.572)
Age × SES index	0.017*	0.002	0.027*	-0.001
	(0.007)	(0.008)	(0.013)	(0.007)
Intercept	-13.679**	-11.713**	-3.728*	-7.118**
	(0.904)	(0.848)	(1.484)	(0.910)

Notes: This table reports the estimated parameters of the interpolated Markov chain model. Observations are weighted by individual sampling weights. Standard errors are in parentheses. ** $p < 0.01$, * $p < 0.05$. Data source: CLHLS.

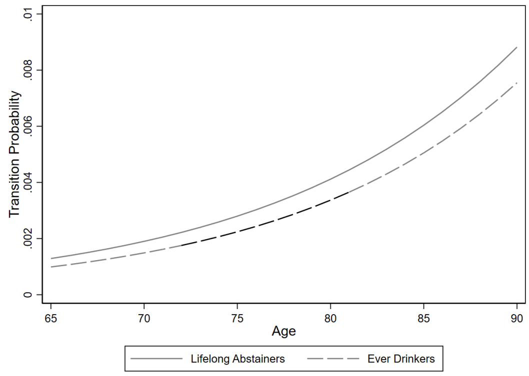
Table S13: Estimated parameters of the interpolated Markov chain model, males

	Disability-free → Disability	Disability-free → Death	Disability → Disability-free	Disability → Death
Age	0.107**	0.078**	-0.007	0.039**
	(0.011)	(0.011)	(0.019)	(0.011)
Former drinkers	2.194	1.069	1.628	1.117
	(1.281)	(1.464)	(2.095)	(1.231)
Age × Former drinkers	-0.025	-0.016	-0.022	-0.010
	(0.016)	(0.019)	(0.027)	(0.015)
Current drinkers	-0.246	-1.511	1.365	0.389
	(1.297)	(1.138)	(1.891)	(1.446)
Age × Current drinkers	0.002	0.017	-0.013	-0.004
	(0.016)	(0.015)	(0.024)	(0.018)
SES index	-1.378*	-0.345	-1.961*	-0.057
	(0.561)	(0.624)	(0.986)	(0.579)
Age × SES index	0.016*	0.002	0.023	-0.000
	(0.007)	(0.008)	(0.012)	(0.007)
Intercept	-13.651**	-11.721**	-3.503*	-7.158**
	(0.894)	(0.842)	(1.462)	(0.910)

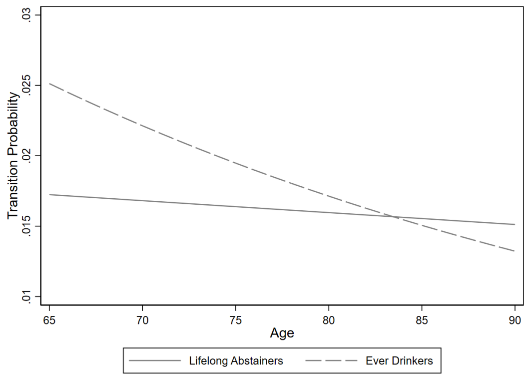
Notes: This table reports the estimated parameters of the interpolated Markov chain model. Observations are weighted by individual sampling weights. Standard errors are in parentheses. ** $p < 0.01$, * $p < 0.05$. Data source: CLHLS.



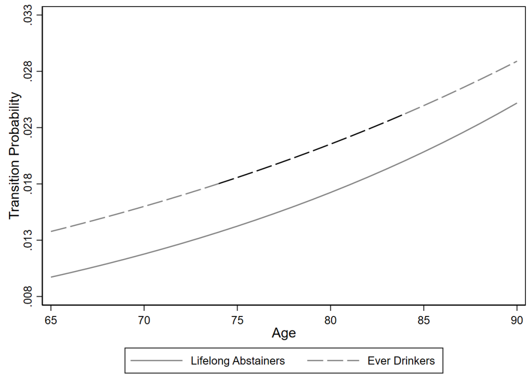
(A1) Disability-free → Disability



(A2) Disability-free → Death



(B1) Disability → Disability-free



(B2) Disability → Death

Figure S3: Monthly transition probability by drinking status, males. Notes: This figure presents age-specific monthly transition probabilities for each drinking status. Transition probabilities are calculated from the estimated coefficients in Table S12. The value of the SES index is kept constant at zero. Segments with significant differences between ever drinkers and lifelong abstainers are in bold. We find out significant differences based on the estimated marginal effects of the ever drinkers indicator in the multinomial logistic regressions. Standard errors of the marginal effects are calculated using the delta method. Data source: CLHLS.

