BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-029184
Article Type:	Research
Date Submitted by the Author:	16-Jan-2019
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Keywords:	EPIDEMIOLOGY, OCCUPATIONAL & INDUSTRIAL MEDICINE, PREVENTIVE MEDICINE, Substance misuse < PSYCHIATRY, PUBLIC HEALTH, SOCIAL MEDICINE

Association between alcohol consumption and impaired work performance (presenteeism): A systematic review

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Word count: 5164

ABSTRACT

Objective: The aim of this review was to explore the notion of alcohol-related presenteeism, i.e., whether evidence in the research literature supports an association between employee alcohol consumption and impaired work performance. **Methods:** Literature searches were performed in seven scientific databases, and in reference lists. Observational studies, published 1990 or later, in peer-reviewed scientific journals in English or a Scandinavian language, were included. Tested associations in the included studies were quality assessed, and analysed with frequency tables, cross tabulations and chi square tests of independence. **Results:** Twenty-six studies, containing 132 tested associations, met the eligibility criteria. The vast majority of tested associations (77 %) indicated that higher levels of alcohol consumption were associated with higher levels of impaired work performance, and these positive associations were considerably more likely than negative associations to be statistically significant. Alcohol exposure measured by hangover episodes and composite instruments were overrepresented among significant positive associations of moderate and high quality. Overall, 61 % of the tested associations were characterised by low quality. **Implications:** Workplace interventions aimed at improving employee productivity and health could benefit from integrating an awareness of a possible relationship between alcohol consumption and impaired work performance. **Conclusions:** Evidence does provide some support for the notion of alcohol-related presenteeism. However, due to low research quality and lack of longitudinal designs, evidence should be characterised as inconclusive. More robust and less heterogeneous research is warranted.

Key words: Alcohol consumption; Presenteeism; Work performance; Sick leave; Employees; Workplace interventions; Workplace health promotion

Strengths and limitations of this study

- To the best of our knowledge, this is the first systematic review to exclusively explore evidence for the notion of alcohol-related presenteeism, i.e., whether evidence supports a possible association between alcohol consumption and impaired work performance.
- Twenty-six studies from 15 countries, containing 132 tested associations between alcohol consumption and work performance, met the eligibility criteria. The majority of tested associations indicated that higher levels of alcohol consumption were associated with impaired work performance. However, evidence was largely characterised by low quality and a large number of associations not reaching statistical significance.
- Due to the heterogeneous nature of the included data, we were not able to conduct meta-analyses.
- Future research on alcohol-related presenteeism should utilise more robust study designs, include potential mediating and moderating variables, and employ measurement instruments with satisfactory psychometric properties.

INTRODUCTION

Alcohol consumption

Excessive alcohol consumption is a major risk factor for disease, disability and mortality, and has been identified as a causal agent in more than 200 disease and injury conditions.[1] Higher alcohol consumption has been found to be associated with lowered life expectancy,[2] and, according to the World Health Organization,[3] harmful alcohol consumption is related to approximately three million annual deaths globally. Among the population aged 15 to 49 years, alcohol has been identified as the leading risk factor for death and disability-adjusted life-years.[4] Alcohol is by far the most used and misused psychoactive substance in the workforce,[5] and one to three out of ten employees can be characterised as risky drinkers in need for interventions,[6-9] i.e., having a consumption pattern that increases the risk for social-, legal-, medical-, occupational-, domestic- and economic problems.[10]

Alcohol can affect mood as well as cognitive and psychomotor performance. Psychopharmacological and experimental workplace simulation studies have explored effects of alcohol intoxication on performance, generally suggesting little consistent impairment at low to moderate intoxication levels (blood alcohol content (BAC) 0.01 % - 0.08 %), while at higher BAC levels (≥ 0.09 %) impairment seems to increase quite linearly with task complexity.[11-14] Hangover episodes, i.e., an adverse mental and physical state experienced after heavy drinking when the BAC level returns to zero,[5, p. 85] include symptoms that may be related to performance decrements, such as headache, nausea, drowsiness, and sensitivity to light/sound.[12, 15, 16]

Alcohol consumption may influence activity performance in a variety of domains, including the occupational sphere. Regarding employees' alcohol consumption, one may distinguish between workforce overall alcohol consumption (consumption regardless of context) and work-related alcohol consumption (consumption prior to or during the workday,

as well as in contexts directly related to the work environment or the employment relationship).[5, 17-19] According to Frone's integrative conceptual model of employee substance use and productivity, not showing up at work (absenteeism) and arriving late at work (tardiness) are primarily believed to be affected by off-the-job drinking, while leaving work early and reduced work performance are thought mainly to be due to on-the-job drinking.[5, 20] However, the model does allow for possible cross-over effects between contexts. Off-the-job drinking "may indirectly affect performance outcomes to the extent that it causes off-the-job substance impairment, which when carried into the workplace becomes workplace impairment".[5, p.134] An association between employees' alcohol consumption and absenteeism is quite well established in the literature, e.g.,[21], while alcohol-related presenteeism stand out as a far more under-researched topic.

Presenteeism

Presenteeism has been defined in a variety of ways and the concept somewhat suffers from a "definitional creep".[22, p.521] Two distinct traditions in presenteeism research have been identified.[22, 23] The first tradition has primarily emphasised the exploration of presenteeism determinants and studied presenteeism as a chosen behaviour or personal choice. In this perspective, presenteeism is defined as the act of "showing up for work even when one is ill",[22, p.519] or "the phenomenon of people who, despite complaints and ill health that should prompt rest and absence from work, are still turning up at their jobs".[24, p.503] Hence, presenteeism may be conceived as an alternative to absenteeism and, as such, even as a health-promoting measure within a return to work framework.[25] The second tradition has been more oriented towards consequences of this behaviour, in particular related to productivity loss. Researchers in this tradition have defined presenteeism as "decreased on-the-job performance due to the presence of health problems",[26, p.548] "the health-related

productivity loss while at paid work",[27, p. 351] or "the measurable extent to which health symptoms, conditions and diseases adversely affect the work productivity of individuals who choose to remain at work".[28, p. 2] Evidently, the first tradition treats presenteeism as a behaviour, regardless of its consequences, while the second tradition claims that adverse performance outcomes are inherent in the conceptualisation of presenteeism.

It is plausible to conceive that a variety of health conditions do not result in productivity impairment and, in an organisational perspective, it may be argued that situations in which employees attend work while sick become of interest primarily when performance decrements are involved. In this systematic review, we understand presenteeism as reduced on-the-job performance due to health problems.[26] As such, presenteeism constitutes a link between on-the-job productivity and employee health,[26] addressing the grey area between optimal work performance and the absence of productivity (i.e., absenteeism).[22] Within this frame, alcohol-related presenteeism can be conceptualised as the presence of a positive association between alcohol consumption and impaired work performance (or conversely as a negative association between alcohol consumption and work performance). Alcohol-related presenteeism is thus operationalised as the product of a relationship between two variables (exposure: alcohol consumption, outcome: work performance) rather than a single variable (attending work while sick), rendering it possible to retain the notion of work performance as inherent in the phenomenon of presenteeism without conflating cause and effect.

Absenteeism and presenteeism have been found to be moderately correlated, and related by baseline presenteeism being a risk factor for future absenteeism.[29] Several authors have argued that presenteeism may carry more substantial societal costs than absenteeism. Hemp stated that "the illnesses people take with them to work (…) usually account for a greater loss in productivity because they are so prevalent, so often go untreated, and typically occur

during peak working years. Those indirect costs have long been largely invisible to employers".[30, p. 2]

Known predictors of presenteeism include diseases and disorders (e.g., musculoskeletal problems, depression and anxiety), certain individual characteristics (e.g., gender, age, job satisfaction, stress and family status), and factors related to the organisational environment (e.g., employment security, work schedules, workload, managerial support, corporate culture and leadership style).[23] Knowledge of mechanisms underlying presenteeism is, however, still quite limited. In particular, the impact of individual health risks or combinations of risks should be researched more extensively.[26]

Rationale and aim

Some studies have explored alcohol-related presenteeism, either directly or indirectly. There is, however, a lack of synthesised knowledge, rendering it difficult to assess the evidence of a possible association between employee alcohol consumption and work performance. In their review of relationships between psychological, physical and behavioural health and work performance, Ford et al. found alcohol consumption to be weakly associated with work performance problems.[31] However, this conclusion was based solely on 12 studies identified in two scientific databases in 2011. It seems imperative to generate new accumulated knowledge in order to aid in deciding whether and how workplace interventions and Workplace Health Promotion Programs (WHPP) should include an emphasis on alcohol consumption.

The aim of this review was to explore whether evidence in the research literature supports the notion of alcohol-related presenteeism, i.e., whether evidence supports an association between alcohol consumption and impaired work performance.

METHODS

Protocol and registration

This review is registered in the International prospective register of systematic reviews (PROSPERO, ID: CRD42017059620), and is part of the Norwegian national WIRUS project (Workplace Interventions preventing Risky Use of alcohol and Sick leave). Original research from the WIRUS project is published elsewhere.[9, 19, 32]

Eligibility criteria

Studies exploring alcohol-related presenteeism, i.e., the relationship between alcohol consumption (exposure) and work performance (outcome) among employees (population) were included in this review. Included studies had to satisfy the following criteria: (i) *type of study* (observational study, e.g., case-control, prospective cohort or cross-sectional study); (ii) *type of participants* (the study reported results from a sample of employees, defined as all salaried persons between 16 and 70 years of age, both workers and managers, regardless of employment sector or branch); (iii) *type of measures/tests* (the study reported one or more statistical test(s) of a relationship between a measure of alcohol consumption and a measure of work performance); (iv) *type of publication and language* (the study was reported as a full text empirical research article published in English or a Scandinavian language in a peer-reviewed scientific journal); and (v) *time* (the study was published year 1990 or later).

Studies were excluded if they (i) reported results from samples in which employees were mixed with other groups (e.g., full-time students, unemployed), unless results were reported independently for each group, and/or (ii) reported tests where alcohol and/or work performance were analysed in combination with other factors (e.g., if on-the-job performance was analysed in combination with absenteeism within a wider productivity variable).

Literature search

A primary database search strategy (based on a Medline structure) was developed and applied in seven scientific databases (Medline; Web of Science; PsycINFO; Cinahl; Amed; Embase; Swemed+). Where necessary, the search strategy was adapted to each database. The primary (Medline) strategy comprised a total of 29 steps, of which 18 were abstract-level text searches, 7 were based on MeSH terms (Medical Subject Headings, Topics, or similar terms), and the remaining were combinations of results applying Boolean operators (OR; AND). First, studies relating to the population (employees) were searched for (employee*; employed; worker*; workforce; work [MeSH]; employment [MeSH]), followed by studies relating to the exposure (alcohol consumption) (alcohol*; drink*; drunk*; hangover; "hang over"; alcohol drinking [MeSH]; binge drinking [MeSH]; drinking behavior [MeSH]), and the outcome (work performance) (presenteeism; "job productiv*"; "work productiv*"; "job capacity"; "work capacity"; "job ability"; "work ability"; "job impair*"; "work impair*"; presenteeism [MeSH]; work performance [MeSH]). Finally, search blocks for population, exposure and outcome were combined.

No restrictions were imposed at the search stage. The primary search strategy was pilot tested by three reviewers prior to conducting the main searches. Databases were initially searched in September 2017. An updated search was conducted in October 2018. Additionally, reference lists in included studies were hand searched for potential relevant studies.

Study and data selection

After searching the seven databases, hand searching in reference lists in included studies and removing duplicates, identified studies were screened for relevance on a title/abstract level. For quality assurance of the search strategy and eligibility criteria, the first 20 studies

were independently screened by three reviewers. The remaining studies were independently screened by two reviewers. Initial disagreements on eligibility were resolved through discussion. The reviewers reached consensus. Hence, it was not necessary to consult with a third reviewer. Potentially relevant studies were independently assessed in full text format for eligibility by two reviewers. Initial disagreements were resolved through discussion, without the need for consulting a third reviewer.

Data from the included studies (study characteristics and outcome data) were extracted independently by two reviewers by utilising data extraction forms. Disagreements were resolved through discussion, without the need to consult a third reviewer.

Quality assessment

Searches indicated that studies fulfilling the inclusion criteria were characterised by different designs, and by containing several statistical associations between alcohol consumption and presenteeism. Included studies were characterised by exploring broader aims related to health and productivity, while this review emphasises the relationship between alcohol and work performance in particular. Hence, it was deemed inappropriate to conduct overall quality assessment of each study. Instead, relevant tested associations in the included studies were assessed on two key domains: (i) sample size (low quality = <500; moderate quality = 500-999; high quality = ≥1000), and (ii) risk of confounding (level of adjustment: low quality = unadjusted or unclear; moderate quality = adjusted for individual *or* work-related/environmental factor(s); high quality = adjusted for individual *and* work-related/environmental factors). Each association was ascribed an overall quality judgement (low, moderate or high) based on the assessment of the two key domains, according to the "worst score counts" algorithm recommended by the COSMIN guidelines.[33] Hence, an association's overall score was equal to its lowest domain assessment. High-quality

associations were thus characterised by being based on at least 1000 observations and being adjusted for individual (e.g., gender; age; personality; disease conditions; drug use) as well as work-related/environmental factors (e.g., work position; work schedule; job characteristics).

The quality assessment procedure was pilot tested on a random sample of 10 associations. Quality assessments were performed independently by two reviewers. Consensus was reached and initial disagreements were resolved through discussion, without the need for consulting a third reviewer.

Analysis

Measures of exposure (alcohol consumption) as well as measures of outcome (work performance) displayed considerable heterogeneity between the included studies. As a result of the heterogeneous nature of the included data, meta-analyses were deemed inappropriate. Included data (associations) were instead analysed with frequency tables and cross tabulations. First, associations were sorted into a frequency table by quality level and overall association characteristics. Next, four contingency tables were constructed in order to explore properties of the identified associations more thoroughly: (i) direction and significance, (ii) quality and direction, (iii) publication year and quality, and (iv) significance and quality. The four 2x2 tables were analysed by means of odds ratios (with 95 % confidence intervals) and chi square tests of independence (with phi coefficients). Finally, measurements of alcohol consumption and work performance applied in the included studies were categorised into subgroups.

Patient and public involvement

No patients or public were involved in this review study.

RESULTS

Overview of the evidence

Searches in the seven databases resulted in 540 articles (Medline: n = 135; Web of Science: n = 128; PsycINFO: n = 63; Cinahl: n = 22; Amed: n = 3; Embase: n = 189; Swemed+: n = 0). Hand searching in reference lists resulted in an additional nine articles. After duplicate removal (n = 282), a total of 267 unique articles remained. Application of the eligibility criteria resulted in exclusion of 158 studies, leaving 109 potentially relevant articles.

Eighty-three studies were excluded after being subjected to full text assessment. The vast majority of these were excluded as a result of not reporting a statistical test of an association between alcohol consumption and work performance (n = 52), or because of publication type (n = 24). Articles not reporting tests of associations were typically characterised by (i) not studying variables that conceptually could be defined as alcohol consumption and/or work performance, and (ii) analysing alcohol consumption and/or work performance in combination with other factors, rendering it impossible to isolate the association of interest. Alcohol being analysed in combination with smoking/other lifestyle factors, and work performance being analysed in combination with absenteeism constitute typical examples. Articles excluded on the basis of publication type were typically conference papers. The study selection process resulted in 26 studies satisfying all inclusion criteria, and is presented in Figure 1.

[Figure 1 about here]

The 26 included studies were based on data from 92 730 employees from a total of 15 countries (Australia, China, Czech republic, Denmark, Finland, Greece, Ireland, Japan, the Netherlands, Norway, Portugal, Slovenia, Sweden, Switzerland and the USA). Employees in the USA constituted the samples in half of the studies (13 of 26). The vast majority of studies (21 of 26) were based on cross-sectional research designs. A total of 132 associations between alcohol consumption and work performance were tested in the 26 included studies. Characteristics of the included studies are presented in Table 1. Characteristics of the included associations are presented in Supplementary File 1.

