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RESEARCH REPORT

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Identifying hazardous alcohol use in primary care using phosphatidylethanol: Timing of screening matters

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Abstract

Background and Aims: Alcohol is a well-established risk factor for numerous health conditions, making screening for hazardous alcohol use in healthcare a critical task. While self-reported data suggest that alcohol consumption varies across seasons, this seasonal fluctuation has not yet been confirmed using objective biological markers. This study aimed to measure whether phosphatidylethanol (PEth) captures variations in hazardous alcohol use across two temporal resolutions: month of the year and day of the week.

Design: Observational cross-sectional study based on data from medical records.

Setting: Healthcare services, Region Dalarna, Sweden, between 2017 and 2023.

Participants/Cases: Adult patients (n = 62 431, 50% females) screened for hazardous alcohol use with PEth within primary care.

Measurements: This study utilizes test results from PEth, with results >0.30 μmol/l defined as hazardous alcohol use. We compared the prevalence of hazardous alcohol use across months and weekdays using logistic regression while adjusting for sex, age, smoking status, the Charlson Comorbidity Index and psychiatric diagnoses.

Findings: The prevalence of hazardous alcohol use increased between May and August, ranging from 13.2% to 15.9%, compared with 10.7% in November. This corresponds to a 48% relative increase in the peak month of July [prevalence ratio (PR) = 1.48, 95% confidence interval (CI) = 1.33–1.64]. Hazardous alcohol use was also more prevalent among patients tested on Mondays (13.0%) compared with Thursdays, with the lowest prevalence (12.0%). The difference was particularly pronounced among female patients, with a 14.0% higher relative prevalence on Mondays (PR = 1.14, 95% CI = 1.02–1.27).

Conclusions: In Sweden, the prevalence of hazardous alcohol use appears to fluctuate seasonally and, to a lesser extent, across weekdays, as measured by blood tests for phosphatidylethanol, a biomarker for hazardous alcohol use. November showed the lowest prevalence and July the highest, consistent across age, sex and the year of the observational period. Hazardous alcohol use showed a slight elevation of prevalence during Mondays compared with Tuesday to Friday.

KEYWORDS
alcohol, assessment, biomarker, PEth, phosphatidylethanol, screening, seasonal bias, time-based bias

INTRODUCTION

Alcohol is a modifiable contributor to several diseases that are estimated to cause 3 million deaths annually worldwide [1]. A systematic review showed a monotonic relationship between increased alcohol consumption and risk of several diagnostic categories, such as cancer, liver diseases, infectious diseases, non-ischemic cardiovascular diseases and injuries [2]. Alcohol can also cause harm to others through alcohol use during pregnancy, an increased risk of violence and an increased risk of injury to others, for example in traffic incidents when driving under the influence [2]. An important task for healthcare is to identify hazardous alcohol use by screening and then – if necessary – offer interventions for patients to reduce consumption. Hitherto, mainly screening based on self-report of alcohol consumption has been utilized in healthcare, which is useful but not without limitations. Uncertainty regarding what constitutes a standard drink, difficulties in recalling consumption and social desirability have been highlighted as biases in these estimates [3, 4].

Consequently, alcohol biomarkers have become more common in healthcare. During the past decade, the use of blood tests for phosphatidylethanol (PEth) have markedly increased within Swedish healthcare [5, 6]. PEth is a specific and sensitive biomarker formed from phosphatidylcholine and ethanol in the cell membrane, able to detect hazardous alcohol use in the previous 2–4 weeks [6]. It has been proposed as a reliable indicator of alcohol consumption, with high sensitivity and specificity [6, 7]. Standard guidelines in Swedish healthcare define 0.05 μmol/L (approx. 35 μg/L) as the lower detection limit and >0.30 μmol/L (approx. 210 μg/L) as the threshold for hazardous alcohol use, indicating regular and high consumption [6]. The half-life of PEth, in the absence of new formation, has been reported to vary widely among individuals [6, 8], with a mean half-life of 4 days [9]. Another study among heavy drinkers reported a median half-life of 6 days [10], and for some individuals it has been reported to be as low as 2.3 days [11].

Despite increased use within healthcare, questions remain regarding the use of PEth as a marker for hazardous alcohol use. One apparent difference is the time frame of the assessment. For example, the commonly used screening tool the Alcohol Use Disorders Identification Test (AUDIT) [12] assesses consumption 'on a typical day when you are drinking', and aims to estimate 'drinking habits during the past year'.

