



Investigating the relationship between health literacy, sociodemographic factors, and alcohol consumption patterns: Findings from the Italian surveillance system PASSI

Patrizio Zanobini¹ · Guglielmo Bonaccorsi¹ · Valentina Saviozzi¹ · Neda Parsa² · Valentina Minardi³ · Valentina Possenti³ · Maria Masocco³ · Giovanna Mereu⁴ · Rossella Cecconi⁴ · Nadia Olimpì⁴ · Chiara Lorini¹

Received: 12 September 2025 / Accepted: 13 January 2026
© The Author(s) 2026

Abstract

Aim This study examined data from a representative sample of Tuscan residents aged 18–69 years in order to investigate the relationship between health literacy (HL), other sociodemographic factors, and their influence on binge and consistent heavy drinking among the general population in Tuscany.

Subject and methods The study examined data gathered from 2017 to 2022 from a subset of the Tuscan population within the Italian Behavioral Risk Factor Surveillance System known as PASSI (Progressi delle Aziende Sanitarie per la Salute in Italia).

Results Among the 12,953 respondents, 8.49% reported engaging in binge drinking, and 3.53% were classified as consistent heavy drinkers. Multivariate logistic regression analysis revealed that participants over 34 years of age, Italians, those with low educational attainment, and those with problematic or inadequate HL levels had higher odds of consistent heavy alcohol consumption. In contrast, females, individuals over 34 years of age, and those of foreign nationality were less likely to engage in binge drinking. While low health literacy was independently associated with consistent heavy drinking, it was not associated with binge drinking.

Conclusion This study reveals distinct factors influencing alcohol consumption. Given that HL affects only consistent heavy drinking, it is advisable for policymakers to focus on HL initiatives tailored to this specific group. On the other hand, campaigns designed to enhance HL with the goal of curbing binge drinking are unlikely to significantly influence the population.

Keywords Health literacy · Alcohol · Binge drinking · Heavy drinking · Cross-sectional survey

Introduction

Alcohol (ethanol) is a psychoactive substance with sedative properties, and its consumption is a socially accepted practice and culturally incorporated as part of social interactions, especially in Italy. However, alcohol represents one of the most significant modifiable risk factors for public health worldwide (WHO 2024). It is classified by the International Agency for Research on Cancer as a carcinogenic substance for humans, emphasizing that there is no safe threshold below which health risks are eliminated (Anderson et al. 2023). Moreover, certain consumption patterns such as episodic consumption of large quantities of alcohol (binge drinking) and consistent high levels of regular alcohol intake have been identified as major health risk factors. In fact, these patterns of consumption are associated with a wide range of physical, mental, and social harms and contribute substantially to the global burden of disease (Rehm & Shield

✉ Patrizio Zanobini
patrizio.zanobini@unifi.it

¹ Department of Health Sciences, University of Florence, Viale Morgagni 48, 50134 Florence, Italy

² Specialization Medical School of Hygiene and Preventive Medicine, University of Florence, Viale Morgagni 48, 50134 Florence, Italy

³ Centro Nazionale per la Prevenzione delle Malattie e la Promozione della Salute, Istituto Superiore di Sanità, Viale Regina Elena 299, 00161 Rome, Italy

⁴ Department of Prevention, Azienda Unità Sanitaria Locale (AUSL) Toscana Centro, Piazza Santa Maria Nuova 1, 50122 Florence, Italy

2019; Schuckit 2009; CDC 2025; Gilmore et al. 2016). The World Health Organization (WHO) estimates that alcohol is responsible for approximately 3 million deaths annually, accounting for 4.7% of all causes of death (WHO 2024). Given these serious consequences, preventing and reducing excessive alcohol consumption is a public health priority. Health literacy (HL) could play a crucial role in achieving a reduction in alcohol consumption across the population. Defined as the personal knowledge and competencies that enable people to access, understand, appraise and use information and services to promote and maintain good health (WHO 2021), HL is considered an important determinant of health (Nutbeam and Lloyd 2021), and it is associated with disease knowledge, disease management, health outcomes, and healthcare costs (Berkman et al. 2011; Stielke et al. 2019). Furthermore, high HL levels are positively associated with healthy behaviors such as physical activity and fruit and vegetable consumption (Liu et al. 2015; Lee et al. 2010; Zanolini et al. 2021; Buja et al. 2020), while they are negatively associated with unhealthy behaviors, particularly smoking (Jayasinghe et al. 2016; Stewart et al. 2013).

The relationship between HL and alcohol consumption remains unclear in the literature. While some studies have found that low HL is associated with higher daily alcohol consumption in adolescents, adults, and the elderly (Liu et al. 2015; Adams et al. 2013), other studies have identified an association between high HL levels and increased alcohol consumption in adolescents and young adults (Chisolm et al. 2014; Dermota et al. 2013). Furthermore, research suggests that different components of HL (“understanding” and “applying” versus “finding” health-related information) can induce different effects on alcohol use (Brandt et al. 2019).

This study aimed to investigate the relationship between HL, other sociodemographic determinants, and their influence on consistent heavy and binge alcohol consumption among the general population aged 18–69 in Tuscany. Data were drawn from the Italian behavioral risk factor surveillance system, known as PASSI (Progressi delle Aziende Sanitarie per la Salute in Italia).

Materials and methods

Since 2008, Italy has maintained a surveillance system, PASSI, promoted by the Ministry of Health and coordinated by the National Institute for Health (Istituto Superiore di Sanità - ISS), to monitor the health status of the adult population (18–69 years) and the behavioral risk factors—including alcohol consumption—related to chronic and preventable diseases. This system aims to collect valuable data for planning and evaluating prevention and health promotion interventions. The goals of the system are to monitor risk factors for chronic diseases (smoking, alcohol consumption,

physical activity, nutrition, etc.); assess the prevalence of preventive health practices (cancer screening, vaccinations, blood pressure and blood glucose measurements, etc.); measure the impact of local health interventions, providing data that can help improve public health services; and promote the adoption of healthy behaviors by monitoring and evaluating the effectiveness of information and awareness campaigns.

