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Social dynamics of substance use through minds and models

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Societal Spirits in the Golden Years



This chapter has been adapted from: Maarten W. J. van den Ende, René Freichel, Han L. J. van der Maas Reinout W. Wiers, Sacha Epskamp. *Societal Spirits in the Silver Streak: Unraveling Complexity in Drinking Habits*

Abstract

In the field of substance use disorder, the interplay between individual behaviour and social environment is a complex and critical area of study. The present study adopts a novel graphical VAR network modeling approach to investigate the dynamics between personal drinking habits and social environmental factors. Utilizing a comprehensive longitudinal dataset from the Framingham Heart Study, we distinguished within-person from between-person associations in a large sample of predominantly senior adults ($N = 1719-5718$). We explored both temporal and contemporaneous associations between individual's drinking habits, smoking behaviour, perceived job prestige, and the drinking behaviours of their social environment. Our findings reveal significant associations between participants' behaviour and their peers' behaviour, with complex, reciprocal interactions. The temporal network showed dynamic associations between individual factors and peers' drinking behaviour, highlighting the influence of the social environment on altering one's drinking habits, but also the effect drinking has on changing one's social circles. At the contemporaneous level, our data suggests that when an individual drinks more than usual, they also tend to have higher cigarette use. Furthermore, in periods where one drinks more (or less) than usual, they are more often connected with heavy (or abstaining) drinkers. The identified positive feedback loops between a person's drinking behaviour and their social environment highlight the crucial role of social influences in shaping drinking behaviours. This emphasises the need to consider social elements in the development of future theories, models, and interventions aimed at addressing alcohol consumption, even among older adults.

5.1 Introduction

Substance use disorders are a significant public health problem that affect various demographic groups, spanning different age groups, socioeconomic statuses and geographical regions (Sudhinaraset et al., 2016). In particular, alcohol use disorder is a widespread and pervasive problem, with effects that extend to both economic and personal levels (Bobo and Husten, 2000), and heavy drinking imposes a high burden on society (Effertz and Mann, 2013a; Rehm et al., 2013). Substance use disorders are complex phenomena, with a wide range of influencing factors, ranging from genetic vulnerability to cultural norms, upbringing and the drinking behaviour of individuals in their social environment (Brooks-Russell et al., 2014; Cruz et al., 2012). Research suggests that individuals with higher socioeconomic status tend to consume more alcohol overall but may be less likely to engage in binge-drinking, exemplifying the intricate interplay between alcohol consumption and socioeconomic factors (Huckle et al., 2010; Collins, 2016). Use of alternate substances such as smoking is closely linked to alcohol use and is often seen as a complementary behaviour (Bien and Burge, 1990; Bobo and Husten, 2000; Room, 2004; Blok et al., 2017). The two behaviours influence each other at all stages of use; in particular, smoking appears to contribute to alcohol relapse rates, and simultaneous cessation of both habits leads to lower relapse rates (Cooney et al., 2015; Weinberger et al., 2015).

One factor that has a major impact on substance use at all use stages is one's social environment (de Visser, 2021; Sönmez Güngör et al., 2021). It is in and of itself the result of complex dynamics. Factors such as peer pressure, family dynamics, and societal influences play pivotal roles in the initiation and continuation of substance use during adolescence (Hawkins et al., 1992; Donovan, 2004). These influences can have lasting effects on patterns of use into adulthood (Chassin et al., 2002). The influence of community context and family structure is significant, shaping individual behaviour and attitudes towards substances even late in life (Moos et al., 2004a). Furthermore, peer influences and social drinking motives continue to play a strong role in driving substance use (Freichel et al., 2023). For example, in the same dataset used in the current study, it was found that individuals connected with heavy drinkers are 50% more likely to drink heavily themselves (Rosenquist, 2010). The reciprocal nature of these relationships often leads to a feedback loop in which substance use is normalised and reinforced within social circles (Borsari and Carey, 2001). Social support also plays a crucial role in moderating substance use, particularly in terms of recovery and prevention. Friends who abstain from substance use can be a positive influence, reinforcing abstinence and promoting healthier behaviours (Witkiewitz and Marlatt, 2009); in the dataset used in the current study, it was found that being surrounded by abstainers, consumption of individuals would decrease by 50%. Interventions that leverage support from social networks have shown promise in reducing substance use and preventing relapse (van den Ende et al., 2024a; Ariss and Fairbairn, 2020; Bliuc et al., 2018). Structured settings such as Alcoholics Anonymous meetings provide supportive communities that can help individuals maintain sobriety, particularly effective for individuals with many heavy drinking connections (Kelly et al., 2011; Group, 1998; Witkiewitz et al., 2007).

