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IMPLEMENTATION TO INCREASE BLOOD PRESSURE CONTROL: WHAT WORKS? (J BRETTLER AND K REYNOLDS, SECTION EDITORS)

Effects of Alcohol Reduction Interventions on Blood Pressure

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Abstract

Purpose of Review Much of alcohol's purported negative impact on a population's health can be attributed to its association with increased blood pressure, rates of hypertension, and incidence of cardiovascular disease (CVD). Less attention, however, has been placed on the association of the positive impact of alcohol reduction interventions on physical health.

Recent Findings This review delineates the evidence of blood pressure reductions as a function of alcohol reduction interventions based on current care models. The findings of this review suggest two things: (1) sufficient evidence exists for a relationship between alcohol reductions and blood pressure generally, and (2) little evidence exists for the relationship between alcohol reductions and blood pressure for any one care model currently employed in the health system.

Summary The evidence base would benefit from more studies using established alcohol reduction interventions examining the impact of these interventions on blood pressure.

Keywords Alcohol · Blood pressure · Screening and brief intervention · Integrated care · Cardiovascular disease

Introduction

The potential beneficial effects of alcohol consumption have been extensively disseminated and popularized [1]. Yet an international collaboration of researchers from the Global Burden of Diseases, Injuries, and Risk Factors Study found that alcohol use at any level is associated with a broad spectrum of health risks associated with alcohol use, such as diabetes, stroke, and cancers [2]. Much of alcohol's purported negative impact on a population's health can be attributed to its association with increased blood pressure, rates of hypertension, and incidence of cardiovascular disease (CVD). Less attention, however, has been focused on impact of alcohol reduction interventions on blood pressure. This narrative review seeks to summarize the literature on the impact of alcohol reduction interventions and blood pressure (specifically systolic blood pressure).

Alcohol Misuse and Health

"Alcohol misuse" is often used to capture the broad range of alcohol consumption patterns that may warrant treatment to reduce alcohol use. Alcohol misuse can refer to either drinking above recommended guidelines (i.e., > 1 drink/day or > 7 drinks/week for women, > 2 drinks/day or > 14 drinks/week for men), binge drinking (consuming > 3 drinks for women or > 4 drinks for men within a single period of approximately 2 h), or experiencing alcohol use–related distress and impairment consistent with a diagnosis of alcohol use disorder (AUD) [3]. Alcohol misuse can also induce acute alcohol poisoning or significant and life-threatening

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autonomic hyperactivity associated with severe withdrawal symptoms [4•]. Since 2000, alcohol misuse in the USA has increased dramatically among most age and racial/ethnic groups, with rates in African American adults and adults over age 65 increasing by over 60%.[5].

The downstream effects of alcohol misuse on cardiovascular problems are striking. Alcohol misuse is associated with more than triple the relative risk for all-cause mortality [6], and more than double the relative risk for CVD-specific mortality [7, 8]. In 2016, the World Health Organization (WHO) estimated that alcohol accounted for 593,000 CVD-related deaths worldwide [9•]. Alcohol misuse has previously been cited as contributing to 11% of the prevalence of hypertension in US men, independent of other factors such as diet and exercise (a burden that has likely grown given more recent increases in high-risk alcohol consumption) [10]. Each drink per day beyond 3 standard drinks is associated with 10 mmHg increase in systolic blood pressure [11]. These findings support the association between alcohol misuse and negative cardiovascular outcomes, from acute increases in blood pressure to long-term risk of CVD-specific mortality. However, a multitude of behavioral factors associated with both increased alcohol misuse and increased blood pressure make it difficult to conclude that simply reducing drinking reverses these negative cardiovascular outcomes.

Causal Pathways Between Alcohol Misuse and Increased Blood Pressure

Two causal pathways appear to be involved in the pathway from alcohol misuse to increased blood pressure and subsequent elevated risk for CVD: (1) a direct, biologically mediated pathway and (2) an indirect and behaviorally mediated pathway. Increased blood pressure plays a significant role in both etiologies (see Fig. 1).