Table 1

Characteristics of the included studies (n = 26) with measurements and included associations (n = 132)

Article/study (author, reference, year,)	Sample	Design	Alcohol measures	Presenteeism measures	Included association(s) (n, ID)
Adler *et al.*,[34] 2011	USA: Military veterans (n = 473)	Cross-sectional	Binge drinking episodes past 3 months	Work Limitations Questionnaire (WLQ)	n = 10 ([1-10])
Airilia *et al.*,[35] 2012	Finland: Fire fighters (n = 403)	Longitudinal	Drinking frequency	Work Ability Index (WAI), subdimensions	n = 6 ([11-16])
Fisher *et al.*,[36] 2000	USA: Military personnel (n = 5389)	Cross-sectional	Drinking frequency and quantity during past year	Number of impaired work ability days during past year	n = 7 ([17-23])
Karlsson *et al.*,[37] 2010	Sweden: Various occupations (n = 341)	Longitudinal	Weekly alcohol intake (grams)	Prognosis of work ability, 6 months	n = 2 ([24],[25])
Kessler & Frank,[38] 1997	USA: Various occupations (n = 4091)	Cross-sectional	DSM-III-R diagnosis (alcohol abuse/dependence)	Number of work cutback days during past 30 days	n = 2 ([26],[27])

Kim *et al.*,[39] 2013	USA: Fibromyalgia patients in various occupations (n = 946)	Cross-sectional	Number of drinks per week	Fibromyalgia Impact Questionnaire (FIQ), item job ability	n = 8 ([28-35])
Kirkham *et al.*,[40] 2015	USA: Computer manufacturer employees (n = 17089)	Longitudinal	CAGE questionnaire, at-risk vs. not at risk	Work Limitations Questionnaire (WLQ)	n = 3 ([36-38)
Odlaug *et al.*,[41] 2016	8 European countries: Patients with alcohol dependence, various occupations (n = 2979)	Cross-sectional	Drinking amount, past 12 months	Work Productivity and Activity Impairment Questionnaire (WPAI), presenteeism item	n = 1 ([39])
Pensola *et al.*,[42] 2016	Finland: People with multisite pain, various occupations (n = 3884)	Cross-sectional	Hangover frequency, past 12 months	Current work ability (0-10)	n = 8 ([40-47])

Richmond *et al.*,[43] 2016	USA: Government employees (n = 344)	Quasi-experimental	Alcohol Use Disorders Identification Test (AUDIT)	Workplace Outcome Suite, presenteeism scale	n = 1 ([48])
Schou *et al.*,[44] 2017	Norway: Various occupations (n = 1407)	Cross-sectional	Drinking frequency	Number of presenteeism episodes, past 12 months	n = 1 ([49])
Steegmann *et al.*,[45] 1997	China: Cycle haulers (n = 45)	Cross-sectional	Alcohol intake/intensity (ml)	Supervisor's estimate of worker's contribution	n = 1 ([50])
Tsuchiya *et al.*,[46] 2012	Japan: Community workers (n = 530)	Cross-sectional	DSM-IV diagnosis (alcohol abuse/dependence)	WHO Health and Work Performance Questionnaire (HPQ)	n = 2 ([51],[52])
van Scheppingen *et al.*,[47] 2014	Netherlands: Dairy company employees (n = 629)	Cross-sectional	Weekly alcohol intake	Presenteeism frequency	n = 1 ([53])

Yu *et al.*,[48] 2015	China: Petrochemical corporation employees (n = 1506)	Cross-sectional	Current alcohol drinker (yes/no)	Presenteeism during past 4 weeks (yes/no)	n = 2 ([54],[55])
Friedman *et al.*,[49] 1992	USA: Supermarket employees (n = 860)	Cross-sectional	DSM-III diagnosis alcohol abuse	Overall job performance (supervisor ratings)	n = 14 ([56-69])
Boles *et al.*,[50] 2004	USA: Employees in a large national employer (n = 2264)	Cross-sectional	CAGE questionnaire, at-risk vs. not at risk	WPAI; % presenteeism during past week	n = 3 ([70-72])
Blum *et al.*,[51] 1993	USA: Employees, various occupations (n = 136)	Cross-sectional	Monthly frequency x typical quantity (past 30 days)	Technical job performance	n = 12 ([73-84])
Burton *et al.*,[52] 2005	USA: Financial services employees (n = 28375)	Cross-sectional	At-risk (>14/wk) vs no-risk drinking	Work Limitations Questionnaire (WLQ), short version	n = 5 ([85-89])
Lim *et al.*,[53] 2000	Australia: Employees, various occupations (n = 4579)	Cross-sectional	DSM-IV diagnosis alcohol abuse	Number of work cutback days past month	n = 2 ([90], [91])

Lowmaster *et al.*,[54] 2012	USA: Police officers (n = 85)	Cross-sectional	Personality Assessment Inventory, subscale Alcohol Problems Scale (ALC)	Supervisor ratings of overall job performance	n = 3 ([92]-[94])
Moore *et al.*,[55] 2000	USA: Manufacturing company employees (n = 2279)	Cross-sectional	CAGE questionnaire, at-risk vs. not at risk	Time at work spent goofing off	n = 13 ([95]-[107])
Ames *et al.*,[17] 1997	USA: Manufacturing plant employees (n = 832)	Longitudinal	Frequency drinking before/during work and hangovers past year	Frequency sleeping on the job and task/co-worker problems past year	n = 14 ([108]-[121])
Furu *et al.*,[56] 2018	Finland: Workers in solvent-exposed fields (n = 1622)	Cross-sectional	Excessive drinking (AUDIT-C, scores 7-12)	Current work ability compared to lifetime best (0-10)	n = 2 ([122], [123])
Aas *et al.*,[32] 2017	Norway: Employees, various occupations (n = 3278)	Cross-sectional	Drinking frequency and binge drinking past year (AUDIT 1, 3)	Quantity presenteeism during past 7 days (degree 0-10)	n = 4 ([124]-[127])

van den Berg *et al.*,[57] 2017	Netherlands: Health care workers	Cross-sectional	Excessive alcohol intake (>10 drinks a week)	Current work ability compared to lifetime best (0-10)	n = 5 ([128]-[132])

Quality of the included data

Ninety-three of the 132 associations (71 %) were based on samples smaller than 1000 employees. Approximately half of the associations were unadjusted (n = 63; 48 %), while 29 associations (22 %) were adjusted for individual factors as well as for work-related/environmental factors. By applying the "worst score counts" algorithm, 80 associations (61 %) were judged as being of low quality, 38 associations (29 %) were of moderate quality, while 14 associations (11 %) were characterised by high quality. Results from quality assessment of the included associations are presented in Supplementary File 2.

Direction, significance, quality and time

One-hundred-two of the 132 tested associations (77 %) indicated a positive relationship between alcohol consumption and work performance, i.e., implying that higher levels of consumption were associated with higher levels of performance impairment. Approximately half of these (n = 56, 55 %) were statistically significant. The majority of positive associations was judged to be of low quality (n = 70, 69 %), followed by moderate (n = 23, 22 %) and high quality (n = 9, 9 %).

Twenty-five of the 132 tested associations (19 %) indicated a negative relationship, i.e., implying that higher levels of alcohol consumption were associated with lower performance impairment (higher work performance). Only two of these associations were statistically significant, and both of these were of low quality. These two associations (ID66 and ID68, in Friedman *et al*.[49]) tested the relationship between duration of alcohol use and overall work performance, and found that longer duration, as opposed to shorter duration, was associated with higher work performance.

Five associations (4 %) were not possible to classify as either positive or negative. They were characterised by (i) finding no differences in work performance between compared

alcohol consumption groups (ID102 in Moore *et al.*[55]; ID130 in van den Berg *et al.*[57]); (ii) by finding significant differences between multiple consumption groups, but without a consistent positive/negative pattern (ID28 and ID29 in Kim *et al.*[39]); or (iii) by finding a J-shaped pattern where abstainers scored comparable to moderate-level drinkers on impaired performance (i.e., higher than low-level drinkers), but still lower than heavy drinkers (ID98 in Moore *et al.*[55]). The identified associations, sorted by quality level and overall association characteristics, are presented in Table 2.

Table 2

Identified associations (n = 132) according to direction/significance and assessed quality level

Quality level	Direction and significance of associations				
	Significant positive[a] association	Significant negative[b] association	Non-significant positive association	Non-significant negative association	Other[c]
Low	[1],[2],[3],[4],[5],[10], [12],[17],[19],[26], [39],[49],[51],[54], [55],[56],[58],[59], [60],[62],[64],[67], [69],[77],[78],[81], [82],[83],[84],[95], [96],[97],[118],[119], [120],[121].[124],[125]	[66],[68]	[6],[7],[8],[9],[11], [13],[14],[16],[18], [20],[21],[23],[25], [27],[48],[50],[53], [57],[61],[63],[65], [73],[74],[75],[76], [79],[80],[104],[107], [122],[131],[132]	[15],[22],[24],[92], [93],[94]	[28],[130]
Moderate	[40],[42],[43],[44], [46],[47],[52], [101], [106],[109],[110], [115],[123]		[34],[35],[45],[91], [100],[103],[105], [117],[128],[129]	[30],[31],[32],[33], [90],[99],[108],[111], [112],[113],[114], [116]	[29],[98],[102]
High	[36],[37],[38],[41], [127]		[70],[71],[72],[126]	[85],[86],[87],[88], [89]	

Note. Number in brackets = association ID; [a] Higher level of alcohol associated with higher level of presenteeism; [b] Lower level of alcohol associated with higher level of presenteeism, or higher level of alcohol associated with lower level of presenteeism; [c] Inconsistent direction, no relationship or J-shaped relationship between alcohol and presenteeism

Positive associations were considerably more likely than negative associations to be statistically significant (OR = 14.00, 95 % CI: 3.1 – 65.5; χ^2 (1, n = 127) = 17.80, p =.000, *phi* = .37). On the other hand, negative associations were less likely than positive associations to be of low quality (OR = 0.22, 95 % CI: 0.1 – 0.6; χ^2 (1, n = 127) = 11.37, p =.001, *phi* = -.30). Furthermore, recent studies (≥ year 2000) were more likely than older studies (< year 2000) to be of moderate or high quality (OR = 2.95, 95 % CI: 1.30 – 6.79; χ^2 (1, n = 132) = 6.96, p =.008, *phi* = .23). There was no significant relationship between whether associations were significant and whether they were of moderate/high or low quality. The four 2x2 contingency tables are presented in Table 3.

Table 3

Crosstabulations of included associations according to direction, significance, quality and publication year

	Direction	
Significance	Positive % (n)	Negative % (n)
Significant	54.9 (56)	8.0 (2)
Non-significant	45.1 (46)	92.0 (23)
	OR= 14.00*** (3.130 – 65.53)	
	χ^2 (1, n = 127) = 17.80, *p* = .000, *phi* = .37	

	Direction	
Quality	Positive % (n)	Negative % (n)
Moderate/high	31.4 (32)	68.0 (17)
Low	68.6 (70)	32.0 (8)
	OR = 0.22** (0.08 – 0.55)	
	χ^2 (1, n = 127) = 11.37, *p* = .001, *phi* = -.30	

	Publication year	
Quality	≥ year 2000 % (n)	< year 2000 % (n)
Moderate/high	47.2 (42)	23.3 (10)
Low	52.8 (47)	76.7 (33)
	OR= 2.95** (1.30 – 6.70)	
	χ^2 (1, n = 132) = 6.96, *p* = .008, *phi* = .23	

	Significance	
Quality	Significant % (n)	Non-sign. % (n)
Moderate/high	32.8 (20)	44.9 (31)
Low	67.2 (41)	55.1 (38)
	OR= 0.60^{ns} (0.29 – 1.22)	
	χ^2 (1, n = 130) = 2.00, *p* = $.157^{ns}$, *phi* = -.12	

OR = odds ratio, with 95% confidence interval; χ^2 = chi square test of independence, with phi coefficient; ** *p* <.01; *** *p* <.001; ns = non-significant

Measurements of alcohol consumption and work performance

Categorisation of the applied measurements of alcohol consumption in the 26 included studies revealed eight subgroups: (i) consumption status (e.g., current alcohol drinker (yes/no), applied in Yu *et al.*[48]); (ii) drinking frequency (e.g., number of times drunk during past three months, applied in Ames *et al.*[17]; typical frequency of alcohol consumption during past year, applied in Aas *et al.*[32]); (iii) drinking intensity (e.g., average number of alcohol drinks during the past week, applied in Adler *et al.*[34]); (iv) drinking volume (e.g., monthly frequency x typical quantity during past 30 days, applied in Blum *et al.*[51]); (v) binge drinking (e.g., binge drinking (6 or more drinks on a single occasion) frequency during past year, applied in Aas *et al.*[32]); (vi) hangover (e.g., frequency of hangover episodes at work during past year, applied in Ames *et al.*[17]); (vii) composite instruments comprising several aspects of consumption, such as frequency, intensity and alcohol problems (e.g., the Alcohol Use Disorders Identification Test,[10] applied in Richmond *et al.*[43]); and (viii) alcohol-related diagnosis (e.g., DSM-IV diagnosis of alcohol abuse, applied in Lim *et al.*[53]).

The 26 included studies contained a total of six work performance measurement categories: (i) overall work performance/impairment (e.g., supervisor ratings of overall work performance, applied in Lowmaster *et al.*[54]; self-reported current work performance compared to lifetime best, applied in Furu *et al.*[56]; Work Limitations Questionnaire sum score,[58] applied in Kirkham *et al.*[40]); (ii) domain-specific work performance/impairment (e.g., Work Limitations Questionnaire subscale Time management,[58] applied in Adler *et al.*[34]); (iii) impaired performance quantity (e.g., number of days working below a normal level of performance during past 12 months, applied in Fisher *et al.*[36]; estimated percent impaired performance during past week, applied in Boles *et al.*[50]); (iv) impaired performance frequency (e.g., frequency of impaired performance episodes during past 12

months, applied in Schou *et al.*[44]); (v) prognosis of work performance (e.g., self-assessed probability of good work performance within frame of 6 months, applied in Karlsson *et al.*[37]); and (vi) work performance status (e.g., impaired work performance during past 4 weeks (yes/no), applied in Yu *et al.*[48]). The identified associations, sorted according to measurements of alcohol consumption and work performance, are presented in Table 4.

Table 4
Identified associations (n = 132) according to measurements of alcohol consumption and work performance

	Work performance measure					
Alcohol measure	Overall work performance/impairment	Domain-specific work performance/ impairment	Impaired performance, quantity	Impaired performance, frequency	Prognosis work performance	Work performance status
Consumption status	*[66↓*],[67↑*]*					*[54↑*],[55↑*]*
Frequency	*[11↓ns],[12↑*],[14↑ns],[15↓ns], [58↑*],[59↑*]*		[108↓ns],[109↑*],*[124↑*]*, **[126↑ns]**	*[49↑*]*, [113↓ns],[114↓ns]	*[13↑ns],[16↑ns]*	
Quantity	*[10↑*],[28|*]*,[29|ns],[30↓ns], [31↓ns],[32↓ns],[33↓ns],[34↑ns], [35↑ns],*[39↑*],[50↑ns]*,**[85↓ns]**, [128↑ns],[129↑ns],*[130|ns], [131↑ns],[132↑ns]*	*[6↑ns],[7↑ns], [8↑ns],[9↑ns]*, **[86↓ns],[87↓ns]**, **[88↓ns],[89↓ns]**		*[53↑ns]*	*[24↓ns],[25↑ns]*	
Volume	*[62↑*],[63↑ns],[68↓*],[69↑*]* , *[73↑ns],[74↑ns],[75↑ns],[76↑ns], [77↑*],[78↑*],[79↑ns],[80↑ns], [81↑*],[82↑*],[83↑*],[84↑*]*		*[17↑*],[18↑ns],[19↑*],[20↑ns], [21↑ns],[22↓ns],[23↑ns]*,[111↓ns]	[116↓ns]		
Heavy episodic/ binge drinking	*[5↑*]*	*[1↑*],[2↑*], [3↑*],[4↑*]*	[112↓ns],*[125↑*]*,**[127↑*]**	[117↑ns]		*[118↑*]*
Hangover episodes	[40↑*],**[41↑*]**,[42↑*],[43↑*], [44↑*],[45↑ns],[46↑*],[47↑*]		[110↑*]	[115↑*]		*[119↑*],[120↑*] ,[121↑*]*
Composite instruments	**[36↑*],[37↑*],[38↑*]**,*[48↑ns], [64↑*],[65↑ns],[92↓ns],[93↓ns], [94↓ns],[122↑ns]*,[123↑*]		**[70↑ns],[72↑ns]**,*[95↑*],[96↑*], [97↑*]*,[98|*],[99↓ns],[100↑ns], [101↑*],[102|ns],[103↑ns], *[104↑ns]*,[105↑ns],[106↑*], *[107↑ns]*			**[71↑ns]**
Diagnosis	*[51↑*]*,[52↑*],*[56↑*],[57↑ns], [60↑*],[61↑ns]*		*[26↑*],[27↑ns]*,[90↓ns],[91↑ns]			

Number in brackets = association ID; assessed quality level indicated by typeface: italic=low, regular=moderate, bold=high; ↑=positive association; ↓=negative association; |=association in non-consistent direction; *significant association; nsnon-significant association

In the 132 included associations, the most frequently applied alcohol measurement was drinking intensity (n = 28, 21 %) and composite instruments (n = 27, 20 %). Overall work performance/impairment (n = 67, 51 %) and quantity of impaired performance (n = 35, 27 %) were the most frequently utilised work performance measures. When exploring the group of associations characterised by being significant positive and of moderate or high quality (n = 18), the vast majority of these (n = 15) applied either hangover (n = 9) or composite instruments (n = 6) as alcohol consumption measures.

DISCUSSION

The aim of this review was to explore whether evidence in the research literature supports the notion of alcohol-related presenteeism, i.e., whether evidence supports an association between employee alcohol consumption and work performance. Twenty-six studies, containing a total of 132 tested associations between alcohol consumption and presenteeism, based on data from 92 730 employees in 15 countries, met the eligibility criteria.

The vast majority of the associations (102 of 132, 77 %) indicated a positive relationship between alcohol consumption and impaired work performance, i.e., implying that higher levels of alcohol consumption were associated with higher levels of impaired performance. Furthermore, positive associations were considerably more likely than negative associations to be statistically significant. Among the included studies in this review, positive associations between alcohol consumption and impaired work performance were identified in a variety of employee samples, e.g., computer manufacturer employees in the USA (Kirkham *et al.*[40]), Finnish employees with multisite pain in various occupations (Pensola *et al.*[42]), Japanese community workers (Tsuchiya *et al.*[46]), and manufacturing plant employees in the USA (Ames *et al.*[17]).