Table S14: Estimated parameters of the interpolated Markov chain model, females

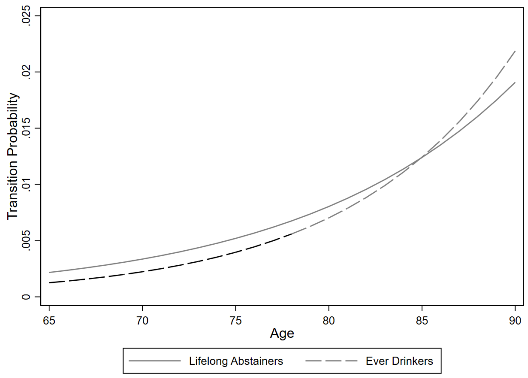
	Disability-free → Disability	Disability-free → Death	Disability → Disability-free	Disability → Death
Age	0.088**	0.051**	-0.074**	0.053**
	(0.005)	(0.008)	(0.009)	(0.006)
Ever drinkers	-2.334*	-1.592	0.172	-1.091
	(1.097)	(1.187)	(1.556)	(1.209)
Age × Ever drinkers	0.027*	0.017	0.005	0.010
	(0.013)	(0.015)	(0.019)	(0.014)
SES index	0.465	-0.266	0.919	0.036
	(0.446)	(0.582)	(0.679)	(0.566)
Age × SES index	-0.007	0.003	-0.014	-0.002
	(0.006)	(0.008)	(0.009)	(0.007)
Intercept	-11.837**	-9.885**	1.749**	-8.531**
	(0.440)	(0.599)	(0.670)	(0.513)

Notes: This table reports the estimated parameters of the interpolated Markov chain model. Observations are weighted by individual sampling weights. Standard errors are in parentheses. ** $p < 0.01$, * $p < 0.05$. Data source: CLHLS.

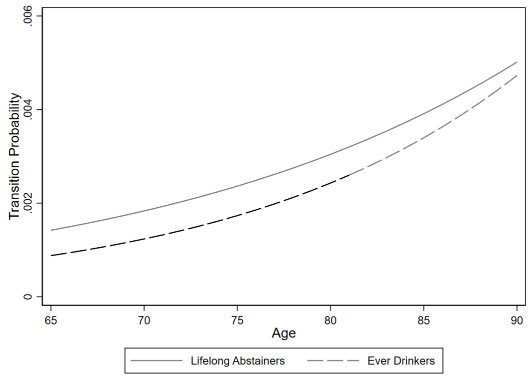
Table S15: Estimated parameters of the interpolated Markov chain model, females

	Disability-free → Disability	Disability-free → Death	Disability → Disability-free	Disability → Death
Age	0.087**	0.052**	-0.074**	0.052**
	(0.005)	(0.008)	(0.009)	(0.006)
Former drinkers	-3.303*	0.677	-1.542	1.110
	(1.459)	(1.996)	(2.180)	(1.352)
Age × Former drinkers	0.041*	-0.015	0.025	-0.013
	(0.018)	(0.026)	(0.027)	(0.015)
Current drinkers	-1.763	-3.187*	0.419	-4.633*
	(1.543)	(1.297)	(2.012)	(2.100)
Age × Current drinkers	0.018	0.040*	0.004	0.047*
	(0.019)	(0.016)	(0.025)	(0.023)
SES index	0.604	-0.459	1.047	0.082
	(0.447)	(0.553)	(0.680)	(0.570)
Age × SES index	-0.009	0.005	-0.015	-0.002
	(0.006)	(0.007)	(0.009)	(0.007)
Intercept	-11.792**	-9.932**	1.778**	-8.503**
	(0.441)	(0.596)	(0.672)	(0.515)