First, there is a well-established direct biological relationship between acute and sustained alcohol misuse and risk of CVD. Most prominent in this pathway are increases in both short-term and long-term systolic blood pressure (i.e., hypertensive disease) [10, 11]. Additional biological changes resulting from chronic alcohol misuse that increase risk for CVD include increased low-density lipoprotein (LDL) cholesterol, increased triglycerides, poorer glycemic and lipid control generally, arteriosclerosis, and atherosclerosis [12••].

Second, alcohol misuse is associated with numerous behavioral factors that increase the risk of CVD. Alcohol misuse is associated with increased stress, increased likelihood of smoking, decreased physical activity, poorer diet, higher body mass index (BMI), and poorer adherence to therapeutic regimens [12••, 13, 14]. Additionally, alcohol misuse is associated with decreased adherence to antihypertensive medications, which are among the most efficacious intervention for lowering blood pressure on a population level [15, 16].

In sum, alcohol misuse contributes to increased blood pressure and negative downstream effects such as CVD through multiple biological and behavioral routes. These complex causal pathways suggest that there are likely heterogeneous therapeutic effects of alcohol reduction on blood pressure. The heterogeneity of interventions for treating alcohol misuse may also contribute to different effects of alcohol reduction on lowering blood pressure.

Overall Impact of Alcohol Reduction Interventions on Blood Pressure

The most comprehensive meta-analysis to date found a statistically and clinically meaningful reduction of systolic blood pressure from reducing alcohol consumption [17••]. In this meta-analysis, Roerecke and colleagues examined 36 trials totaling 2865 participants and found that reductions in alcohol consumption were associated with decreases in systolic blood pressure of −5.5 mmHg (95% confidence interval (C.I.) [−6.7: −4.3]) for patients initially drinking 6 or more drinks a day, −3.0 mmHg (95% C.I. [−4.0: −2.0]) for patients initially drinking 4–5 drinks a day, −1.2 mmHg (95% C.I. [− 2.3: −0.0]) for patients initially drinking 3 drinks a day, and −0.2 mmHg (95% C.I. [−1.0: 0.7]) for patients initially drinking 2 or fewer drinks per day (rounded to a single decimal). To provide context for this effect, a meta-analysis of intensive counseling and education trials for multiple risk factors associated with CVD yielded an average decrease of −2.7 mmHg in blood pressure over 6 months [18]. In contrast, screening and relatively brief alcohol reduction interventions for patients drinking 4 or more drinks per day may be impactful on lowering blood pressure at relatively low cost to the healthcare system [19].

As expected, patients who drink more prior to being randomized to alcohol reduction show greater decreases in blood pressure following a reduction in alcohol. However, considerable variability still exists. Additionally, many of the trials evaluated in Roerecke and colleagues' meta-analysis were randomized experimental designs carried out in controlled study environments. Finally, the experimental manipulation used in many of these interventions was non-interventional in the sense that participants were not explicitly presented with educational or motivational resources to aid alcohol reduction, but rather, it was assumed that informing them of allocation to the alcohol reduction group was a sufficient manipulation. Thus, greater characterization of the impact of alcohol reduction interventions on blood pressure in real-world settings may provide additional insight into the public health benefits of these interventions when implemented in the community.