One aspect of screening for hazardous alcohol use is that consumption fluctuates over time and follows a seasonal variation, a fact known for half a century through studies of surveys and sales data [12]. Data from self-reported past 30-day alcohol consumption highlight December and July as the peak of consumption in the northern hemisphere [13]. In addition to seasonal variation, for some individuals, alcohol use is mainly concentrated on weekends and holidays, and weekdays in between are characterized by much lower consumption levels or abstinence [14]. Hence, the timing of screening (i.e. the season and day of the week) might affect the reported prevalence of hazardous alcohol use among patients, particularly when PEth is utilized for estimations, with its shorter time frame, compared with methods assessing alcohol use patterns over more extended periods.

To our knowledge, no study has hitherto investigated whether PEth results are sensitive to the timing of screening and to what extent the known self-reported seasonal variations in alcohol consumption influence the prevalence of hazardous alcohol use measured with PEth. In addition, it remains to be investigated whether increased alcohol use during weekends is reflected in PEth sampled early in the week. Therefore, this study aims to examine whether PEth captures variations in hazardous alcohol use across two temporal resolutions: month of the year and weekday.

METHODS

Design

This cross-sectional study was based on medical records from Region Dalarna. The data consisted of results from venous blood samples tested for PEth 16:0/18:1 collected within primary care in Region Dalarna between January 2017 and December 2023. The study population included all adult patients of legal drinking age (≥18 years) screened with PEth within primary care. The study was approved by the Swedish Ethical Review Authority, registration number 2023–07540–01. Neither this study nor its analytical protocol was pre-registered.

Hazardous alcohol use

Guidelines applied within Region Dalarna healthcare recommend that physicians within primary care include PEth in screening when a patient presents with symptoms that could potentially be related to hazardous alcohol consumption. Examples of these are increased fatigue, sleep difficulties, anxiety, depression, palpitations (sometimes atrial fibrillation), gastrointestinal issues, high blood pressure (especially diastolic) and elevated liver enzymes. Hazardous alcohol use can be defined as a level or pattern of alcohol consumption that increases the risk of adverse health outcomes for patients [15], and was defined as a PEth test result of >0.30 μmol/L [16]. This threshold has been applied within Swedish healthcare during this period and indicates frequent, high intake of alcohol at hazardous levels [6, 16]. To prevent any imbalance arising from patients being selected for repeated testing, the first recorded test within the observational period was selected for all patients. Similarly, we excluded any weekend tests as typically they are sampled during emergency visits carried out within primary care. PEth was analyzed with a verified method by liquid chromotography–tandem mass spectrometry (LC–MS/MS) using API4000 (Sciex, Toronto, Canada) [17].

Setting

Dalarna is a region in Sweden with approximately 280 000 inhabitants. The health records utilized have full coverage of data collected within Region Dalarna healthcare. Results from PEth analysis were retrieved from medical journals within primary care. In addition, all diagnoses within Region Dalarna healthcare during 2013–2023 were retrieved for each screened patient with their *International Statistical Classification of Diseases and Related Health Problems, 10th Revision* (ICD-10) code (i.e. also including specialized care because some diagnosis requires specialists). Age, sex, marital status and demographic characteristics at the time point of the index PEth test were collected from the DalFolke register. Smoking status was collected from the patient's medical journal.

Data preparation

The PEth results were dichotomized, with results >0.30 μmol/L coded as hazardous alcohol use. The seasonality indicators of interest were calendar month and weekday (Monday–Friday), with both extracted from the PEth test date. Information was also obtained to account for patient characteristics potentially associated with both the seasonality indicators and the outcome, and a Charlson comorbidity index (CCI) [18] was calculated from ICD-10 diagnoses registered in patients' health records over a period of 11 years (2013–2023). Several versions of the CCI have been used since its inception, and the version in the present study is the adaptation weighted for Swedish register studies (CCIw) [19]. The CCIw includes the following diseases: 'myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, pulmonary diseases, rheumatic disease, dementia, hemiplegia, diabetes, chronic kidney disease, liver disease, peptic ulcer disease, cancer and HIV/AIDS' [19, p. 21]. Each condition was assigned a weighted score from 1 to 6 depending on their predicted 1-year mortality, resulting in an overall score ranging between 0 and 17. As the CCIw does not include psychiatric diagnoses, an additional index for psychiatric status was calculated by summing the number of unique ICD-10 F-chapter diagnoses, excluding F0 diagnoses of organic disease (e.g. dementia), yielding a total score between 0 and 9.

