# A systematic review and meta-analysis on the association between solitary drinking and alcohol problems in adults

Carillon J. Skrzynski[1] (iD) & Kasey G. Creswell[2] (iD)

Department of Psychology and Neuroscience, University of Colorado Boulder, Boulder, CO, USA[1] and Department of Psychology, Carnegie Mellon University, Pittsburgh, PA, USA[2]

## ABSTRACT

**Background and aims**   Solitary drinking in adolescents and young adults is associated with greater risk for alcohol problems, but it is unclear whether this association exists in older demographics. The current paper is the first meta-analysis and systematic review, to our knowledge, to determine whether adult solitary drinking is associated with greater risk for alcohol problems. **Methods**   PsychINFO, PubMed and Google Scholar were searched following a pre-registered International Prospective Register of Systematic Reviews (PROSPERO) protocol (CRD42019147075) and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology. Following the methodology used in our recent systematic review and meta-analysis on adolescent/young adult solitary drinking, we systematically reviewed solitary drinking measures/definitions, prevalence rates and associated demographic variables in adults. We then meta-analyzed (using random-effects models) associations between adult solitary drinking and alcohol use/problems, negative affect and negative/positive reinforcement-related variables (e.g. drinking to cope or for enhancement). **Results**   Solitary drinking was defined as drinking while physically alone in nearly all studies, but measures varied. Prevalence rates were generally in the 30–40% range, with some exceptions. In general, males were more likely than females to report drinking alone, and married individuals were less likely than unmarried individuals to report drinking alone; racial/ethnic differences were mixed. Meta-analytical results showed significant effects for the associations between solitary drinking and the following factors: alcohol consumption, $r = 0.25$, 95% confidence interval (CI) = 0.18, 0.33, $k = 15$, $I^2 = 97.41$; drinking problems, $r = 0.15$, 95% CI = 0.10, 0.21, $k = 14$, $I^2 = 92.70$; and negative reinforcement, $r = 0.24$, 95% CI = 0.14, 0.32, $k = 11$, $I^2 = 89.77$; but not positive reinforcement, $r = 0.02$, 95% CI = 0.06, 0.09, $k = 8$, $I^2 = 76.18$; or negative affect, $r = 0.03$, 95% CI = −0.02, 0.08, $k = 8$, $I^2 = 52.06$. Study quality moderated the association between solitary drinking and negative affect ($\beta = -0.07$, $P < 0.01$) such that lower-quality studies were significantly associated with larger effect sizes. Study quality was generally low; the majority of studies were cross-sectional. **Conclusions**   Solitary drinking appears to have a small positive association with alcohol problems.

**Keywords**   Adults, alcohol use disorder, drinking alone, drinking to cope, meta-analysis, mid-life adults, older adults, solitary drinking, systematic review.

## INTRODUCTION

The prevalence of binge drinking and alcohol use disorder (AUD) among US middle-aged and older adults is high and increasing [1–5]. Indeed, the majority of total binge drinks consumed by US adults in 2015 were consumed by those aged 35+ years [6]. Compared to younger individuals, the mental and physical health consequences of heavier drinking in older individuals are often more serious [7], with greater risks of harmful drug interactions, injury

and depression, to name a few (e.g. [8–10]). Although problem drinking is evident throughout the life-span, and despite calls for research on older populations (e.g. [11]), the bulk of the literature on at-risk drinking and AUD focuses on adolescents and young adults. Far less is known about the correlates and mechanisms of risk for problematic drinking in older individuals [12]. To develop more effective prevention/intervention programs for all those at risk, research is needed on risk factors associated with problematic drinking in populations beyond

adolescents and young adults (i.e. adults aged > 30 years, referred to herein as adults).

Risk factors in younger individuals might also be relevant for older populations. The social context of alcohol use is an important determinant of risk for alcohol and psychosocial problems in adolescents and young adults [13,14]. Among these individuals, solitary drinking is associated with increased concurrent and prospective alcohol use and alcohol-related problems (e.g. [14–18]), as well as problems in academic [19], legal [20], physical health [19], emotional [21] and social domains (e.g. [22]). We recently conducted a meta-analysis on solitary drinking in adolescents (ages 12–18) and young adults (mean age between 18 and 30 or the majority of the sample aged < 30 years), and found small to medium effects for the associations between solitary drinking and alcohol consumption, drinking problems, negative affect and social discomfort (the latter of which included variables such as social anxiety, loneliness and dissatisfaction with social networks) [16]. Two additional factors, labeled negative and positive reinforcement, were also investigated to illuminate the potential mechanisms that might drive solitary drinking in order to inform prevention/intervention efforts. Included in these factors were motives, expectancies and situations related to drinking to alleviate negative affect or to enhance positive affect, respectively. While associations between solitary drinking and both of these factors were significant, the effect size for the negative reinforcement factor was three times greater than the positive reinforcement factor [16]. Together, these results suggest that solitary drinking is a risky drinking pattern among adolescents and young adults and may be primarily motivated by the desire to alleviate negative affect.

It is unclear whether solitary drinking serves as a reliable indicator of alcohol problems among adults [13]. Prevalence rates of solitary dinking in adults are often much higher than rates in adolescents and young adults (e.g. [23,24]), in some cases reaching 2.5 times the rates of younger samples [25], suggesting that drinking alone may become a more normative and potentially less problematic drinking style as individuals age. Indeed, results from an adult sample (mean age = 40 years) showed that solitary drinking was only problematic when individuals were drinking heavily while alone [23,26]. Findings are mixed, however. While adult solitary drinking is often associated with greater alcohol consumption (e.g. [27,28]), results regarding alcohol problems are inconsistent (e.g. [28–30] cf. [31–33]). Synthesizing results across studies will illuminate whether solitary drinking is reliably associated with greater alcohol use/problems in adults, as it is in younger demographics.

If solitary drinking is associated with at-risk alcohol consumption among adults, it is important to understand why these individuals drink alone to develop targeted intervention/prevention programs. Solitary drinking may be imbued with a different meaning in older versus younger individuals. While adolescent and young adult solitary drinking is associated with negative reinforcement factors (e.g. drinking to cope [15,16]), adult solitary drinking may be linked to positive reinforcement factors (e.g. drinking to enhance positive affect), given that adults report drinking alone during situations often linked to positive affect (e.g. while enjoying a meal, during leisure time) [26,34,35]. However, findings are also mixed for associations between adult solitary drinking and negative affect (e.g. [25,36] cf. [37]), negative reinforcement factors (e.g. [38,39] cf. [27,40]) and positive reinforcement factors (e.g. [27,41] cf. [38,42]). Thus, it remains unclear whether negative or positive reinforcement is more important in motivating adult solitary drinking.