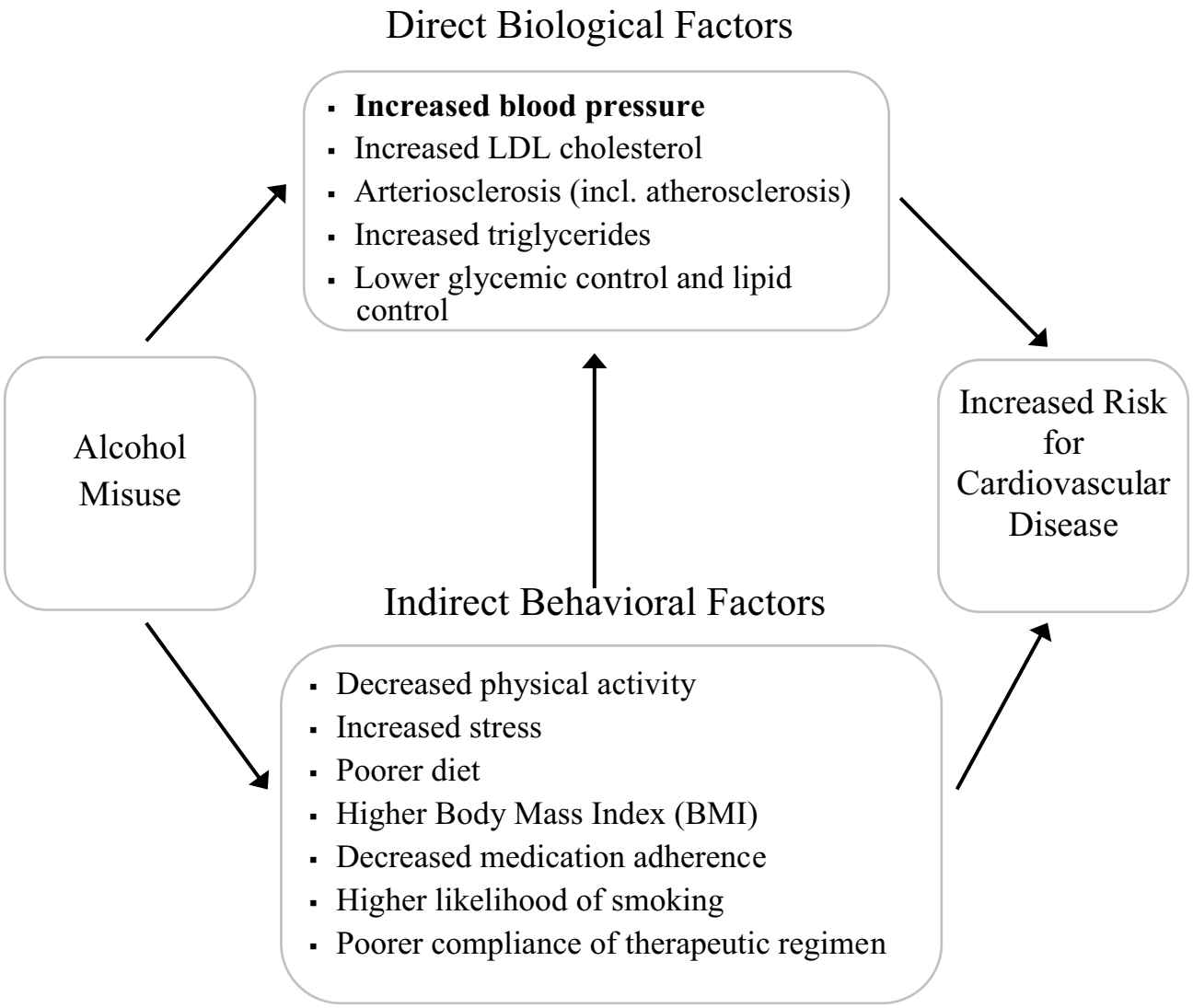

Fig. 1 Established causal pathways from alcohol misuse to increased CVD risk

Impact of Allocation to Alcohol Reduction Group on Blood Pressure in Experimental Non-Interventional Studies

The vast majority of research has measured the impact of alcohol reduction on blood pressure as a function of allocation to an alcohol reduction arm in a highly controlled and experimental fashion. While an experimental manipulation was present, it was non-interventional in that no additional educational or motivational resources were provided. The results of these experimental non-interventional studies range from non-significant increases in blood pressure to statistically and clinically significant decreases in blood pressure, but the majority of studies fall into the latter group (14 of 27 studies included in this review detected significant improvements; see Table 1). Importantly, these studies do not include any observational or epidemiological studies, which are not the focus of the current review.