Current research on social dynamics and drinking behaviour has predominantly focused on adolescents and young adults (Freichel et al., 2023; Hawkins et al., 1992;

Donovan, 2004). However, there are compelling reasons to suspect that the social network dynamics observed in younger cohorts may not be applicable to older demographics. For example, while peer influence may decline in later life, other aspects of the social environment, such as the effects of loneliness, may become more dominant (Wrzus et al., 2013). In addition, as people age, continued substance use is often associated with stable coping mechanisms or long-established habits (Simoni-Wastila and Yang, 2006; Moos et al., 2004b; Chernick and Kuerbis, 2016). At the same time, the physiological effects of alcohol consumption are changing, with alcohol-related health risks increasing with age (Knox et al., 2019). Despite these known factors, the impact of social networks on alcohol consumption in mature adult populations remains poorly understood and has been identified as an area for further research (Knox et al., 2019). Thus, while the importance of the role of the social environment is undeniable, the dynamics of these complex interactions remain poorly understood particularly for mature adults. As several reviews indicated, psychological theories and formal modelling efforts often overlook the reciprocal nature of the relationships between individuals and their social environments (van den Ende et al., 2022; Kato et al., 2022; van der Wal et al., 2021). Without a full understanding of this key factor, we may miss potential intervention strategies that are critical for both onset and relapse prevention (Marlatt et al., 2004).

Our research aims to fill the existing gap in understanding the complex relationships between alcohol consumption, personal factors such as tobacco use and job prestige, the perceived social status of one's occupation — a key aspect of socioeconomic status (SES) (Hughes et al., 2022), which we use as an operationalisation of SES — and the influence of drinking habits within one's social circle. To achieve this, we use the comprehensive longitudinal social network dataset with participants having an average age of about 55 years. By classifying the drinking behavior of individuals' social connections into abstainers, moderate, and heavy drinkers, we are able to distinguish their different social influences.

Our study employs novel dynamic network modelling techniques to investigate two principal categories of effects: contemporaneous effects and temporal effects (Epskamp, 2020). The former covers the simultaneous associations that occur within the same time frame, aiming to elucidate how various variables might be interrelated at a specific moment. In contrast, the latter focuses on the average effects that unfold over time within an individual, shedding light on the progression of certain factors and their impact on an individual's behavior or experiences. A critical element of the research is the differentiation between within-person and between-person effects (Curran and Bauer, 2011). Within-person effects examine the changes occurring in individuals over time, whereas between-person effects analyze the persistent differences among various individuals. The distinction between these effects is crucial; interventions designed to modify social network dynamics must be informed by a nuanced understanding of these individual processes.

5.2 Methods

Data source

Our analysis uses data from the Framingham Heart Study [dataset](Dawber et al., 1951), an ongoing longitudinal cohort study initiated in 1948. The data are derived from two cohorts:

1. The ‘Original Cohort’ of 5209 participants, started in 1948.
2. The ‘Offspring Cohort’ of 5124 participants, started in 1971.

The dataset provides an extensive array of information collected over decades, primarily centered on physical health obtained from clinical examinations. Included within this dataset are a limited number of lifestyle variables that are relevant to our research, notably alcohol consumption, cigarette use and a measure of job prestige. In also it contains the ‘Social Net’, a social network constructed from participants’ reported relationships and additional data such as family ties and address records (Christakis and Fowler, 2007). By aligning the the annual data from the Original Cohort with the nearest corresponding data from the Offspring Cohort, we have aggregated the data into nearly three-year intervals, spanning seven waves of assessment over a 32-year period between 1971 and 2003.