Statistical analysis

Seasonality in hazardous alcohol use was assessed by calendar month and by weekday in two multivariable logistic regression models of complete cases. In both models, the seasonality indicator (either the months January–December or the weekdays Monday–Friday) was included as a factor, alongside sex (female or male), four age groups (18–34, 35–49, 50–65 or 65+ years), and their interactions. To mitigate potential confounding, both models were adjusted for the patient's smoking status (non-smoker, smoker or missing data, which was dummy-coded as unknown), the CCIw (as cubic polynomial), the number of unique ICD-10 F-chapter diagnoses (as cubic polynomial) and the year of the PEth test (2017–2023, as a factor). From the models we calculated the marginal probabilities of hazardous alcohol use by marginal standardization [20], with inference based on the delta method, and compared them across months and weekdays, both overall and separately by sex and age group (marginaleffects 0.22.0 in R 4.4.1) [21]. Finally, we evaluated the robustness of our results in three sensitivity analyses: (1) repeating the same protocol using a cut-off of 0.12 μmol/L, as defined by Skråstad *et al.* [22]; (2) repeating the same protocol using a cut-off of 0.22 μmol/L, as defined by Hammarberg *et al.* [5]; and (3) based on a model of the 90th percentile using quantile regression (quantreg 5.98 in R 4.4.1).

RESULTS

A total of 110 447 PEth results in 63 497 unique primary care patients from 2017 to 2023 were first extracted, and PEth results from 62 431 patients were included in the analysis. The following test results (no unique patient excluded) were excluded: n = 1069 (n = 916) patients below the age of 18 years; n = 194 (n = 85) weekend tests; n = 46 688 repeated tests; and n = 65 (n = 65) invalid tests. The number of tests conducted during the summer was lower compared with other months. In July, 3129 tests were performed, whereas 6499 tests were conducted in October. There were also fewer patients tested on Fridays (n = 9543) compared with Tuesdays (n = 13 927). For the number of tests and patient characteristics by month and weekday, see Tables S2 and S3.

Overall, males were more often identified with hazardous alcohol use, and the highest prevalence of hazardous alcohol use was found among male patients between the ages of 50 and 65 years. Patients who screened positive for hazardous alcohol use were more often smokers (27% vs 12%), divorced (24% vs 17%) and had more psychiatric diagnoses and higher CCIw scores (i.e. had more severe somatic diagnoses). Table 1 describes the cohort (see Table S1 for patient characteristics by sex).

Prevalence of hazardous alcohol use by month

Figure 1 displays the estimated prevalence of hazardous alcohol use among primary care patients during the 7-year period. November had the lowest overall prevalence (10.7%) of patients with hazardous alcohol use, whereas the highest overall prevalence was observed in July (15.9%). The seasonal variation in prevalence remained consistent when stratifying the patients by sex and age (Figure 2), albeit with a systematically higher prevalence in males and patients aged 50–65 years. There was also an increase in patients identified with hazardous alcohol use during December and January, during and after the Christmas and New Year holidays. Table 2 presents marginal estimates of hazardous alcohol use by month based on our multivariable model, whereas supplementary Figures S1 and S2 present the observed monthly prevalence. Finally, our results remained consistent in the sensitivity analyses (Table S4).

TABLE 1 Patient characteristics.

Variable	Full sample, *n* = 62431[a]	PEth ≤ 0.30 μmol/L, *n* = 54 742[a]	PEth > 0.30 μmol/L, *n* = 7689[a]
Sex			
Female	31 273 (50%)	28 653 (53%)	2620 (34%)
Male	30 900 (50%)	25 868 (47%)	5032 (66%)
Unknown	258	221	37
Age, years	58 (18)	58 (19)	60 (14)
Age category			
18–34 years	9068 (15%)	8615 (16%)	453 (5.9%)
35–49 years	10 178 (16%)	9116 (17%)	1062 (14%)
50–65 years	17 707 (28%)	14 683 (27%)	3024 (39%)
65+ years	25 478 (41%)	22 328 (41%)	3150 (41%)
Marital status			
Partner	22 776 (39%)	20 100 (39%)	2676 (38%)
Single	20 579 (35%)	18 324 (36%)	2255 (32%)
Divorced	10 254 (18%)	8578 (17%)	1676 (24%)
Widow/widower	4785 (8.2%)	4316 (8.4%)	469 (6.6%)
Unknown	4037	3424	613
CCIw	1.14 (1.83)	1.13 (1.81)	1.24 (1.90)
Unknown	5	4	1
Number of psychiatric diagnoses (ICD-10 F-chapters 1–9)	0.97 (1.11)	0.94 (1.10)	1.19 (1.15)
Unknown	5	4	1
Smoking			
Yes	8533 (14%)	6464 (12%)	2069 (27%)
No	43 685 (70%)	39 413 (72%)	4272 (56%)
Unknown	10 213 (16%)	8865 (16%)	1348 (17%)

Abbreviations: CCIw, weighted Charlson comorbidity index; ICD-10, *International Statistical Classification of Diseases and Related Health Problems, 10th Revision*.
[a]*n* (%); mean (SD).