These experimental non-interventional studies typically involve between-group designs to examine the difference between initiation of drinking versus non-initiation of drinking, inferring that an alcohol "reduction" from the drinking to non-drinking groups would be associated with the same level of blood pressure reduction from the drinking to non-drinking groups. Similarly, these studies often recruit patients without existing alcohol misuse problems, but with other CVD risk factors. One of the studies with the most robust findings to date randomly assigned 224 participants with type 2 diabetes mellitus to drink one glass of red wine with dinner for 2 years and assigned another group to drink mineral water with dinner for 2 years [20]. While the point estimate effect of blood pressure reduction based on only

Table 1 Impact of allocation to alcohol reduction group on systolic blood pressure in experimental non-interventional studies

Study designs without clear alcohol intervention models					
Study	*N*	Length of study	Sex, age, country	Alcohol intervention	Systolic blood pressure change in mmHg [95% C.I.]
Chiva-Blanch et al. [21]	67	4 weeks	M, 55–75 years, Spain	Diet plus red wine or gin (30 g alcohol per day) vs. diet plus de-alcoholized red wine	−3.50 [−5.93, −1.07]
Estruch et al. [48]	40	4 weeks	M, 30–50 years, Spain	Diet and 30 g/day (red wine or gin) with dinner vs. washout period (abstinence)	1.00 [−0.79, 2.79]
Flanagan et al. [49]	21	1 week	M/W, 21–41 years, UK	Three units of alcohol daily for 1 week vs. abstinence	0.00 [−7.01, 7.01]
Gepner et al. [20]	224	104 weeks	M/W 59 years (mean), Israel	White or red wine vs. mineral water with dinner; drinks were provided	−4.67 [−10.89, 1.55]
Gepner et al. [50]	54	26 weeks	M/W, 57 years (mean), Israel	Diet with dry red or white wine vs. diet with mineral water	Not listed
Hansen et al. [51]	69	4 weeks	M/W, 38–75 years, Denmark	Red wine (men: 38.3 g alcohol/day, women: 25.5 g alcohol/day) vs. water and grape extract tablets (wine-equivalent dose or half dose) or water and placebo tablets	2.00 [−2.39, 6.39]
Howes et al. [52]	10	1 week	M, 18–35 years, UK	0.8 g alcohol/kg bodyweight per day (taken between 1700 and midnight) vs. abstinence	−3.00 [−5.79, −0.21]
Hsieh et al. [53]	17	4 weeks	M, 49 years (mean), Japan	Usual alcohol intake vs. counseling to reduce alcohol intake as much as possible	−5.50 [−9.44, −1.56]
Kawano et al. [54]	34	4 weeks	M, 36–76 years, Japan	Usual drinking vs. abstinence or reduced alcohol intake	1.00 [−2.68, 4.68] High Volume −2.00 [−6.73, 2.73] Low Volume
Kim et al. [55]	20	8 weeks	M/W, 30–65 years, USA	30 g/day (vodka or red wine) with dinner or before bedtime vs. no alcohol intake; beverages were provided	−2.00 [−7.02, 3.02]
Mori et al. [22]	24	4 weeks	W, 24–45 years, Australia	Higher volume red wine (lower level drinkers, 146 g alcohol per week; higher level drinkers, 218 g alcohol per week) vs. equal amounts of de-alcoholized red wine. Lower volume red wine (lower level drinkers, 42 g alcohol per week; higher level drinkers, 73 g alcohol per week) vs. equal amounts of dealcoholized red wine	−2.00 [−3.18, −0.82] High Volume −0.40 [−1.58, 0.78] Low Volume
Mori et al. [23]	24	4 weeks	M/W, 40–70 years, Australia	Red wine vs. equivalent volumes of dealcoholized red wine or water	−1.05 [−2.26, 0.16]

Table 1 (continued)