Alcohol use has the potential for influencing cognitive and psychomotor performance, which may explain why employees' alcohol consumption is associated with work performance. In particular, hangover episodes are characterised by symptoms that can induce work impairments (headache, nausea, drowsiness etc.),[12, 15, 16] and alcohol intoxication, at least at higher blood alcohol content, may produce work impairments that increase linearly with task complexity.[11-14] Positive associations between alcohol consumption and performance impairments are not so surprising in light of knowledge on the relationship between alcohol consumption and absenteeism. In their review, Schou and Moan found that employees' consumption was positively associated with both short-term and long-term sick leave.[21] The complementary hypothesis of the relationship between absenteeism and presenteeism claims that these behaviours are both related to employees' overall health status and that they are positively associated.[23] Research has demonstrated moderate positive correlations between absenteeism and presenteeism and that presenteeism may be a risk factor for future absenteeism.[23, 29]

Alcohol measurements based on hangovers and composite instruments were overrepresented in associations characterised by being significant positive and of moderate or high quality. Hangovers tend to result from binge drinking episodes, or drinking shortly before work. Such short-term impairment-producing consumption may be more predictive of work impairments than for instance typical drinking frequency, which instead may be more predictive of long-term ill-health consequences.[59] Composite instruments, such as the Alcohol Disorders Identification Test,[10] tend to assume a more complex relationship between alcohol, health and performance than what may be the case for more basic measurements (e.g., drinking frequency or intensity). Hence, a composite instrument measuring both consumption and experienced alcohol problems may be more predictive of productivity outcomes such as work performance.

However, the majority of positive associations were judged to be of low quality, and 25 of 132 associations (19 %) even indicated a negative relationship, i.e., implying that higher levels of alcohol consumption were associated with lower performance impairments (higher performance). Moreover, five associations were inconsistent, i.e., not possible to classify as positive or negative, or did not reveal any association between alcohol consumption and work performance at all. Negative associations were less likely than positive associations to be of low quality.

The relationship between alcohol consumption and health outcomes has, in some studies, been described as a J-shaped curve where low to moderate consumption is associated with better health outcomes than non-drinking.[60] In their study of manufacturing company employees in the USA, Moore et al. found a J-shaped relationship between alcohol consumption and percentage of time at work spent goofing off.[55] In this study, abstainers scored higher on goof-off time than low-moderate drinkers but lower than heavy drinkers. It is, however, somewhat unclear whether low-moderate levels of alcohol consumption in fact have some protective effects or whether such findings are products of confounding.[4, 60, 61] Nevertheless, potential curvilinear relationships between alcohol consumption and health outcomes may contribute to explain why a considerable proportion of associations failed to demonstrate significant positive relationships. Moreover, on-the-job performance outcomes may be more directly affected by on-the-job drinking than by off-the-job drinking, even though off-the-job consumption may translate into workplace impairment.[5] Among the studies included in this review, only one (Ames *et al.*[17]) contained explicit measures of on-the-job drinking, while the remaining studies measured overall consumption (consumption regardless of context). Moreover, overall consumption may have differential impact on different domains. In a study of employees in Norway, Aas *et al.*[32] found that overall consumption demonstrated stronger associations with performance impairments outside the

workplace compared to work performance, which may be due to employees moderating (self-regulating) their behaviour at work as a result of potential sanctions from employers. Self-regulatory motivations and mechanisms may contribute to hide alcohol-related presenteeism, which may complicate the exploration of associations between alcohol consumption and work performance.

Implications

Overall, this review does provide some support for the notion of alcohol-related presenteeism, i.e., that employee alcohol consumption may be associated with performance decrements at work. Workplace interventions aimed at improving employee productivity and health could benefit from integrating an awareness of such a possible relationship.

However, it is not possible to draw firm conclusions regarding the relationship between alcohol consumption and work performance. Based on research identified in this review, one cannot plausibly conclude that alcohol consumption constitutes a risk factor for impaired work performance. The majority of identified evidence was of low quality as a result of low power (small sample sizes) and/or risk of confounding. Moreover, the majority of identified studies were cross-sectional, and thereby unable to draw causal inferences about the relationship between exposure and outcome. Above all, this review implies the need for further research. First, future research would benefit from studying alcohol-related presenteeism by means of more robust study designs that better enable exploration of causal mechanisms (e.g., case-control and cohort studies), as well as by including potential mediating and moderating variables. Second, both alcohol consumption and presenteeism are conceptualised and measured very differently across studies. Such heterogeneity makes it difficult to explore findings in the literature by means of meta-analyses. Progress in the field seems to hinge on researchers' ability to reach more agreement on how to conceptualise these

variables and measure them by utilising instruments with satisfactory psychometric properties. This seems particularly true for the concept of presenteeism. According to an expert panel from the American College of Occupational and Environmental Medicine,[27, p. 351] productivity instruments should be supported by scientific evidence, be applicable to the specific work setting, support decision making, and be practical. Based on their review of measurement properties and quality of presenteeism instruments, Ospina *et al.*[62] concluded that the following three instruments were most strongly supported by evidence: The Stanford Presenteeism Scale (6-item version;[63]), the Endicott Work Productivity Scale (EWPS;[64]), and the Health and Work Questionnaire (HWQ;[65]). Regarding measurement of alcohol consumption, future research could benefit from differentiating between overall consumption (e.g., measured with a composite instrument such as the Alcohol Use Disorders Identification Test;[10]), hangover episodes, on-the-job drinking and off-the-job drinking. By employing such distinctions, researchers would be better able to explore a potential correspondence between consumption contexts, impairment contexts and performance outcomes.[5, 20]

Methodological considerations

This review has some limitations. First and foremost, due to the heterogeneous nature of the identified data, we were unable to perform meta-analyses on the included data.

Second, it may be considered a limitation that this review utilised associations and not studies as the unit of interest. Associations were deemed the appropriate unit of interest in this review for two reasons: (i) included studies were characterised by exploring broader aims related to health and productivity, while this review specifically aimed at exploring the relationship between alcohol consumption and work performance, and (ii) in several studies, multiple associations between alcohol consumption and work performance were tested (often with different measures and subgroups within each study).

Third, this review did not utilise a previously validated critical appraisal tool (CAT) for assessment of included primary research. One reason for this is that studies based on different study designs were included in the review. At present, there exists no generic gold standard CAT for application across study designs.[66, 67] A second reason is that the current review emphasised associations rather than studies as the unit of interest. Hence, it was deemed more appropriate to develop a parsimonious and conservative quality assessment system in which each association was evaluated based on power (sample size) and risk of confounding (level of adjustment). Deliberately, we chose a conservative approach to quality assessment by ascribing each association an overall score in accordance with the "worst score counts" algorithm. Such an approach is in line with the COSMIN guidelines.[33]

Fourth, we chose to utilise the concept of presenteeism in line with researchers who define it in terms of decreased on-the-job productivity due to health problems.[26] Such an understanding does ascribe valence to the phenomenon, i.e., a behaviour contributing to lost productivity that may carry negative influence on the overall work environment.[68] We are, however, aware of differing opinions among scholars regarding conceptualisations of presenteeism. Different definitions have different strengths and weaknesses. According to Johns,[22] a proper definition should (i) neither ascribe motives nor consequences to presenteeism, and (ii) avoid conflating cause and effect by perceiving productivity loss itself as presenteeism. To some extent, we do agree with such objections against a productivity-based definition. A more open understanding, such as simply "showing up for work even when one is ill",[22, p. 519] does not ascribe a certain valence to the phenomenon, nor does it presuppose or exclude any particular consequence. We believe, however, that in a socioeconomic and organisational perspective, situations in which employees attend work while ill become of interest primarily when performance decrements are in fact involved. In order to avoid conflating cause and effect, we operationalised alcohol-related presenteeism as

the product of a relationship between two measurable variables, i.e., alcohol consumption (predictor/exposure) and work performance (outcome).

CONCLUSIONS

Alcohol-related presenteeism (impaired work performance associated with alcohol consumption) stands out as an important but under-researched topic in the research literature. According to this review, evidence does provide some support for the notion that employee alcohol consumption may be associated with impaired work performance. However, due to low research quality and lack of longitudinal designs, existing evidence should still be characterised as inconclusive regarding the prevalence, nature and impact of alcohol-related presenteeism in the workforce. More robust and less heterogeneous research is warranted.

DECLARATIONS

Contributors

RWA is the principal investigator and project manager of the WIRUS project. This review study was designed by MMT and RWA. MMT analysed the data and drafted the manuscript. Data selection was performed by MMT, NH and RWA; data extraction by MMT and TB; and quality assessment by MMT and IK. TB, NH, IK WVM and RWA provided scientific input to the different drafts and provided data interpretation. All authors made critical revisions and provided intellectual content to the manuscript, approved the final version to be published, and agreed to be accountable for all aspects of this work.

Funding

The review study is funded by the Norwegian Directorate of Health and the Research Council of Norway. The funding bodies had no role in the design of the review or in data analysis or interpretation.

Competing interests

None declared.

Availability of data and materials

Data from the review study are available from the project owner (University of Stavanger, Faculty of Health Sciences, Department of Public Health, Research group Societal Participation in School and Work) by principal investigator and project manager Randi Wågø Aas on reasonable request.

SUPPLEMENTARY FILES

Supplementary File 1: Results of quality assessment of included associations (PDF)

Supplementary File 2: Characteristics of tested associations in included studies (PDF)

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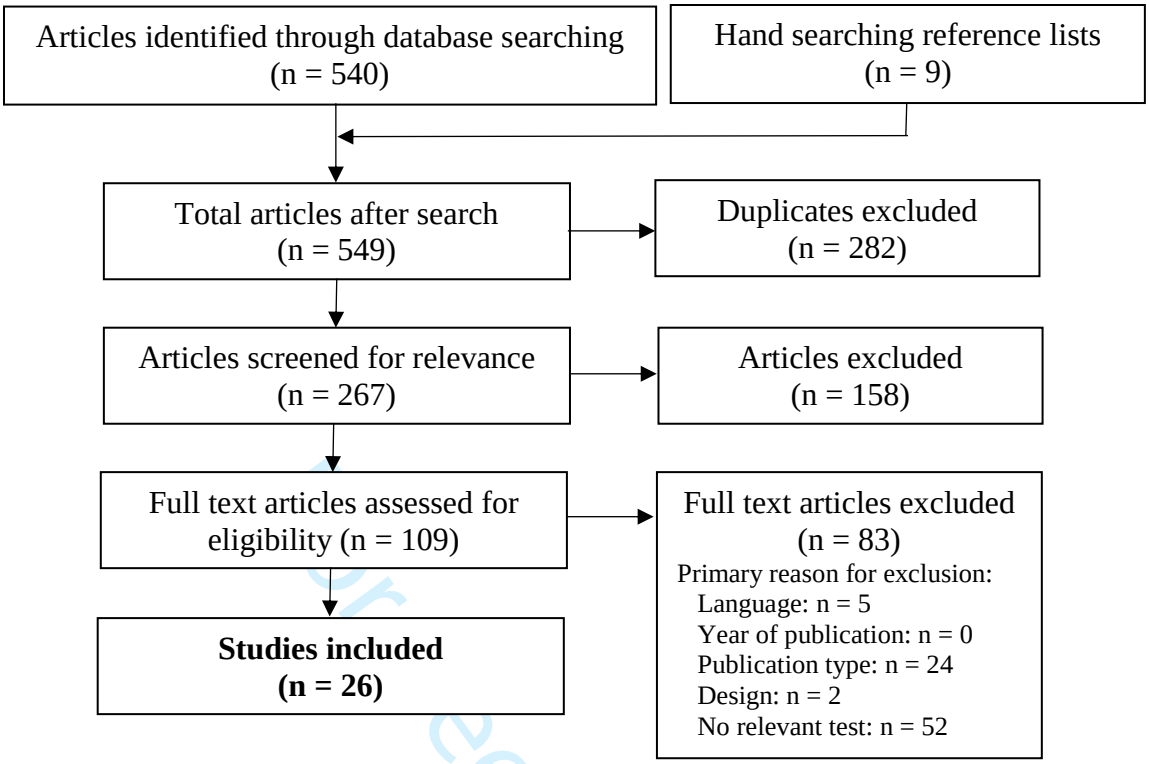
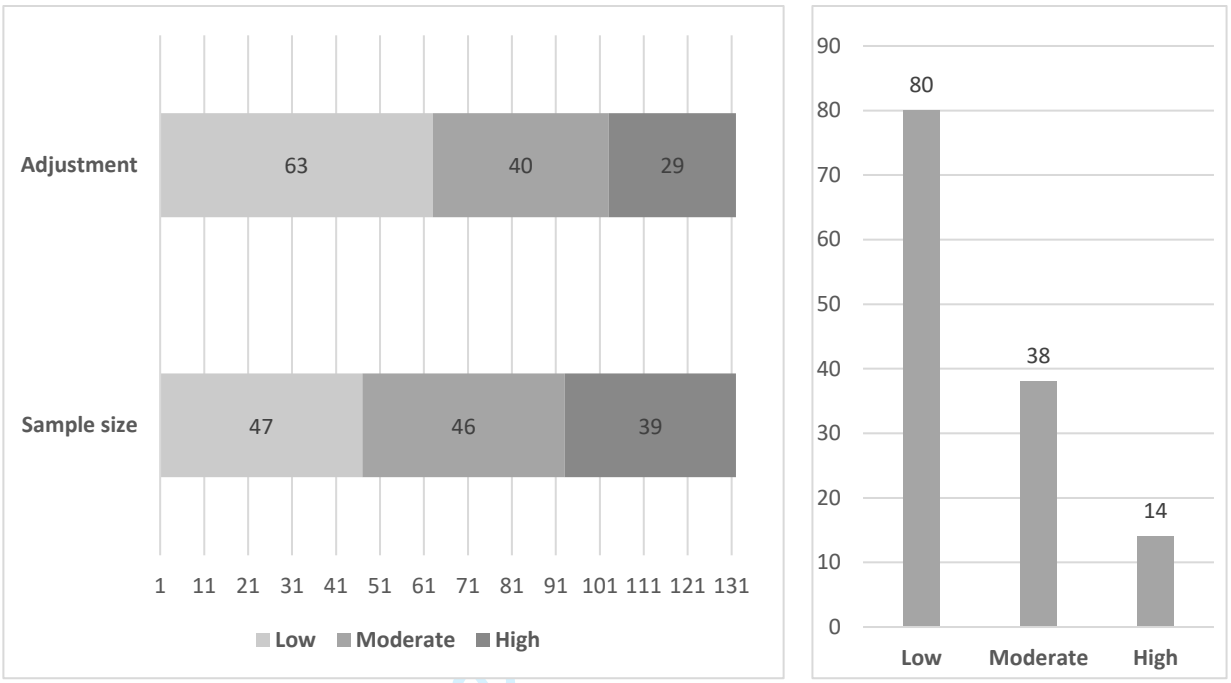
1 FIGURE TITLE/LEGEND

2 *Figure 1*. PRISMA flow chart of the study selection process



Supplementary File 1. Results of quality assessment of included associations (n = 132)



Panel A **Panel B**

Panel A displays quality assessments separately on two key domains; Panel B displays overall assessments according to the "worst score counts algorithm"

Supplementary File 2. Overview of tested associations (n = 132) in the included studies (n = 26)

Association ID	Study (author, year, reference)	Effect size[a]	Significance	Sample size	Adjustment	Classification in review[b]
1	Adler *et al.*, 2011 [34]	*r* = .11	*p* = .01	473	Unadjusted	↑ * L
2	"	*r* = .10	*p* = .03	473	Unadjusted	↑ * L
3	"	*r* = .14	*p* = .002	473	Unadjusted	↑ * L
4	"	*r* = .14	*p* = .002	473	Unadjusted	↑ * L
5	"	*r* = .16	*p* <.001	473	Unadjusted	↑ * L
6	"	*r* = .07	*p* = .16	473	Unadjusted	↑ ns L
7	"	*r* = .08	*p* = .08	473	Unadjusted	↑ ns L
8	"	*r* = .09	*p* = .50	473	Unadjusted	↑ ns L
9	"	*r* = .07	*p* = .11	473	Unadjusted	↑ ns L
10	"	*r* = .10	*p* = .04	473	Unadjusted	↑ * L
11	Airila *et al.*, 2012 [53]	*r* = -.05	ns	403	Unadjusted	↑ ns L
12	"	*r* = -.10	*p* <.05	403	Unadjusted	↑ * L
13	"	*r* = -.05	ns	403	Unadjusted	↑ ns L
14	"	b = -.07	95% CI: -.18, .05	403	Age; work ability at baseline	↑ ns L
15	"	b = .01	95% CI: -.07, .09	403	Age; work ability at baseline	↓ ns L
16	"	b = -.06	95% CI: -.16, .05	403	Age; work ability at baseline	↑ ns L
17	Fisher *et al.*, 2000 [42]	RR = 1.52	*p* <.05; 95% CI: 1.36, 1.70	Unclear	Age	↑ * L

18	"	RR = 1.18	95% CI: 0.88, 1.60	Unclear	Age	↑ ns L
19	"	RR = 1.76	*p* <.05; 95% CI: 1.34, 2.33	Unclear	Age	↑ * L
20	"	RR = 1.38	95% CI: 0.72, 2.61	Unclear	Age	↑ ns L
21	"	RR = 1.25	95% CI: 0.96, 1.62	Unclear	Age	↑ ns L
22	"	RR = 0.58	95% CI: 0.26, 1.30	Unclear	Age	↓ ns L
23	"	RR = 1.39	95% CI: 0.62, 3.12	Unclear	Age	↑ ns L
24	Karlsson *et al.*, 2010 [45]	OR = 0.91	95% CI: 0.33, 2.55	300	Gender; age	↓ ns L
25	"	OR = 2.33	95% CI: 0.84, 6.51	289	Gender; age	↑ ns L
26	Kessler & Frank, 1997 [54]	b = .88	*p* <.05	4091	Unadjusted	↑ * L
27	"	b = .17	ns	4091	Unadjusted	↑ ns L
28	Kim *et al.*, 2013 [30]	unclear	*p* <.001	946	Unadjusted	| * L
29	"	unclear	*p* = .03	946	Age; employment; education; body mass index; drug use	| * M
30	"	unclear	*p* = .10	884	Age; employment; education; body mass index; drug use	↓ ns M
31	"	unclear	*p* = .11	577	Age; employment; education; body mass index; drug use	↓ ns M
32	"	unclear	*p* = .98	577	Age; employment; education; body mass index; drug use	↓ ns M