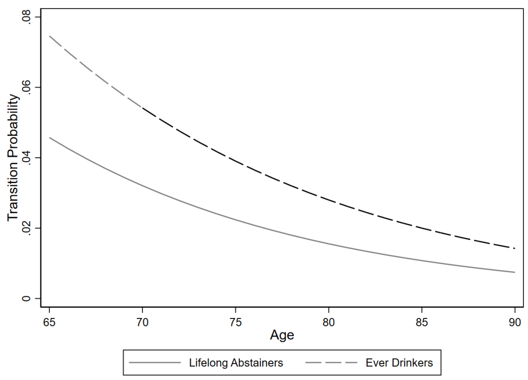
Notes: This table reports the estimated parameters of the interpolated Markov chain model. Observations are weighted by individual sampling weights. Standard errors are in parentheses. ** $p < 0.01$, * $p < 0.05$. Data source: CLHLS.



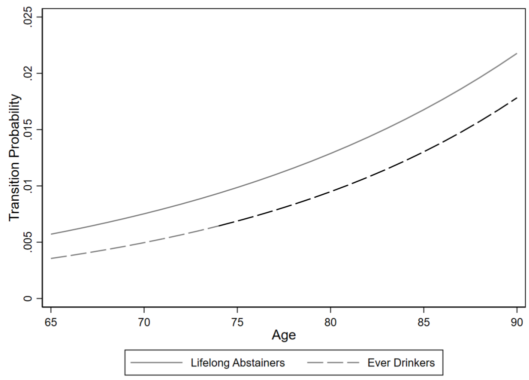
(A1) Disability-free → Disability



(A2) Disability-free → Death

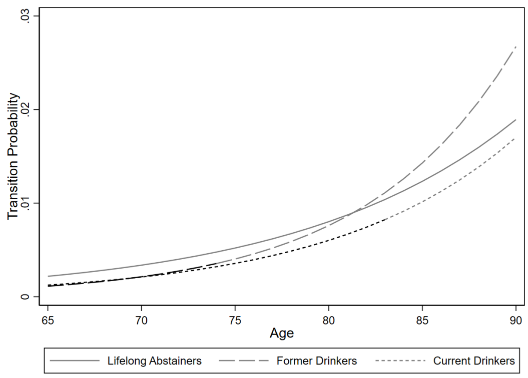


(B1) Disability → Disability-free

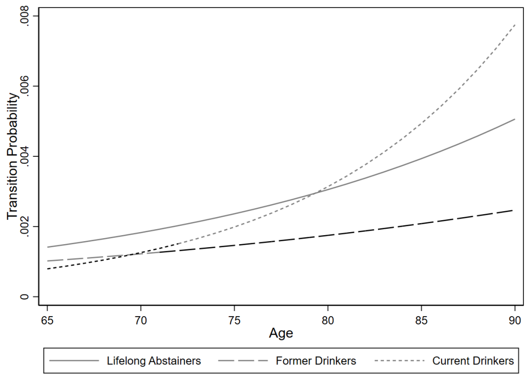


(B2) Disability → Death

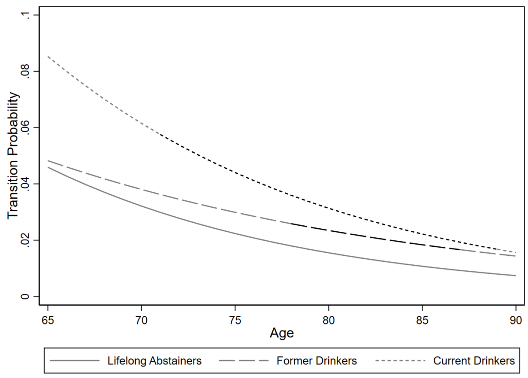
Figure S4: Monthly transition probability by drinking status, females. Notes: This figure presents age-specific monthly transition probabilities for each drinking status. Transition probabilities are calculated from the estimated coefficients in Table S14. The value of the SES index is kept constant at zero. Segments with significant differences between ever drinkers and lifelong abstainers are in bold. We find out significant differences based on the estimated marginal effects of the ever drinkers indicator in the multinomial logistic regressions. Standard errors of the marginal effects are calculated using the delta method. Data source: CLHLS.