The current study is the first to provide a systematic review and quantitative analysis on solitary drinking among adults. The aims and methodology mirror our prior systematic review and meta-analysis on adolescents and young adults [16]. Specifically, we first provide a context for understanding adult solitary drinking by systematically reviewing how it has been defined/measured, prevalence rates and associated demographic factors. We then provide a systematic review and meta-analysis on associations between adult solitary drinking and five superordinate factors from our prior review on adolescents and young adults: alcohol consumption (i.e. quantity/frequency), drinking problems (e.g. AUD symptoms), negative affect (e.g. depression), negative reinforcement and positive reinforcement (i.e. drinking motives/expectancies/situations related to ameliorating negative affect or enhancing positive affect, respectively[1]). We hypothesized that solitary drinking among adults, as with younger samples, would be positively associated with alcohol consumption and problems. Given conflicting evidence, we tested the associations between solitary drinking, negative affect and negative versus positive reinforcement factors without proposing specific hypotheses.

## METHOD

We report methodology in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines [44] (see Supporting information, Table S1) and following a pre-registered International Prospective Register of Systematic Reviews (PROSPERO) protocol (http://www.crd.york.ac.uk/PROSPERO/,

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[1]We had hoped to test a 'social discomfort' factor as we did in our prior meta-analysis, especially given the increasing prevalence of loneliness/social isolation associated with aging [43]. However, there were only three studies that included relevant variables, and two of them focused exclusively on social support.
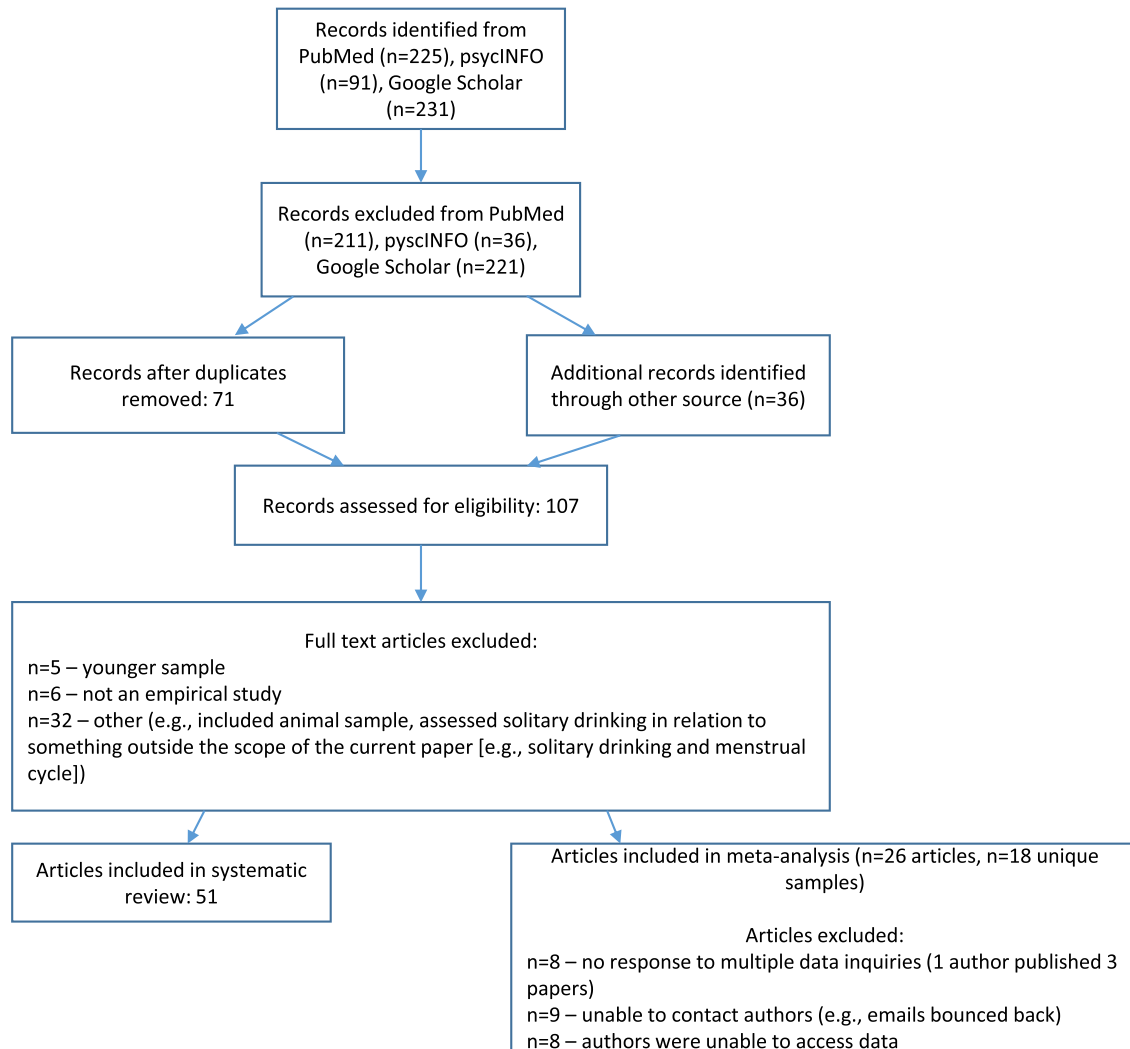
**Figure 1** Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram for papers selected for both the systematic review and meta-analysis. [Colour figure can be viewed at wileyonlinelibrary.com]

registration number CRD42019147075). Literature searches were conducted in December 2018 and again in August 2019 using Google Scholar, psycINFO and PubMed, with search terms including [alcohol or drinking] and [solitary, alone or non-social] (see also Supporting information, Figs S1–S3). The reference lists of identified studies were also scanned, and reverse searches were generated and scanned for appropriate studies (see Fig. 1). Articles were included in both the systematic review and meta-analysis if solitary drinking was assessed in adults (i.e. samples in which the mean age/majority of participants was > 30 years). To be included in the systematic review, studies had to report on at least one of the following data points in regards to solitary drinking: definition/measures, prevalence rates, associated demographic factors or associations with at least one variable included in one of the five superordinate factors (see Supporting information, Table S2 for a detailed list of variables included in each factor). To be included in the

meta-analysis, studies had to provide data on the associations between solitary drinking and at least one variable included in one of the five superordinate factors. Exclusionary criteria for both reviews included non-human animal, non-English language and non-peer reviewed/unpublished studies.

**Data extraction, coding and statistical analysis**

Following the same format as our prior meta-analysis [16], we extracted statistics (i.e. correlations, means, odds ratios) on the associations between solitary drinking and the five superordinate factors [16]. When these statistics were not available, we requested them from authors.[2] A second member of the study team independently extracted these variables to create the superordinate factors, which resulted in excellent inter-rater reliability ($k$ = 0.96). The few discrepancies that existed were reconciled by team discussion. Analyses were run using

Comprehensive Meta Analysis (CMA version 2.0) software [45] and Pearson's *r* values are reported as final effect sizes.[3] The threshold for significance for all analyses was set at $P < 0.05$.