Study designs without clear alcohol intervention models					
Study	*N*	Length of study	Sex, age, country	Alcohol intervention	Systolic blood pressure change in mmHg [95% C.I.]
Naissides et al. [56]	45	6 weeks	W, 50–70 years, Australia	Diet with red wine vs. diet with water or de-alcoholized red wine	−2.24 [−5.90, 1.42]
Parker et al. [57]	59	4 weeks	M, 20–70 years, Australia	Usual alcohol intake vs. alcohol reduction (substitution with low alcohol content); drinks were provided	−5.40 [−9.20, −1.60]
Puddey et al. [58]	46	6 weeks	M, 25–65 years, Australia	Usual alcohol intake vs. alcohol reduction (substitution with low alcohol content); drinks were provided	−2.98 [−5.13, −0.83]
Puddey et al. [59]	44	6 weeks	M, 25–65 years, Australia	Usual alcohol intake vs. alcohol reduction (substitution with low alcohol content); drinks were provided	−5.00 [−7.74, −2.26]
Puddey et al. [65]	86	16 weeks	M, 25–70 years, Australia	Usual alcohol intake vs. alcohol reduction (substitution with low alcohol content); drinks were provided	−4.80 [−7.30, −2.30]
Queipo-Ortuno et al. [60]	10	3 weeks	M, 45–50 years, Spain	Red wine or gin (30 g/day) vs. de-alcoholized red wine or abstinence (initial washout period)	−4.15 [−12.90, 4.60]
Rakic et al. [61]	55	4 weeks	M, 21–65 years, Australia	Usual alcohol intake vs. alcohol reduction (substitution with low alcohol content); drinks were provided	−2.20 [−3.20, −1.20] Daily −3.10 [−5.01, −1.19] Weekend
Shai et al. [62]	91	12 weeks	M/W, 41–74 years, Israel	Diet with initiation of alcohol intake (red or white wine with dinner) vs. diet with non-alcoholic diet malt beer with dinner; beverages were provided	2.71 [−4.03, 9.45]
Ueshima et al. [63]	49	2 weeks	M, 30–59 years, Japan	Usual alcohol intake vs. alcohol reduction (abstention or reduction as much as possible)	−3.34 [−5.58, −1.11]
Ueshima et al. [64]	54	3 weeks	M, 30–59 years, Japan	Usual alcohol intake vs. alcohol reduction (abstention or reduction as much as possible)	−5.50 [−7.35, −3.65]
Zilkens et al. [24]	16	4 weeks	M, 20–65 years, Australia	Usual alcohol intake vs. alcohol reduction (abstention or reduction as much as possible)	−5.00 [−8.56, −1.44]
Zilkens et al. [66]	24	4 weeks	M, 39–65 years, Australia	Red wine or beer vs. abstinence or de-alcoholized red wine	−1.35 [−1.93, −0.77]

*Studies not reported in the Roerecke et al. [17••] meta-analysis

one drink/day difference was promising (−4.67 mmHg), this study found a wide range of differences in blood pressure between groups (−10.89 to 1.55), likely due to the lack of control over how participants actually consumed alcohol over the 2-year period. Other more controlled interventions, however, have found slightly smaller and more reliable effects [21–23].

Some experimental research has also utilized an additional within-group component. These studies often involve recruiting participants without existing alcohol misuse problems, but with other conditions like hypertension or type 2 diabetes mellitus. These participants are brought into a laboratory setting and randomizing them to a regimen of abstinence or daily alcohol intake (typically ranging from 1 to 4 drinks per day) for days or weeks and concurrently measuring blood pressure along with other clinically meaningful values (e.g., cholesterol, glycemic control). Next, all participants are instructed to abstain from alcohol for a specific time period while their blood pressure continues to be measured. For example, one study provided participants 48 cans of 4.9% alcohol by volume (abv) lager for a 4-week period (equating to roughly 1–2 drinks per day), and subsequently randomized half of these participants to either receive another 48 cans of the same 4.9% abv lager, or 48 cans of "non-alcoholic" lager (0.9% abv). This study found a substantial pre- to post-manipulation reduction in systolic blood pressure in the very low (0.9%) alcohol content lager group of a mean of 8 mmHg compared to a reduction of a mean of 3 mmHg in the group continuing to drink 4.9% alcohol content lager. This difference of 5 mmHG, 95% C.I. [−8.56, −1.44] persisted in clinical and statistical significance when compared to the reduction in the group continuing alcohol use (see results by Zilliken et al., 2003, in Table 1) [24].