Study population, sampling criteria, and data collection

This study was conducted among a representative sample of the Tuscan population extracted from the PASSI surveillance system between 2017 and 2022. Data from 2020 and 2021 were excluded due to the COVID-19 pandemic and lockdown policies adopted in Italy during these 2 years, which may have influenced people’s health behaviors, particularly alcohol consumption. The sample was selected each month by random sampling of residents aged 18–69, stratified by sex and age in proportion to the size of each stratum in the general population, from each Local Health Unit (LHU) participating in PASSI. Exclusion criteria included the unavailability of a telephone number, inability to speak Italian or to participate in the interview, and hospitalization or institutionalization during the survey period.

Data were collected by trained staff from the public health departments of each LHU using computer-assisted telephone interviewing (CATI). Telephone numbers of the extracted participants were obtained from the registry list, from telephone directories, or through self-contact with the participants who called to schedule after receiving a notification letter.

The questionnaire comprises 114 questions structured into 12 modules, addressing key areas such as self-perceived health, behavioral risk factors—including diet, physical activity, smoking, and alcohol use—the utilization of preventive healthcare services, and compliance with essential preventive measures such as cancer screening and vaccinations. In Tuscany, a dedicated module for assessing HL was introduced and has been in use since 2017 (Zanolini et al. 2021). HL data were therefore available for all survey years included in the present analysis (2017–2019 and 2022). Additional information on the survey methodology, sampling process, and PASSI questionnaire content is available in previous studies (Baldissera et al. 2011, 2014). This research was conducted in compliance with the principles of the Declaration of Helsinki and as part of the PASSI Italian healthcare surveillance system. The Ethics Committee of the Italian National Institute of Health (Istituto Superiore di Sanità) reviewed and approved the ethical aspects of the PASSI behavioral surveillance system, under protocol number CE-ISS 06/158, dated March 8, 2007.

Measures

The sociodemographic variables examined were sex (male and female), age group (18–34, 35–49, and 50–69 years), education level (classified as “low” for individuals with an intermediate school diploma or lower, and “high” for those with a high school diploma or higher), employment status (employed, retired, or unemployed), and nationality (Italian or foreign). Financial status was assessed based on respondents’ self-reported ability to make ends meet. Responses were grouped into two categories: “good” (“very easily” or “quite easily”) and “poor” (“with some difficulties” or “with many difficulties”). Additionally, the study analyzed two patterns of alcohol consumption: consistent heavy drinking and binge drinking. Alcohol consumption behavior was based on the number of alcoholic units (one unit is equal to 12 g of ethanol consumed). Alcohol consumers were defined as individuals who had consumed at least one alcoholic unit in the past 30 days. Consistent heavy drinking was defined as consuming an average of more than two alcoholic units per day (i.e., more than 60 units in the last 30 days) for males and an average of more than one alcoholic unit per day (i.e., more than 30 units in the last 30 days) for females; binge drinking was defined as consuming at least five alcoholic units on a single occasion for males or four units for females. HL was assessed using the Italian version of the six-item European Health Literacy Survey Questionnaire (HLS-EU-Q6), a short form of the 47-item HLS-EU-Q47 (Sørensen et al. 2013), validated by Lorini et al. (2019). Responses were self-reported on a Likert scale, and the final score, averaging the item scores, ranged from 1 to 4. Only participants who responded to at least five items were included in the analysis. Based on the final score, three levels of HL were identified: inadequate HL (score of 1 to 2), problematic HL (score above 2 to below 3), and sufficient HL (score of 3 to 4). Among 12,953 respondents aged 18–69 years, HL information was available for 12,044 individuals (93.0%), while 909 (7.0%) had missing HL data. Participants with missing HL information were excluded from analyses involving HL.

Statistical analysis

Weighted percentage estimates were calculated by assigning each record a probability weight equal to the reciprocal of the sampling fraction within each LHU stratum, as described by Baldissera et al. (2014). We used the standard survey weights provided by PASSI, which already account for the complex sampling design and overall survey nonresponse; no additional re-weighting was performed specifically for HL missing data.

Multivariate logistic regression analyses were performed to examine the association between alcohol consumption, HL level, and sociodemographic factors. Two models were developed: the first with binge drinking as the dependent variable and the second with consistent heavy drinking as the dependent variable. A backward selection (starting with all sociodemographic covariates) was performed with a significance level of $\alpha = 0.10$ for staying in the model; all factors significant at $p \leq 0.10$ were retained in the final model. The goodness of fit of the final logistic regression model was assessed using the Hosmer–Lemeshow test. Potential multicollinearity between predictors in the full models was assessed by examining correlation matrices and variance inflation factors; all variance inflation factors were well below 2, indicating no relevant multicollinearity problems.

All confidence intervals (CI) were calculated at the 95% confidence level, and an alpha level of 0.05 was considered significant.

Statistical analyses and figures (forest plots) were produced using Stata version 19 (StataCorp LLC, College Station, TX, USA).

Results

In the sample of 12,953 respondents residing in Tuscany, the majority were aged 50–69 years (42.78%, 95% CI 42.25–43.32), had a high level of education (70.08%, 95% CI 69.28–70.87), had good financial status (59.94%, 95% CI 59.05–60.82), were of Italian nationality (92.75%, 95% CI 92.27–93.21), had a sufficient HL level (61.94%, 95% CI 61.03–62.84), and were employed (66.78%, 95% CI 65.98–67.58). Overall, 3.53% (95% CI 3.21–3.88) reported consistent heavy alcohol consumption, and 8.49% (95% CI 7.98–9.02) engaged in binge drinking behaviors (see Table 1).

Binge drinking was more prevalent among individuals aged 18–34 years (12.88%, 95% CI 11.68–14.18), males (10.82%, 95% CI 10.01–11.69), employed individuals (9.29%, 95% CI 8.65–9.98), those with a higher educational level (9%, 95% CI 8.38–9.66), and those of Italian nationality (8.64%, 95% CI 8.11–9.19).

Consistent heavy drinking was more prevalent among older adults aged 50–69 years (4.84%, 95% CI 4.27–5.48), those with a low education level (4.85%, 95% CI 4.18–5.61), those with a poor financial status (3.88%, 95% CI 3.36–4.48), and those with an inadequate HL level (5.32%, 95% CI 4.15–6.80) (see Table 2).