33	"	unclear	p = .51	577	Age; employment; education; body mass index; drug use	↓ ns M
34	"	unclear	p = .97	369	Age; employment; education; body mass index; drug use	↑ ns M
35	"	unclear	p = .53	62	Age; employment; education; body mass index; drug use	↑ ns M
36	Kirkham *et al.*, 2015 [41]	β = .20	p <.001; 95% CI: .14, .27	27459	Age; gender; region of residence; misc. work-related factors	↑ * H
37	"	β = .22	p <.001; 95% CI: .13, .32	10639	Age; gender; region of residence; misc. work-related factors	↑ * H
38	"	β = .20	p <.001; 95% CI: .10, .29	16820	Age; gender; region of residence; misc. work-related factors	↑ * H
39	Odlaug *et al.*, 2016 [55]	unclear	p <.05	1373	Unadjusted	↑ * L
40	Pensola *et al.*, 2016 [46]	PRR = 1.22	95% CI: 1.1, 1.4	1351	Age; gender	↑ * M
41	"	PRR = 1.15	95% CI: 1.0, 1.3	1351	Age; gender; misc. work-related, physical and psychosocial factors	↑ * H
42	"	PRR = 1.30	95% CI: 1.1, 1.6	546	Age	↑ * M
43	"	PRR = 1.21	95% CI: 1.0, 1.5	546	Age; gender; misc. work-related, physical and psychosocial factors	↑ * M

44	"	PRR = 1.15	95% CI: 1.0, 1.4	805	Age	↑ * M
45	"	PRR = 1.01	95% CI: 0.9, 1.2	573	Age; gender	↑ ns M
46	"	PRR = 1.92	95% CI: 1.4, 2.7	778	Age; gender	↑ * M
47	"	PRR = 1.80	95% CI: 1.3, 2.6	778	Age; gender; misc. work-related, physical and psychosocial factors	↑ * M
48	Richmond *et al.*, 2016 [36]	b = 0.017; β = .057	ns	338	Baseline presenteeism	↑ ns L
49	Schou *et al.*, 2017 [44]	r = .458	p <.01	1406	Unadjusted	↑ * L
50	Steegmann *et al.*, 1997 [56]	r = .073	ns	45	Unadjusted	↑ ns L
51	Tsuchiya *et al.*, 2012 [47]	b = -1.1	95% CI: -2.1, -0.0	530	Unadjusted	↑ * L
52	"	b = -1.1	95% CI: -2.1, -0.1	530	Gender; age; education; job category; work time	↑ * M
53	van Scheppingen *et al.*, 2014 [57]	r = .01	ns	629	Unadjusted	↑ ns L
54	Yu *et al.*, 2015 [31]	χ^2 = 4.6	p <.05	1506	Unadjusted	↑ * L
55	"	OR = 1.76	95% CI: 1.02, 3.03	1506	unclear	↑ * L
56	Friedman *et al.*, 1992 [27]	r = -.09	p <.01	860	Unadjusted	↑ * L
57	"	r = .02	ns	860	Unadjusted	↑ ns L
58	"	r = -.14	p <.01	973	Unadjusted	↑ * L

59	"	r = .09	p <.01	973	Unadjusted	↑ * L
60	"	r = -.12	p <.01	886	Unadjusted	↑ * L
61	"	r = .05	ns	886	Unadjusted	↑ ns L
62	"	r = -.13	p <.01	852	Unadjusted	↑ * L
63	"	r = .06	ns	852	Unadjusted	↑ ns L
64	"	r = 09	p <.01	863	Unadjusted	↑ * L
65	"	r = .03	ns	863	Unadjusted	↑ ns L
66	"	r = .10	p <.01	1229	Unadjusted	↓ ns L
67	"	r = .06	p <.05	1229	Unadjusted	↑ * L
68	"	r = .09	p <.01	1229	Unadjusted	↓ * L
69	"	r = .07	p <.05	1229	Unadjusted	↑ * L
70	Boles *et al.*, 2004 [43]	unclear	ns	2264	Age; gender; misc. risk factors	↑ ns H
71	"	OR = 3.74	p = .115	2264	Age; gender; misc. risk factors	↑ ns H
72	"	b = 0.901	p = .930	2264	Age; gender; misc. risk factors	↑ ns H
73	Blum *et al.*, 1993 [35]	r = -.016	ns	136	Unadjusted	↑ ns L
74	"	M_{diff} = 0.01	ns	136	Unadjusted	↑ ns L
75	"	M_{diff} = 0.21	ns	136	Unadjusted	↑ ns L
76	"	M_{diff} = 0.05	ns	136	Unadjusted	↑ ns L

77	"	r = -.185	p <.05	136	Unadjusted	↑ * L
78	"	M_{diff} = 0.19	p <.05	136	Unadjusted	↑ * L
79	"	M_{diff} = 0.16	ns	136	Unadjusted	↑ ns L
80	"	M_{diff} = 0.03	ns	136	Unadjusted	↑ ns L
81	"	r = -.233	p <.01	136	Unadjusted	↑ * L
82	"	M_{diff} = 0.28	p <.01	136	Unadjusted	↑ * L
83	"	M_{diff} = 0.35	p <.01	136	Unadjusted	↑ * L
84	"	M_{diff} = 0.03	p <.05	136	Unadjusted	↑ * L
85	Burton *et al.*, 2005 [58]	M_{diff} = -0.0748	ns	28375	Age; gender; diseases; misc. risk factors	↓ ns H
86	"	M_{diff} = -0.0447	ns	28375	Age; gender; diseases; misc. risk factors	↓ ns H
87	"	M_{diff} = -0.0833	ns	28375	Age; gender; diseases; misc. risk factors	↓ ns H
88	"	M_{diff} = -0.0853	ns	28375	Age; gender; diseases; misc. risk factors	↓ ns H
89	"	M_{diff} = -0.0865	ns	28375	Age; gender; diseases; misc. risk factors	↓ ns H
90	Lim *et al.*, 2000 [37]	b = -0.92	ns	4579	Physical and mental disorders	↓ ns M
91	"	b = 0.18	ns	4579	Physical and mental disorders	↑ ns M
92	Lowmaster *et al.*, 2012 [38]	r = .21	ns	85	Unadjusted	↓ ns L
93	"	r = .12	ns	29	Unadjusted	↓ ns L

94	"	r = .23	ns	56	Unadjusted	↓ ns L
95	Moore *et al.*, 2000 [28]	unclear	p <.05	1521	Unadjusted	↑ * L
96	"	unclear	p <.05	1378	Unadjusted	↑ * L
97	"	unclear	p <.05	520	Unadjusted	↑ * L
98	"	unclear	p <.05	2256	Demographic variables	| * M
99	"	M_{diff} = 0.1	p = .65	1780	Demographic variables	↓ ns M
100	"	M_{diff} = 0.2	p = .10	520	Demographic variables	↑ ns M
101	"	M_{diff} = 0.3	p <.01	1378	Demographic variables	↑ * M
102	"	M_{diff} = 0.0	p = .68	676	Demographic variables	| ns M
103	"	M_{diff} = 0.1	p = .09	1534	Demographic variables	↑ ns M
104	"	M_{diff} = 0.2	p = .10	274	Demographic variables	↑ ns L
105	"	M_{diff} = 0.1	p =.42	663	Demographic variables	↑ ns M
106	"	M_{diff} = 0.2	p <.05	1521	Demographic variables	↑ * M
107	"	M_{diff} = 0.1	p = .22	261	Demographic variables	↑ ns L
108	Ames *et al.*, 1997 [32]	b = -0.02; β = -.02	ns	832	Drinking variables; job characteristics	↓ ns M
109	"	b = 0.08; β = .08	p <.05	832	Drinking variables; job characteristics	↑ * M
110	"	b = 0.08; β = .08	p <.05	832	Drinking variables; job characteristics	↑ * M
111	"	b = -0.01; β = -.01	ns	832	Drinking variables; job characteristics	↓ ns M

112	"	b = -0.03; β = -.03	ns	832	Drinking variables; job characteristics	↓ ns M
113	"	b = -0.02; β = -.02	ns	832	Drinking variables; sociodemographics	↓ ns M
114	"	b = -0.01; β = -.01	ns	832	Drinking variables; sociodemographics	↓ ns M
115	"	b = 0.21; β = .21	*p* <.001	832	Drinking variables; sociodemographics	↑ * M
116	"	b = -0.01; β = -.01	ns	832	Drinking variables; sociodemographics	↓ ns M
117	"	b = 0.00; β = .00	ns	832	Drinking variables; sociodemographics	↑ ns M
118	"	η^2 = .01	*p* <.02	832	Unadjusted	↑ * L
119	"	η^2 = .01	*p* <.05	832	Unadjusted	↑ * L
120	"	η^2 = .02	*p* <.01	832	Unadjusted	↑ * L
121	"	η^2 = .01	*p* <.05	832	Unadjusted	↑ * L
122	Furu *et al.*, 2018 [39]	OR = 1.25	95% CI: 0.98, 1.61	1622	Unadjusted	↑ ns L
123	"	OR = 1.36	95% CI: 1.05, 1.77	1622	Age	↑ * M
124	Aas *et al.*, 2017 [33]	*r* = .049	*p* <.01	3278	Unadjusted	↑ * L
125	"	*r* = .076	*p* <.001	3278	Unadjusted	↑ * L
126	"	b = 0.016; β = .028	ns	3278	Gender; age; education; living status; employment sector; binge drinking	↑ ns H

127	"	b = 0.040; β = .057	*p* <.01	3278	Gender; age; education; living status; employment sector; drinking frequency	↑ * H
128	van den Berg *et al.*, 2017 [29]	OR = 1.23	95% CI: 0.87, 1.74	509	Gender; age; education	↑ ns M
129	"	OR = 1.28	95% CI: 0.99, 1.65	1267	Gender; age; education	↑ ns M
130	"	OR = 1.00	ns	410	Gender; age; education	| ns L
131	"	OR = 1.18	95% CI: 0.66, 3.11	413	Gender; age; education	↑ ns L
132	"	OR = 1.52	95% CI: 0.96, 2.41	335	Gender; age; education	↑ ns L

[a] *r* = correlation coefficient; b = unstandardised regression coefficient; RR = relative risk; OR = odds ratio; β = standardised regression coefficient; PRR = prevalence risk ratio; χ^2 = chi square; M_{diff} = mean difference; η^2 = eta squared

[b] ↑ = positive association; ↓ = negative association; | = inconsistent direction; * = significant association; ns = non-significant association; L = low quality association; M = moderate quality association; H = high quality association

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	7
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	7
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	8
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	8
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	9
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	9
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	9-10
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	10
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	10
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	10-11
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	n/a[1]
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	11

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	n/a[1]
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	n/a[1]
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	12-13, Fig.1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Table1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	20,SF1[2]
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	20-28, Table2, Table 4, SF2[3]
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	23, Table3
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	n/a[1]
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	n/a[1]
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	28-31
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	32-34
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	31-32
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	34-35

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

PRISMA 2009 Checklist

[1] n/a = not applicable
[2] SF1 = Supplementary File 1
[3] SF2 = Supplementary File 2

BMJ Open

Association between alcohol consumption and impaired work performance (presenteeism): A systematic review

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-029184.R1
Article Type:	Research
Date Submitted by the Author:	20-Mar-2019
Complete List of Authors:	Thørrisen, Mikkel; OsloMet - Oslo Metropolitan University, Bonsaksen, Tore; OsloMet - Oslo Metropolitan University; VID Specialized University Hashemi, Neda; University of Stavanger Kjeken, Ingvild; OsloMet - Oslo Metropolitan University; Diakonhjemmet Hospital Van Mechelen, Willem; VU University Medical Center, Public and Occupational Health Aas, Randi; University of Stavanger; OsloMet - Oslo Metropolitan University
Primary Subject Heading:	Public health
Secondary Subject Heading:	Addiction, Occupational and environmental medicine, Public health, Epidemiology
Keywords:	EPIDEMIOLOGY, OCCUPATIONAL & INDUSTRIAL MEDICINE, PREVENTIVE MEDICINE, Substance misuse < PSYCHIATRY, PUBLIC HEALTH, SOCIAL MEDICINE

Association between alcohol consumption and impaired work performance (presenteeism): A systematic review

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Word count: 6661

ABSTRACT

Objectives The aim of this review was to explore the notion of alcohol-related presenteeism, i.e., whether evidence in the research literature supports an association between employee alcohol consumption and impaired work performance.

Design Systematic review of observational studies.

Data sources Medline, Web of Science, PsycINFO, Cinahl, Amed, Embase and Swemed+ were searched through October 2018. Reference lists in included studies were hand searched for potential relevant studies.

Eligibility criteria We included observational studies, published 1990 or later as full text empirical articles in peer-reviewed journals in English or a Scandinavian language, containing one or more statistical tests regarding a relationship between a measure of alcohol consumption and a measure of work performance.

Data extraction and synthesis Two independent reviewers extracted data. Tested associations between alcohol consumption and work performance within the included studies were quality assessed, and analysed with frequency tables, cross tabulations and chi square tests of independence.

Results Twenty-six studies were included, containing 132 tested associations. The vast majority of associations (77 %) indicated that higher levels of alcohol consumption were associated with higher levels of impaired work performance, and these positive associations were considerably more likely than negative associations to be statistically significant (OR = 14.00, *phi* = .37, $p < .001$). Alcohol exposure measured by hangover episodes and composite instruments were overrepresented among significant positive associations of moderate and high quality (15 of 17 associations). Overall, 61 % of the associations were characterised by low quality.

Conclusions Evidence does provide some support for the notion of alcohol-related presenteeism. However, due to low research quality and lack of longitudinal designs, evidence should be characterised as somewhat inconclusive. More robust and less heterogeneous research is warranted. This review, however, does provide support for targeting alcohol consumption within the frame of workplace interventions aimed at improving employee health and productivity.

PROSPERO registration number CRD42017059620

Key words: Alcohol consumption; Presenteeism; Work performance; Sick leave; Employees; Workplace interventions; Workplace health promotion

Strengths and limitations of this study

- This systematic review is, to the best of our knowledge, the first to exclusively explore evidence for the notion of alcohol-related presenteeism.
- The review was based on comprehensive searches in seven scientific databases as well as in reference lists, and included studies containing data from more than 92 000 employees across 15 countries
- As a result of included studies often being characterised by exploring broader aims related to health and productivity, and by testing several relevant associations between alcohol consumption and work performance, associations were chosen as the unit of analysis.
- Due to the heterogeneous nature of the included data, meta-analyses were deemed inappropriate, in particular since measures of alcohol consumption were difficult to compare across studies/associations (e.g., abstainer vs. drinker; frequency; volume; hangovers; binge drinking; composite instruments and dependence/abuse diagnoses).

- Included data were quality assessed on an association level by means of a parsimonious and conservative assessment system developed specifically for this review.

INTRODUCTION

Alcohol consumption

Excessive alcohol consumption is a major risk factor for disease, disability and mortality, and has been identified as a causal agent in more than 200 disease and injury conditions.[1] Higher alcohol consumption has been found to be associated with lowered life expectancy,[2] and, according to the World Health Organization,[3] harmful alcohol consumption is related to approximately three million annual deaths globally. Among the population aged 15 to 49 years, alcohol has been identified as the leading risk factor for death and disability-adjusted life-years.[4] Alcohol is by far the most used and misused psychoactive substance in the workforce,[5] and one to three out of ten employees can be characterised as risky drinkers in need for interventions,[6-9] that is, having a consumption pattern that increases the risk for social-, legal-, medical-, occupational-, domestic- and economic problems.[10] Even though adverse consequences of alcohol tend to accumulate in concordance with increased consumption,[2, 4] it is far from straightforward to establish an appropriate threshold distinguishing between no/low-risk and risky drinking. Whether a particular drinking pattern or consumption level can be conceived of as risky, depends on several factors, such as: (i) effects of alcohol consumption interact with other individual characteristics, such as general health, sociodemographic, physiological and other lifestyle factors,[11] and (ii) any level of drinking may be risky given certain circumstances, such as when being pregnant, operating heavy machinery and taking medications known to interact with alcohol.[12] International drinking guidelines, often expressed in terms of a number of alcohol units during a specific

time frame, vary considerably across countries and, moreover, even standard drink sizes vary internationally.[12] In both research and clinical practice, thresholds for risky drinking are often applied based on scores on composite instruments, assuming a more complex relationship between alcohol and health, such as a score of 8 or higher on the Alcohol Use Disorders Identification Test (AUDIT).[10, 13]

Alcohol can affect mood as well as cognitive and psychomotor performance. Psychopharmacological and experimental workplace simulation studies have explored effects of alcohol intoxication on performance, generally suggesting little consistent impairment at low to moderate intoxication levels (blood alcohol content (BAC) 0.01 % - 0.08 %), while at higher BAC levels (≥ 0.09 %) impairment seems to increase quite linearly with task complexity.[14-17] For comparison, one standard UK drink approximates a BAC of 0.02 % for a male (age: 40, body weight: 80 kg) or 0.04 % for a female (age: 40, body weight: 60 kg).[18] For both, a BAC of ≥0.09 % would be surpassed after three drinks. In a six-hour time window, a BAC of ≥0.09 % would be present after nine (male) or six (female) drinks. Hangover episodes, defined as an adverse mental and physical state experienced after heavy drinking when the BAC level returns to zero,[5(p85)] include symptoms that may be related to performance decrements, such as headache, nausea, drowsiness, and sensitivity to light/sound.[15, 19, 20]

Alcohol consumption may influence activity performance in a variety of domains, including the occupational sphere. Regarding employees' alcohol consumption, one may distinguish between workforce overall alcohol consumption (consumption regardless of context) and work-related alcohol consumption (consumption prior to or during the workday, as well as in contexts directly related to the work environment or the employment relationship).[5, 21-23] According to Frone's integrative conceptual model of employee substance use and productivity, not showing up at work (absenteeism) and arriving late at work

(tardiness) are primarily believed to be affected by off-the-job drinking, while leaving work early and reduced work performance are thought mainly to be due to on-the-job drinking, that is, drinking within two hours before work, during breaks, or while performing the job.[5, 24] However, the model does allow for possible cross-over effects between contexts. Off-the-job drinking "may indirectly affect performance outcomes to the extent that it causes off-the-job substance impairment, which when carried into the workplace becomes workplace impairment".[5(p134)] An association between employees' alcohol consumption and absenteeism is quite well established in the literature, e.g.,[25], while alcohol-related presenteeism stands out as a far more under-researched topic.