Individual measures

We included individual behavioural measures focused on drinking habits, smoking behaviours, and occupational prestige. Drinking behaviour is determined by self-reporting the average number of drinks consumed per week in the past year, asking separately for beer, wine, and liquor. We summed these different types to obtain a total drink count for every participant. Similarly, the item ‘cigarettes per day’ assessed the self-reported average number of cigarettes smoked per day in the previous year.

Social status was assessed using the Treiman occupational prestige score (Treiman, 2013). Occupations receive a score between 0 and 100, following a survey in which respondents rate the prestige of various occupations. Higher scores correlate with greater prestige. This measure does not correspond exactly to SES (Socioeconomic Status), which includes more than just occupation, but it can serve as an indicative measure of social status.

Social measures

Our social network data includes three primary metrics. The first metric, Total Connections, represents the total number of social connections recorded in the dataset for each participant. These connections comprise a small number of self-reported friendships, municipally recorded familial ties, and individuals residing at the same address. For our analysis of social connections, we excluded co-workers and geographic neighbours, as there is insufficient evidence that these are actual social connections (Christakis and Fowler, 2008) or whether these types of connections significantly influence each other’s drinking behaviour (Rosenquist, 2010). We also excluded individuals with no or only

one known connection, as this removes individuals for whom the social network data is severely lacking which makes their social environment not suitable for an analysis that categorises connections into proportions based on drinking status.

Second, to assess social drinking environment, we have classified the connections into three categories based on their drinking habits. This categorisation, as proposed by Epskamp et al. (2022) and confirmed as a valid option in the FHS dataset (van den Ende et al., 2024a), consists of abstainers (0 weekly consumptions), moderate drinkers (1 – 7 for women, 1 – 14 for men (Gunzerath et al., 2004)), and heavy drinkers (> 7 for women, > 14 for men). Given that the total number of connections varies for each individual, the number of social connections in each category doesn't serve as a direct indicator of the social drinking environment. Instead, it's more closely related to the total number of connections. To obtain a more accurate representation of the drinking environment, we calculate, for each individual, the relative proportion of connections in each of the three drinking categories. We then use the the percentage of abstainers and the percentage of heavy drinkers as variables, indicating to what extend the ones social environment lies outside of the norm of moderate drinkers. We also include the total number of ties, which we expect to take into account the longitudinal effects of data attrition, as the reduction in the number of ties is mostly due to death.

Data analysis

A panel graphical vector autoregression model (GVAR) (Epskamp et al., 2020) was used to model the interaction between individual factors (number of drinks, cigarettes, job prestige) and social connections. The panel GVAR model is similar to a random intercept cross-lagged panel model (Epskamp, 2020). We used full information maximum likelihood (FIML) estimation; a preeminent approach providing unbiased estimates similar to multiple imputation procedures, which assumes data missing at random (Schafer and Graham, 2002). The model estimates autoregressive (i.e. nodes predict themselves) and cross-lagged (i.e. different nodes predict each other) associations. The innovation (co-) variances of the model are modelled by a Gaussian graphical model (GGM) (Epskamp et al., 2018), to obtain contemporaneous partial associations (within the same time window). Therefore, the temporal dependencies of the data structure is taken into account. The model was estimated using the psychometrics R package (Epskamp et al., 2020) and visualised using the qgraph R package (Epskamp et al., 2012). After estimating a saturated model (including all edges), the model was pruned at an alpha level of 0.05 (Blanken et al., 2022). The pruning process involves removing non-significant effects and re-estimating the model with non-significant estimates set to zero.