Prevalence of hazardous alcohol use by weekday

Figure 3 displays the estimated prevalence of hazardous alcohol use by weekday for all patients combined, whereas Figure 4 displays this stratified by sex and age groups. We found the highest overall prevalence of primary care patients with hazardous alcohol use on Mondays (13%), and the lowest overall prevalence (12%) on Thursdays. There was a slight significant decline in the prevalence from Monday to Tuesday and then a slight increase on Fridays. Based on our adjusted model, there was a 14% relative increase in hazardous alcohol use among female patients on Mondays compared with Thursdays. Among other subgroups, this decline was most prominent among males aged 18–35 years and females aged 35–49 years. Table 3 presents marginal estimates of hazardous alcohol use by weekday based on our multivariable model, whereas Figures S3 and S4 present the observed prevalence per weekday. Finally, our results remained consistent in the sensitivity analyses (Table S5).

DISCUSSION

Based on PEth test results from 62 431 primary care patients, our results confirmed the seasonal variation in the prevalence of hazardous alcohol use previously reported. November showed the lowest prevalence and July the highest, which was consistent across age, sex and year of observational period. To a lesser extent, hazardous alcohol use also differed across weekdays, with a slight elevation of prevalence on Monday compared with Tuesday–Friday.

The seasonal variation in consumption reflected in PEth concentrations thus aligns with previous studies using self-reported data. Sweden has a climate with distinct seasons and an established vacation period during July. Likewise, similar summer patterns have been reported in Australia, where November was the peak month [23]. There are seasonal variations in healthcare-seeking for conditions where hazardous alcohol use is a risk factor, mirroring the variations in the present study. One such, the 'holiday heart syndrome', discussed in the literature for almost half a century, describes atrial

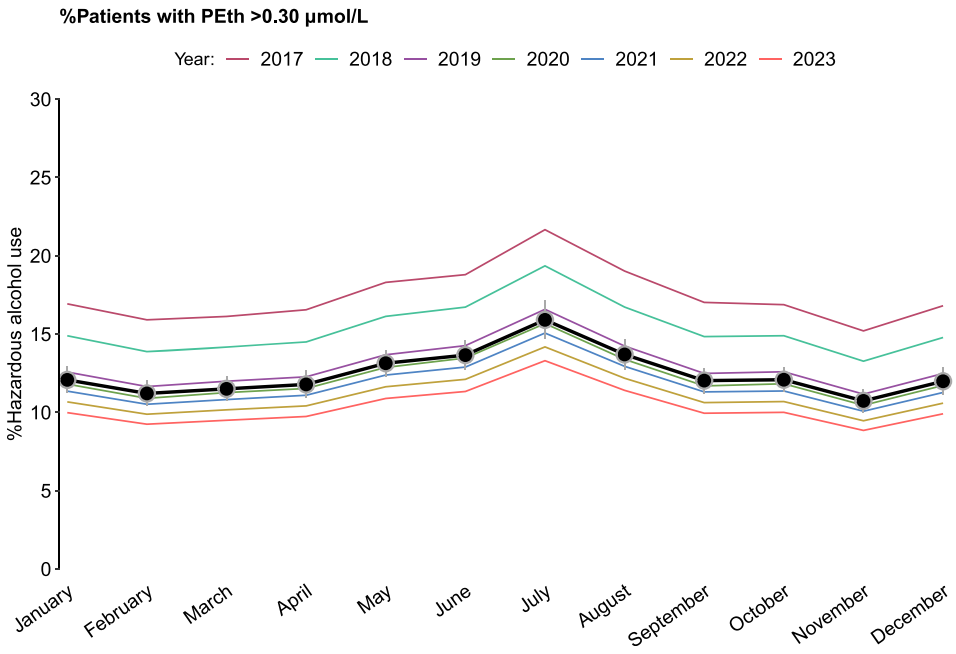

FIGURE 1 Percent of patients with hazardous alcohol use per month. Points denote marginal point estimates with 95% confidence intervals (95% CIs) from our multivariable logistic regression model. Lines denote marginal point estimates by year.