Presenteeism

Presenteeism has been defined in a variety of ways and the concept somewhat suffers from a "definitional creep".[26(p521)] Two distinct traditions in presenteeism research have been identified.[26, 27] The first tradition has primarily emphasised the exploration of presenteeism determinants and studied presenteeism as a chosen behaviour or personal choice. In this perspective, presenteeism is defined as the act of "showing up for work even when one is ill",[26(p519)] or "the phenomenon of people who, despite complaints and ill health that should prompt rest and absence from work, are still turning up at their jobs".[28(p503)] Hence, presenteeism may be conceived as an alternative to absenteeism and, as such, even as a health-promoting measure within a return to work framework.[29] The second tradition has been more oriented towards consequences of this behaviour, in particular related to productivity loss. Researchers in this tradition have defined presenteeism as "decreased on-the-job performance due to the presence of health problems",[30(p548)] "the health-related productivity loss while at paid work",[31(p351)] or "the measurable extent to which health symptoms, conditions and diseases adversely affect the work productivity of individuals who choose to

remain at work".[32(p2)] Evidently, the first tradition treats presenteeism as a behaviour, regardless of its consequences, while the second tradition claims that adverse performance outcomes are inherent in the conceptualisation of presenteeism.

It is plausible to conceive that a variety of health conditions do not result in productivity impairment and, from an organisational perspective, it may be argued that situations in which employees attend work while sick become of interest primarily when performance decrements are involved. In this systematic review, we consider presenteeism as reduced on-the-job performance due to health problems.[30] As such, presenteeism constitutes a link between on-the-job productivity and employee health,[30] addressing the grey area between optimal work performance and the absence of productivity (i.e., absenteeism).[26] Within this frame, alcohol-related presenteeism can be conceptualised as the presence of a positive association between alcohol consumption and impaired work performance (or conversely as a negative association between alcohol consumption and work performance). Alcohol-related presenteeism is thus operationalised as the product of a relationship between two variables (exposure: alcohol consumption, outcome: work performance) rather than a single variable (attending work while sick), rendering it possible to retain the notion of work performance as inherent in the phenomenon of presenteeism without conflating cause and effect.

Performance outcomes at work comprise several phenomena related to productivity. The concept of presenteeism is most directly associated with task performance. However, performance may as well be related to contextual performance (such as working extra hours and helping coworkers), counterproductive behaviour (such as workplace aggression and property damage) and issues related to job safety, such as injuries resulting from accidents.[5(p132)] A recent Norwegian study revealed that employees' alcohol consumption was a major concern relating to safety issues,[33] and several studies support an association between alcohol and occupational injuries.[34-36] However, in the context of the present review, we

focused on work performance related to task performance, which can be conceived of as most directly related to on-the-job productivity.

Absenteeism and presenteeism have been found to be moderately correlated, and related by baseline presenteeism being a risk factor for future absenteeism.[37] Several authors have argued that presenteeism may carry more substantial societal costs than absenteeism. Hemp stated that "the illnesses people take with them to work (…) usually account for a greater loss in productivity because they are so prevalent, so often go untreated, and typically occur during peak working years. Those indirect costs have long been largely invisible to employers".[38(p2)]

Known predictors of presenteeism include diseases and disorders (e.g., musculoskeletal problems, depression and anxiety), certain individual characteristics (e.g., gender, age, job satisfaction, stress and family status), and factors related to the organisational environment (e.g., employment security, work schedules, workload, managerial support, corporate culture and leadership style).[27] Knowledge of mechanisms underlying presenteeism is, however, still quite limited. In particular, the impact of individual health risks or combinations of risks should be researched more extensively.[30]

Rationale and aim

Some studies have explored alcohol-related presenteeism, either directly or indirectly. There is, however, a lack of synthesised knowledge, rendering it difficult to assess the evidence of a possible association between employee alcohol consumption and work performance. In their review of relationships between psychological, physical and behavioural health and work performance, Ford et al. found alcohol consumption to be weakly associated with work performance problems.[39] However, this conclusion was based solely on 12 studies identified in two scientific databases in 2011. It seems imperative to generate new

accumulated knowledge in order to aid in deciding whether and how workplace interventions and Workplace Health Promotion Programs (WHPP) should include an emphasis on alcohol consumption.

The aim of this review was to explore whether evidence in the research literature supports the notion of alcohol-related presenteeism, i.e., whether evidence supports an association between employee alcohol consumption (overall, as well as work-related) and impaired work performance.

METHODS

Protocol and registration

This review is registered in the International prospective register of systematic reviews (PROSPERO, ID: CRD42017059620), and is part of the Norwegian national WIRUS project (Workplace Interventions preventing Risky Use of alcohol and Sick leave). Original research from the WIRUS project is published elsewhere.[9, 23, 40]

Eligibility criteria

Studies exploring alcohol-related presenteeism, i.e., the relationship between alcohol consumption (exposure) and work performance (outcome) among employees (population) were included in this review. Included studies had to satisfy the following criteria: (i) *type of study* (observational study, e.g., case-control, prospective cohort or cross-sectional study); (ii) *type of participants* (the study reported results from a sample of employees, defined as all salaried persons between 16 and 70 years of age, both workers and managers, regardless of employment sector or branch); (iii) *type of measures/tests* (the study reported one or more statistical test(s) of a relationship between a measure of alcohol consumption and a measure of work performance); (iv) *type of publication and language* (the study was reported as a full

text empirical research article published in English or a Scandinavian language in a peer-reviewed scientific journal); and (v) *time* (the study was published year 1990 or later).

Studies were excluded if they (i) reported results from samples in which employees were mixed with other groups (e.g., full-time students, unemployed), unless results were reported independently for each group, and/or (ii) reported tests where alcohol and/or work performance were analysed in combination with other factors (e.g., if on-the-job performance was analysed in combination with absenteeism within a wider productivity variable). Time restrictions were set a priori due to drinking behaviour, in particular, resulting from complex and interacting antecedents that are susceptible to changes over time.[24, 41, 42] Hence, very old studies may suffer from low external validity.

Literature search

A primary database search strategy (based on a Medline structure, see Supplementary File 1) was developed and applied in seven scientific databases (Medline; Web of Science; PsycINFO; Cinahl; Amed; Embase; Swemed+). Where necessary, the search strategy was adapted to each database. The primary (Medline) strategy comprised a total of 31 steps, of which 20 were abstract-level text searches, 7 were based on MeSH terms (Medical Subject Headings, Topics, or similar terms), and the remaining were combinations of results applying Boolean operators (OR; AND). First, studies relating to the population (employees) were searched for (employee*; employed; worker*; workforce; work [MeSH]; employment [MeSH]), followed by studies relating to the exposure (alcohol consumption) (alcohol*; drink*; drunk*; hangover; "hang over"; alcohol drinking [MeSH]; binge drinking [MeSH]; drinking behavior [MeSH]), and the outcome (work performance) (presenteeism; "job productiv*"; "work productiv*"; "job capacity"; "work capacity"; "job ability"; "work ability"; "job impair*"; "work impair*"; "job performance"; "work performance";

presenteeism [MeSH]; work performance [MeSH]). Finally, search blocks for population, exposure and outcome were combined. Database search results were transferred to EndNote.

No restrictions were imposed at the search stage. The primary search strategy was pilot tested by three reviewers prior to conducting the main searches. Databases were initially searched in September 2017. An updated search was conducted in October 2018. Additionally, reference lists in included studies were hand searched for potential relevant studies.

Study and data selection

After searching the seven databases, hand searching in reference lists in included studies and removing duplicates, identified studies were screened for relevance on a title/abstract level. Study selection was based on the results of combining the three main search blocks in the database search strategy (population, exposure and outcome). For quality assurance of the search strategy and eligibility criteria, the first 20 studies were independently screened by three reviewers. The remaining studies were independently screened by two reviewers. Initial disagreements on eligibility were resolved through discussion. The reviewers reached consensus. Hence, it was not necessary to consult with a third reviewer. Potentially relevant studies were independently assessed in full text format for eligibility by two reviewers. Initial disagreements were resolved through discussion, without the need for consulting a third reviewer.

Data extraction

Data from the included studies were extracted independently by two reviewers. Disagreements were resolved through discussion, without the need to consult a third reviewer.

We were unable to locate standardised extraction forms appropriate for this review. Therefore, we developed and applied two extraction forms.

First, on a study characteristics extraction form, the following pieces of information were extracted from each included article: title, author(s), year of publication, characteristics of study sample, study setting, number of participants included in the study (study sample size), gender and age distribution, study design, data collection method(s), information on the measures of exposure and outcome, and the number of tested associations relevant to the review research question. Second, on an association characteristics extraction form, the following pieces of information were extracted about each relevant association: type of statistical test, number of participants included in association (association sample size), effect size, p-value and/or confidence interval, and information on the measures of exposure and outcome. Extracted data were entered in spreadsheets for further analysis.

Quality assessment

Searches indicated that studies fulfilling the inclusion criteria were characterised by different designs, and by containing several statistical associations between alcohol consumption and presenteeism. Included studies were characterised by exploring broader aims related to health and productivity, while this review emphasises the relationship between alcohol and work performance in particular. Hence, it was deemed inappropriate to conduct overall quality assessment of each study. Instead, relevant tested associations in the included studies were assessed on two key domains: (i) sample size (low quality = <500; moderate quality = 500-999; high quality = ≥1000), and (ii) risk of confounding (level of adjustment, the extent to which associations between exposure and outcome were controlled for possible confounding variables: low quality = unadjusted or unclear; moderate quality = adjusted for individual *or* work-related/environmental factor(s); high quality = adjusted for individual *and*

work-related/environmental factors). The sample size thresholds were based on the assumption that alcohol-related presenteeism is a relatively low-prevalent phenomenon in the workforce. The study of rare events requires greater statistical strength than the study of frequent events.[43] Samples consisting of less than 500 observations were defined as small. Sample size categorisations were similar to thresholds applied in a recent association-based review of alcohol-related absenteeism.[25] Each association was ascribed an overall quality judgement (low, moderate or high) based on the assessment of the two key domains, according to the "worst score counts" algorithm recommended by the COSMIN guidelines.[44] Hence, an association's overall score was equal to its lowest domain assessment. High-quality associations were thus characterised by being based on at least 1000 observations and being adjusted for individual (e.g., gender; age; personality; disease conditions; drug use) as well as work-related/environmental factors (e.g., work position; work schedule; job characteristics).

The quality assessment procedure was pilot tested on a random sample of 10 associations. Quality assessments were performed independently by two reviewers. Consensus was reached and initial disagreements were resolved through discussion, without the need for consulting a third reviewer.

Analysis

Measures of exposure (alcohol consumption) as well as measures of outcome (work performance) displayed considerable heterogeneity between the included studies. As a result of the heterogeneous nature of the included data, meta-analyses were deemed inappropriate. Included data (associations) were instead analysed with frequency tables and cross tabulations. First, associations were sorted into a frequency table by quality level and overall association characteristics. Next, four contingency tables were constructed in order to explore properties of the identified associations more thoroughly: (i) direction and significance, (ii)

quality and direction, (iii) publication year and quality, and (iv) significance and quality. The four 2x2 tables were analysed by means of odds ratios (with 95 % confidence intervals) and chi square tests of independence (with phi coefficients). Finally, measurements of alcohol consumption and work performance applied in the included studies were categorised into subgroups.

Patient and public involvement

No patients or public were involved in this review study.

RESULTS

Overview of the evidence

Searches in the seven databases resulted in 540 articles (Medline: n = 135; Web of Science: n = 128; PsycINFO: n = 63; Cinahl: n = 22; Amed: n = 3; Embase: n = 189; Swemed+: n = 0). Hand searching in reference lists resulted in an additional nine articles. After duplicate removal (n = 282), a total of 267 unique articles remained. Application of the eligibility criteria resulted in exclusion of 158 studies, leaving 109 potentially relevant articles.

Eighty-three studies were excluded after being subjected to full text assessment. The vast majority of these were excluded as a result of not reporting a statistical test of an association between alcohol consumption and work performance (n = 52), or because of publication type (n = 24). Articles not reporting tests of associations were typically characterised by (i) not studying variables that conceptually could be defined as alcohol consumption and/or work performance, and (ii) analysing alcohol consumption and/or work performance in combination with other factors, rendering it impossible to isolate the

association of interest. Alcohol being analysed in combination with smoking/other lifestyle factors, and work performance being analysed in combination with absenteeism constitute typical examples. Articles excluded on the basis of publication type were typically conference papers. The study selection process resulted in 26 studies satisfying all inclusion criteria, and is presented in Figure 1.

[Figure 1 about here]

The 26 included studies were based on data from 92 730 employees from a total of 15 countries (Australia, China, Czech republic, Denmark, Finland, Greece, Ireland, Japan, the Netherlands, Norway, Portugal, Slovenia, Sweden, Switzerland and the USA). Employees in the USA constituted the samples in half of the studies (13 of 26). The vast majority of studies (21 of 26) were based on cross-sectional research designs. A total of 132 associations between alcohol consumption and work performance were tested in the 26 included studies. Characteristics of the included studies are presented in Table 1. Characteristics of the included associations are presented in Supplementary File 2.

Table 1

Characteristics of the included studies (n = 26) with measurements and included associations (n = 132)

Article/study (author, reference, year,)	Sample	Design	Alcohol measures	Presenteeism measures	Included association(s) (n, ID)
Adler *et al.*,[45] 2011	USA: Military veterans (n = 473)	Cross-sectional	Binge drinking episodes past 3 months	Work Limitations Questionnaire (WLQ)	n = 10 ([1-10])
Airilia *et al.*,[46] 2012	Finland: Fire fighters (n = 403)	Longitudinal	Drinking frequency	Work Ability Index (WAI), subdimensions	n = 6 ([11-16])
Fisher *et al.*,[47] 2000	USA: Military personnel (n = 5389)	Cross-sectional	Drinking frequency and quantity during past year	Number of impaired work ability days during past year	n = 7 ([17-23])
Karlsson *et al.*,[48] 2010	Sweden: Various occupations (n = 341)	Longitudinal	Weekly alcohol intake (grams)	Prognosis of work ability, 6 months	n = 2 ([24],[25])
Kessler & Frank,[49] 1997	USA: Various occupations (n = 4091)	Cross-sectional	DSM-III-R diagnosis (alcohol abuse/dependence)	Number of work cutback days during past 30 days	n = 2 ([26],[27])

Kim *et al.*,[50] 2013	USA: Fibromyalgia patients in various occupations (n = 946)	Cross-sectional	Number of drinks per week	Fibromyalgia Impact Questionnaire (FIQ), item job ability	n = 8 ([28-35])
Kirkham *et al.*,[51] 2015	USA: Computer manufacturer employees (n = 17089)	Longitudinal	CAGE questionnaire, at-risk vs. not at risk	Work Limitations Questionnaire (WLQ)	n = 3 ([36-38])
Odlaug *et al.*,[52] 2016	8 European countries: Patients with alcohol dependence, various occupations (n = 2979)	Cross-sectional	Drinking amount, past 12 months	Work Productivity and Activity Impairment Questionnaire (WPAI), presenteeism item	n = 1 ([39])
Pensola *et al.*,[53] 2016	Finland: People with multisite pain, various occupations (n = 3884)	Cross-sectional	Hangover frequency, past 12 months	Current work ability (0-10)	n = 8 ([40-47])

Richmond *et al.*,[54] 2016	USA: Government employees (n = 344)	Quasi-experimental	Alcohol Use Disorders Identification Test (AUDIT)	Workplace Outcome Suite, presenteeism scale	n = 1 ([48])
Schou *et al.*,[55] 2017	Norway: Various occupations (n = 1407)	Cross-sectional	Drinking frequency	Number of presenteeism episodes, past 12 months	n = 1 ([49])
Steegmann *et al.*,[56] 1997	China: Cycle haulers (n = 45)	Cross-sectional	Alcohol intake/intensity (ml)	Supervisor's estimate of worker's contribution	n = 1 ([50])
Tsuchiya *et al.*,[57] 2012	Japan: Community workers (n = 530)	Cross-sectional	DSM-IV diagnosis (alcohol abuse/dependence)	WHO Health and Work Performance Questionnaire (HPQ)	n = 2 ([51],[52])
van Scheppingen *et al.*,[58] 2014	Netherlands: Dairy company employees (n = 629)	Cross-sectional	Weekly alcohol intake	Presenteeism frequency	n = 1 ([53])