5.3 Results

As shown in Table 1, describing the sample characteristics per wave, the initial sample consisted of $n = 5718$ individuals. There was substantial attrition with $n = 1719$ individuals at the final wave. This attrition was mainly due to the death of members of the original cohort as they aged. The average number of connections saw a gradual decrease from 4.03 to 2.99. In terms of alcohol consumption, the average number of drinks consumed

	N	Mean (std) Drinks	Mean (std) Age	Men %	Mean (std) Contacts	Heavy %	Abstain %
1	5718	7.55 (10.74)	47.98 (15.97)	53.28	4.13 (1.81)	22.35	19.81
2	3962	7.12 (10.48)	53.32 (16.38)	54.18	3.78 (1.68)	21.31	31.42
3	3355	6.29 (9.34)	55.17 (15.51)	54.84	3.65 (1.68)	18.44	35.30
4	3244	5.34 (8.56)	57.20 (15.17)	53.83	3.62 (1.85)	14.83	38.12
5	2810	4.96 (7.75)	59.41 (14.28)	54.80	3.50 (1.87)	14.00	38.07
6	1682	5.12 (8.01)	58.19 (9.65)	51.91	3.01 (1.29)	14.97	40.31
7	1719	5.42 (8.23)	60.82 (9.60)	52.32	2.99 (1.32)	16.25	35.71

Table 5.1: Sample characteristics of all examination waves (1–7). Columns ‘Heavy %’ and ‘Abstain %’ show the drinking behaviour of the social connections; the mean of the percentage of connections of all individuals that drink heavily or abstain respectively.

per week started at 7.62, but fell to around 5 in subsequent waves. The standard deviation for this metric ranged from 7.7 to 10.7. Over the 32 years of the study, the average age of participants increased from 48.0 to 60.8. The average number of abstaining contacts varied between 0.75 and 1.23, with most waves approximating 1.10. The average number of heavy drinking connections showed a slight decline from 0.90 in the first wave, to about 0.65 in the later waves. We applied the saturated panel network model to our data and obtained an excellent fit (RMSEA = 0.039, CFI = 0.92, TLI = 0.92). To increase robustness against false positive findings, we implemented standard pruning procedures with $\alpha = 0.05$. This resulted in a similar good fit of (RMSEA = 0.038, CFI = 0.92, TLI = 0.92).

Contemporaneous network

The contemporaneous network, shown in Figure 1, displays the cross-sectional partial correlations among all variables at a given measurement point, while adjusting for their time-related interdependencies (Epskamp, 2020). This illustrates the influences of different behaviours and social social environment within individuals at that particular time.

There is a large negative association between abstaining connections and heavy drinking connections, which is an expected result of our operationalisation of connections: any abstaining connection is by definition not a heavy drinking connection and therefore always reduces the proportion of heavy drinking connections. Therefore, this large effect (with edge-weight of -0.22) is not necessarily indicative of any impact.

The network reveals strong association between drinking behaviour and the social environment. Notably, the quantity of alcohol consumed appears to co-occur positively with social connections that frequently engage in heavy drinking and negatively co-occur with abstaining connections. This pattern might suggest that when participants drink more than they usually do, they could potentially gain more heavy drinking connections. The network also highlights a strong positive co-occurrence of alcohol and cigarette use. This association indicates that individuals who consume more alcohol than they typically would also tend to smoke more frequently, and vice versa.