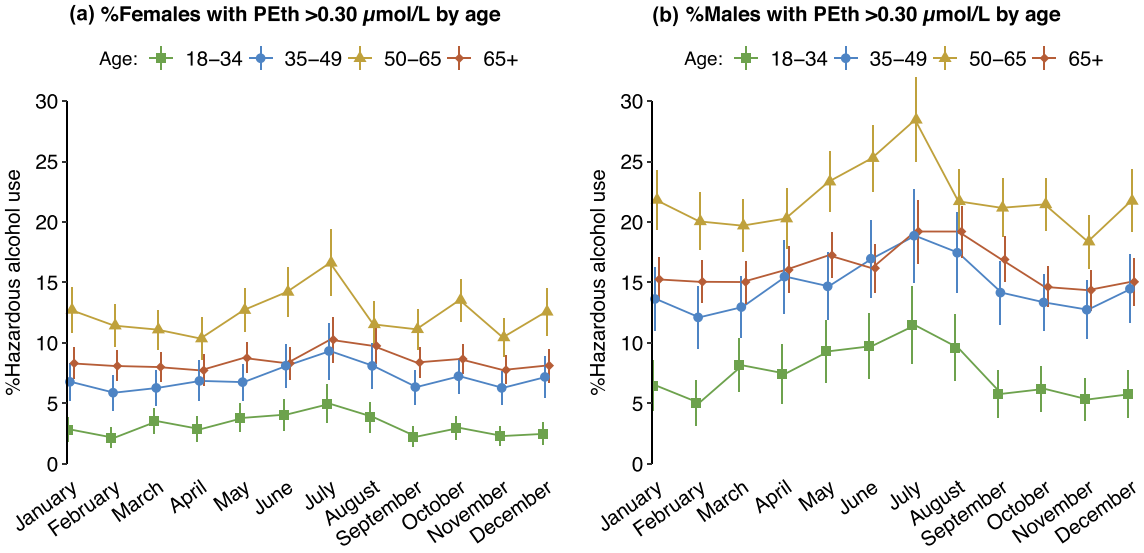

FIGURE 2 Percent of patients with hazardous alcohol use per month by sex and age group. Points denote marginal point estimates with 95% confidence intervals (95% CIs) from our multivariable logistic regression model.

fibrillation and other types of arrhythmias that can occur during or after holidays, particularly in conjunction with excessive alcohol consumption [24]. The Christmas holiday is another time point described when the risk of cardiac mortality is the highest, with alcohol use as a contributory factor [25, 26]. In addition, during summertime, hospital admissions for alcohol-related hepatitis peak in July [27].

Apart from time off work, national holidays, such as the Swedish Midsummer Eve party at the end of June or the Christmas holiday, provide another partial explanation for seasonal differences.

Moreover, data on psychiatric diagnoses in Sweden and Finland show the opposite pattern, with a drop during summer followed by an increase in depressive disorders and ADHD diagnoses during the fall [28, 29]. This aligns with data on treatment-seeking for alcohol use disorder in Danish health registers, which showed that treatment entries drop during periods of high consumption (July and December) and thereafter increase [30]. This is putatively a delayed effect arising from concerns raised from a period of hazardous alcohol use in combination with increased demands from work during periods following a holiday. In all, this points towards a heightened awareness of the increased risk of hazardous alcohol use during certain times of the year, and our results confirm that PEth captures this seasonal pattern. It is noteworthy that although we observed a lower prevalence of hazardous alcohol use during autumn and February, public health initiatives such as 'Dry January' or 'Sober October' that prompt

TABLE 2 Hazardous alcohol use by month, for patients overall and divided by sex.