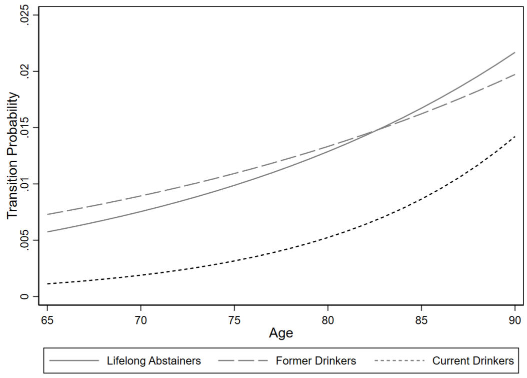
(A1) Disability-free → Disability



(A2) Disability-free → Death



(B1) Disability → Disability-free



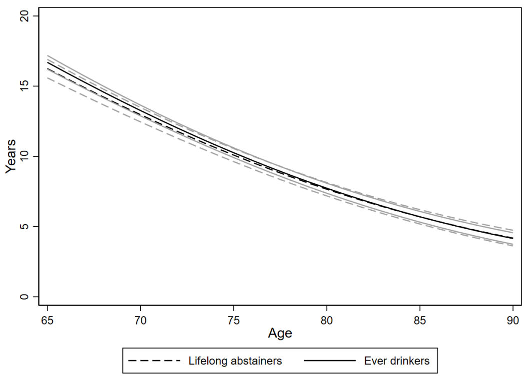
(B2) Disability → Death

Figure S5: Monthly transition probability by drinking status, females. Notes: This figure presents age-specific monthly transition probabilities for each drinking status. Transition probabilities are calculated from the estimated coefficients in Table S15. The value of the SES index is kept constant at zero. Segments with significant differences between drinkers and lifelong abstainers are in bold. We find out significant differences based on the estimated marginal effects of each drinking indicator in the multinomial logistic regressions. Standard errors of the marginal effects are calculated using the delta method. Data source: CLHLS.

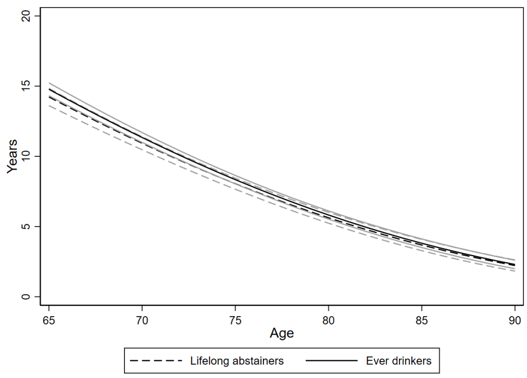
Table S16: Life expectancies at selected ages by drinking status, males

	Lifelong abstainers			
Age	TLE	DFLE	DLE	DFLE/TLE
65	16.25	14.23	2.021	0.876
70	12.97	10.94	2.034	0.843
75	10.09	8.051	2.040	0.798
80	7.658	5.625	2.033	0.735
85	5.689	3.682	2.007	0.647
90	4.176	2.222	1.954	0.532
	Ever drinkers			
Age	TLE	DFLE	DLE	DFLE/TLE
65	16.70	14.78	1.918	0.885
70	13.27	11.34	1.922	0.855
75	10.26	8.339	1.919	0.813
80	7.728	5.820	1.908	0.753
85	5.694	3.809	1.886	0.669
90	4.147	2.295	1.851	0.553

Notes: This table reports the estimated total life expectancy (TLE), disability-free life expectancy (DFLE), and life expectancy with disability (DLE) at selected ages. These results are derived from the estimated interpolated Markov chain model while keeping the value of the SES index constant at zero. Data source: CLHLS.