In the multivariate logistic regression model, age, nationality, and HL levels were significantly associated with consistent heavy alcohol consumption. Specifically, respondents aged 50–69 and those with problematic (OR = 1.66, $p < 0.001$) or inadequate (OR = 2.14, $p < 0.001$) HL levels were significantly associated with consistent heavy alcohol consumption.

Table 1 Sociodemographic characteristics, financial status, occupation, health literacy level, and alcohol-related behaviors (binge drinking and consistent heavy drinking) in the study sample (Italian adults aged 18–69 years; $N = 12,953$)

			Total % ($N = 12,953$)	
			%	95% CI
Age (years)	18–34		24.59	24.13–25.06
	35–49		32.63	32.13–33.13
	50–69		42.78	42.25–43.32
Sex	Male		49.38	48.84–49.91
	Female		50.62	50.09–51.16
Education level	Low		29.92	29.13–30.72
	High		70.08	69.28–70.87
Nationality	Italian		92.75	92.27–93.21
	Foreign		7.25	6.79–7.73
Financial status	Good		59.94	59.05–60.82
	Poor		40.06	39.18–40.95
Occupation	Employed		66.78	65.98–67.58
	Not employed		6.72	6.3–7.17
	Retired		26.49	25.75–27.25
Health literacy level	Sufficient		61.94	61.03–62.84
	Problematic		26.82	26.01–27.65
	Inadequate		11.24	10.65–11.86
Consistent heavy drinking	Consistent heavy drinkers		3.53	3.21–3.88
	Not consistent heavy drinkers		96.47	96.12–96.79
Binge drinking	Binge drinkers		8.49	7.98–9.02
	Not binge drinkers		91.51	90.98–92.02

Table 2 Prevalence (%) and 95% confidence intervals of binge drinking and consistent heavy drinking by sociodemographic characteristics and health literacy level among Italian adults aged 18–69 years; $N = 12,953$

		Binge drinkers (% = 8.49)		Consistent heavy drinkers (% = 3.53)	
		%	95% CI	%	95% CI
Age (years)	18–34	12.88	11.68–14.18	1.98	1.54–2.55
	35–49	8.23	7.38–9.16	2.97	2.49–3.53
	50–69	6.16	5.51–6.89	4.84	4.27–5.48
Sex	Male	10.82	10.01–11.69	3.56	3.10–4.07
	Female	6.24	5.66–6.87	3.50	3.07–3.99
Education level	Low	7.29	6.46–8.22	4.85	4.18–5.61
	High	9.00	8.38–9.66	2.97	2.63–3.36
Nationality	Italian	8.64	8.11–9.19	3.62	3.28–3.99
	Foreign	6.47	4.94–8.43	2.49	1.63–3.78
Financial status	Good	8.84	8.17–9.55	3.00	2.63–3.42
	Poor	8.12	7.35–8.96	3.88	3.36–4.48
Occupation	Employed	9.29	8.65–9.98	3.48	3.10–3.91
	Not employed	8.84	7.05–11.04	2.99	1.99–4.47
	Retired	6.36	5.55–7.28	3.78	3.17–4.50
Health literacy level	Sufficient	8.79	8.14–9.49	2.56	2.22–2.96
	Problematic	8.45	7.48–9.54	4.67	3.97–5.50
	Inadequate	6.99	5.61–8.67	5.32	4.15–6.80

HL levels were more likely to be consistent heavy drinkers. Conversely, having a foreign nationality was negatively associated ($OR = 0.50$, $p = 0.013$) with consistent heavy alcohol consumption. After backward elimination, age,

nationality, education level, and HL were significant predictors of consistent heavy drinking (Hosmer–Lemeshow test $p = 0.462$) (see Fig. 1 and Table 1 in the Supplementary Material).