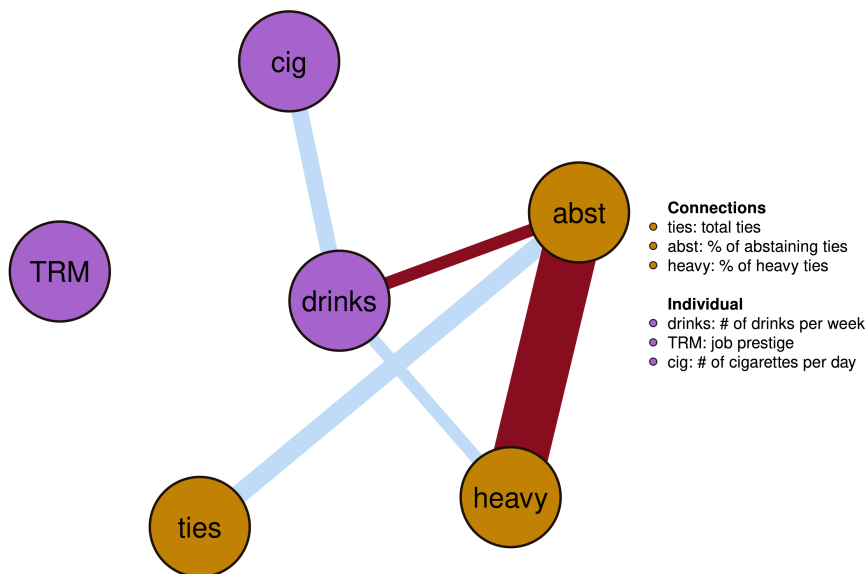


Figure 1: Fixed-effect contemporaneous associations within the same time window. Blue are positive and red are negative associations, the width of the edge represents the strength. Node color indicates personal (purple) or social (gold) variable.

Between-subjects network

The between-subjects network, depicted in Figure 2, represents an undirected partial correlation network that captures the relationships between individuals' consistent average behaviours; this reflects the typical patterns observed across the entire population. We observed a notable association between social environment and drinking behaviour. Individuals who typically consume more alcohol seem to have fewer abstaining connections and more heavy drinking connections. Conversely, people with more heavy drinking connections generally appear to consume more alcohol themselves. We also found a positive association between smoking and drinking. This suggests that people who tend to smoke more cigarettes also seem to consume more alcohol, and vice versa. Interestingly, our data shows that individuals who smoke more often have a higher percentage of abstaining connections as well as connections to heavy drinkers, implying that smokers may have fewer moderate drinking connections. Lastly, the network suggests that individuals with higher job prestige often have fewer abstaining connections and tend to smoke less on average.

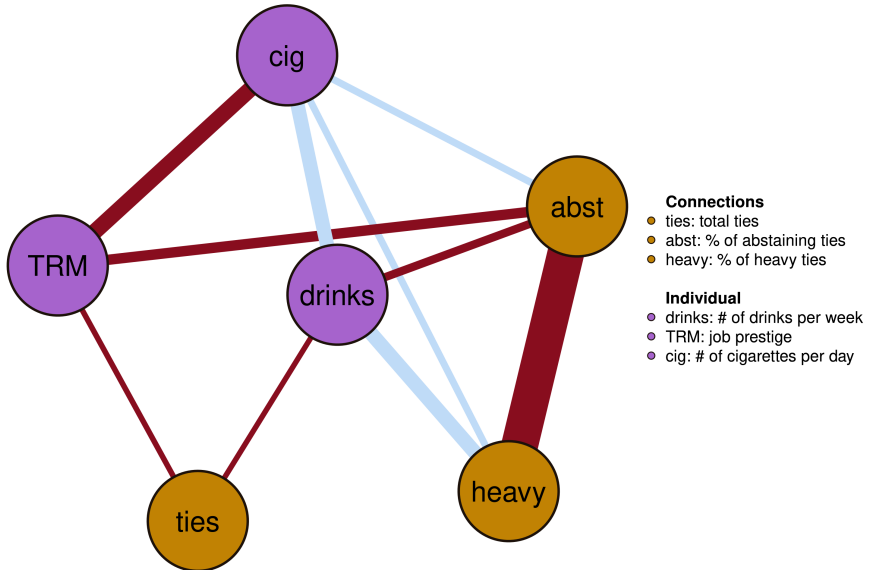


Figure 2: Fixed-effect between associations within the same time window. Blue are positive and red are negative associations, the width of the edge represents the strength. Node color indicates personal (purple) or social (gold) variable.

Temporal network

The temporal network depicted in Figure 3 illustrates potential predictive associations between variables (i.e., partial directed correlations) between an individual's social drinking environment (gold) and measures of alcohol use, cigarette use, and job prestige (purple). This within-person level network yields a pattern characterized by bidirectional feedback loops and auto-regressive effects (i.e., a node predicting itself). These patterns may suggest a reciprocal influence between an individual's drinking behaviour and their social environment's drinking habits. For instance, alterations in an individual's drinking habits might correspond with a change in their social connections with other drinkers. Similarly, changes in one's social connections could potentially influence their own drinking behaviour; the total number of social connections appears to predict an increase in drinking behaviour. However, variations in job prestige or smoking behaviour do not seem to impact drinking behaviour according to this analysis.