(1) Total life expectancy: Ever drinkers



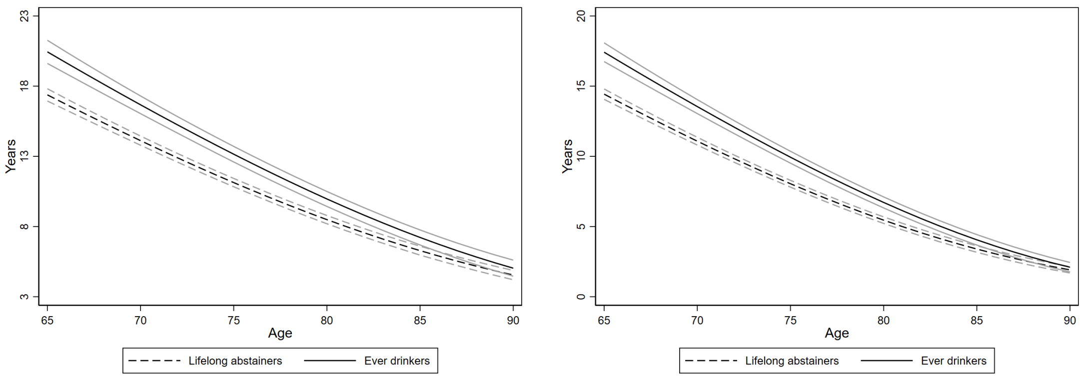
(2) Disability-free life expectancy: Ever drinkers

Figure S6: Life expectancies by drinking status, males. Notes: This figure presents age-specific total life expectancy and disability-free life expectancy for each drinking status. These results are derived from the estimated interpolated Markov chain model while keeping the value of the SES index constant at zero. 95% confidence intervals are depicted with grey lines. Data source: CLHLS.

Table S17: Life expectancies at selected ages by drinking status, females

	Lifelong abstainers			
Age	TLE	DFLE	DLE	DFLE/TLE
65	17.38	14.43	2.949	0.830
70	14.12	11.08	3.039	0.785
75	11.13	8.049	3.081	0.723
80	8.492	5.454	3.038	0.642
85	6.283	3.397	2.887	0.541
90	4.542	1.912	2.630	0.421
	Ever drinkers			
Age	TLE	DFLE	DLE	DFLE/TLE
65	20.44	17.42	3.026	0.852
70	16.67	13.55	3.127	0.812
75	13.15	9.938	3.215	0.756
80	9.965	6.717	3.248	0.674
85	7.221	4.053	3.168	0.561
90	5.034	2.102	2.932	0.418

Notes: This table reports the estimated total life expectancy (TLE), disability-free life expectancy (DFLE), and life expectancy with disability (DLE) at selected ages. These results are derived from the estimated interpolated Markov chain model while keeping the value of the SES index constant at zero. Data source: CLHLS.



(1) Total life expectancy: Ever drinkers

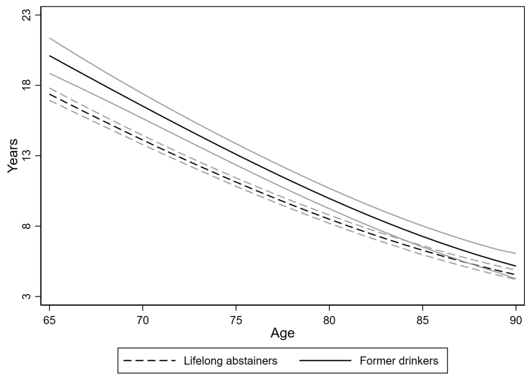
(2) Disability-free life expectancy: Ever drinkers

Figure S7: Life expectancies by drinking status, females. Notes: This figure presents age-specific total life expectancy and disability-free life expectancy for each drinking status. These results are derived from the estimated interpolated Markov chain model while keeping the value of the SES index constant at zero. 95% confidence intervals are depicted with grey lines. Data source: CLHLS.