	Overall		Females		Males	
	Prevalence (95% CI)	Prevalence ratio (95% CI)	Prevalence (95% CI)	Prevalence ratio (95% CI)	Prevalence (95% CI)	Prevalence ratio (95% CI)
January	12.1 (11.2, 12.9)	1.12 (1.02, 1.24)	8.4 (7.3, 9.4)	1.13 (0.95, 1.35)	15.8 (14.5, 17.1)	1.12 (0.99, 1.26)
February	11.2 (10.4, 12.0)	1.04 (0.94, 1.15)	7.7 (6.7, 8.7)	1.04 (0.87, 1.24)	14.7 (13.5, 16.0)	1.05 (0.92, 1.18)
March	11.5 (10.7, 12.3)	1.07 (0.97, 1.19)	7.9 (6.9, 8.8)	1.07 (0.90, 1.27)	15.2 (14.0, 16.5)	1.08 (0.96, 1.22)
April	11.8 (11.0, 12.7)	1.10 (1.00, 1.22)	7.6 (6.5, 8.6)	1.02 (0.85, 1.23)	16.1 (14.7, 17.5)	1.15 (1.01, 1.29)
May	13.2 (12.3, 14.0)	1.23 (1.12, 1.35)	8.7 (7.7, 9.8)	1.19 (1.00, 1.40)	17.7 (16.3, 19.0)	1.25 (1.11, 1.41)
June	13.7 (12.7, 14.6)	1.28 (1.16, 1.41)	9.2 (8.1, 10.4)	1.25 (1.05, 1.49)	18.2 (16.6, 19.7)	1.29 (1.14, 1.45)
July	15.9 (14.6, 17.1)	1.48 (1.33, 1.64)	11.0 (9.5,12.5)	1.49 (1.24, 1.79)	20.8 (18.9, 22.7)	1.48 (1.30, 1.68)
August	13.7 (12.8, 14.7)	1.28 (1.16, 1.41)	9.0 (7.9, 10.2)	1.22 (1.03, 1.46)	18.4 (16.9, 20.0)	1.31 (1.16, 1.48)
September	12.0 (11.2, 12.8)	1.12 (1.02, 1.24)	7.8 (6.8, 8.8)	1.06 (0.89, 1.26)	16.3 (15.0, 17.6)	1.16 (1.03, 1.30)
October	12.1 (11.3, 12.8)	1.12 (1.02, 1.24)	8.8 (7.9, 9.8)	1.20 (1.02, 1.41)	15.3 (14.1, 16.5)	1.08 (0.96, 1.22)
November	10.7 (10.0, 11.5)	Ref.	7.4 (6.5, 8.3)	Ref.	14.1 (12.9, 15.3)	Ref.
December	12.0 (11.1, 12.9)	1.12 (1.01, 1.24)	8.3 (7.2, 9.4)	1.12 (0.94, 1.35)	15.7 (14.3, 1 7.1)	1.11 (0.98, 1.26)

Note: Marginal point estimates with 95% confidence intervals based on our multivariable logistic regression model.

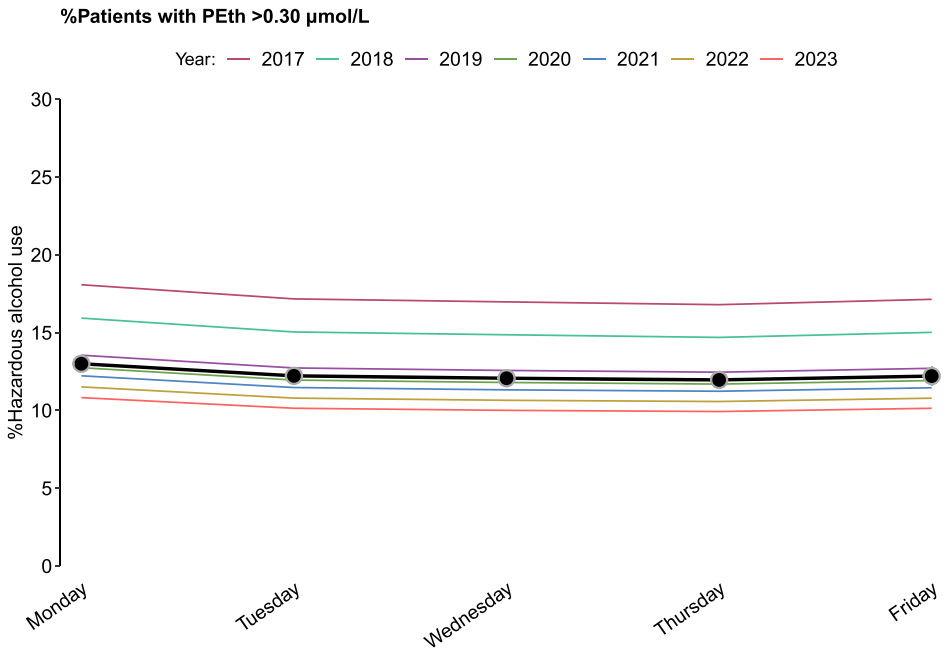

FIGURE 3 Percent of patients with hazardous alcohol use per weekday. Points denote marginal point estimates with 95% confidence intervals (95% CIs) from our multivariable logistic regression model. Lines denote marginal point estimates by year.

drinkers to be abstinent for one month [31] have not been implemented in Sweden. This raises questions about whether campaigns for moderation or abstention should be directed towards periods of more prevalent hazardous alcohol use.