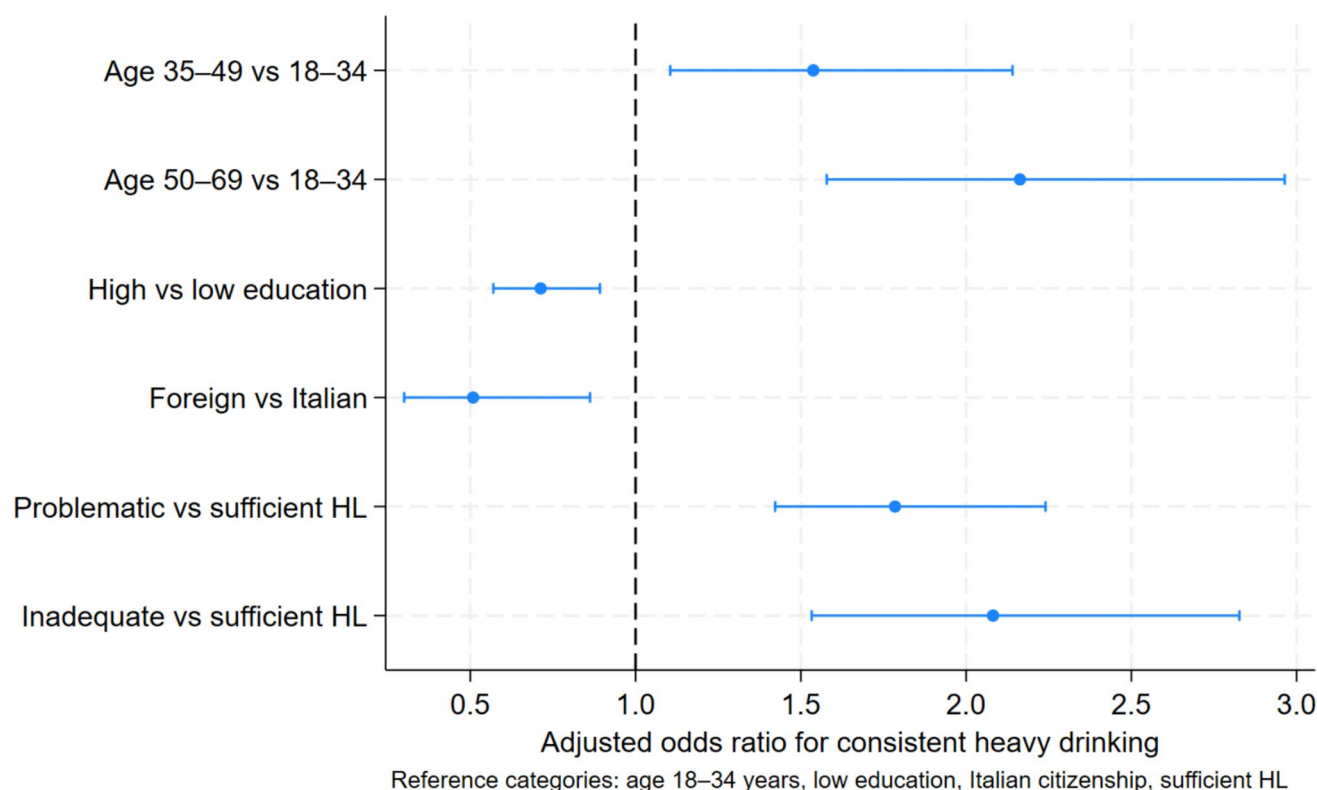


Fig. 1 Adjusted odds ratios (95% confidence intervals) for consistent heavy drinking by age group, education level, nationality, and health literacy level. Survey-weighted logistic regression model, Ital-

ian adults aged 18–69 years ($N = 12,044$). Reference categories: age 18–34 years, low education, Italian citizenship, sufficient health literacy (HL)

Binge drinking behavior appeared to be influenced by age, sex, nationality, and employment status. Individuals aged 35–49 years ($OR = 0.56$, $p < 0.001$) and 50–69 years ($OR = 0.43$, $p < 0.001$), females ($OR = 0.57$, $p < 0.001$), foreign citizens ($OR = 0.64$, $p = 0.010$), and retired individuals ($OR = 0.74$, $p = 0.001$) were significantly less likely to engage in binge drinking. HL levels did not appear to influence the likelihood of binge drinking. After backward elimination, age, sex, nationality, and occupation were identified as significant predictors of binge drinking (Hosmer–Lemeshow test $p = 0.601$) (see Fig. 2 and Table 2 in the Supplementary Material)

Discussion

Our study aimed to investigate the determinants of risky alcohol consumption behaviors (consistent heavy alcohol consumption and binge drinking), with a particular focus on the role of HL. In this large, representative sample of Tuscan adults, risky alcohol consumption was not rare: binge drinking and consistent heavy drinking affected a non-negligible proportion of the population. The two drinking patterns showed partly distinct determinants. Lower HL and lower

education were independently associated with consistent heavy drinking, whereas binge drinking was more frequent among younger men, Italians, and employed individuals, and was not related to HL.

Surprisingly, low HL, which is a predictor of different unhealthy behaviors (Jayasinghe et al. 2016; Stewart et al. 2013), was associated with consistent heavy alcohol consumption but not with binge drinking. Specifically, having problematic or inadequate HL levels increased the likelihood of regularly consuming high amounts of alcohol but did not appear to influence binge drinking behaviors. These findings align with studies indicating that low HL levels are associated with high daily alcohol consumption (Liu et al. 2015; Adams et al. 2013; Lincoln et al. 2006) and may help explain why other studies focusing on young adults—who typically engage in binge drinking—found no association with HL (Chisolm et al. 2014; Dermota et al. 2013).

This differential association can be interpreted in light of dual-process models of alcohol use, which posit that drinking behavior results from the interplay between reflective processes, involving deliberate risk evaluation and self-regulation, and impulsive, affect-driven processes that are more sensitive to cues and social influences (Stacy and Wiers

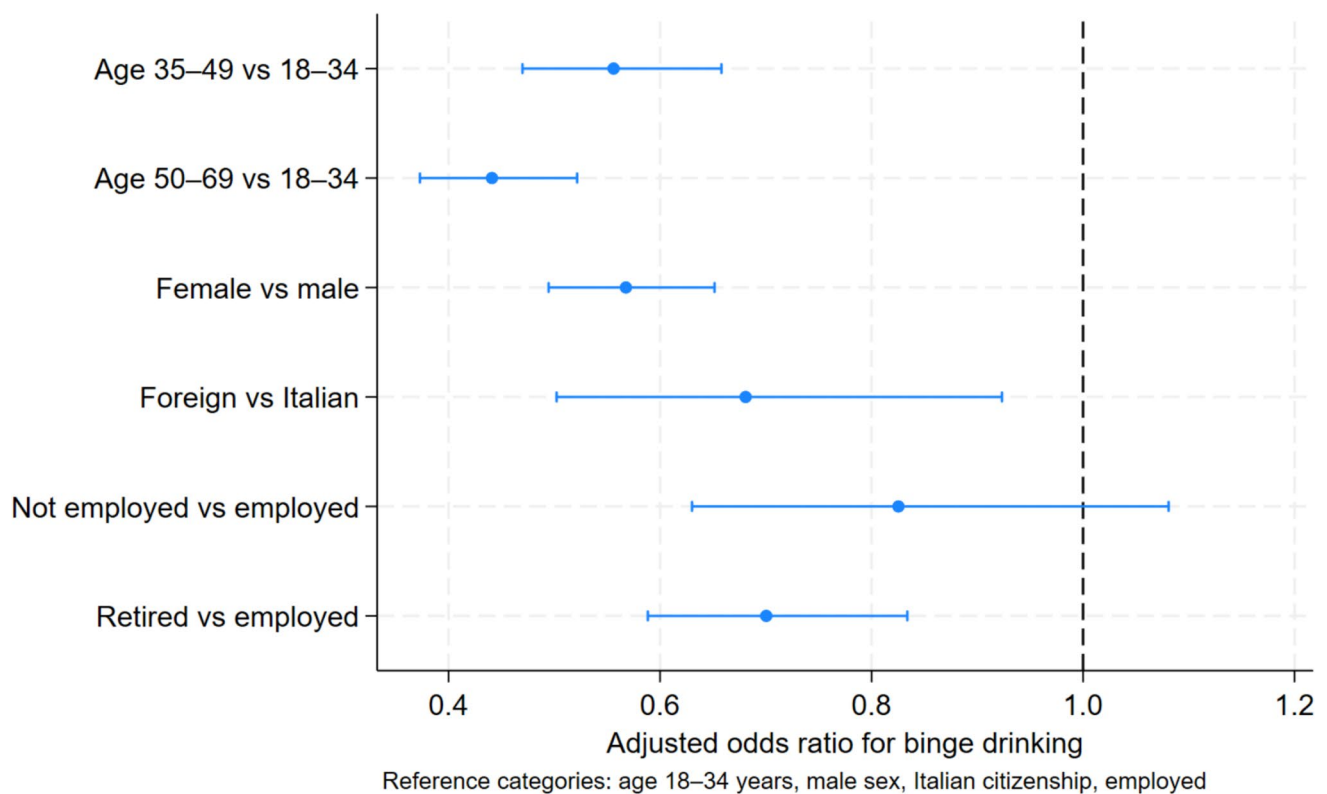


Fig. 2 Adjusted odds ratios (95% confidence intervals) for binge drinking by age group, sex, nationality, and employment status. Survey-weighted logistic regression model, Italian adults aged 18–69

years ($N = 12,044$). Reference categories: age 18–34 years, male sex, Italian citizenship, employed