While the experimental studies summarized in Table 1 provide important controlled investigations on the impact of alcohol reductions on blood pressure free from many other confounds, they provide little information on the potential effect on blood pressure of available alcohol treatment for persons misusing alcohol. Thus, there is a need to examine studies that have been conducted in "real-world" clinical settings or with "real-world" alcohol reduction interventions.

The Range of Widely Implemented Intervention Models to Treat Alcohol Misuse

The most widely implemented interventions for treating alcohol misuse can be grouped into four categories of increasing intensity: screening and brief intervention (SBI), integrated primary-mental healthcare, specialty outpatient treatment, and higher level of care treatment. Table 2 organizes each of the studies cited in this section by treatment category and displays the number of study participants and reported effect on systolic blood pressure.

SBI is the most accessible and least intensive treatment for alcohol reduction and has become an increasingly common intervention in health systems over the last 20 years. SBI involves frequent measurement-based screening of alcohol use during primary care visits, each followed by a brief 5- to 15-min intervention (usually education, normative feedback, and brief goal setting) by the primary care physician or nurse if the patient endorses drinking above the recommended limits [25].

Integrated primary-mental healthcare refers to a broad spectrum of services available to primary care patients, from a mental health clinician being physically co-located in a primary care clinic to full collaborative care where a team of medical and mental health clinicians longitudinally and proactively discuss a patient's whole health within the context of any mental health concerns, including substance use [26]. To date, few integrated care models have been implemented specifically for alcohol misuse outside of randomized clinical trials.

Specialty outpatient treatment for alcohol misuse typically involves a set number of weekly group or individual sessions (typically 8 to 16) with a behavioral health clinician specializing in substance use treatment. While this model has been the predominant model of alcohol misuse treatment for decades, low referral rates and low treatment-seeking rates from individuals have limited the impact of this model on a population level [27].

Higher levels of care for alcohol misuse, including intensive outpatient services, inpatient treatment, and hospital-based acute detoxification units, are highly efficacious in the short term for patients with severe alcohol misuse-related problems. Unfortunately, these models are also very time and resource-intensive and are often a last resort for patients and clinicians [28]. The American Society of Addiction Medicine provides useful criteria for determining appropriate level of care for patients, specifically when deciding among higher levels of care (http://www.asam.org/asam-criteria/about).

Below, we describe what, if any, studies exist examining the impact of alcohol reduction on blood pressure within the context of each of these care models.

Impact on Blood Pressure by Intensity of Alcohol Reduction Intervention

Almost no published studies to date examining the impact of alcohol reduction interventions on blood pressure specifically classify the intervention as fitting into one of the four care models described above. However, several studies describe interventions that fit closely with the intensity and guiding principles of each of these care models.