We found a small but significantly higher prevalence (1% absolute increase) of hazardous alcohol use among patients tested on Mondays compared with Thursdays. The clinical relevance of this is questionable, but the more pronounced difference among specific subgroups is worth noting. Females and males aged 18–34 years showed more differences in prevalence on different weekdays, and weekend alcohol use among those groups might partly explain this. It is also noteworthy that those groups, females and males of younger age, showed an overall lower prevalence of hazardous alcohol use compared with middle-aged patients. This reflects the trend in recent years that younger generations seem to drink less, an observation coined as the 'sober generation' [32]. However, episodes of weekend binge alcohol use could, in itself, be problematic and cause harm to the individual and their surroundings.

On the other hand, studies show that, typically, weekend alcohol use is more often driven by social and enhancement motives, whereas alcohol use during weekdays is more often a coping mechanism [33]. Nevertheless, a PEth value of >0.30 µmol/L does not solely result from a single episode of heavy alcohol use. Still, for some patients, it is plausible that heavy binge alcohol use during weekends might push

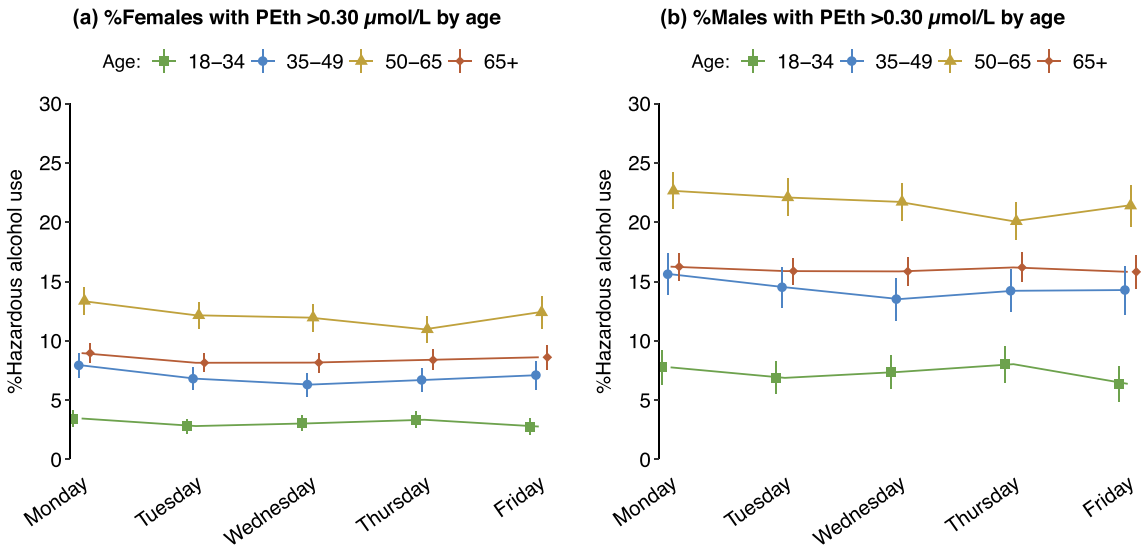

FIGURE 4 Percent of patients with hazardous alcohol use per weekday by sex and age group. Points denote marginal point estimates with 95% confidence intervals (95% CIs) from our multivariable logistic regression model.

TABLE 3 Hazardous alcohol use identified during different weekdays, for patients overall and divided by sex.

	Overall		Females		Males	
	Prevalence (95% CI)	Prevalence ratio (95% CI)	Prevalence (95% CI)	Prevalence ratio (95% CI)	Prevalence (95% CI)	Prevalence ratio (95% CI)
Monday	13.0 (12.4, 13.5)	1.09 (1.02, 1.16)	9.1 (8.5, 9.8)	1.14 (1.02, 1.27)	16.9 (16.0, 17.8)	1.06 (0.98, 1.14)
Tuesday	12.2 (11.7, 12.7)	1.02 (0.96, 1.09)	8.2 (7.6, 8.8)	1.02 (0.91, 1.14)	16.3 (15.5, 17.2)	1.02 (0.95, 1.10)
Wednesday	12.1 (11.5, 12.6)	1.01 (0.95, 1.08)	8.1 (7.4, 8.7)	1.01 (0.90, 1.13)	16.1 (15.3, 17.0)	1.01 (0.94, 1.09)
Thursday	12.0 (11.4, 12.5)	Ref.	8.0 (7.3, 8.7)	Ref.	15.9 (15.1, 16.8)	Ref.
Friday	12.2 (11.6, 12.8)	1.02 (0.95, 1.10)	8.5 (7.7, 9.3)	1.06 (0.93, 1.20)	16.0 (15.0, 17.0)	1.00 (0.92, 1.09)