2010; Wiers and Stacy 2006; Rooke et al. 2011). General HL, as captured by the HLS-EU-Q6, reflects reflective skills that facilitate the understanding and appraisal of cumulative health risks and the regulation of habits over time. These skills are likely to be relevant to decisions about maintaining or reducing a consistently high level of alcohol intake, when health risks clearly outweigh potential social benefits, in line with health behavior and risk perception models such as the Health Belief Model and the Theory of Planned Behavior (Rosenstock 1974; Ajzen 1991). By contrast, binge drinking is typically an episodic, socially driven behavior occurring in contexts characterized by strong peer norms, positive alcohol expectancies, and immediate emotional rewards. Different levels of HL may lead to different cognitive appraisals of risk in such situations, but perceived social and emotional benefits may still dominate over health concerns and lead to similar binge-drinking behaviors. HL may thus play a stronger role in shaping long-term, self-regulated patterns of drinking than in preventing occasional binge episodes. Our findings can also be viewed within the broader European context. In the international Health Literacy Survey 2019–2021 (HLS₁₉), higher general HL was associated with more favorable alcohol consumption patterns in only a subset of participating countries, and the magnitude and significance

of this association varied considerably across settings (The HLS19 Consortium of the WHO Action Network M-POHL 2021). This suggests that the impact of HL on alcohol use is context-dependent and may differ according to how alcohol consumption is measured and which drinking patterns are considered. Our results are consistent with this heterogeneity, showing that HL is related to consistent heavy drinking but not to binge drinking in our regional context, and underline the importance of distinguishing between different risky drinking patterns when examining the role of HL. The same considerations apply to educational level, as lower education is significantly associated with consistent heavy drinking but not with binge drinking.

Regarding gender differences, our results confirm that women are less likely than men to engage in binge drinking, whereas the gender gap is less pronounced for consistent heavy alcohol consumption. This pattern is consistent with evidence that women generally drink less than men (Stokkeland et al. 2008; Wilsnack et al. 1994) and can be partly explained by their greater physiological sensitivity to alcohol and higher susceptibility to its toxic effects (Ely et al. 1999; Nolen-Hoeksema and Hilt 2006).

In addition, binge drinking is a socially and physically riskier behavior for women. Women often perceive stronger

social sanctions against drinking than men (Nolen-Hoeksema and Hilt 2006; Gombert 1988; Moinddini and Goel 2016), leading them to feel more stigmatized and reluctant to engage in public drinking behaviors. Furthermore, women are disproportionately victims of physical and sexual abuse, and alcohol consumption increases their vulnerability to such crimes (Giancola 2003; Giancola and Zeichner 1995). This social and physical vulnerability likely contributes to the lower prevalence of binge drinking among women, which is typically more socially driven. In contrast, the gender difference is less pronounced in high regular alcohol consumption, which is less influenced by social contexts or public gatherings.

Compared to Italians, foreigners are less likely to consume alcohol, both regular and binge drinking. This may be due to cultural, religious, and biological differences. For instance, studies have shown how the ALDH2 genetic variant, common in East Asian populations, impairs alcohol metabolism, leading to adverse physical reactions and reducing the propensity to consume alcohol (Nakano et al. 2016; Liao et al. 2021). Additionally, in Italy, drinking is deeply integrated into the social and gastronomic life of the country, making it a prominent part of every individual's life.

Our results showed that workers are more likely to engage in binge drinking behaviors than retirees. This could be explained by work-related stressors, which increase the use and abuse of alcohol among workers, often as a maladaptive coping strategy (Colell et al. 2014). Other studies have also found increased alcohol consumption in workers relative to nonworkers, leading to the conclusion that this phenomenon results from the effects of alienation and work-related stress (Frone 1999). Another contributing factor could be related to the job performance required in the workplace, which may be incompatible with alcohol consumption during working hours. Therefore, employed individuals are more likely to drink on weekends, when they have the opportunity to rest afterward. Lastly, as previously mentioned, binge drinking occurs more frequently in social contexts. It is therefore possible to assume that social occasions are more common for working individuals than for retirees, providing them with more opportunities to engage in this behavior.

Another factor strongly correlated with alcohol consumption is age: while binge drinking is more common among younger adults, older respondents report a higher prevalence of consistent heavy drinking. This trend has also been observed in other studies where older adults regularly consumed more alcohol than younger individuals (Veerbeek et al. 2019; Moos et al. 2009; Knott et al. 2013). The prevalence of consistent heavy alcohol consumption in older adults may be explained by the fact that binge drinking, common in youth, can become a risk factor for the development of high regular alcohol consumption over time (Tavolacci et al. 2019); the development of alcohol

dependence typically takes longer than for other psychoactive substances, as alcoholism often manifests through a gradual accumulation of problem drinking behaviors and psychological adaptations, leading to the development of dependence in adulthood or later. Furthermore, from a biological perspective, older individuals seem to experience a more rapid onset of alcohol withdrawal symptoms than younger individuals, resulting in more frequent and higher consumption (Shaw et al. 2011).