Table 2 Impact on blood pressure by intensity of alcohol reduction intervention

Study	Number	Length of study	Sex, age, country	Alcohol intervention	Systolic blood pressure change in mmHg [95% C.I.]
Screening and brief intervention (SBI)					
Wallace et al. [29]	641	52 weeks	M/W, 17–69 years, UK	Brief advice on general health with counseling to reduce alcohol *vs.* brief advice on general health with no counseling to reduce alcohol; both groups reduced their alcohol consumption	−4.70 [−6.07, −3.33] control −6.80 [−8.17, −5.43] intervention
Integrated primary-mental healthcare					
Droste et al. [38]	100	20 weeks	M/W, 63 years (mean), Luxembourg	Diet and exercise with red wine vs. diet and exercise with abstinence	1.10 [−2.25, 4.45]
Kabayama et al. [36]*	53	26 weeks	M, 64 years (mean), Japan	Usual outpatient treatment with nurse-led health guidance regarding alcohol vs. usual outpatient treatment only	−12.60 [−19.10, −6.20] home blood pressure −6.80 [−14.50, 1.00] office blood pressure
Lang et al. [37]	106	104 weeks	M/W. 43 years (mean), France	Counseling to reduce alcohol intake (by trained physicians) vs. continuing care (by physicians not trained); both groups reduced their alcohol consumption	−4.60 [−8.21, −0.99] control −11.90 [−16.22, −7.58] intervention
Specialty outpatient treatment					
Baros et al. [40]	120	12 weeks	M/W, 44 years (mean), USA	Naltrexone combined with either cognitive behavioral or motivational enhancement therapy for alcohol dependence; outcome: continued drinking vs. abstinence	−9.00 [−14.56, −3.44]
Cushman et al. [41]	549	104 weeks	M/W, 21–79 years, USA	Cognitive-behavioral alcohol reduction intervention program or control observation; both groups reduced their alcohol consumption	−3.60 [−4.97, −2.23] control −5.40 [−6.77, −4.03] intervention
Maheswaran et al. [39]	41	8 weeks	M, 44 years (mean), UK	Counseling to reduce alcohol intake vs. no counseling	−5.20 [−10.43, 0.03]
Stewart et al. [42]*	1383	16 weeks	M/W, 44 years (mean), USA	Medications plus counseling to reduce alcohol vs. medications only to reduce alcohol vs. counseling only to reduce alcohol	−12.00 (not reported, $p < .001$) above median SBP 1.10 (not reported, $p = .06$) below median SBP
Witkiewitz et al. [44•]*	1142	16 weeks	M/W, 44 years (mean), USA	Medications plus counseling to reduce alcohol vs. medications only to reduce alcohol vs. counseling only to reduce alcohol	−7.99 (not reported, $p < .001$) WHO 1−level reduction[a] vs. none −7.38 (not reported, $p < .001$) WHO 2-level reduction[a] vs. 1-level or none
Higher levels of care					
Aguilera et al. [45]	42	4.5 weeks	M, 24–53 years, Spain	Hospital-based alcohol administration (total dose 2 g/kg) vs. 1 month of abstinence (verified by interviews of relatives and GGT levels)	−7.20 [−9.82, −4.58]
Kawano et al. [47]	16	1 week	M, 35–69 years, Japan	Hospital-based alcohol administration (1 mL/kg bodyweight, at dinner) vs. non-alcoholic drinks (same calories, at dinner)	1.00 [−3.59, 5.59]
Maiorano et al. [46]	15	1 week	M, 46 years (mean), Italy	Hospital-based usual alcohol intake abstinence	−7.00 [−11.05, −2.95]

*Studies not reported in the Roerecke et al. [17••] meta-analysis

[a]WHO drinking levels defined in World Health Organization, 2000 [43]

SBI To our knowledge, there no published studies that have examined the impact of SBI for alcohol misuse on blood pressure. This absence of information may be in part because screening for alcohol misuse is only now being widely implemented outside of Veterans Affairs Health Care Systems. However, one older study has examined the impact of advice to reduce or abstain from alcohol by physicians in a primary care setting on blood pressure compared to usual care [29]. This study found a sizeable decrease in blood pressure in patients randomized to the advice arm (−6.80 mmHg, 95% C.I. [−8.17, −5.43]), which was greater than the noticeable decrease in blood pressure in the control arm. As this study is more than 30 years old, advances in our understanding of alcohol misuse and efforts to standardize and implement SBI more broadly necessitate additional research on SBI's impact on blood pressure.

Integrated Primary-Mental Healthcare Similar to SBI, we are not aware of any published studies to date that have examined the impact of integrated primary-mental healthcare for alcohol misuse on blood pressure. Again, this absence of information is likely due to the nascent state of integrated primary-mental healthcare for alcohol misuse. Only six controlled trials have examined integrated primary-mental healthcare for alcohol misuse [30–35]. However, at least three other studies have reported on blood pressure reductions from interventions similar to integrated primary-mental healthcare. The interventions in these studies are similar to integrated primary-mental healthcare in that they occur in a co-located primary care setting, involve intentional collaboration among different types of clinicians, or both [36–38]. Two of these studies involved training physicians or nurses on providing alcohol reduction intervention over time and reported substantial reductions in blood pressure (physicians providing intervention: −11.90 mmHg, 95% C.I. [−16.22, −7.58]; home blood pressure with nurses providing intervention: −12.60 mmHg, 95% C.I. [−19.10, −6.20]), which were significantly greater than blood pressure reductions in the usual care control group [36, 37]. Another study involved a multidisciplinary team of interventionists advising on alcohol intake and diet, and did not find a significant reduction in blood pressure associated with the alcohol reduction intervention (1.10 mmHg, 95% C.I. [−2.25, 4.45]) [38]. Given that neither of these studies fully embodies the procedural tenants of integrated primary-mental healthcare, additional research on more complete models of integrated primary-mental healthcare on blood pressure is needed.