Yu *et al.*,[59] 2015	China: Petrochemical corporation employees (n = 1506)	Cross-sectional	Current alcohol drinker (yes/no)	Presenteeism during past 4 weeks (yes/no)	n = 2 ([54],[55])
Friedman *et al.*,[60] 1992	USA: Supermarket employees (n = 860)	Cross-sectional	DSM-III diagnosis alcohol abuse	Overall job performance (supervisor ratings)	n = 14 ([56-69])
Boles *et al.*,[61] 2004	USA: Employees in a large national employer (n = 2264)	Cross-sectional	CAGE questionnaire, at-risk vs. not at risk	WPAI; % presenteeism during past week	n = 3 ([70-72])
Blum *et al.*,[62] 1993	USA: Employees, various occupations (n = 136)	Cross-sectional	Monthly frequency x typical quantity (past 30 days)	Technical job performance	n = 12 ([73-84])
Burton *et al.*,[63] 2005	USA: Financial services employees (n = 28375)	Cross-sectional	At-risk (>14/wk) vs no-risk drinking	Work Limitations Questionnaire (WLQ), short version	n = 5 ([85-89])
Lim *et al.*,[64] 2000	Australia: Employees, various occupations (n = 4579)	Cross-sectional	DSM-IV diagnosis alcohol abuse	Number of work cutback days past month	n = 2 ([90], [91])

Lowmaster *et al.*,[65] 2012	USA: Police officers (n = 85)	Cross-sectional	Personality Assessment Inventory, subscale Alcohol Problems Scale (ALC)	Supervisor ratings of overall job performance	n = 3 ([92]-[94])
Moore *et al.*,[66] 2000	USA: Manufacturing company employees (n = 2279)	Cross-sectional	CAGE questionnaire, at-risk vs. not at risk	Time at work spent goofing off	n = 13 ([95]-[107])
Ames *et al.*,[21] 1997	USA: Manufacturing plant employees (n = 832)	Longitudinal	Frequency drinking before/during work and hangovers past year	Frequency sleeping on the job and task/co-worker problems past year	n = 14 ([108]-[121])
Furu *et al.*,[67] 2018	Finland: Workers in solvent-exposed fields (n = 1622)	Cross-sectional	Excessive drinking (AUDIT-C, scores 7-12)	Current work ability compared to lifetime best (0-10)	n = 2 ([122], [123])
Aas *et al.*,[40] 2017	Norway: Employees, various occupations (n = 3278)	Cross-sectional	Drinking frequency and binge drinking past year (AUDIT 1, 3)	Quantity presenteeism during past 7 days (degree 0-10)	n = 4 ([124]-[127])

van den Berg *et al.*,[68] 2017	Netherlands: Health care workers	Cross-sectional	Excessive alcohol intake (>10 drinks a week)	Current work ability compared to lifetime best (0-10)	n = 5 ([128]-[132])

Quality of the included data

Ninety-three of the 132 associations (71 %) were based on samples smaller than 1000 employees. Approximately half of the associations were unadjusted (n = 63; 48 %), while 29 associations (22 %) were adjusted for individual factors as well as for work-related/environmental factors. By applying the "worst score counts" algorithm, 80 associations (61 %) were judged as being of low quality, 38 associations (29 %) were of moderate quality, while 14 associations (11 %) were characterised by high quality. Results from quality assessment of the included associations are presented in Supplementary File 3.

Direction, significance, quality and time

One-hundred-two of the 132 tested associations (77 %) indicated a positive relationship between alcohol consumption and work performance, i.e., implying that higher levels of consumption were associated with higher levels of performance impairment. Approximately half of these (n = 56, 55 %) were statistically significant. The majority of positive associations was judged to be of low quality (n = 70, 69 %), followed by moderate (n = 23, 22 %) and high quality (n = 9, 9 %). For instance, in a sample of employees in the USA, Kirkham *et al.*[51] found that risky drinking, as measured with the CAGE questionnaire,[69] was associated with impaired work performance, measured with the Work Limitations Questionnaire,[70] both overall (ID36, β = .20, p <.001) as well as among those aged <45 (ID37, β = .22, p <.001) and ≥45 (ID38, β = .20, p <.001). Among Finnish employees, Pensola *et al.*[53] found that high hangover frequency (at least six hangovers during the past 12 months), compared to low frequency (no alcohol or less than six hangovers during the past 12 months), was associated with moderate or poor self-reported work ability (ID41, PRR = 1.15, 95% CI: 1.0, 1.3). In a study of Norwegian employees, Aas *et al.*[40] found that higher binge drinking frequency (measured with a single item from the AUDIT)[10, 13] was positively related to the

experienced degree of impaired work performance (measured with a single item from the Work Productivity and Activity Impairment questionnaire)[71] during the past seven days (ID127, β = .06, p <.01).

Twenty-five of the 132 tested associations (19 %) indicated a negative relationship, i.e., implying that higher levels of alcohol consumption were associated with lower performance impairment (higher work performance). Only two of these associations were statistically significant, and both of these were of low quality. These two associations (ID66, r =.10, p <.01, and ID68, r = .09, p <.01, in Friedman *et al.*[60]) tested the relationship between duration of alcohol use and overall work performance, and found that longer duration, as opposed to shorter duration, was associated with higher work performance.

Five associations (4 %) were not possible to classify as either positive or negative. They were characterised by (i) finding no differences in work performance between compared alcohol consumption groups (ID102, M_{diff} = 0.0, p =.68, in Moore *et al.*[66]; ID130, OR = 1.00, p = ns, in van den Berg *et al.*[68]); (ii) by finding significant differences between multiple consumption groups, but without a consistent positive/negative pattern (ID28, unclear effect size, p <.001), and ID29, unclear effect size, p =.03, in Kim *et al.*[50]); or (iii) by finding a J-shaped pattern where abstainers scored comparable to moderate-level drinkers on impaired performance (i.e., higher than low-level drinkers), but still lower than heavy drinkers (ID98, unclear effect size, p <.05, in Moore *et al.*[66]). The identified associations, sorted by quality level and overall association characteristics, are presented in Table 2.

Table 2

Identified associations (n = 132) according to direction/significance and assessed quality level

Quality level	Direction and significance of associations				
	Significant positive[a] association	Significant negative[b] association	Non-significant positive association	Non-significant negative association	Other[c]
Low	[1],[2],[3],[4],[5],[10], [12],[17],[19],[26], [39],[49],[51],[54], [55],[56],[58],[59], [60],[62],[64],[67], [69],[77],[78],[81], [82],[83],[84],[95], [96],[97],[118],[119], [120],[121].[124],[125]	[66],[68]	[6],[7],[8],[9],[11], [13],[14],[16],[18], [20],[21],[23],[25], [27],[48],[50],[53], [57],[61],[63],[65], [73],[74],[75],[76], [79],[80],[104],[107], [122],[131],[132]	[15],[22],[24],[92], [93],[94]	[28],[130]
Moderate	[40],[42],[43],[44], [46],[47],[52], [101], [106],[109],[110], [115],[123]		[34],[35],[45],[91], [100],[103],[105], [117],[128],[129]	[30],[31],[32],[33], [90],[99],[108],[111], [112],[113],[114], [116]	[29],[98],[102]
High	[36],[37],[38],[41], [127]		[70],[71],[72],[126]	[85],[86],[87],[88], [89]	

Note. Number in brackets = association ID; [a] Higher level of alcohol associated with higher level of presenteeism; [b] Lower level of alcohol associated with higher level of presenteeism, or higher level of alcohol associated with lower level of presenteeism; [c] Inconsistent direction, no relationship or J-shaped relationship between alcohol and presenteeism

Positive associations were considerably more likely than negative associations to be statistically significant (OR = 14.00, 95 % CI: 3.1 – 65.5; χ^2 (1, n = 127) = 17.80, *p* =.000, *phi* = .37). On the other hand, negative associations were less likely than positive associations to be of low quality (OR = 0.22, 95 % CI: 0.1 – 0.6; χ^2 (1, n = 127) = 11.37, *p* =.001, *phi* = -.30). Furthermore, recent studies (≥ year 2000) were more likely than older studies (< year 2000) to be of moderate or high quality (OR = 2.95, 95 % CI: 1.30 – 6.79; χ^2 (1, n = 132) = 6.96, *p* =.008, *phi* = .23). There was no significant relationship between whether associations were significant and whether they were of moderate/high or low quality. The four 2x2 contingency tables are presented in Table 3.

Table 3

Cross tabulations of included associations according to direction, significance, quality and publication year

	Direction	
Significance	Positive % (n)	Negative % (n)
Significant	54.9 (56)	8.0 (2)
Non-significant	45.1 (46)	92.0 (23)
	OR= 14.00*** (3.130 – 65.53)	
	χ^2 (1, n = 127) = 17.80, *p* = .000, *phi* = .37	

	Direction	
Quality	Positive % (n)	Negative % (n)
Moderate/high	31.4 (32)	68.0 (17)
Low	68.6 (70)	32.0 (8)
	OR = 0.22** (0.08 – 0.55)	
	χ^2 (1, n = 127) = 11.37, *p* = .001, *phi* = -.30	

	Publication year	
Quality	≥ year 2000 % (n)	< year 2000 % (n)
Moderate/high	47.2 (42)	23.3 (10)
Low	52.8 (47)	76.7 (33)
	OR= 2.95** (1.30 – 6.70)	
	χ^2 (1, n = 132) = 6.96, *p* = .008, *phi* = .23	

	Significance	
Quality	Significant % (n)	Non-sign. % (n)
Moderate/high	32.8 (20)	44.9 (31)
Low	67.2 (41)	55.1 (38)
	OR= 0.60^{ns} (0.29 – 1.22)	
	χ^2 (1, n = 130) = 2.00, *p* = $.157^{ns}$, *phi* = -.12	

OR = odds ratio, with 95% confidence interval; χ^2 = chi square test of independence, with phi coefficient; ** *p* <.01; *** *p* <.001; ns = non-significant

Measurements of alcohol consumption and work performance

Categorisation of the applied measurements of alcohol consumption in the 26 included studies revealed eight subgroups: (i) consumption status (e.g., current alcohol drinker (yes/no), applied in Yu *et al.*[59]); (ii) drinking frequency (e.g., number of times drunk during past three months, applied in Ames *et al.*[21]; typical frequency of alcohol consumption during past year, applied in Aas *et al.*[40]); (iii) drinking intensity (e.g., average number of alcohol drinks during the past week, applied in Adler *et al.*[45]); (iv) drinking volume (e.g., monthly frequency x typical quantity during past 30 days, applied in Blum *et al.*[62]); (v) binge drinking (e.g., binge drinking (6 or more drinks on a single occasion) frequency during past year, applied in Aas *et al.*[40]); (vi) hangover (e.g., frequency of hangover episodes at work during past year, applied in Ames *et al.*[21]); (vii) composite instruments comprising several aspects of consumption, such as frequency, intensity and alcohol problems (e.g., the AUDIT,[10, 13] applied in Richmond *et al.*[54]); and (viii) alcohol-related diagnosis (e.g., DSM-IV diagnosis of alcohol abuse, applied in Lim *et al.*[64]).

The 26 included studies contained a total of six work performance measurement categories: (i) overall work performance/impairment (e.g., supervisor ratings of overall work performance, applied in Lowmaster *et al.*[65]; self-reported current work performance compared to lifetime best, applied in Furu *et al.*[67]; Work Limitations Questionnaire sum score,[70] applied in Kirkham *et al.*[51]); (ii) domain-specific work performance/impairment (e.g., Work Limitations Questionnaire subscale Time management,[70] applied in Adler *et al.*[45]); (iii) impaired performance quantity (e.g., number of days working below a normal level of performance during past 12 months, applied in Fisher *et al.*[47]; estimated percent impaired performance during past week, applied in Boles *et al.*[61]); (iv) impaired performance frequency (e.g., frequency of impaired performance episodes during past 12 months, applied in Schou *et al.*[55]); (v) prognosis of work performance (e.g., self-assessed probability of good work

performance within frame of 6 months, applied in Karlsson *et al.*[48]); and (vi) work performance status (e.g., impaired work performance during past 4 weeks (yes/no), applied in Yu *et al.*[59]). The identified associations, sorted according to measurements of alcohol consumption and work performance, are presented in Table 4.

Table 4
Identified associations (n = 132) according to measurements of alcohol consumption and work performance

	Work performance measure					
Alcohol measure	Overall work performance/impairment	Domain-specific work performance/ impairment	Impaired performance, quantity	Impaired performance, frequency	Prognosis work performance	Work performance status
Consumption status	*[66↓*],[67↑*]*					*[54↑*],[55↑*]*
Frequency	*[11↓ns],[12↑*],[14↑ns],[15↓ns], [58↑*],[59↑*]*		[108↓ns],[109↑*],*[124↑*]*, **[126↑ns]**	*[49↑*]*, [113↓ns],[114↓ns]	*[13↑ns],[16↑ns]*	
Quantity	*[10↑*],[28|*]*,[29|ns],[30↓ns], [31↓ns],[32↓ns],[33↓ns],[34↑ns], [35↑ns],*[39↑*],[50↑ns]*,**[85↓ns]**, [128↑ns],[129↑ns],*[130|ns], [131↑ns],[132↑ns]*	*[6↑ns],[7↑ns], [8↑ns],[9↑ns]*, **[86↓ns],[87↓ns]**, **[88↓ns],[89↓ns]**		*[53↑ns]*	*[24↓ns],[25↑ns]*	
Volume	*[62↑*],[63↑ns],[68↓*],[69↑*]* , *[73↑ns],[74↑ns],[75↑ns],[76↑ns], [77↑*],[78↑*],[79↑ns],[80↑ns], [81↑*],[82↑*],[83↑*],[84↑*]*		*[17↑*],[18↑ns],[19↑*],[20↑ns], [21↑ns],[22↓ns],[23↑ns]*,[111↓ns]	[116↓ns]		
Heavy episodic/ binge drinking	*[5↑*]*	*[1↑*],[2↑*], [3↑*],[4↑*]*	[112↓ns],*[125↑*]*,**[127↑*]**	[117↑ns]		*[118↑*]*
Hangover episodes	[40↑*],**[41↑*]**,[42↑*],[43↑*], [44↑*],[45↑ns],[46↑*],[47↑*]		[110↑*]	[115↑*]		*[119↑*],[120↑*] ,[121↑*]*
Composite instruments	**[36↑*]**,**[37↑*]**,**[38↑*]**,*[48↑ns], [64↑*],[65↑ns],[92↓ns],[93↓ns], [94↓ns],[122↑ns]*,[123↑*]		**[70↑ns]**,**[72↑ns]**,*[95↑*],[96↑*], [97↑*]*,[98|*],[99↓ns],[100↑ns], [101↑*],[102|ns],[103↑ns], *[104↑ns]*,[105↑ns],[106↑*], *[107↑ns]*			**[71↑ns]**
Diagnosis	*[51↑*]*,[52↑*],*[56↑*],[57↑ns], [60↑*],[61↑ns]*		*[26↑*],[27↑ns]*,[90↓ns],[91↑ns]			

Number in brackets = association ID; assessed quality level indicated by typeface: italic=low, regular=moderate, bold=high; ↑=positive association; ↓=negative association; |=association in non-consistent direction; *significant association; nsnon-significant association

In the 132 included associations, the most frequently applied alcohol measurement was drinking intensity (n = 28, 21 %) and composite instruments (n = 27, 20 %). Overall work performance/impairment (n = 67, 51 %) and quantity of impaired performance (n = 35, 27 %) were the most frequently utilised work performance measures. When exploring the group of associations characterised by being significant positive and of moderate or high quality (n = 18), the vast majority of these (n = 15) applied either hangover (n = 9) or composite instruments (n = 6) as alcohol consumption measures.

DISCUSSION

The aim of this review was to explore whether evidence in the research literature supports the notion of alcohol-related presenteeism, i.e., whether evidence supports an association between employee alcohol consumption and work performance. Twenty-six studies met the eligibility criteria, containing a total of 132 tested associations between alcohol consumption and presenteeism, based on data from 92 730 employees in 15 countries.

The vast majority of the associations (102 of 132, 77 %) indicated a positive relationship between alcohol consumption and impaired work performance, implying that higher levels of alcohol consumption were associated with higher levels of impaired performance. Furthermore, positive associations were considerably more likely than negative associations to be statistically significant.

Alcohol use has the potential for influencing cognitive and psychomotor performance, which may explain why employees' alcohol consumption is associated with work performance. In particular, hangover episodes are characterised by symptoms that can induce work impairments (headache, nausea, drowsiness etc.),[15, 19, 20] and alcohol intoxication, at least at higher blood alcohol content, may produce work impairments that increase linearly with task complexity.[14-17] Positive associations between alcohol consumption and

performance impairments are not so surprising in light of knowledge on the relationship between alcohol consumption and absenteeism. In their review, Schou and Moan found that employees' consumption was positively associated with both short-term and long-term sick leave.[25] The complementary hypothesis of the relationship between absenteeism and presenteeism claims that these behaviours are both related to employees' overall health status and that they are positively associated.[27] Research has demonstrated moderate positive correlations between absenteeism and presenteeism and that presenteeism may be a risk factor for future absenteeism.[27, 37]

Alcohol measurements based on hangovers and composite instruments were overrepresented in associations characterised by being significant positive, and of moderate or high quality. Hangovers tend to result from binge drinking episodes, or drinking shortly before work. Such short-term impairment-producing consumption may be more predictive of work impairments than for instance typical drinking frequency, which instead may be more predictive of long-term ill-health consequences.[72] Composite instruments, such as the AUDIT,[10, 13] tend to assume a more complex relationship between alcohol, health and performance than what may be the case for more basic measurements (e.g., drinking frequency or intensity). Hence, a composite instrument measuring both consumption and experienced alcohol problems may be more predictive of productivity outcomes such as work performance.