5.4 Discussion

In the present study, we employed an innovative analysis, based on Graphical VAR network models, to investigate the associations between individual and social environmental

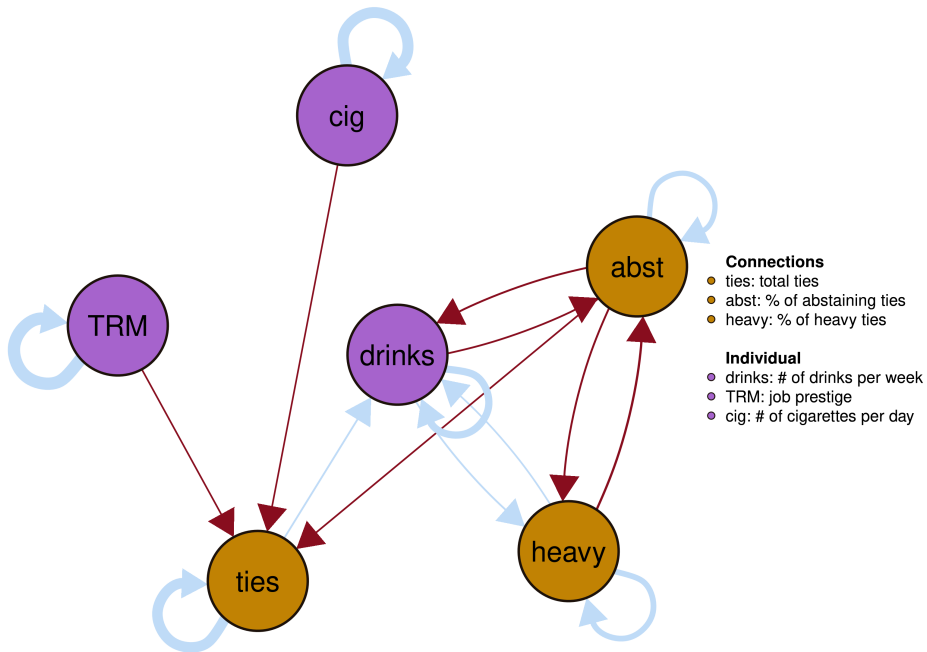


Figure 3: Fixed effect temporal associations. Blue are positive and red are negative associations. The thickness of the arrow indicates the strength of the association. Node color indicates personal (purple) or social (gold) drinking behaviour variables.

factors. We leveraged the comprehensive longitudinal dataset from the Framingham Heart Study, including its social network data, to distinguish between within-person and between-person associations in a sample of consisting of between $N = 5718$ and $N = 1719$ individuals. In addition, we modelled temporal and contemporaneous relationships between an individual's drinking habits, smoking behaviour, perceived job prestige and, notably, the drinking behaviours of their social connections. This approach is notable for its innovative consideration of an individual's social network in relation to their personal habits, as well as the novel application of GVAR to factors that extend beyond personal symptoms or traits. Hence, we were able to explore not only the correlations between individuals, but also the correlations within individuals and the unique dynamics of how these factors influence other factors over time.

At the contemporaneous level, we find that drinking behaviour is similar to the drinking behaviour of peers. It also confirms that smoking and drinking often go together (Room, 2004; Bobo and Husten, 2000); if one drinks more than usual, one also tends to consume more cigarettes. These findings are consistent with the between-subjects network that also shows a negative association between job prestige scores and cigarette use and alcohol abstinence, supporting prior research that higher socioeconomic status tends to be associated with more regular drinking but less smoking (Huckle et al., 2010;

Hiscock et al., 2012). Note that the high multicollinearity between alcohol abstinence and heavy drinking connections, an inherent result of using the proportion of connections, might mask their distinct associations with other variables and reduce the likelihood of detecting different effects. We expect this not to be the case, however, as edges with different nodes still persist, and the actual edge weight of -0.22 is smaller than the visualisation might imply.

