UK Health Security Agency

# Minimum amount of alcohol to cause dehydration

## A rapid evidence summary

# Contents

# Main messages

1. This rapid evidence summary (search up to 28 July 2023) identified and summarised evidence investigating the minimum amount of alcohol needed to initiate dehydration in adults.

2. No study had investigated a dose-response relationship between amount of alcohol drunk and levels of dehydration. Therefore, evidence in this review is not able to directly answer the research question.

3. Most studies reported surrogate markers of dehydration as there is not a clear definition of dehydration currently available in the literature.

4. Studies consisted mostly of within-subject control trials assessing the impact of alcohol ingestion either by drinking beer, spirit, wine, or ethanol on several outcomes including but not limited to urine output and osmolality with participants acting as their own controls.

5. Urine output is a risk indicator for dehydration. Several studies included urine output as an outcome. However, the evidence investigating whether drinking alcohol increased urine output was unclear with some, but not all, studies showing increased urine output straight after alcohol ingestion and others reporting no change in urine output.

6. Osmolality is also a risk indicator for dehydration and there was some evidence indicating alcohol consumption lowered osmolality levels suggesting increased risk of dehydration.

7. Studies mostly consisted of mostly healthy young and middle-aged males with one study including habitual drinkers with mild-moderate hypertension and only 2 which included females. Therefore, study results may not be generalisable to the wider population, females, or those with comorbidities.

8. All included studies carried important methodological limitations such as small sample sizes, consisting of primarily male participants, no randomisation and most lacking a control group. These methodological limitations decrease confidence in the results and limit the extent to which they can be generalised to a broader population including females.

# Purpose

The purpose of this rapid evidence summary was to identify and assess the available evidence that discussed the minimum amount of alcohol needed to cause dehydration in adults.

# Methods

The review question was:

1. What is the minimum amount of alcohol derived from alcoholic beverages needed to cause dehydration in adults?

A rapid evidence summary was completed in August 2023, which identified evidence to answer the research question specified above. We searched Medline, Embase and Web of Science in August 2023 for relevant evidence published prior to 28 July 2023.

Screening on title and abstracts was undertaken in duplicate for 10% of the potentially relevant studies, with the remainder completed by one reviewer. Full text screening followed the same process. Disagreement was resolved by discussion between 2 reviewers. Data extraction was completed by one reviewer. Due to time constraints, formal critical appraisal of included studies was not undertaken.

A protocol was produced before the literature search was conducted, including the review question above, the eligibility criteria, and all other methods, see Annexe A. There were no deviations from the protocol.

# Evidence

In total, 2,754 studies were screened on title and abstract, of which 25 studies were eligible for full text screening. Fourteen studies were included in this rapid evidence summary following full text review (1 to 14). One study report could not be obtained for full text screening, and a further 10 were ineligible after full text screening.

A specific and clear definition of dehydration is lacking (15). Studies included in this review assessed surrogate markers of dehydration such as urine output, urine osmolality, urinary creatinine level, urinary sodium level, thirst, fluid intake, fluid balance, and blood or plasma volume. See the data extraction tables in Annexe B.

## Urine output and fluid balance

Several studies investigated the impact of alcohol intake on urine output (1, 3 to 13), which has a complex relationship with dehydration. In a dehydrated state urine output may reduce as the body tries to conserve water (16). However, some substances may cause excessive urine output (excessive diuresis), which may also be a risk factor for dehydration (17).

Some studies documented acute increases in urine output (the volume of urine produced over a set time period) after ingestion of alcohol (1, 4, 5, 7, 11 to 13); although not all studies found this effect (6, 8 to 10), and in one case increased urine output only occurred after 5 to 6 days of daily alcohol rather than in the acute post ingestion phase (5). One study reported that drinking alcohol significantly increased urine output compared to drinking water in people with a sufficient amount of water in the body (euhydrated) but not in those who had reduced total body water content (hypohydrated) (3). Differences in the results may be due to methodological limitations of the studies, such as having recruited too few participants to be able to detect dehydration following alcohol ingestion or to inform reliable results, or the variation in participants' ages between studies adults (range from early 20s to adults aged 50 years and over). Individuals at different ages may process alcohol at different rates resulting in different amounts of urine output. Overall, there appears to be some evidence indicating ingestion of alcohol may increase urine output which could lead to loss of total bodily fluid and increase the risk of dehydration. However, the evidence carries important methodological limitations including lack of a control group, small sample sizes mostly comprised of healthy males, and often lacking randomisation which leads to uncertainty in confidence in the findings. It is not possible to translate findings to females or wider populations including those living with comorbidities.

## Osmolality

Several studies investigated the association between ingestion of alcohol and either urine osmolality levels (1, 2) (the concentration of urine), or plasma osmolality (3) (the concentration of blood). Lower levels of osmolality in urine can be considered an indicator of dehydration whereas, a rise in plasma osmolality can be associated with dehydration (15).