Each value contributing to an aggregate effect size was independent of all other values. When studies included multiple solitary drinking measures (e.g. ever/never versus 5+ drinks alone [23]), to be conservative we included the solitary drinking variable demonstrating the weakest association with the variable of interest. When studies reported associations between solitary drinking and multiple variables categorized within the same superordinate factor (e.g. daily stress and depressive symptoms), which were both included in the negative affect superordinate factor, an average effect size was computed across the variables [45,46]. Similarly, when different papers using the same sample of participants contributed multiple variables to a single factor, an average effect size was computed across the variables. This ensured that papers with shared samples contributed only one weighted effect size per superordinate factor.

Random-effects models were used for all analyses [47]. The heterogeneity of effect sizes among studies for each superordinate factor was tested with the $I^2$- and $Q$-statistics [45]. When the heterogeneity test was significant, we tested for potential moderation by study quality, assessed using a system similar to Mason [15].[4] Studies were coded on representative sampling, standardized measurement, prospective longitudinal analysis and whether alcohol consumption was controlled for in associations between solitary drinking and variables included in the superordinate factors. Each study received a score of 0–4, depending on the absence/presence (0/1) of each feature. Publication bias was evaluated with methods commonly used in the literature (i.e. Begg's rank correlation test [48], funnel plots and trim-and-fill methods [49]). Importantly, however, these methods do not always indicate publication bias (e.g. asymmetry of funnel plots may reflect reporting bias, instances of chance and/or be a result of significant heterogeneity) [50].

## RESULTS

A total of 547 studies were identified in the search. Fifty-one articles were included in the systematic review;

26 articles, including 18 unique samples and 51 600 individuals, were included in the meta-analysis (see Fig. 1). The average study quality rating across studies was generally low at 1.20 (standard deviation = 0.83); the majority received a score of 1 (47%) or 2 (27%) (see Table 1). Below, we first present the results of the systematic review on solitary drinking definitions and measures, prevalence rates, and associated demographic factors. Following this, we provide the results for the five superordinate factors, presenting the systematic review findings first and then the meta-analytical results.

### Definition and measures

The definitions and measures of solitary drinking, including the time-frames assessed, for each study are shown in Table 1. Adult solitary drinking has almost exclusively been defined as drinking without others present, either through explicit wording (e.g. '... has it happened that you drank without being in the company of other people'; [23]) or allowing participants to indicate the presence/absence of drinking companions (e.g. drinking with spouse versus drinking alone; [51])[5] (see Table 1). In three papers using two samples, drinking alone included drinking in the presence of non-interacting others [29,52,53].[6]

While solitary drinking definitions are fairly consistent, measurements have differed. Some researchers categorized individuals into groups (solitary versus social-only drinkers [23,26,28,30,33,36,41,51,54–59]), while some measured solitary drinking quantity [25,27,52,53,60–62], frequency [24,27,29,32,34,35,42,61,63–70] or the percentage of total drinking episodes in solitary settings [40,71,72]. Time-frame assessments also varied across studies with researchers measuring use throughout the life-time [41,67–69,73], past week [37], past month [29,55], past 3 months [23,26], past 6 months [59] or past year [27,32,33,38,54,56,65,71,72,74]. Ecological momentary assessment (EMA) or daily diary studies assessed solitary drinking on a day-to-day basis [25,40,52,53, 60,62,75], usually over 30 days.

### Prevalence rates

Prevalence rates of solitary drinking varied among studies. Several studies on adult drinkers reported prevalence rates of approximately 30–40% [23,24,61,63,76], even when sampling heavy drinkers [58,74] and those with alcohol

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[2] Data were obtained for 10 independent samples, while data no longer existed for eight samples. Six authors did not respond to multiple queries, and nine authors were unable to be contacted because they were deceased or we were unable to locate current e-mail addresses.

[3] CMA uses Fisher's Z-transformations to pool data.

[4] We considered testing the following moderator variables: sample type (i.e. clinical versus community), age, solitary drinking measure (e.g. frequency versus quantity) and time-frame assessed (e.g. past year versus past month). However, we lacked sufficient sample sizes for each subgroup within each factor (or, with age, sufficient variation across samples) to conduct these analyses.

[5] In several cases, the definitions for drinking alone were not explicitly stated (e.g. Stickley *et al.* [24] asked participants: 'How often do you drink alone?' without clarifying what 'alone' meant), but we assume that participants interpreted 'drinking alone' to be drinking without others physically present.

[6] Excluding these studies from the meta-analytical findings presented below did not change the results.

**Table 1** Characteristics of articles included in the systematic review and meta-analysis

| Citation | Population | Design | Definition/measure/time-frame of solitary drinking | Study quality rating |
|---|---|---|---|---|
| Annis & Graham, 1995 | Canadian population: clinical sample (n = 286) | Cross-sectional | Single item assessing percentage of time drinking alone in the past year | (1)[d] |
| Armeli et al. 2003 | US population: community sample (n = 100) | Cross-sectional | Number of drinks since previous day 'alone/not interacting with others' versus 'with others/in a social setting' over 30 days | (1)[b] |
| Arpin, Mohr & Brannan, 2015 | US population: community sample (n = 49) | Cross-sectional | Number of drinks since previous interview 'alone' versus 'with others/in a social setting' over 30 days | (1)[b] |
| Assanangkornchai, Saunders & Conigrave, 2000 | Thai population: clinical (n = 282) and community sample (n = 30) | Cross-sectional | Drinking context questions asking with whom and where one usually drinks[1] | (1)[c] |
| Assanangkornchai et al. 2010 | Thai population: representative community sample from 2007 NHSSA survey (n = 26 633) | Cross-sectional | Drinking context questions asking with whom and where one usually drinks[1] | (2)[b,c] |
| Babb, Stewart & Bachman, 2012 | US population: non-traditional college sample (n = 1092) | Cross-sectional | Drinking context questions asking with whom and where one usually drinks[1] | (2)[c] |
| Bourgault & Demers, 1997 | Canadian population: community sample (n = 2015) | Cross-sectional | Single item assessing drinking alone (i.e. without others present) in the past 3 months (yes/no)[3] | (2)[b,d] |
| Brown, 1985 | US population: clinical sample (n = 324) | Cross-sectional | Drinking context questions asking with whom and where one usually drinks[1] | (1)[c] |
| Clarke & Ebbett, 2010 | Maori population: convenience sample of university students and outside community members known to the researchers (n = 447) | Cross-sectional | Single item assessing drinking alone during life-time (yes/no) | (1)[b] |
| Cooper et al. 1992 | US population: community sample (n = 1206) | Cross-sectional | Drinking context questions asking with whom and where one drank alone in the past year | (2)[b,c] |
| Cranford, Nolen-Hoeksema & Zucker, 2011 | US population: National Household Survey (n = 43 093) | Cross-sectional | Single item assessing frequency of drinking alone in the past year | (1)[b] |
| Cutter & O'Farrell, 1984 | US population: professional and nonprofessional staff of Veterans Administration Medical Center (n = 80) | Cross-sectional | Drinking context questions asking with whom and where one usually drinks[1] | (1)[c] |
| Demers & Bourgault, 1996 | Canadian population: community sample (n = 2015) | Cross-sectional | Single item assessing drinking alone (i.e. without others present) in the past 3 months (yes/no) | (1)[b] |
| Engels et al. 2005 | Dutch population: community sample drawn from a nationally representative panel of 2400 households (n = 553) | Cross-sectional | Drinking context questions asking with whom and where one drank in the past year | (2)[b,c] |
| Fortin et al. 2015 | Canadian population: community sample from the Gender, Alcohol, and Culture International study survey (n = 1714) | Cross-sectional | Drinking context questions asking with whom and where one usually drank in the past year | (2)[b,c] |
| Gaunekar, Patel & Rane, 2005 | Indian population: male industrial workers from a survey of drinking behavior (n = 234) | Cross-sectional | Drinking context questions asking with whom and where one drank[1] | (1)[c] |
| Glynn et al. 1983 | US population: community sample from the Normative Aging Study (n = 2280) | Cross-sectional | Drinking context questions asking with whom and where one usually drinks[1] | (2)[b,c] |
| Grønkjær et al. 2010 | Danish population: community sample from the National Health and Morbidity Survey (n = 14 566) | Cross-sectional | Drinking context questions asking with whom and where one drank in the last month | (2)[b,c] |
| Henderson & Galen, 2003 | US population: male inpatients from a chemical dependence treatment program (n = 147) | Cross-sectional | Drinking context questions asking with whom one typically drinks[1] | (1)[c] |