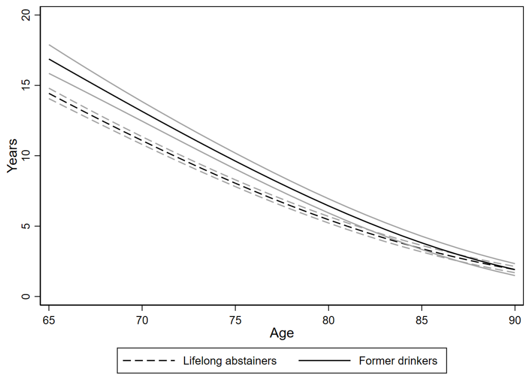
Table S18: Life expectancies at selected ages by drinking status, females

Age	TLE	DFLE	DLE	DFLE/TLE
	Lifelong abstainers			
65	17.38	14.43	2.949	0.830
70	14.12	11.08	3.039	0.785
75	11.13	8.049	3.081	0.723
80	8.492	5.454	3.038	0.642
85	6.283	3.397	2.887	0.541
90	4.542	1.912	2.630	0.421
	Former drinkers			
Age	TLE	DFLE	DLE	DFLE/TLE
65	20.11	16.87	3.240	0.839
70	16.52	13.15	3.373	0.796
75	13.10	9.622	3.479	0.734
80	9.961	6.440	3.521	0.647
85	7.265	3.811	3.453	0.525
90	5.161	1.910	3.251	0.370
	Current drinkers			
Age	TLE	DFLE	DLE	DFLE/TLE
65	20.65	17.90	2.747	0.867
70	16.71	13.90	2.814	0.832
75	13.11	10.23	2.880	0.780
80	9.921	7.005	2.915	0.706
85	7.209	4.342	2.867	0.602
90	5.038	2.358	2.680	0.468

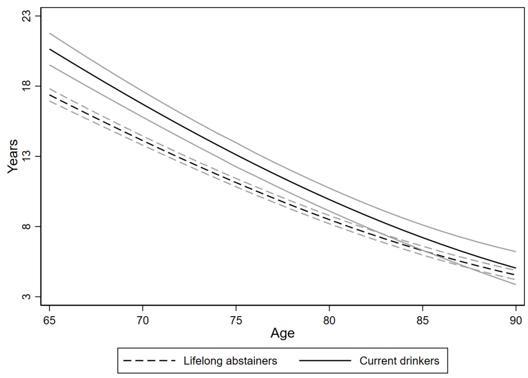
Notes: This table reports the estimated total life expectancy (TLE), disability-free life expectancy (DFLE), and life expectancy with disability (DLE) at selected ages. These results are derived from the estimated interpolated Markov chain model while keeping the value of the SES index constant at zero. Data source: CLHLS.



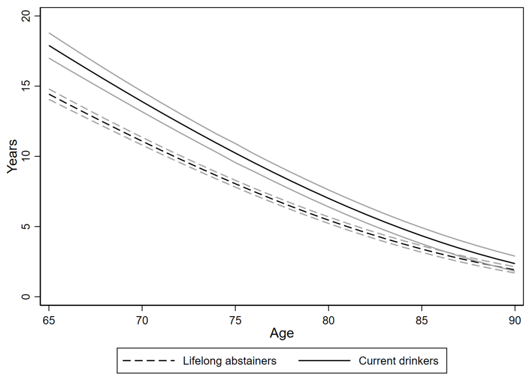
(A1) Total life expectancy: Former drinkers