One study found lower levels of urine osmolality and increased urine output after healthy participants had ingested one litre of beer (4 grams of ethanol) within 30 minutes. Once participants started drinking water again, osmolality values returned to normal within 105 minutes (1).

There was evidence from other studies, including a randomised cross-over trial (3), suggesting that ingestion of 960 millilitres (ml) alcohol free beer with 40ml 100% ethanol resulted in higher plasma osmolality within one hour (3) and that higher osmolality may correlate with degree of thirst which is a risk indicator of dehydration (2). Conversely, another randomised diet-controlled crossover trial reported no significant increase in osmolality with different alcoholic beverages including beer, spirits, and wine (9). All studies had small numbers of participants, with 7 (1), 8 (2), 12 (3) and 22 (9) leading to a total of only 47 males and 2 females across all studies. Two studies used experimental designs with participants as their own controls (1, 2), while the other 2 were randomised cross-over trials (3, 9). The methodological limitations of the included studies lead to lack of confidence in the evidence. Small studies in select populations (mainly males) lacking a separate control group reduce the quality of the evidence, carry a greater risk of bias and limit the extent to which results can be generalised across broader populations, particularly in females where evidence was lacking.

# Urine creatinine

Two studies investigated ingestion of alcohol on urine creatinine levels (1, 5); excess urinary creatine may be caused by dehydration. One study with a small sample of 5 men and 2 women found a decrease in urine creatinine following ingestion of beer (1). The other study, in 14 men with mild to moderate hypertension, reported that ingestion of salt and alcohol did not cause significant changes in urine creatinine (5). However, it is important to note that the addition of salt may have had an impact on the results. Neither study had a separate control group and results were compared to the participants baseline levels.

For these studies, it is important to note that participants were habitual drinkers, which may have attenuated the impact of alcohol ingestion on kidney function.

# Other outcomes

Two studies assessed the thirst response to alcohol compared to a control liquid (2, 7). In one study of 8 adult men, participants drank either 20% volume/volume ethanol mixed with orange juice at 0.5 to 1ml per kilogram (kg) over 10 minutes, or a control of orange juice only at the same volume and rate (2). Participants acted as their own controls, with experiments separated by at least one week. The authors found that ethanol caused thirst to be experienced later compared to the control condition and at a higher corresponding plasma osmolality (2). Another study of 14 male social drinkers also adopting a within-subject control design showed drinking either whiskey with diet soda (7-up) at a dose of 0.8 grams per kg body weight over 90 minutes or diet 7-up with trace whiskey and food colouring as a control had no effect on water intake (7). Findings from this study may suggest alcohol intake did not increase thirst in this sample of participants, and therefore would not suggest risk of dehydration. These conflicting findings regarding the effect of alcohol on the thirst response may reflect study limitations such as very small sample sizes and lack of randomisation, restricting the validity of the findings.

A further study assessed plasma arginine vasopressin (AVP) levels in 7 men when drinking water compared to 15% weight per volume ethanol at 10ml per kg (14). AVP is a hormone secreted to reduce water loss, and so increased AVP levels are indicative of dehydration.

Drinking ethanol was associated with higher AVP levels (and so higher likelihood of dehydration) but with significant between-subject variation. Higher AVP levels also appeared to correlate with worse hangover symptoms (nausea and vomiting), which is also indicative of dehydration as dehydration is a contributor to these. Again, the very small samples sizes involved, and lack of randomisation make it very difficult to draw firm conclusions.

# Health inequalities

The majority of included studies recruited only male participants with just 2 including females. This is an important methodological limitation which affects the extent to which conclusions can be generalised across the population, especially for females. Findings from this review highlight a relevant health disparity in the literature on alcohol and hydration levels between males and females.

# Limitations

This rapid evidence summary used streamlined systematic methods to accelerate the review process. Most article screening was completed without duplication, and therefore it is possible relevant studies may have been missed. Due to time constraints critical appraisal was not undertaken which limits our ability to interpret the findings in the context of risk of bias. As with all reviews, the evidence identified may be subject to publication bias, whereby null or negative results are less likely to have been published.

There is a lack of consensus on the definition of dehydration in the literature and in clinical practice (15). Surrogate makers or alternative indicators of dehydration can be difficult to interpret as they may be affected by other factors, for example, urine creatine levels may be affected by kidney impairment or the diuretic process following fluid ingestion. Additionally, alternative indicators of dehydration such as urine output and urine osmolality may not accurately reflect the degree of dehydration, reducing the reliability of the findings (15).

The included studies carried several important methodological limitations rendering the translation of study outcomes to real-world setting problematic. For example, most studies were not randomised or did not have a separate control group. In some within-subject studies, participants acted as their own controls. Studies had small sample sizes of mostly healthy male participants and only measured surrogate markers of dehydration. Because of these methodological limitations, firm conclusions cannot be drawn from the evidence, and it is not possible to translate findings to a wider population, including females or those with comorbidities.