(*Continues*)

**Table 1.** (Continued)

| Citation | Population | Design | Definition/measure/time-frame of solitary drinking | Study quality rating |
|---|---|---|---|---|
| Hoffmann *et al.* 1987 | US population: clinical sample from CATOR (Chemical Abuse-Addiction Treatment Outcome Registry) (*n* = 1370) | Longitudinal | Single item assessing usually drinking alone[3] | (1)[a] |
| Jacob *et al.* 2005 | US population: clinical veteran sample from the Vietnam Era Twin Registry (*n* = 330) | Cross-sectional | Single item assessing drinking alone at least half the time (yes/no) during life-time | (0) |
| Jacob *et al.* 2009 | US population: clinical veteran sample from the Vietnam Era Twin Registry (*n* = 420) | Cross-sectional | Single item assessing drinking alone at least half the time (yes/no) during life-time | (0) |
| Jacob *et al.* 2012 | US population: clinical veteran sample from the Vietnam Era Twin Registry (*n* = 420) | Cross-sectional | Single item assessing drinking alone at least half the time (yes/no) during life-time | (0) |
| Ko & Sohn, 2018 | Korean population: community sample (*n* = 1185) | Cross-sectional | Drinking context questions asking with whom and where one drank in the last year | (2)[b,c] |
| Koppes *et al.* 2002 | Netherlands population: community sample (*n* = 368) | Cross-sectional | Single item assessing whether one usually drank alone (5-point scale with higher values indicating drinking more often socially)[c] | (1)[b] |
| Lima *et al.* 2007 | Brazilian population: community sample (*n* = 1473) | Cross-sectional | Single item assessing drinking alone (yes/no)[1] | (1)[b] |
| Luoma *et al.* 2018 | US population: community sample (*n* = 70) | Cross-sectional | Number of drinks since previous interview 'alone' versus 'while interacting with others' over 30 days | 1[b] |
| Mäkelä, Mustonen & Lintonen, 2016 | Finnish population: representative community sample (*n* = 2725) | Cross-sectional | Drinking context questions asking with whom and where one drinks in the past year | (2)[b,c] |
| Mäkelä, Tigerstedt & Mustonen, 2012[2] | Finnish population: representative community sample (*n* = 16 385) | Longitudinal | Drinking context questions asking with whom and where one drinks in the past year | (2)[b,c] |
| Marczynski *et al.* 1999 | US population: community sample (*n* = 1076) | Cross-sectional | Drinking context questions asking with whom and where one drank in the past month | (3)[b,c,d] |
| Martin & Casswell, 1987 | New Zealand population: community sample of men from a larger survey not specified (*n* = 1070) | Cross-sectional | Drinking context questions asking with whom and where one drank in the past week | (2)[b,c] |
| Martin & Casswell, 1988 | New Zealand population: community sample of women from a larger survey not specified (*n* = 1055) | Cross-sectional | Drinking context questions asking with whom and where one drank in the past week | (2)[b,c] |
| Moore, Grunberg & Greenberg, 1999 | US population: employees at a large manufacturing organization (*n* = 1108) | Cross-sectional | Drinking context questions asking with whom and where one usually drank[1] | (1)[c] |
| Moore, Grunberg & Greenberg, 2003 | US population: employees at a large manufacturing organization (*n* = 998) | Prospective longitudinal | Drinking context questions asking with whom and where one usually drank[1] | (3)[a,c,d] |
| Mustonen & Mäkelä, 1999 | Finnish population: representative community sample (*n* = 2856) | Cross-sectional | Drinking context questions asking with whom and where one drinks in the past year | (3)[b,c,d] |
| Mustonen, Mäkelä & Lintonen, 2016 | Finnish population: representative community sample (*n* = 1511) | Cross-sectional | Drinking context questions asking with whom and where one drinks in the past year | (2)[b,c] |
| Mohr *et al.* 2001 | US population: community sample (*n* = 100) | Cross-sectional | Number of drinks since previous interview 'alone/not interacting with others' versus 'while interacting with others' over 30 days | (1)[b] |
| Mohr *et al.* 2013 | US population: community sample (*n* = 49) | Prospective longitudinal | Number of drinks since previous interview 'alone/not interacting with others' versus 'while interacting with others' over 30 days | (2)[a,b] |
| Mohr, Arpin & McCabe, 2015 | US population: community sample (*n* = 49) | Cross-sectional | Number of drinks since previous interview 'alone/not interacting with others' versus 'while interacting with others' over 30 days | (1)[b] |

(*Continues*)