(A2) Disability-free life expectancy: Former drinkers

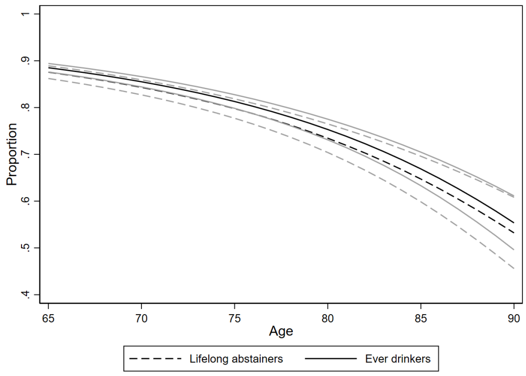


(B1) Total life expectancy: Current drinkers

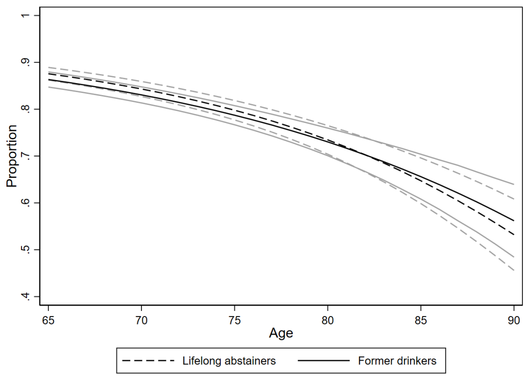


(B2) Disability life expectancy: Current drinkers

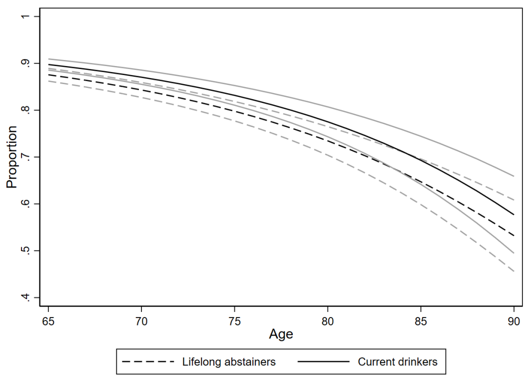
Figure S8: Life expectancies by drinking status, females. Notes: This figure presents age-specific total life expectancy and disability-free life expectancy for each drinking status. These results are derived from the estimated interpolated Markov chain model while keeping the value of the SES index constant at zero. 95% confidence intervals are depicted with grey lines. Data source: CLHLS.



(A1) DFLE/TLE: Ever drinkers

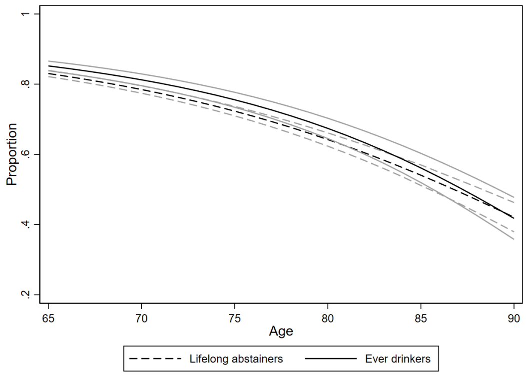


(B1) DFLE/TLE: Former drinkers

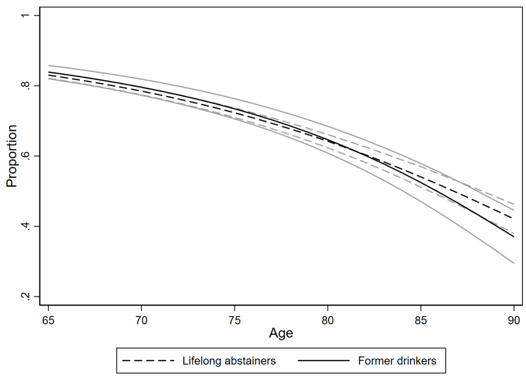


(C1) DFLE/TLE: Current drinkers

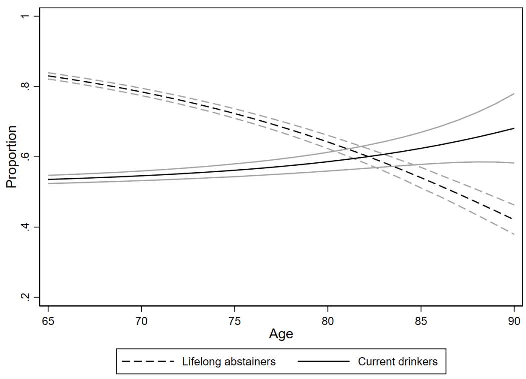
Figure S9: Proportion of disability-free life expectancy (DFLE) in total life expectancy (TLE) by drinking status, males. Notes: These results are derived from the estimated interpolated Markov chain model while keeping the value of the SES index constant at zero. 95% confidence intervals are depicted with grey lines. Data source: CLHLS.



(A1) DFLE/TLE: Ever drinkers



(B1) DFLE/TLE: Former drinkers



(C1) DFLE/TLE: Current drinkers

Figure S10: Proportion of disability-free life expectancy (DFLE) in total life expectancy (TLE) by drinking status, females. Notes: These results are derived from the estimated interpolated Markov chain model while keeping the value of the SES index constant at zero. 95% confidence intervals are depicted with grey lines. Data source: CLHLS.