While most alcohol measures in the included studies can be said to capture somewhat different aspects of alcohol consumption (e.g., frequency, intensity, volume, binge episodes and hangovers), four studies did report abuse/dependence diagnoses (diagnosis vs. no diagnosis) as measure of exposure.[49, 57, 60, 64] One may argue that an alcohol-related diagnosis, focusing on harms and consequences as well as on use, is conceptually different from more direct measures of consumption. These studies are thus difficult to compare with other studies

in this review, even though they do not differ considerable in terms of overall conclusions regarding the relationship between exposure and outcome. Moreover, these studies are difficult to interpret in the context of the present review's research question. One may assume that individuals satisfying the criteria for an alcohol-related diagnosis are indeed characterised by having high consumption levels. However, the consumption levels of those not satisfying the diagnostic criteria in these studies remain unknown.

The majority of positive associations were judged to be of low quality, and 25 of 132 associations (19 %) even indicated a negative relationship, i.e., implying that higher levels of alcohol consumption were associated with lower performance impairments (higher performance). Moreover, five associations were inconsistent, i.e., not possible to classify as positive or negative, or did not reveal any association between alcohol consumption and work performance at all. Negative associations were less likely than positive associations to be of low quality.

Only two associations categorised as negative reported statistically significant findings. These associations, both reported in Friedman *et al.*[60], tested the relationship between duration of alcohol use and overall work performance, and found that longer duration (higher exposure) was associated with lower work impairment. Basically, these results may imply that more experienced drinkers report lower levels of work impairment than less experienced drinkers. As such, rather than implying that higher consumption could be related to lower impairments, they may reflect that experienced drinkers have developed higher tolerance levels and more sophisticated coping strategies than less experienced drinkers.

The relationship between alcohol consumption and health outcomes has, in some studies, been described as a J-shaped curve where low to moderate consumption is associated with better health outcomes than non-drinking.[73] In their study of manufacturing company employees in the USA, Moore et al.[66] found a J-shaped relationship between alcohol

consumption and percentage of time at work spent "goofing off". In this study, abstainers scored higher on "goof-off time" than low-moderate drinkers, but lower than heavy drinkers. J-shaped relationships have also been found between alcohol consumption and cognitive outcomes.[74] It is, however, somewhat unclear whether low-moderate levels of alcohol consumption in fact have some protective effects or whether such findings are products of confounding.[4, 73, 75] For instance, studies have demonstrated that heavy drinking is associated with cognitive deficits that endure long after abstinence.[76] Such deficits, due to former heavy drinking, may impair work performance, even though the employee is currently categorised as an abstainer. A recent review found no mortality benefits for low-volume drinking compared to lifestime abstention or occasional drinking, when adjusting for study design and characteristics.[77] Nevertheless, potential curvilinear relationships between alcohol consumption and health outcomes may contribute to explain why a considerable proportion of associations failed to demonstrate significant positive relationships. Moreover, on-the-job performance outcomes may be more directly affected by on-the-job drinking (within two hours before work, during breaks or while performing the job) than by off-the-job drinking, even though off-the-job consumption may translate into workplace impairment.[5] Among the studies included in this review, only one (Ames *et al.*[21]) contained explicit measures of on-the-job drinking, while the remaining studies measured overall consumption (consumption regardless of context). Moreover, overall consumption may have differential impact on different domains. In a study of employees in Norway, Aas *et al.*[40] found that overall consumption demonstrated stronger associations with performance impairments outside the workplace compared to work performance, which may be due to employees moderating (self-regulating) their behaviour at work as a result of potential sanctions from employers. Self-regulatory motivations and mechanisms may contribute to hide alcohol-related presenteeism,

which may complicate the exploration of associations between alcohol consumption and work performance.

Implications

Overall, this review provides support for the notion of alcohol-related presenteeism, i.e., that employee alcohol consumption may be associated with performance decrements at work. Research has, although often demonstrating somewhat mixed results, shown that employees' alcohol consumption is related to occupational outcomes, including absenteeism and occupational injuries.[25, 34-36] The results of this review on alcohol-related presenteeism imply that impaired work performance may be an additional detrimental occupational outcome related to alcohol consumption. As such, this review provides further support for targeting alcohol consumption within workplace interventions aimed at improving employee health and productivity, rather than implying that interventions should specifically target presenteeism behaviour. Further research is necessary for determining whether and how presenteeism should be targeted directly in interventions.

It is not possible to draw firm conclusions regarding the relationship between alcohol consumption and work performance. The majority of identified evidence was of low quality as a result of low power (small sample sizes) and/or risk of confounding. Moreover, the majority of identified studies were cross-sectional, and thereby unable to draw causal inferences about the relationship between exposure and outcome. Above all, this review implies the need for further research. First, future research would benefit from studying alcohol-related presenteeism by means of more robust study designs that better enable exploration of causal mechanisms and development over time. A more thorough exploration of alcohol as a risk factor for impaired work performance could be done by means of retrospective case-control studies, where historical data sources containing information on

alcohol consumption (such as medical records) are utilised in order to compare work impaired (cases) with non-impaired employees (controls). How the relationship between alcohol and work performance develops over time can be explored with prospective cohort studies, where researchers can follow and compare risky and non-risky drinkers with repeated measurements of work performance.

Second, both alcohol consumption and work performance are conceptualised and measured very differently across current studies. Such heterogeneity makes it difficult to explore findings in the literature by means of meta-analyses. Progress in the field seems to hinge on researchers' ability to reach more agreement on how to conceptualise these variables and measure them utilising instruments with satisfactory psychometric properties. This seems particularly true for the concept of presenteeism. According to an expert panel from the American College of Occupational and Environmental Medicine,[31(p351)] productivity instruments should be supported by scientific evidence, be applicable to the specific work setting, support decision making, and be practical. Ospina *et al.*[78] concluded that the following three instruments were most strongly supported by evidence: The Stanford Presenteeism Scale (6-item versjon),[79] the Endicott Work Productivity Scale (EWPS),[80] and the Health and Work Questionnaire (HWQ).[81] Regardless of design, future research would benefit from measurement triangulation. For instance, alcohol consumption could be measured with a validated self-report composite measure (e.g., the AUDIT measuring both consumption and alcohol-related harm, or the abbreviated AUDIT-C measuring only consumption),[10, 13] items separating off-the-job and on-the-job drinking and hangovers, and an alcohol biomarker test (such as the carbohydrate-deficient transferrin (CDT) test). Work performance could be measured with a validated self-report composite instrument (e.g., the Stanford Presenteeism Scale),[79] as well as with supervisors' ratings of employee work performance and, where possible, register data on task performance. Measurement

triangulation may provide more valid measures as well as enabling exploration of a potential correspondence between consumption contexts, impairment contexts and performance outcomes.

Third, future research would benefit from taking possible mediators and moderators of the relationship between alcohol and work performance into account, such as sociodemographic, general health, work-related, and other lifestyle factors.

Methodological considerations

This review has some limitations. First and foremost, due to the heterogeneous nature of the identified data, we were unable to perform meta-analyses on the included data.

Second, it may be considered a limitation that this review utilised associations and not studies as the unit of interest. Associations were deemed the appropriate unit of interest in this review for two reasons: (i) included studies were characterised by exploring broader aims related to health and productivity, while this review specifically aimed at exploring the relationship between alcohol consumption and work performance, and (ii) in several studies, multiple associations between alcohol consumption and work performance were tested (often with different measures and subgroups within each study).

Third, this review did not utilise a previously validated critical appraisal tool (CAT) for assessment of included primary research. One reason for this is that studies based on different study designs were included in the review. At present, there exists no generic gold standard CAT for application across study designs.[82, 83] A second reason is that the current review emphasised associations rather than studies as the unit of interest. Hence, it was deemed more appropriate to develop a parsimonious and conservative quality assessment system in which each association was evaluated based on power (sample size) and risk of confounding (level of adjustment). Deliberately, we chose a conservative approach to quality assessment by

ascribing each association an overall score in accordance with the "worst score counts" algorithm. Such an approach is in line with the COSMIN guidelines.[44]

Fourth, articles published before 1990 were not eligible for inclusion in this review. This exclusion criterion was set a priori as a result of old studies having limited external validity due to changes in drinking behaviour over time. Time restrictions were imposed at the study selection phase, not in the literature search phase of the review. This decision was made in order to be able to assess the magnitude of potentially relevant research published prior to 1990. Seventeen articles from the 1980s were excluded in the title/abstract screening. However, these articles did not satisfy all the other inclusion criteria and were, thus, not exclusively excluded based on year of publication. Hence, we do not find it very likely that relevant studies published before 1990 have been missed.

Fifth, we chose to utilise the concept of presenteeism in line with researchers who define it in terms of decreased on-the-job productivity due to health problems.[30] Such an understanding does ascribe valence to the phenomenon, i.e., a behaviour contributing to lost productivity that may carry negative influence on the overall work environment.[84] We are, however, aware of differing opinions among scholars regarding conceptualisations of presenteeism. Different definitions have different strengths and weaknesses. According to Johns,[26] a proper definition should (i) neither ascribe motives nor consequences to presenteeism, and (ii) avoid conflating cause and effect by perceiving productivity loss itself as presenteeism. To some extent, we do agree with such objections against a productivity-based definition. A more open understanding, such as simply "showing up for work even when one is ill",[26(p519)] does not ascribe a certain valence to the phenomenon, nor does it presuppose or exclude any particular consequence. We believe, however, that in a socioeconomic and organisational perspective, situations in which employees attend work while ill become of interest primarily when performance decrements are in fact involved. In order to avoid conflating cause and effect, we

operationalised alcohol-related presenteeism as the product of a relationship between two measurable variables, i.e., alcohol consumption (predictor/exposure) and work performance (outcome).

CONCLUSIONS

Alcohol-related presenteeism (impaired work performance associated with alcohol consumption) stands out as an important but under-researched topic in the research literature. According to this review, evidence provides support for the notion that employee alcohol consumption may be associated with impaired work performance. However, due to low research quality and lack of longitudinal designs, existing evidence should still be characterised as inconclusive regarding the prevalence, nature and impact of alcohol-related presenteeism in the workforce. More robust and less heterogeneous research is warranted.

DECLARATIONS

Contributors

RWA is the principal investigator and project manager of the WIRUS project. This review study was designed by MMT and RWA. MMT analysed the data and drafted the manuscript. Data selection was performed by MMT, NH and RWA; data extraction by MMT and TB; and quality assessment by MMT and IK. TB, NH, IK WVM and RWA provided scientific input to the different drafts and provided data interpretation. All authors made critical revisions and provided intellectual content to the manuscript, approved the final version to be published, and agreed to be accountable for all aspects of this work.

Funding

The review study is funded by the Norwegian Directorate of Health and the Research Council of Norway. The funding bodies had no role in the design of the review or in data analysis or interpretation.

Competing interests

For the avoidance of doubt, WvM wishes to declare that he is director-shareholder of VUmc spin-off company Evalua Nederland B.V. and non-executive board member of Arbo Unie B.V.. Both companies operate in the Dutch occupational health care market.

Availability of data and materials

Data from the review study are available from the project owner (University of Stavanger, Faculty of Health Sciences, Department of Public Health, Research group Societal Participation in School and Work) by principal investigator and project manager Randi Wågø Aas on reasonable request.

SUPPLEMENTARY FILES

Supplementary File 1: Primary database search strategy (based on search in Medline) (PDF)

Supplementary File 2: Characteristics of tested associations in included studies (PDF)

Supplementary File 3: Results of quality assessment of included associations (PDF)

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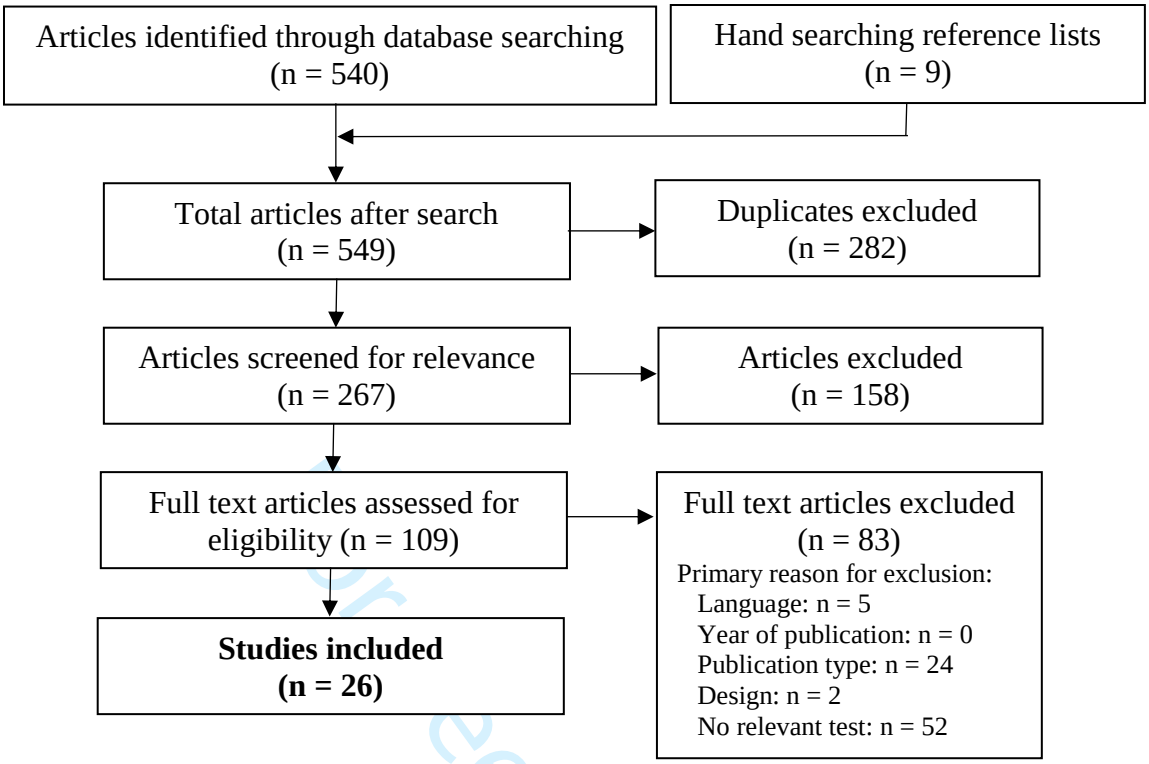
FIGURE TITLE/LEGEND

Figure 1. PRISMA flow chart of the study selection process



Supplementary File 1. Primary database search strategy (based on search in Medline)

		Search#	Query	Search type	Search level
Population	*Employees*	1	employee*	Text	Abstract
		2	employed	Text	Abstract
		3	worker*	Text	Abstract
		4	workforce	Text	Abstract
		5	work	MeSH	-
		6	employment	MeSH	-
		7	**1 OR 2 OR 3 OR 4 OR 5 OR 6**		
Exposure	*Alcohol consumption*	8	alcohol*	Text	Abstract
		9	drink*	Text	Abstract
		10	drunk*	Text	Abstract
		11	hangover	Text	Abstract
		12	"hang over"	Text	Abstract
		13	alcohol drinking	MeSH	-
		14	binge drinking	MeSH	-
		15	drinking behavior	MeSH	-
		16	**8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15**		
Outcome	*Work performance*	17	presenteeism	Text	Abstract
		18	"job productiv*"	Text	Abstract
		19	"work productiv*"	Text	Abstract
		20	"job capacity"	Text	Abstract
		21	"work capacity"	Text	Abstract
		22	"job ability"	Text	Abstract
		23	"work ability"	Text	Abstract
		24	"job impair*"	Text	Abstract
		25	"work impair*"	Text	Abstract
		26	"job performance"	Text	Abstract
		27	"work performance"	Text	Abstract
		28	presenteeism	MeSH	-
		29	work performance	MeSH	-
		30	**17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29**		
		31	**7 AND 16 AND 30**		

Note. This primary database search strategy was applied in Medline. When applied in the other databases (Web of Science, PsycINFO, Cinahl, Amed, Embase and Swemed+), the strategy was adapted to each database.