**Table 1.** (Continued)

| Citation | Population | Design | Definition/measure/time-frame of solitary drinking | Study quality rating |
|---|---|---|---|---|
| Neff, 1997 | US population: male community sample (*n* = 481) | Cross-sectional | Two items assessing frequency of drinking at home and alone[3] | (1)[b] |
| Neve, Lemmens & Drop, 1997 | US population: male clinical sample (*n* = 107) and community sample (*n* = 46) | Cross-sectional | Single item not specified[1] | (0) |
| Rabinowitz & Marjefsky, 1998 | Israeli population: clinical male sample (*n* = 676) | Cross-sectional | Single item assessing presence or absence of a drinking partner (yes/no)[1] | (0) |
| Joséa, Bongers & Garretsen, 1999 | Netherlands population: community sample from Risky Lifestyles in Rotterdam survey (*n* = 8000) | Cross-sectional | Single item assessing drinking alone (i.e. without anyone else present) in the past 6 months | (1)[b] |
| Stickley *et al.* 2015 | European population: nationally representative community sample across 9 countries from the Health in Times of Transition survey (*n* = 3716) | Cross-sectional | Single item assessing frequency of drinking alone (never/sometimes/often)[3] | (1)[b] |
| Sacco *et al.* 2015 | US population: residents in an independent living continuing care retirement community (*n* = 71) | Cross-sectional | Drinking context question asking where drinking occurred and whether individuals were alone converted into a single item assessing percentage of solitary drinking days in the past 8 days | (1)[c] |
| Sobhee *et al.* 2016 | Mauritius population: clinical sample (*n* = 300) | Cross-sectional | Single item assessing drinking alone (yes/no)[1] | (0) |
| Tate *et al.* 2004 | US population: clinical sample (*n* = 210) | Cross-sectional | Single item assessing drinking alone (yes/no)[1] | (0) |
| Turner, Annis & Sklar, 1997 | Canadian population: clinical sample (*n* = 338)[3] | Cross-sectional | Single item assessing percentage of time drinking alone (i.e. without others present) in the past year | (0) |
| Victorio-Estrada & Mucha, 1997 | German population: majority student sample (*n* = 73) | Cross-sectional | Single item assessing drinking alone (i.e. without others present) (yes/no)[1] | (1)[b] |
| Walker *et al.* 2012 | US population: Veterans participating in the Prevention and Treatment of Hypertension Study (*n* = 511) | Cross-sectional | Single item assessing percentage of time drinking alone in the past week | (0) |
| Wanberg & Knapp, 1970 | US population: clinical sample (*n* = 2022) | Cross-sectional | Single item assessing drinking alone (yes/no)[1] | (0) |

[a]Prospective longitudinal design; [b]representative sample; [c]standardized measure of solitary use; [d]controlled for alcohol consumption in analyses. NHSSA = National Household Survey on Substance and Alcohol Use. [1]Specific timeframe not given. [2]Though the study was longitudinal, the data we received from authors was correlational. [3]This sample size represents only those clients admitted for alcohol problems, which was used in the meta-analysis.

dependence [63]. However, some studies reported lower rates of approximately 15–20% for both solitary drinkers [70,77,78] and the percentage of drinking occasions that were in a solitary context [78]. One study on adult drinkers with a life-time diagnosis of alcohol dependence reported a higher rate of 48% [67], as did another study on moderate-to-heavy drinking adults who reported the context of their alcohol use daily over 30 days (68% [25]). Rates of solitary drinking were much lower when the definition of solitary drinking was restricted to drinking alone in bars (rather than, for example, drinking at home alone (7.6% [29]) and when participants were classified into a solitary drinking cluster based on their common drinking contexts (2% [34,35]). Prevalence rates were unsurprisingly low when non-drinkers were included in the calculation (4–5% [55,66]).

### Demographics

Solitary drinking was generally more common in older relative to younger adults [23,24,54,55,64]. For instance, according to a study surveying adult males in nine countries of the former Soviet Union, rates of drinking alone steadily rose among increasing age brackets, with approximately 27% of males aged 30–39 reporting occasional or frequent solitary drinking compared to approximately 35% of males aged 40–49, and approximately 46% of males aged 60 years and older [24]. Drinking alone was also positively associated with being single, separated, divorced or widowed and negatively associated with being married [26,34,35,37,40,59]. In general, males were more likely to report drinking alone than females [23,33,51,54,55,57,59,64,70,77]. However, one study

reported no sex differences [34,35][7] and two found that females were more likely to report drinking alone than males [76,79]. Finally, only two studies reported on race, and these generated conflicting findings. In a sample of 20–50-year-old male participants, African Americans were more likely to report frequent drinking while alone compared to Anglo or Hispanic individuals [78]. Among non-traditional college students (mean$_{age}$ = 33.2), drinking alone was more strongly endorsed by Caucasians, followed by African Americans, and then Hispanics [51].

### Superordinate factors

*Alcohol consumption and drinking problems*

Several studies found that adult solitary drinking was associated with greater quantity and frequency of alcohol consumption [27,28,31,60] as well as heavy and/or hazardous drinking [24,28,74,78,80], alcohol dependence [63,68,69,73], alcohol-related problems such as injuring oneself while drinking [28,29] and increased likelihood of quitting or being expelled from alcohol treatment [58]. Several other studies presented conflicting results among different measures of alcohol use and problems [23,24,26,31,33,37]. For example, one study found that frequency but not quantity of alcohol use was related to the percentage of time spent drinking alone [37], while another found that drinking alone was not associated with having alcohol-related arguments, but was marginally associated with having been asked to cut down on drinking by a spouse/family member [33]. Finally, solitary drinking was not significantly associated with drinking problems or hazardous use in some studies [31,37,40]. Of note, meta-analytical results revealed significant small effect sizes for the associations between solitary drinking and both greater alcohol consumption and drinking problems (see Table 2 and Supporting information, Fig. S4). There was significant heterogeneity across studies for both factors, but this heterogeneity was not explained by study quality for either factor (see Tables 2 and 3).

*Negative affect*

Negative affect variables were associated with adult solitary drinking in many studies. Solitary drinking was associated with depression [37], and the quantity of alcohol consumed while alone was associated with affect variability [62], which is thought to indicate emotional dysregulation and may itself be a source of distress [62,81]. Additionally, individuals with concurrent alcohol dependence and major depression reported significantly more solitary drinking days than those who only experienced alcohol dependence [65] and individuals in a low substance severity class (characterized by a lower number of substance abuse problems), who also showed the highest rates of depression, were the most likely to drink alone [36].

Solitary drinking was not significantly associated with negative affect in the meta-analysis, however (see Table 2 and Supporting information, Fig. S4). There was significant heterogeneity among studies, and a portion of this variability was explained by study quality, such that lower quality studies were associated with larger effect sizes (see Tables 2 and 3).

*Negative reinforcement*

Negative reinforcement variables were associated with adult solitary drinking in many studies. For instance, solitary drinking was linked to drinking to cope motives [30,38,39,41] (although see [27,37,40,78] for null findings[8]) and, in the one study that tested for it, the association between solitary drinking frequency and coping motives held even after controlling for all other drinking motives (i.e. social, enhancement and conformity motives) [38]. There is also research showing associations between solitary drinking and expectancies/beliefs of tension reduction from alcohol use [26,42]. Notably, results from our meta-analysis revealed a significant small effect size for the association between solitary drinking and negative reinforcement (see Table 2 and Supporting information, Fig. S4). There was significant heterogeneity among studies, but this was not explained by study quality (see Tables 2 and 3).