To the best of our knowledge, this is the first study to investigate the effect of HL on alcohol consumption in a large and representative sample, while also distinguishing between those who engage in binge drinking and those who engage in heavy regular drinking. Among the limitations of our study, one is related to the sample selection: the PASSI system does not include the population over the age of 69, and the foreign population is highly selective, as only those with residence in the territory and able to speak Italian are included. This exclusion of older adults and non-Italian speakers is a potential source of selection bias, because these groups may have different levels of HL and different alcohol use patterns compared with the rest of the population. As a consequence, our findings cannot be generalized to the oldest age groups and to minorities with language barriers, and the prevalence of risky drinking and the strength of the associations observed in our study may underestimate the burden and inequalities in these groups. Another limitation is that alcohol consumption was self-reported. Self-reported measures of alcohol use are prone to recall errors and social desirability bias, and are likely to underestimate the true level of consumption and the prevalence of risky drinking patterns. As a consequence, the absolute prevalence estimates reported in this study may be conservative.

Moreover, the decision to exclude 2020–2021 data was motivated by the profound disruption in daily life and health-related behaviors caused by the COVID-19 pandemic and related restrictions. European studies have shown that, during the early phases of the pandemic, overall alcohol consumption often decreased among many moderate drinkers, while some high-risk and vulnerable groups increased their use and shifted towards drinking at home and in isolation (Rehm et al. 2020). By excluding these 2 years, we avoided conflating acute, context-specific changes driven by lockdown measures with more stable drinking patterns; however, our estimates cannot be extrapolated to the peak pandemic period, when alcohol availability and psychosocial stress were markedly different from usual conditions, and the 2022 data already reflect a population that had lived through 2 years of pandemic, in which persistent changes in alcohol use and in the distribution of risk factors may have influenced both prevalence and the observed associations between HL and alcohol outcomes. Finally, causality cannot be inferred from our cross-sectional data. Although we

interpreted low HL as a potential risk factor for consistent heavy drinking, reverse causality is also plausible: long-term heavy alcohol use may impair cognitive and functional abilities and negatively influence how people perceive and report their HL. Longitudinal studies are needed to disentangle these pathways.

Conclusion

In conclusion, our results suggest that HL and sociodemographic factors influence different alcohol consumption behaviors. These results highlight the need for tailored interventions to reduce these risk behaviors. At the population level, strategies to strengthen general HL and to improve the clarity and accessibility of information on alcohol-related risks may contribute to reducing habitual heavy drinking in adults, whereas structural alcohol control policies (e.g., regulation of availability, pricing, and marketing) are likely to be more relevant for preventing binge drinking, particularly among younger people. In addition, targeted HL-sensitive interventions should focus on subgroups with low education and low HL, who are at higher risk of consistent heavy drinking—for example, through tailored counselling and educational programs in primary care and community settings. In a challenging period for healthcare system sustainability, it is crucial to use economic resources efficiently and target the appropriate populations with tailored interventions.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10389-026-02690-7>.

Acknowledgements The authors extend their sincere appreciation to all the coordinators and interviewers involved in the PASSI surveillance system for their valuable contributions to data collection.

Authors' contributions Conceptualization: Patrizio Zanobini, Chiara Lorini, Valentina Saviozzi, Neda Parsa, Valentina Minardi, Valentina Possenti, Maria Masocco, Giovanna Mereu, Nadia Olimpi, Rossella Cecconi, and Guglielmo Bonaccorsi; Methodology: Patrizio Zanobini, Chiara Lorini, and Valentina Saviozzi; Formal analysis: Patrizio Zanobini; Data curation: Patrizio Zanobini, Chiara Lorini, Valentina Minardi, Valentina Possenti, and Maria Masocco; Writing—Original draft preparation: Patrizio Zanobini, Chiara Lorini, Valentina Saviozzi, Neda Parsa, and Guglielmo Bonaccorsi; Writing—Review and editing: Patrizio Zanobini, Chiara Lorini, Neda Parsa, Valentina Minardi, Valentina Possenti, Maria Masocco, Giovanna Mereu, Nadia Olimpi, Rossella Cecconi, and Guglielmo Bonaccorsi; Supervision, Valentina Saviozzi, Giovanna Mereu, Nadia Olimpi, Rossella Cecconi, and Guglielmo Bonaccorsi; Project administration: Patrizio Zanobini, Chiara Lorini, Valentina Minardi, Valentina Possenti, Maria Masocco, Giovanna Mereu, Nadia Olimpi, Rossella Cecconi, and Guglielmo Bonaccorsi. All authors have read and agreed to the published version of the manuscript.

Funding Open access funding provided by Università degli Studi di Firenze within the CRUI-CARE Agreement.

Data availability The data that support the findings of this study are drawn from the Italian Behavioral Risk Factor Surveillance System (PASSI). Due to privacy regulations and ethical restrictions related to the use of personal health data, the dataset is not publicly available. Access to the data may be granted upon reasonable request to the Istituto Superiore di Sanità, subject to approval and compliance with applicable data protection laws.

Declarations

Ethical approval This research was conducted in compliance with the principles of the Declaration of Helsinki and as part of the Italian healthcare surveillance system, PASSI (Progressi delle Aziende Sanitarie per la Salute in Italia). The Ethics Committee of the Italian National Institute of Health (Istituto Superiore di Sanità) reviewed and approved the ethical aspects of the PASSI behavioral surveillance system, under protocol number CE-ISS 06/158, dated March 8, 2007.

Conflicts of interest The authors declare no conflicts of interest.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Adams RJ, Piantadosi C, Ettridge K, Miller C, Wilson C, Tucker G, Hill CL (2013) Functional health literacy mediates the relationship between socio-economic status, perceptions and lifestyle behaviors related to cancer risk in an Australian population. *Patient Educ Couns* 91(2):206–212. <https://doi.org/10.1016/j.pec.2012.12.001>
- Anderson BO, Berdzuli N, Ilbawi A, Kestel D, Kluge HP, Krech R, Mikkelsen B, Neufeld M, Poznyak V, Rekve D, Slama S, Tello J, Ferreira-Borges C (2023) Health and cancer risks associated with low levels of alcohol consumption. *Lancet Public Health* 8(1):e6–e7. [https://doi.org/10.1016/S2468-2667\(22\)00317-6](https://doi.org/10.1016/S2468-2667(22)00317-6)
- Ajzen I (1991) The theory of planned behavior. *Organizational Behavior and Human Decision Processes* 50(2):179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Baldissera S, Campostrini S, Binkin N, Minardi V, Minelli G, Ferrante G, Salmaso S, PASSI Coordinating Group (2011) Features and initial assessment of the Italian Behavioral Risk Factor Surveillance System (PASSI), 2007–2008. *Preventing Chronic Disease* 8(1):A24
- Baldissera S, Ferrante G, Quarchioni E, Minardi V, Possenti V, Carrozzi G, Masocco M, Salmaso S (2014) Field substitution of nonresponders can maintain sample size and structure without altering survey estimates—the experience of the Italian behavioral risk factors surveillance system (PASSI). *Ann Epidemiol* 24(4):241–245. <https://doi.org/10.1016/j.annepidem.2013.12.003>
- Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K (2011) Low health literacy and health outcomes: an updated systematic