The temporal network revealed dynamic associations between an individual's factors and their peers' drinking behaviour. We find positive feedback loops in the spread of drinking behaviour (induction (Christakis and Fowler, 2007)); our analysis suggests that increasing the number of heavy drinking connections makes one drink more over time, and similarly, having more abstaining connections can help one become abstinent. Vice versa, we find that drinking more over time also increases one's proportion of heavy drinking connections. Again, this could be due to induction, but it could also be due to homophily, a process where changing drinking behaviour leads people to change their social connections to better match their drinking behaviour. This results in a positive feedback loop, demonstrating the existence of non-linear dynamics in the interplay between one's drinking behaviour and their social environment.

Our results substantiate previous findings that drinking behaviour within the same time period is highly correlated with the drinking behaviour of peers, even for mature individuals (Borsari and Carey, 2001; Sudhinaraset et al., 2016; Larsen et al., 2012; Morris et al., 2020; Cruz et al., 2012). It also builds on research conducted by Rosenquist (2010) which uses the same dataset. Using bivariate regression, they found that being surrounded by heavy drinkers was associated with an increase in the number of drinks consumed. By being able to distinguish a reciprocal effect, our study offers a more nuanced understanding of the complex nature of interactions within the social environment, and the positive feedback loops found highlight the importance of interventions at the social level, even for older people.

This finding is reinforced by the absence of clear associations over time between smoking habits, job prestige and drinking, suggesting that the social environment is a more influential factor in modifying drinking behaviour than these individual factors. This is the case for increased drinking associated with heavy drinking as well as for abstinent relationships and reduced drinking, corroborating previous research (Rees and Wallace, 2015; Kelly et al., 2011). This finding is consistent with previous research suggesting that fostering supportive social networks can be particularly effective in promoting sobriety, as demonstrated by organisations such as Alcoholics Anonymous (Longabaugh et al., 1998; Groh et al., 2008; Bond et al., 2003).

Our findings need to be interpreted with a number of limitations in mind. First, the dataset used has inherent limitations. Drinking and smoking behaviours were self-reported, potentially compromising their accuracy (Del Boca and Darkes, 2003). Second, the social network data are not fully comprehensive. The Framingham Heart Study was not primarily designed to capture a complete social network and is therefore limited in the number of connections, particularly in terms of friendships (Christakis and Fowler, 2007). Furthermore, certain connections, such as family ties, were collected through municipal databases, and we cannot conclusively verify that these are actual social connections. In addition, job prestige might not be a fully accurate operationalization of socio-economic status, and our measurement only considers quantity of drinking,

which may not fully capture the nuances associated with varying frequencies of alcohol consumption. Finally, there is a degree of variability in the time between observations; they range from two to three years with an outlier of eight years; while the panel GVAR model assumes an approximately stationary time-series. Although studies have shown that alcohol consumption remains stable within two to four year windows (van den Ende et al., 2024a; Epskamp et al., 2022), the extended duration between study waves could mean that short-term variability may not be captured.

In addition, the current panel GVAR model can only uncover linear, lag-1 associations, meaning it cannot capture non-linear dynamics or correlations at different time lags (Epskamp et al., 2020). Furthermore, while the temporal associations imply Granger causality, suggesting temporal precedence and directional effects that are useful for exploring potential mechanisms and informing hypothesis generation, they do not establish definitive causality. These relationships can, therefore, guide further research but must be interpreted with caution, recognizing that they are indicative rather than confirmatory.

Lastly, it is important to note that our dataset, collected between 1971 and 2003, reflects the cultural and social context of that time period. Given potential shifts in culture and drinking behaviours in more recent years, our findings may not be directly applicable to contemporary populations.

Our results highlight the pivotal role of the social environment in shaping individual drinking behaviour, apparent in all network models evaluated. In particular, the temporal model revealed bidirectional feedback loops between individuals and their social contexts, highlighting that an individual's drinking behaviour is both influenced by and contributes to the dynamics within their social environment. Recognising the importance of these interactions is not only promising, but essential for a comprehensive understanding of drinking behaviour. Consequently, we suggest that future research efforts should focus on unravelling the complexity of these social factors. Future theoretical and empirical work would greatly benefit from incorporating these social dimensions in order to better understand and address alcohol consumption patterns and to develop more effective intervention strategies.