*Positive reinforcement*

Three studies found an association between adult solitary drinking and positive reinforcement variables [27,37,41]. In one study, adult solitary drinkers reported higher positive reinforcement scores (e.g. endorsement of drinking to feel happy) and negative reinforcement scores (e.g. endorsement of drinking to relax) than social-only drinkers [41]. Another study found that the amount of alcohol consumed while drinking alone was positively associated with social-enhancement motives but not coping-conformity motives [27],[9] and a final study showed that percentage of time drinking alone was significantly positively associated with drinking to socialize [37].

However, these findings were in contradiction to the majority of findings regarding the association between

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[7]Two papers were published from the same sample.
[8]The results from Sacco *et al.* [40] and Walker *et al.* [37] presented here were not reported in their original papers, but rather came from data we requested from them for the meta-analysis (see Table 2).
[9]This finding may be confounded by the combination of conformity and coping motives, given that conformity motives do not seem to play a role in drinking alone. Due to this confounding, we did not include these data in the meta-analysis.

**Table 2** Meta-analysis of superordinate factors and solitary drinking

| Study Authors | Superordinate factor | n | r | 95% CI | P |
|---|---|---|---|---|---|
| | Alcohol consumption | | | | |
| Assanangkornchai *et al.* 2010 | | 7091 | 0.11 | 0.09, 0.13 | < 0.001 |
| Cranford, Nolen-Hoeksema & Zucker, 2011 | | 26 582 | 0.32 | 0.31, 0.33 | < 0.001 |
| Demers & Bourgault, 1996[a] | | 2015 | 0.25 | 0.19, 0.32 | < 0.001 |
| Bourgault & Demers, 1997[a] | | 2015 | | | |
| Engels *et al.* 2005 | | 553 | 0.44 | 0.37, 0.51 | < 0.001 |
| Lima *et al.* 2007 | | 642 | 0.52 | 0.26, 0.71 | < 0.001 |
| Luoma *et al.* 2018 | | 70 | 0.80 | 0.70, 0.87 | < 0.001 |
| Marczynski *et al.* 1999 | | 1289 | 0.34 | 0.30, 0.39 | < 0.001 |
| Mohr *et al.* 2013[b] | | 39 | 0.24 | −0.07, 0.51 | 0.13 |
| Arpin, Mohr & Brannan, 2015[b] | | 47 | | | |
| Moore, Grunberg & Greenberg, 2003[c] | | 663 | 0.11 | −0.15, 0.36 | 0.40 |
| Mustonen & Mäkelä, 1999[d] | | 6874 | 0.15 | 0.12, 0.17 | < 0.001 |
| Mäkelä, Tigerstedt & Mustonen, 2012[d] | | 6874 | | | |
| Mäkelä, Mustonen & Lintonen, 2016[d] | | 6874 | | | |
| Mustonen, Mäkelä & Lintonen, 2016[d] | | 6874 | | | |
| Sacco *et al.* 2015 | | 69 | −0.03 | −0.26, 0.21 | 0.82 |
| Stickley *et al.* 2015 | | 3716 | −0.07 | −0.16, 0.02 | 0.12 |
| Turner, Annis & Sklar, 1997 | | 254 | 0.08 | −0.05, 0.20 | 0.22 |
| Victorio-Estrada & Mucha, 1997 | | 73 | 0.45 | 0.25, 0.62 | < 0.001 |
| Walker *et al.* 2012 | | 511 | 0.09 | −0.00, 0.17 | 0.06 |
| | Overall estimate | | 0.25 | 0.18, 0.33 | < 0.001 |
| | | | | $I^2/Q = 97.41/541.26; P < 0.001$ | |
| | Drinking problems | | | | |
| Assanangkornchai, Saunders & Conigrave, 2000 | | 312 | 0.33 | 0.11, 0.53 | < 0.01 |
| Assanangkornchai *et al.* 2010 | | 7091 | 0.04 | 0.02, 0.06 | < 0.005 |
| Bourgault & Demers, 1997 | | 2015 | −0.02 | −0.10, 0.06 | 0.63 |
| Cranford, Nolen-Hoeksema & Zucker, 2011 | | 26 701 | 0.16 | 0.15, 0.18 | < 0.001 |
| Luoma *et al.* 2018 | | 70 | 0.52 | 0.33, 0.67 | < 0.001 |
| Marczynski *et al.* 1999 | | 1289 | 0.27 | 0.22, 0.32 | < 0.001 |
| Mohr *et al.* 2013 | | 39 | 0.26 | −0.07, 0.53 | 0.12 |
| Moore, Grunberg & Greenberg, 2003[c] | | 979 | 0.12 | −0.08, 0.32 | 0.23 |
| Mustonen & Mäkelä, 1999[d] | | 2856 | 0.11 | 0.08, 0.13 | < 0.001 |
| Mäkelä, Mustonen & Lintonen, 2016[d] | | 6874 | | | |
| Mustonen, Mäkelä & Lintonen, 2016[d] | | 6874 | | | |
| Sacco *et al.* 2015 | | 69 | −0.02 | −0.26, 0.22 | 0.87 |
| Stickley *et al.* 2015 | | 3716 | 0.20 | 0.15, 0.24 | < 0.001 |
| Turner, Annis & Sklar, 1997 | | 337 | 0.07 | −0.04, 0.18 | 0.20 |
| Victorio-Estrada & Mucha, 1997 | | 73 | 0.56 | 0.38, 0.70 | < 0.001 |
| Walker *et al.* 2012 | | 506 | 0.04 | −0.05, 0.13 | 0.38 |
| | Overall estimate | | 0.15 | 0.10, 0.21 | < 0.001 |
| | | | | $I^2/Q = 92.70/178.12; P < 0.001$ | |
| | Negative affect | | | | |
| Armeli *et al.* 2003 | | 100 | 0.00 | −0.19, 0.20 | 0.98 |
| Cranford, Nolen-Hoeksema & Zucker, 2011 | | 26 701 | 0.02 | 0.00, 0.03 | < 0.01 |
| Luoma *et al.* 2018 | | 70 | 0.17 | −0.07, 0.39 | 0.17 |
| Marczynski *et al.* 1999 | | 1289 | −0.05 | −0.10, 0.01 | 0.09 |
| Mohr *et al.* 2013[b] | | 47 | 0.07 | −0.23, 0.35 | 0.67 |
| Arpin, Mohr & Brannan, 2015[b] | | 49 | | | |
| Mohr *et al.* 2015[b] | | 47 | | | |
| Sacco *et al.* 2015 | | 69 | −0.07 | −0.31, 0.17 | 0.55 |
| Turner, Annis & Sklar, 1997 | | 243 | 0.15 | 0.03, 0.28 | 0.02 |
| Walker *et al.* 2012 | | 511 | 0.09 | −0.00, 0.17 | 0.05 |
| | Overall estimate | | 0.03 | −0.02, 0.08 | 0.24 |
| | | | | $I^2/Q = 52.06/14.60; P < 0.05$ | |