Note: Marginal point estimates with 95% confidence intervals based on our multivariable logistic regression model.

the result above this threshold. Noteworthy is that there are no known sources of bias related to age or frailty, such as liver disease, affecting these variations across age groups [7, 34]. In a clinical setting, assessing hazardous alcohol use should involve a compound measure along with PEth, with sufficiently spaced repeated PEth tests, self-reports and clinical interviews, to reduce seasonal bias. Based on these results, identification rates drop during spring and fall, and false negatives increase (i.e. the risk of ruling out hazardous alcohol use associated with temporary abstention), leading to missed opportunities to offer interventions. With this seasonal variation in mind, preventive actions could be applied before peak seasons, aiming at reducing the risk of relapses among patients with alcohol dependence and the adverse effects of hazardous alcohol use.

The results have implications for research, given that data are typically collected during a limited time in a cross-sectional design. Even self-reported data estimating more extended periods (e.g. 12 months) have shown to be affected by recent alcohol use patterns [35], with a recency effect giving more weight to recent events when estimating average consumption. The results of the present study suggest that typical consumption might be underestimated if data are collected in November, for example, and vice versa in July. In addition, clinical trials using PEth as an outcome, including patients in the intervention group during summer after a period of frequent and heavy alcohol use and using November tests as a follow-up, would risk misinterpreting seasonal changes as intervention effects. Statistical adjustment for the season (i.e. by including calendar month in statistical models) of testing could reduce this bias.

A considerable strength of this study was the complete coverage of primary care screening results in a region during the observational period, which facilitates generalizability to patients with similar characteristics. This study also has some limitations. Most importantly, patient characteristics not considered in the analyses could provide an alternative explanation for the observed results. However, by adjusting for potential confounding factors that may contribute both to the probability of being tested during a specific month and the risk of hazardous alcohol use, we mitigated this risk. Moreover, the consistency of the seasonal variation across age, sex and year of the test provides some robustness to our results. The seasonal variations found in this study mostly mirror the seasonal patterns of behavior seen in Swedes, and so might foremost apply to similar countries. Cultural practices,

holidays and the distinct seasons in Sweden certainly contribute to the observed variations. Finally, there might be healthcare utilization patterns and sociodemographic variables linked to alcohol consumption and the probability of seeking primary care that are not adjusted for.

CONCLUSION

In conclusion, our results have confirmed previous self-reports of seasonal variation in alcohol consumption using the biological marker PEth. Clinicians should consider seasonal variations in alcohol use patterns when identifying hazardous alcohol use with PEth. Assessment with PEth could be combined with a clinical interview and a re-test for a more valid indication of overall alcohol use patterns. In summary, this calls for an increased awareness of seasonal variations in PEth results in clinical assessment and adequate adjustment in research studies.

AUTHOR CONTRIBUTIONS

Viktor Månsson: Conceptualization (lead); data curation (equal); formal analysis (supporting); funding acquisition (lead); investigation (lead); methodology (equal); project administration (lead); visualization (supporting); writing—original draft (lead); writing—review and editing (lead). **Maria Hårdstedt:** Conceptualization (supporting); investigation (supporting); methodology (supporting); project administration (supporting); writing—review and editing (lead). **Anders Hammarberg:** Conceptualization (equal); supervision (equal); writing—review and editing (equal). **Anders Hake:** Data curation (equal); project administration (supporting); resources (lead); writing—review and editing (supporting). **Riccardo LoMartire:** Conceptualization (supporting); data curation (lead); formal analysis (lead); funding acquisition (supporting); investigation (equal); methodology (equal); project administration (supporting); software (lead); visualization (lead); writing—original draft (equal); writing—review and editing (equal).

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DECLARATION OF INTERESTS

None.

DATA AVAILABILITY STATEMENT

Part of the data that support the findings of this study are available on reasonable request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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