Specialty Outpatient Treatment Despite specialty outpatient treatment being the dominant care model for alcohol misuse, only five studies of four separate samples have examined its effect on blood pressure. Four of these studies detected significant changes in blood pressure following outpatient alcohol use treatment. The only study to not find a significant effect on blood pressure was the oldest study with the smallest sample size, yet it still found a clinically meaningful point estimate decrease in blood pressure although its 95% C.I. included 0 (−5.20 mmHg, 95% C.I. [10.43, 0.03]) [39]. Two newer studies with larger sample sizes both found clinically and statistically significant decreases in blood pressure after specialty outpatient treatment, even when compared to usual care controls (−9.00 mmHg, 95% C.I. [−14.56, −3.44]); −5.40 mmHg, 95% C.I. [−6.77, −4.03]) [40, 41]. The remaining two studies were secondary data analyses of the large federally funded COMBINE trial examining various combinations of behavioral therapy and medications. One of these secondary analyses found that patients with above average blood pressure values at intake showed substantial reductions in blood pressure during treatment (−12.00 mmHg, $p < 0.001$) [42]. The other study found that patients who reduced their alcohol consumption by at least one WHO risk drinking level (ranging from 0 to > 100 g of alcohol/day) [43] showed substantial reductions in blood pressure (−7.99 mmHg, $p < 0.001$) [44•].

Even within the specialty outpatient treatment modality, the studies presented offered vastly different theoretical orientations (e.g., behavioral/cognitive therapy vs. psychodynamic/interpersonal therapy vs. medication-assisted treatment). Given the plethora of potential variations in treatment orientation, length, and setting, additional research is necessary to parse out what specialty outpatient treatment delivery factors result in the largest improvements in blood pressure.

Higher Levels of Care The large short-term decreases in alcohol misuse seen in many higher levels of care (e.g., intensive outpatient treatment, inpatient treatment, hospital-based detoxification programs) would seem to make this treatment setting ideal for examining improvements in blood pressure following alcohol use reduction. However, only three studies have explicitly reported on blood pressure outcomes within higher level care levels. Surprisingly, these studies did not yield notably improved blood pressure in comparison to other studies at lower levels of care. Two studies did find statistically and clinically meaningful reductions (−7.20 mmHg, 95% C.I. [−9.82, −4.58; −7.00 mmHg, 95% C.I. [−11.05, −2.95]).[44•, 45]. However, one study did not find a significant decrease in blood pressure (1.00 mmHg, 95% C.I. [−3.59, 5.59]) [47]. Given the large range in values observed despite a more controlled treatment setting, as well as the time elapsed since each of these studies were conducted, additional investigations on more recent treatments in higher levels of care would offer meaningful insight into this relationship.

Conclusion

Ample evidence exists that (1) alcohol consumption at almost any level increases blood pressure; (2) alcohol consumption at higher levels is associated with significant morbidity and mortality, with blood pressure often playing some causal role in this process; and (3) alcohol reductions of almost any level are associated with decreases in systolic blood pressure, with reductions from severe levels being associated with decreases in morbidity and mortality. Unfortunately, there are a limited number of studies involving the evaluation of the association between alcohol reductions and blood pressure reductions in real-world treatment settings where these alcohol reductions are likely to take place. Researchers and policy-makers continue to weigh the advantages and drawbacks of alcohol reduction treatments to address the cardiovascular and other effects of alcohol misuse on a population level. These impactful and costly decisions on population-level treatments would benefit greatly from more information on how these treatments relate to blood pressure control and ensuing CVD-related outcomes that represent the largest health threat to most populations around the world.

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Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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•• Of major importance

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