(**Continues**)

**Table 2.** (Continued)

| Study Authors | Superordinate factor | n | r | 95% CI | P |
|---|---|---|---|---|---|
| | Negative reinforcement | | | | |
| Annis & Graham 1995 | | 68 | 0.68 | 0.53, 0.79 | < 0.001 |
| Cranford, Nolen-Hoeksema & Zucker, 2011 | | 26 701 | 0.21 | 0.19, 0.23 | < 0.001 |
| Demers & Bourgault, 1996 | | 2015 | 0.23 | 0.17, 0.29 | < 0.001 |
| Engels *et al.* 2005 | | 553 | 0.07 | −0.01, 0.15 | 0.10 |
| Mohr *et al.* 2001 | | 100 | 0.30 | 0.11. 0.47 | < 0.005 |
| Mohr *et al.* 2013 | | 39 | 0.43 | 0.13, 0.65 | < 0.01 |
| Moore, Grunberg & Greenberg, 2003[c] | | 872 | 0.12 | −0.11, 0.34 | 0.30 |
| Sacco *et al.* 2015 | | 69 | 0.03 | −0.21, 0.26 | 0.81 |
| Turner, Annis & Sklar, 1997 | | 338 | 0.16 | 0.06, 0.26 | < 0.005 |
| Victorio-Estrada & Mucha, 1997 | | 73 | 0.60 | 0.43, 0.73 | < 0.001 |
| Walker *et al.* 2012 | | 495 | −0.08 | −0.16, 0.01 | 0.10 |
| | Overall estimate | | 0.24 | 0.14, 0.32 | < 0.001 |
| | | | | $I^2/Q = 89.77/97.70$; $P < 0.001$ | |
| | Positive reinforcement | | | | |
| Demers & Bourgault, 1996 | | 2015 | 0.03 | −0.05, 0.10 | 0.47 |
| Engels *et al.* 2005 | | 553 | 0.17 | 0.09, 0.25 | < 0.001 |
| Mohr *et al.* 2013 | | 39 | −0.14 | −0.43, 0.19 | 0.41 |
| Mustonen & Mäkelä, 1999 | | 2856 | 0.00 | −0.04, 0.04 | 1.00 |
| Sacco *et al.* 2015 | | 69 | −0.16 | −0.38, 0.08 | 0.18 |
| Turner, Annis & Sklar, 1997 | | 338 | −0.13 | −0.23, −0.02 | 0.02 |
| Victorio-Estrada & Mucha, 1997 | | 73 | 0.00 | −0.23, 0.23 | 1.00 |
| Walker *et al.* 2012 | | 495 | 0.12 | 0.03, 0.21 | < 0.01 |
| | Overall estimate | | 0.02 | −0.06, 0.09 | 0.63 |
| | | | | $I^2/Q = 76.18/29.38$; $P < 0.001$ | |

For studies with multiple variables of interest within the same superordinate factor, these variables were averaged over to generate an overall *r*, 95% confidence interval (CI) and *P*-value. [a,b,d]These studies used the same sample; we averaged over the statistics. The sample size noted for d corresponds to the dataset we received from the authors upon request. [c]These data included subgroups (e.g., female managers, female non-managers) which were averaged across for each superordinate factor.

**Table 3** Meta-regression using quality level as a moderator

| Superordinate factor | n | Point estimate | Confidence interval | Z-value | P-value |
|---|---|---|---|---|---|
| Alcohol consumption | 15 | 0.04 | −0.06, 0.15 | 0.83 | 0.41 |
| Drinking problems | 14 | 0.01 | −0.05, 0.07 | 0.37 | 0.71 |
| Negative affect | 8 | −0.04 | −0.07, −0.01 | −3.06 | < 0.001 |
| Negative reinforcement | 11 | 0.02 | −0.09, 0.14 | 0.38 | 0.70 |
| Positive reinforcement | 8 | 0.03 | −0.07, 0.12 | 0.57 | 0.57 |

positive reinforcement and solitary drinking in adults. For instance, neither social nor enhancement motives were related to frequency of drinking alone in one study [38], and another study found that social/enhancement motives decreased the odds of reporting solitary drinking [40]. Further, adult solitary drinking was not related to positive affect or drinking during positive affective states [25,82], and it was either not associated or negatively associated with drinking during pleasant times with others and positive interpersonal exchanges [28,53,72]. Finally, adults grouped into a social festive profile of drinkers (categorized by strong motivations to socialize and celebrate) reported never drinking alone [54]. Supporting this, there was no association between solitary drinking and positive reinforcement in our meta-analysis (see Table 2 and Supporting information, Fig. S4). There was significant heterogeneity across studies, but this was not explained by study quality (see Tables 2 and 3).

### Publication bias

Begg's rank correlation test resulted in null findings for all factors, and both visual inspection of funnel plots and trim-and-fill analyses suggested there was little evidence of

publication bias for all factors, given that imputation of missing studies did not alter effect sizes appreciably (see Supporting information, Fig. S5 and Tables S3 and S4).

## DISCUSSION

Most research investigating problem drinking is conducted on adolescents and young adults, yet there is evidence of alcohol misuse throughout the life-span [1–6], and the health consequences of excessive drinking among mid-life and older adults are often more serious than in younger individuals [7–10]. Thus, understanding the correlates and mechanisms of adult problematic drinking are research priorities. The current systematic review and meta-analysis focused on adult solitary drinking, as our prior meta-analysis revealed that it is a reliable marker of greater risk for AUD in younger demographics [16] (see also [13,15,17,18]).

### Definitions, prevalence and demographic correlates

Solitary drinking has been defined fairly consistently across studies on adults as drinking without others present; however, three papers (using two unique samples) included drinking in the presence of non-interacting others in their definition of solitary drinking [29,52,53]. No studies explicitly excluded virtual others in their definitions of solitary drinking, which may be important to do going forward given the probable increase of virtual get-togethers during the COVID-19 pandemic [13,83]. There was considerable variability in how solitary drinking was assessed (e.g. ever/never, percentage of total drinking episodes) and the time-frames for which it was assessed (ranging from life-time to past day). Future research would benefit from a standardized definition of solitary drinking as drinking while others are not physically or virtually present [13] and a standardized measure of solitary drinking as percentage of total drinking episodes (rather than as a count or frequency of solitary-drinking occurrences, in order to avoid the confound of greater frequency of drinking being associated with both social and solitary drinking contexts) [14].