- review. *Annals of Internal Medicine* 155(2):97–107. <https://doi.org/10.7326/0003-4819-155-2-201107190-00005>
- Brandt L, Schultes MT, Yanagida T, Maier G, Kollmayer M, Spiel C (2019) Differential associations of health literacy with Austrian adolescents' tobacco and alcohol use. *Public Health* 174:74–82. <https://doi.org/10.1016/j.puhe.2019.05.033>
- Buja A, Rabensteiner A, Sperotto M, Grotto G, Bertoncello C, Cocchio S, Baldovin T, Contu P, Lorini C, Baldo V (2020) Health literacy and physical activity: a systematic review. *J Phys Act Health* 17(12):1259–1274. <https://doi.org/10.1123/jpah.2020-0161>
- Centers for Disease Control and Prevention (CDC) (2025) Alcohol use and your health. <https://www.cdc.gov/alcohol/about-alcohol-use/index.html>. Accessed 16 June 2025.
- Chisolm DJ, Manganello JA, Kelleher KJ, Marshal MP (2014) Health literacy, alcohol expectancies, and alcohol use behaviors in teens. *Patient Educ Couns* 97(2):291–296. <https://doi.org/10.1016/j.pec.2014.07.019>
- Colell E, Sánchez-Niubò A, Benavides FG, Delclos GL, Domingo-Salvany A (2014) Work-related stress factors associated with problem drinking: a study of the Spanish working population. *Am J Ind Med* 57(7):837–846. <https://doi.org/10.1002/ajim.22333>
- Dermota P, Wang J, Dey M, Gmel G, Studer J, Mohler-Kuo M (2013) Health literacy and substance use in young Swiss men. *Int J Public Health* 58(6):939–948. <https://doi.org/10.1007/s00038-013-0487-9>
- Ely M, Hardy R, Longford NT, Wadsworth ME (1999) Gender differences in the relationship between alcohol consumption and drink problems are largely accounted for by body water. *Alcohol Alcohol* 34(6):894–902. <https://doi.org/10.1093/alcalc/34.6.894>
- Frone MR (1999) Work stress and alcohol use. *Alcohol Res Health* 23(4):284–291
- Giancola PR (2003) The moderating effects of dispositional empathy on alcohol-related aggression in men and women. *J Abnorm Psychol* 112(2):275–281. <https://doi.org/10.1037/0021-843X.112.2.275>
- Giancola PR, Zeichner A (1995) An investigation of gender differences in alcohol-related aggression. *J Stud Alcohol* 56(5):573–579. <https://doi.org/10.15288/jsa.1995.56.573>
- Gilmore W, Chikritzhs T, Stockwell T, Jernigan D, Naimi T, Gilmore I (2016) Alcohol: taking a population perspective. *Nat Rev Gastroenterol Hepatol* 13(7):426–434. <https://doi.org/10.1038/nrgastro.2016.70>
- Gomberg ES (1988) *Alcoholic women in treatment: the question of stigma and age*. Alcohol and Alcoholism (Oxford, Oxfordshire) 23(6):507–514
- Jayasinghe UW, Harris MF, Parker SM, Litt J, van Driel M, Mazza D, del Mar C, Lloyd J, Smith J, Zwar N, Taylor R (2016) The impact of health literacy and lifestyle risk factors on health-related quality of life of Australian patients. *Health Qual Life Outcomes* 14(1):68. <https://doi.org/10.1186/s12955-016-0471-1>
- Knott CS, Scholes S, Shelton NJ (2013) Could more than three million older people in England be at risk of alcohol-related harm? A cross-sectional analysis of proposed age-specific drinking limits. *Age Ageing* 42(5):598–603. <https://doi.org/10.1093/ageing/afu039>
- Lee SYD, Tsai TI, Tsai YW, Kuo KN (2010) Health literacy, health status, and healthcare utilization of Taiwanese adults: results from a national survey. *BMC Public Health* 10(1):614. <https://doi.org/10.1186/1471-2458-10-614>
- Liao WL, Chan FC, Chang KP, Chang YW, Chen CH, Su WH, Chang HH (2021) Associations between ALDH genetic variants, alcohol consumption, and the risk of nasopharyngeal carcinoma in an East Asian population. *Genes* 12(10):1547. <https://doi.org/10.3390/genes12101547>
- Lincoln A, Paasche-Orlow MK, Cheng DM, Lloyd-Travaglini C, Caruso C, Saitz R, Samet JH (2006) Impact of health literacy on depressive symptoms and mental health-related quality of life among adults with addiction. *J Gen Intern Med* 21(8):818–822. <https://doi.org/10.1111/j.1525-1497.2006.00533.x>
- Liu YB, Liu L, Li YF, Chen YL (2015) Relationship between health literacy, health-related behaviors and health status: a survey of elderly Chinese. *Int J Environ Res Public Health* 12(8):9714–9725. <https://doi.org/10.3390/ijerph120809714>
- Lorini C, Lastrucci V, Mantwill S, Vettori V, Bonaccorsi G, Florence Health Literacy Research Group (2019) Measuring health literacy in Italy: a validation study of the HLS-EU-Q16 and of the HLS-EU-Q6 in Italian language, conducted in Florence and its surroundings. *Annali dell'Istituto Superiore di Sanità* 55(1):10–18. https://doi.org/10.4415/ANN_19_01_04
- Moinuddin A, Goel A (2016) Alcohol consumption and gender: a critical review. *Journal of Psychology & Psychotherapy* 6(3):1000267. <https://doi.org/10.4172/2161-0487.1000267>
- Moos RH, Schutte KK, Brennan PL, Moos BS (2009) Older adults' alcohol consumption and late-life drinking problems: a 20-year perspective. *Addiction* 104(8):1293–1302. <https://doi.org/10.1111/j.1360-0443.2009.02604.x>
- Nakano Y, Ochi H, Onohara Y, Sairaku A, Tokuyama T, Matsumura H, Tomomori S, Amioka M, Hironomobe N, Motoda C, Oda N, Chayama K, Chen CH, Gross ER, Mochly-Rosen D, Kihara Y (2016) Genetic variations of aldehyde dehydrogenase 2 and alcohol dehydrogenase 1B are associated with the etiology of atrial fibrillation in Japanese. *J Biomed Sci* 23(1):89. <https://doi.org/10.1186/s12929-016-0304-x>
- Nolen-Hoeksema S, Hilt L (2006) Possible contributors to the gender differences in alcohol use and problems. *J Gen Psychol* 133(4):357–374. <https://doi.org/10.3200/GENP.133.4.357-374>
- Nutbeam D, Lloyd JE (2021) Understanding and responding to health literacy as a social determinant of health. *Annu Rev Public Health* 42(1):159–173. <https://doi.org/10.1146/annurev-publhealth-090419-102529>
- Rehm J, Shield KD (2019) Global burden of alcohol use disorders and alcohol liver disease. *Biomedicine* 7(4):99. <https://doi.org/10.3390/biomedicine7040099>
- Rehm J, Kilian C, Ferreira-Borges C, Jernigan D, Monteiro M, Parry CDH, Sanchez ZM, Manthey J (2020) Alcohol use in times of the COVID-19: implications for monitoring and policy. *Drug Alcohol Rev* 39:301–304. <https://doi.org/10.1111/dar.13074>
- Rooke SE, Hine DW, Thorsteinsson EB (2011) A dual process account of adolescent and adult binge drinking. *Addict Behav* 36(4):341–346. <https://doi.org/10.1016/j.addbeh.2010.12.008>
- Rosenstock IM (1974) The health belief model and preventive health behavior. *Health Educ Monogr* 2(4):354–386. <https://doi.org/10.1177/109019817400200405>
- Schuckit MA (2009) Alcohol-use disorders. *Lancet* 373(9662):492–501. [https://doi.org/10.1016/S0140-6736\(09\)60009-X](https://doi.org/10.1016/S0140-6736(09)60009-X)
- Shaw BA, Krause N, Liang J, McGeever K (2011) Age differences in long-term patterns of change in alcohol consumption among aging adults. *J Aging Health* 23(2):207–227. <https://doi.org/10.1177/0898264310381276>
- Sørensen K, van den Broucke S, Pelikan JM, Fullam J, Doyle G, Slonska Z, Kondilis B, Stoffels V, Osborne RH, Brand H (2013) Measuring health literacy in populations: illuminating the design and development process of the European Health Literacy Survey Questionnaire (HLS-EU-Q). *BMC Public Health* 13(1):948. <https://doi.org/10.1186/1471-2458-13-948>
- Stacy AW, Wiers RW (2010) Implicit cognition and addiction: a tool for explaining paradoxical behavior. *Annu Rev Clin Psychol* 6:551–575. <https://doi.org/10.1146/annurev.clinpsy.121208.131444>
- Stewart DW, Adams CE, Cano MA, Correa-Fernández V, Li Y, Waters AJ, Wetter DW, Vidrine JI (2013) Associations between health literacy and established predictors of smoking cessation. *Am J Public Health* 103(7):e43–e49. <https://doi.org/10.2105/AJPH.2012.301062>