Supplementary File 2. Overview of tested associations (n = 132) in the included studies (n = 26)

Association ID	Study (author, year, reference)	Effect size[a]	Significance	Sample size	Adjustment	Classification in review[b]
1	Adler *et al.*, 2011 [45]	*r* = .11	*p* = .01	473	Unadjusted	↑ * L
2	"	*r* = .10	*p* = .03	473	Unadjusted	↑ * L
3	"	*r* = .14	*p* = .002	473	Unadjusted	↑ * L
4	"	*r* = .14	*p* = .002	473	Unadjusted	↑ * L
5	"	*r* = .16	*p* <.001	473	Unadjusted	↑ * L
6	"	*r* = .07	*p* = .16	473	Unadjusted	↑ ns L
7	"	*r* = .08	*p* = .08	473	Unadjusted	↑ ns L
8	"	*r* = .09	*p* = .50	473	Unadjusted	↑ ns L
9	"	*r* = .07	*p* = .11	473	Unadjusted	↑ ns L
10	"	*r* = .10	*p* = .04	473	Unadjusted	↑ * L
11	Airila *et al.*, 2012 [46]	*r* = -.05	ns	403	Unadjusted	↑ ns L
12	"	*r* = -.10	*p* <.05	403	Unadjusted	↑ * L
13	"	*r* = -.05	ns	403	Unadjusted	↑ ns L
14	"	b = -.07	95% CI: -.18, .05	403	Age; work ability at baseline	↑ ns L
15	"	b = .01	95% CI: -.07, .09	403	Age; work ability at baseline	↓ ns L
16	"	b = -.06	95% CI: -.16, .05	403	Age; work ability at baseline	↑ ns L
17	Fisher *et al.*, 2000 [47]	RR = 1.52	*p* <.05; 95% CI: 1.36, 1.70	Unclear	Age	↑ * L

18	"	RR = 1.18	95% CI: 0.88, 1.60	Unclear	Age	↑ ns L
19	"	RR = 1.76	*p* <.05; 95% CI: 1.34, 2.33	Unclear	Age	↑ * L
20	"	RR = 1.38	95% CI: 0.72, 2.61	Unclear	Age	↑ ns L
21	"	RR = 1.25	95% CI: 0.96, 1.62	Unclear	Age	↑ ns L
22	"	RR = 0.58	95% CI: 0.26, 1.30	Unclear	Age	↓ ns L
23	"	RR = 1.39	95% CI: 0.62, 3.12	Unclear	Age	↑ ns L
24	Karlsson *et al.*, 2010 [48]	OR = 0.91	95% CI: 0.33, 2.55	300	Gender; age	↓ ns L
25	"	OR = 2.33	95% CI: 0.84, 6.51	289	Gender; age	↑ ns L
26	Kessler & Frank, 1997 [49]	b = .88	*p* <.05	4091	Unadjusted	↑ * L
27	"	b = .17	ns	4091	Unadjusted	↑ ns L
28	Kim *et al.*, 2013 [50]	unclear	*p* <.001	946	Unadjusted	| * L
29	"	unclear	*p* = .03	946	Age; employment; education; body mass index; drug use	| * M
30	"	unclear	*p* = .10	884	Age; employment; education; body mass index; drug use	↓ ns M
31	"	unclear	*p* = .11	577	Age; employment; education; body mass index; drug use	↓ ns M
32	"	unclear	*p* = .98	577	Age; employment; education; body mass index; drug use	↓ ns M

33	"	unclear	p = .51	577	Age; employment; education; body mass index; drug use	↓ ns M
34	"	unclear	p = .97	369	Age; employment; education; body mass index; drug use	↑ ns M
35	"	unclear	p = .53	62	Age; employment; education; body mass index; drug use	↑ ns M
36	Kirkham *et al.*, 2015 [51]	β = .20	p <.001; 95% CI: .14, .27	27459	Age; gender; region of residence; misc. work-related factors	↑ * H
37	"	β = .22	p <.001; 95% CI: .13, .32	10639	Age; gender; region of residence; misc. work-related factors	↑ * H
38	"	β = .20	p <.001; 95% CI: .10, .29	16820	Age; gender; region of residence; misc. work-related factors	↑ * H
39	Odlaug *et al.*, 2016 [52]	unclear	p <.05	1373	Unadjusted	↑ * L
40	Pensola *et al.*, 2016 [53]	PRR = 1.22	95% CI: 1.1, 1.4	1351	Age; gender	↑ * M
41	"	PRR = 1.15	95% CI: 1.0, 1.3	1351	Age; gender; misc. work-related, physical and psychosocial factors	↑ * H
42	"	PRR = 1.30	95% CI: 1.1, 1.6	546	Age	↑ * M
43	"	PRR = 1.21	95% CI: 1.0, 1.5	546	Age; gender; misc. work-related, physical and psychosocial factors	↑ * M

44	"	PRR = 1.15	95% CI: 1.0, 1.4	805	Age	↑ * M
45	"	PRR = 1.01	95% CI: 0.9, 1.2	573	Age; gender	↑ ns M
46	"	PRR = 1.92	95% CI: 1.4, 2.7	778	Age; gender	↑ * M
47	"	PRR = 1.80	95% CI: 1.3, 2.6	778	Age; gender; misc. work-related, physical and psychosocial factors	↑ * M
48	Richmond *et al.*, 2016 [54]	b = 0.017; β = .057	ns	338	Baseline presenteeism	↑ ns L
49	Schou *et al.*, 2017 [55]	r = .458	p <.01	1406	Unadjusted	↑ * L
50	Steegmann *et al.*, 1997 [56]	r = .073	ns	45	Unadjusted	↑ ns L
51	Tsuchiya *et al.*, 2012 [57]	b = -1.1	95% CI: -2.1, -0.0	530	Unadjusted	↑ * L
52	"	b = -1.1	95% CI: -2.1, -0.1	530	Gender; age; education; job category; work time	↑ * M
53	van Scheppingen *et al.*, 2014 [58]	r = .01	ns	629	Unadjusted	↑ ns L
54	Yu *et al.*, 2015 [59]	χ^2 = 4.6	p <.05	1506	Unadjusted	↑ * L
55	"	OR = 1.76	95% CI: 1.02, 3.03	1506	unclear	↑ * L
56	Friedman *et al.*, 1992 [60]	r = -.09	p <.01	860	Unadjusted	↑ * L
57	"	r = .02	ns	860	Unadjusted	↑ ns L
58	"	r = -.14	p <.01	973	Unadjusted	↑ * L

59	"	r = .09	p <.01	973	Unadjusted	↑ * L
60	"	r = -.12	p <.01	886	Unadjusted	↑ * L
61	"	r = .05	ns	886	Unadjusted	↑ ns L
62	"	r = -.13	p <.01	852	Unadjusted	↑ * L
63	"	r = .06	ns	852	Unadjusted	↑ ns L
64	"	r = 09	p <.01	863	Unadjusted	↑ * L
65	"	r = .03	ns	863	Unadjusted	↑ ns L
66	"	r = .10	p <.01	1229	Unadjusted	↓ ns L
67	"	r = .06	p <.05	1229	Unadjusted	↑ * L
68	"	r = .09	p <.01	1229	Unadjusted	↓ * L
69	"	r = .07	p <.05	1229	Unadjusted	↑ * L
70	Boles *et al.*, 2004 [61]	unclear	ns	2264	Age; gender; misc. risk factors	↑ ns H
71	"	OR = 3.74	p = .115	2264	Age; gender; misc. risk factors	↑ ns H
72	"	b = 0.901	p = .930	2264	Age; gender; misc. risk factors	↑ ns H
73	Blum *et al.*, 1993 [62]	r = -.016	ns	136	Unadjusted	↑ ns L
74	"	M_{diff} = 0.01	ns	136	Unadjusted	↑ ns L
75	"	M_{diff} = 0.21	ns	136	Unadjusted	↑ ns L
76	"	M_{diff} = 0.05	ns	136	Unadjusted	↑ ns L

77	"	r = -.185	p <.05	136	Unadjusted	↑ * L
78	"	M_{diff} = 0.19	p <.05	136	Unadjusted	↑ * L
79	"	M_{diff} = 0.16	ns	136	Unadjusted	↑ ns L
80	"	M_{diff} = 0.03	ns	136	Unadjusted	↑ ns L
81	"	r = -.233	p <.01	136	Unadjusted	↑ * L
82	"	M_{diff} = 0.28	p <.01	136	Unadjusted	↑ * L
83	"	M_{diff} = 0.35	p <.01	136	Unadjusted	↑ * L
84	"	M_{diff} = 0.03	p <.05	136	Unadjusted	↑ * L
85	Burton *et al.*, 2005 [63]	M_{diff} = -0.0748	ns	28375	Age; gender; diseases; misc. risk factors	↓ ns H
86	"	M_{diff} = -0.0447	ns	28375	Age; gender; diseases; misc. risk factors	↓ ns H
87	"	M_{diff} = -0.0833	ns	28375	Age; gender; diseases; misc. risk factors	↓ ns H
88	"	M_{diff} = -0.0853	ns	28375	Age; gender; diseases; misc. risk factors	↓ ns H
89	"	M_{diff} = -0.0865	ns	28375	Age; gender; diseases; misc. risk factors	↓ ns H
90	Lim *et al.*, 2000 [64]	b = -0.92	ns	4579	Physical and mental disorders	↓ ns M
91	"	b = 0.18	ns	4579	Physical and mental disorders	↑ ns M
92	Lowmaster *et al.*, 2012 [65]	r = .21	ns	85	Unadjusted	↓ ns L
93	"	r = .12	ns	29	Unadjusted	↓ ns L

94	"	r = .23	ns	56	Unadjusted	↓ ns L
95	Moore *et al.*, 2000 [66]	unclear	p <.05	1521	Unadjusted	↑ * L
96	"	unclear	p <.05	1378	Unadjusted	↑ * L
97	"	unclear	p <.05	520	Unadjusted	↑ * L
98	"	unclear	p <.05	2256	Demographic variables	| * M
99	"	M_{diff} = 0.1	p = .65	1780	Demographic variables	↓ ns M
100	"	M_{diff} = 0.2	p = .10	520	Demographic variables	↑ ns M
101	"	M_{diff} = 0.3	p <.01	1378	Demographic variables	↑ * M
102	"	M_{diff} = 0.0	p = .68	676	Demographic variables	| ns M
103	"	M_{diff} = 0.1	p = .09	1534	Demographic variables	↑ ns M
104	"	M_{diff} = 0.2	p = .10	274	Demographic variables	↑ ns L
105	"	M_{diff} = 0.1	p =.42	663	Demographic variables	↑ ns M
106	"	M_{diff} = 0.2	p <.05	1521	Demographic variables	↑ * M
107	"	M_{diff} = 0.1	p = .22	261	Demographic variables	↑ ns L
108	Ames *et al.*, 1997 [21]	b = -0.02; β = -.02	ns	832	Drinking variables; job characteristics	↓ ns M
109	"	b = 0.08; β = .08	p <.05	832	Drinking variables; job characteristics	↑ * M
110	"	b = 0.08; β = .08	p <.05	832	Drinking variables; job characteristics	↑ * M
111	"	b = -0.01; β = -.01	ns	832	Drinking variables; job characteristics	↓ ns M

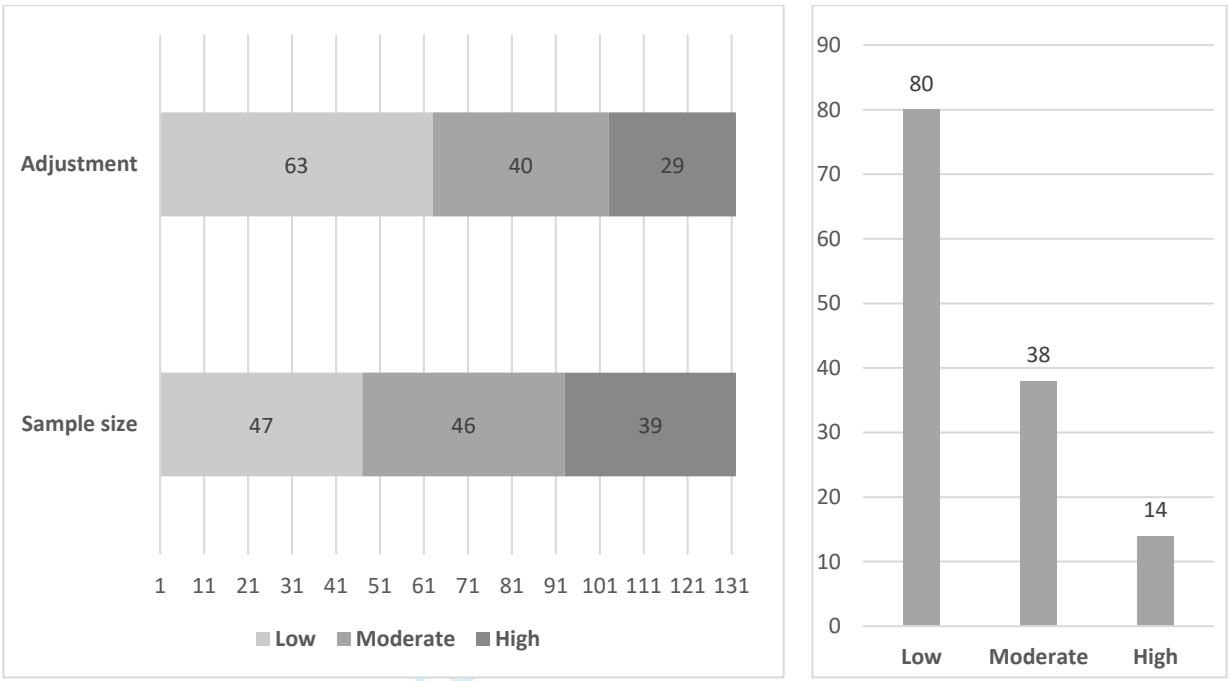
112	"	b = -0.03; β = -.03	ns	832	Drinking variables; job characteristics	↓ ns M
113	"	b = -0.02; β = -.02	ns	832	Drinking variables; sociodemographics	↓ ns M
114	"	b = -0.01; β = -.01	ns	832	Drinking variables; sociodemographics	↓ ns M
115	"	b = 0.21; β = .21	*p* <.001	832	Drinking variables; sociodemographics	↑ * M
116	"	b = -0.01; β = -.01	ns	832	Drinking variables; sociodemographics	↓ ns M
117	"	b = 0.00; β = .00	ns	832	Drinking variables; sociodemographics	↑ ns M
118	"	η^2 = .01	*p* <.02	832	Unadjusted	↑ * L
119	"	η^2 = .01	*p* <.05	832	Unadjusted	↑ * L
120	"	η^2 = .02	*p* <.01	832	Unadjusted	↑ * L
121	"	η^2 = .01	*p* <.05	832	Unadjusted	↑ * L
122	Furu *et al.*, 2018 [67]	OR = 1.25	95% CI: 0.98, 1.61	1622	Unadjusted	↑ ns L
123	"	OR = 1.36	95% CI: 1.05, 1.77	1622	Age	↑ * M
124	Aas *et al.*, 2017 [40]	*r* = .049	*p* <.01	3278	Unadjusted	↑ * L
125	"	*r* = .076	*p* <.001	3278	Unadjusted	↑ * L
126	"	b = 0.016; β = .028	ns	3278	Gender; age; education; living status; employment sector; binge drinking	↑ ns H

127	"	b = 0.040; β = .057	*p* <.01	3278	Gender; age; education; living status; employment sector; drinking frequency	↑ * H
128	van den Berg *et al.*, 2017 [68]	OR = 1.23	95% CI: 0.87, 1.74	509	Gender; age; education	↑ ns M
129	"	OR = 1.28	95% CI: 0.99, 1.65	1267	Gender; age; education	↑ ns M
130	"	OR = 1.00	ns	410	Gender; age; education	| ns L
131	"	OR = 1.18	95% CI: 0.66, 3.11	413	Gender; age; education	↑ ns L
132	"	OR = 1.52	95% CI: 0.96, 2.41	335	Gender; age; education	↑ ns L

[a] *r* = correlation coefficient; b = unstandardised regression coefficient; RR = relative risk; OR = odds ratio; β = standardised regression coefficient; PRR = prevalence risk ratio; χ^2 = chi square; M_{diff} = mean difference; η^2 = eta squared

[b] ↑ = positive association; ↓ = negative association; | = inconsistent direction; * = significant association; ns = non-significant association; L = low quality association; M = moderate quality association; H = high quality association

Supplementary File 3. Results of quality assessments of included associations (n = 132)



Panel A **Panel B**

Panel A displays quality assessments separately on two key domains (sample size and level of adjustment). Panel B displays overall assessments according to the "worst score counts" algorithm.

MOOSE Checklist for Meta-analyses of Observational Studies

Item No	Recommendation	Reported on Page No
Reporting of background should include		
1	Problem definition	2,9
2	Hypothesis statement	n/a
3	Description of study outcome(s)	6-8
4	Type of exposure or intervention used	4-6
5	Type of study designs used	9
6	Study population	5-6,9
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	1,10-11
8	Search strategy, including time period included in the synthesis and key words	10-11, SF1
9	Effort to include all available studies, including contact with authors	11
10	Databases and registries searched	10, SF1
11	Search software used, name and version, including special features used (eg, explosion)	11
12	Use of hand searching (eg, reference lists of obtained articles)	11
13	List of citations located and those excluded, including justification	n/a
14	Method of addressing articles published in languages other than English	9-10
15	Method of handling abstracts and unpublished studies	9-10
16	Description of any contact with authors	n/a
Reporting of methods should include		
17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	9-10,11
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	11-12
19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	11-12
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	12-13
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	12-13
22	Assessment of heterogeneity	12
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	13-14
24	Provision of appropriate tables and graphics	Fig1, SF1
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	n/a
26	Table giving descriptive information for each study included	Table1
27	Results of sensitivity testing (eg, subgroup analysis)	n/a
28	Indication of statistical uncertainty of findings	SF2

Item No	Recommendation	Reported on Page No
Reporting of discussion should include		
29	Quantitative assessment of bias (eg, publication bias)	22, SF3
30	Justification for exclusion (eg, exclusion of non-English language citations)	37
31	Assessment of quality of included studies	36
Reporting of conclusions should include		
32	Consideration of alternative explanations for observed results	32-34
33	Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	34
34	Guidelines for future research	34-35
35	Disclosure of funding source	38-39

From: Stroup DF, Berlin JA, Morton SC, et al, for the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) Group. Meta-analysis of Observational Studies in Epidemiology. A Proposal for Reporting. *JAMA*. 2000;283(15):2008-2012. doi: 10.1001/jama.283.15.2008.

SF1 = Supplementary File 1
SF2 = Supplementary File 2
SF3 = Supplementary File 3