Prevalence rates of adult solitary drinking generally ranged from approximately 30 to 40% [23,24,61,63,76], with some reporting rates as high as approximately 50–70% [25,68], which are substantially higher than rates in adolescents (14% [15]) and young adults (15–24% [16]). In general, solitary drinking prevalence rates increased across ages in adulthood (e.g. [24]). Findings for other demographic factors were mixed but, in general, males were more likely to report solitary drinking than females, and married individuals were less likely to drink alone compared to unmarried individuals. Only two studies examined potential racial/ethnic differences,

and results were mixed. Future studies are indicated to identify individual difference variables associated with adult solitary drinking.

### Superordinate factor correlates

Despite higher prevalence rates of solitary drinking in adults, links between adult solitary drinking and greater alcohol use and problems were generally consistent with findings in adolescents and young adults. Meta-analytical results showed small but significant effect sizes between adult solitary drinking and greater alcohol consumption and problems. The effect size for greater alcohol consumption in solitary drinking adults ($r = 0.25$) was similar to the effect size found in adolescents and young adults ($r = 0.23$), but the effect size for alcohol problems in solitary drinking adults was somewhat smaller than in adolescents and young adults ($r = 0.15$ versus $r = 0.23$) [16]. Taken together, our findings suggest that adult solitary drinking may also be a risky drinking behavior with links to greater alcohol use and problems.

Potential reasons for adult solitary drinking also paralleled research among younger individuals. Meta-analytical results revealed a small but significant effect size for the association between solitary drinking and the negative reinforcement factor ($r = 0.24$), which was again comparable to that found among adolescents and young adults ($r = 0.28$) [16]. Also similar to adolescents and young adults, the positive reinforcement factor was not associated with adult solitary drinking. Thus, across ages, individuals who report drinking alone also endorse expectancies and motives related to drinking to ameliorate negative affect, as well drinking in the context of negative affect [16]. These self-medication patterns of alcohol use are prospectively predictive of the development and persistence of AUD symptoms [84], and may explain the link between solitary drinking and greater alcohol use and problems [13,15,16]. It is important to note, however, that all prior studies examining these associations have been cross-sectional.

Despite the negative reinforcement factor being linked to adult solitary drinking, the negative affect factor was not associated with adult solitary drinking ($r = 0.03$), but it was for adolescents and young adults with a small but significant effect size ($r = 0.21$) [16]. The null finding in adults may be due to age-related decreases in the experience of negative affect (e.g. [85]), or differences in the way that negative affect variables were assessed across adolescents/young adults and adults (e.g. primarily measures of depression/anxiety symptoms in adolescents/young adults and primarily measures of trait/state negative affect in adults). Alternatively, after the young adulthood period, it may be that only drinking heavily while alone is

associated with negative affect. Future studies are indicated to explore this discrepancy.

## LIMITATIONS, RECOMMENDATIONS AND CONCLUSIONS

A major limitation of this review is the quality of the studies included. The vast majority of studies used cross-sectional designs (e.g. only four longitudinal studies were identified [25,56,57,66], with only two contributing data to the meta-analysis [25,57]), and very few studies controlled for alcohol consumption when examining associations between solitary drinking and alcohol problems and negative reinforcement variables [23,29,32,57,71]. It is noteworthy, however, that results from these high-quality studies generally supported the meta-analytical findings. Solitary drinking prospectively predicted alcohol consumption/problems [57] and drinking to cope motives [25], and associations between solitary drinking and drinking problems and negative reinforcement variables held after controlling for alcohol consumption [23,29,57,71]. Nonetheless, there is a clear need for additional longitudinal studies and ones that control for alcohol consumption when examining associations between solitary drinking and other variables of interest. Finally, experimental research that manipulates potentially important variables (e.g. drinking to cope) would be useful to discover the causal sources behind drinking alone among adults.

There was significant heterogeneity across studies within each factor, and this heterogeneity was not explained by study quality in all but the negative affect factor. Another important limitation is that we were unable to examine other potential sources of heterogeneity (e.g. age, measures of solitary drinking) due to either a lack of variability or insufficient numbers of studies within subgroups. Interestingly, however, the one prior study that tested whether age moderated the association between motives/expectancies and solitary drinking did not find evidence of an interaction [27]. As more solitary drinking studies are published, future research is indicated to investigate potential sources of heterogeneity.

There was also a paucity of studies that compared differing quantities of alcohol consumed in solitary settings in relationship to alcohol problems. It would be helpful in future studies to know whether the quantity of alcohol consumed in solitary settings moderates the relationship between solitary drinking and alcohol problems (as some research indicates that only heavy drinking while alone is problematic in adults [23]). Further, we are unaware of studies that have assessed drinking motives specifically for adult solitary alcohol use—studies have rather assessed motives for alcohol use and then correlated those responses with solitary drinking measures. Studies that explicitly ask about solitary drinking motives are necessary to fully understand reasons for drinking alone among adults. Similarly, studies that control for other drinking motives or expectations (e.g. social, enhancement) are lacking. Without such analyses, it is unclear whether the desire to ameliorate negative affect is uniquely associated with solitary drinking beyond other drinking motives/expectations. However, it is noteworthy that drinking to cope motives continued to be associated with solitary drinking after controlling for all other drinking motives in the one study that tested this [38].

In addition, there is a need for research that includes more representative samples (e.g. nation-wide surveys) and clinical populations who may be more vulnerable to solitary drinking and risky substance use more generally (e.g. [14,86]). As solitary use of other substances (e.g. marijuana) has been linked to negative outcomes in adolescents and young adults [15,87], future studies are indicated to determine whether this is also the case for adults. Finally, it is important to note that we excluded unpublished studies, which may have inflated the meta-analytical results, given that unpublished studies typically have null findings (although analyses commonly used to assess publication bias did not indicate this).

In summary, findings suggest that for adults, as with adolescents and young adults, drinking alone is a risky drinking behavior associated with the desire to alleviate negative affect. More specifically, adult solitary drinking was associated with greater alcohol consumption, more alcohol-related problems and negative reinforcement processes. In contrast, adult solitary drinking was not significantly associated with negative affect, as it was for adolescents and young adults. Given the apparent risky nature of this drinking pattern across all ages, more research is needed to understand the mechanisms underlying solitary drinking and the pathways by which drinking alone leads to adverse outcomes.

### Author contributions

**Carillon J. Skrzynski:** Conceptualization; formal analysis; investigation; methodology. **Kasey G. Creswell:** Conceptualization; funding acquisition; investigation; methodology; supervision.

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## Supporting Information

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

**Table S1** PRISMA checklist

**Table S2** Superordinate factors and underlying variables of interest

**Table S3** Duvall and Tweedie's Trim-and-fill

**Table S4** Begg's Rank correlation test

**Fig S1** Search strategy using PsycINFO

**Fig S2** Search strategy using PubMed

**Fig S3** Search strategy using Google Scholar

**Fig S4** Forest plots of superordinate factors.

**Fig S5** Funnel plots of superordinate factors including imputed studies.