- Stielke A, Dyakova M, Ashton K, van Dam T (2019) The social and economic benefit of health literacy interventions in the WHO EURO region. *Eur J Public Health* 29(Suppl 4):ckz186.390. <https://doi.org/10.1093/eurpub/ckz186.390>
- Stokkeland K, Hilm G, Spak F, Franck J, Hultcrantz R (2008) Different drinking patterns for women and men with alcohol dependence with and without alcoholic cirrhosis. *Alcohol Alcohol* 43(1):39–45. <https://doi.org/10.1093/alcalc/agm135>
- Tavolacci MP, Berthon Q, Cerasuolo D, Dechelotte P, Ladner J, Baguet A (2019) Does binge drinking between the age of 18 and 25 years predict alcohol dependence in adulthood? A retrospective case–control study in France. *BMJ Open* 9(5):e026375. <https://doi.org/10.1136/bmjopen-2018-026375>
- The HLS19 Consortium of the WHO Action Network M-POHL (2021) International report on the methodology, results, and recommendations of the European Health Literacy Population Survey 2019–2021 (HLS19) of M-POHL. Austrian National Public Health Institute, Vienna. Available at: https://m-pohl.net/Int_Report_methodology_results_recommendations
- Veerbeek MA, ten Have M, van Dorsselaer SA, Oude Voshaar RC, Rhebergen D, Willemse BM (2019) Differences in alcohol use between younger and older people: results from a general population study. *Drug Alcohol Depend* 202:18–23. <https://doi.org/10.1016/j.drugalcdep.2019.04.023>
- Wiers RW, Stacy AW (2006) Implicit cognition and addiction. *Curr Dir Psychol Sci* 15(6):292–296. <https://doi.org/10.1111/j.1467-8721.2006.00455.x>
- Wilsnack SC, Wilsnack RW, Hiller-Sturmhöfel S (1994) How women drink: epidemiology of women's drinking and problem drinking. *Alcohol Health Res World* 18(3):173–181
- World Health Organization (WHO) (2021) Health promotion glossary of terms 2021. <https://iris.who.int/bitstream/handle/10665/350161/9789240038349-eng.pdf>. Accessed 16 June 2025.
- World Health Organization (WHO) (2024) Global status report on alcohol and health and treatment of substance use disorders. <https://www.who.int/publications/i/item/9789240096745>. Accessed 16 June 2025.
- Zanobini P, Lorini C, Lastrucci V, Minardi V, Possenti V, Masocco M, Garofalo G, Mereu G, Bonaccorsi G (2021) Health literacy, socioeconomic determinants, and healthy behaviours: results from a large representative sample of Tuscany Region, Italy. *Int J Environ Res Public Health* 18(23):12432. <https://doi.org/10.3390/ijerph182312432>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.