# Evidence gaps

No study was identified that assessed dose-response relationship between amount of alcohol intake and degree of dehydration. There was also a lack of statistically powered randomised controlled trials investigating the ingestion of alcohol and initiation of dehydration processes. This prevents robust conclusion being made regarding the minimum amount of alcohol that is safe to ingest before dehydration occurs. Furthermore, lack of female participants in the literature on alcohol ingestion and dehydration means study outcomes from the current evidence base cannot be generalised to the female population.

# Conclusion

Overall, there is some limited evidence suggesting ingestion of alcohol, in the form of alcoholic beverage or pure ethanol, may have an impact on surrogate markers of dehydration such as osmolality or urine output. However, there was large variation in results between studies, likely due to small study samples and methodological limitations of the included studies meaning firm conclusions cannot be made.

The quality of the included studies was low with many studies lacking random allocation as well as using participants as their own controls rather than having separate control groups and having small sample sizes. As most studies recruited only healthy male participants, results cannot be generalised to a wider population. No study assessed a dose-response relationship between amount of alcohol ingested and degree of dehydration as measured by any surrogate marker. It was therefore not possible to establish how much alcohol is needed to cause dehydration.

# Acknowledgments

We would like to thank colleagues within the All Hazards Public Health Response division who either reviewed or input into aspects of the review.

# Disclaimer

UKHSA's rapid reviews and summaries aim to provide the best available evidence to decision makers in a timely and accessible way, based on published peer-reviewed scientific papers, unpublished reports and papers on preprint servers. Please note that the reviews:

- use accelerated methods and may not be representative of the whole body of evidence publicly available
- have undergone an internal, but not independent, peer review

- are only valid as of the date stated on the review

In the event that this rapid evidence summary is shared externally, please note additionally, to the greatest extent possible under any applicable law, that UKHSA accepts no liability for any claim, loss or damage arising out of, or connected with the use of, this review by the recipient and/or any third party including that arising or resulting from any reliance placed on, or any conclusions drawn from, the review.

# References

1. Bendtsen P and others. 'Impact of water-induced diuresis on excretion profiles of ethanol, urinary creatinine, and urinary osmolality' Journal of Analytical Toxicology 1999: volume 23, issue 7, pages 565 to 569
2. Eisenhofer G and others. 'Effects of ethanol ingestion on thirst and fluid consumption in humans' American Journal of Physiology 1983: volume 244, issue 4, pages R568 to R572
3. Hobson RM and others. 'Hydration status and the diuretic action of a small dose of alcohol'. Alcohol and Alcoholism 2010: volume 45, issue 4, pages 366 to 373
4. Irwin C and others. 'Alcohol pharmacokinetics and risk-taking behaviour following exercise-induced dehydration' Pharmacology, Biochemistry and Behavior 2012: volume 101, issue 4, pages 609 to 616
5. Kawano Y and others. 'Effects of repeated alcohol intake on blood pressure and sodium balance in Japanese males with hypertension' Hypertension Research: Clinical and Experimental 2004: volume 27, issue 3, pages 167 to 172
6. Kawano Y and others. 'Different effects of alcohol and salt on 24-hour blood pressure and heart rate in hypertensive patients' Hypertension Research: Clinical and Experimental 1996: volume 19, issue 4, pages 255 to 261
7. Lawson DM. 'The dipsogenic effect of alcohol and the loss of control phenomenon' Advances in Experimental Medicine and Biology 1977: volume 85, pages 547 to 568
8. Maughan RJ and others. 'A randomized trial to assess the potential of different beverages to affect hydration status: Development of a beverage hydration index' American Journal of Clinical Nutrition 2016: volume 103, pages 717 to 723
9. Polhuis K and others. 'The diuretic action of weak and strong alcoholic beverages in elderly men: a randomized diet-controlled crossover trial' Nutrients 2017: volume 9, issue 7, page 28
10. Shirreffs SM and others. 'Restoration of fluid balance after exercise-induced dehydration: effects of alcohol consumption' Journal of Applied Physiology 1997: volume 83, issue 4, pages 1,152 to 1,158
11. Wijnen AH and others. 'Post-exercise rehydration: effect of consumption of beer with varying alcohol content on fluid balance after mild dehydration' Frontiers in Nutrition 2016: volume 3, page 45

12. Ek J and others. 'The influence of beer on the renal excretion of water, sodium and potassium' Acta Physiologica Scandinavica 1953: volume 28, issue 4, pages 355 to 363
13. Jones AW. 'Excretion of alcohol in urine and diuresis in healthy men in relation to their age, the dose administered and the time after drinking' Forensic Science International 1990: volume 45, issue 3, pages 217 to 224
14. Linkola J and others. 'Plasma vasopressin in ethanol intoxication and hangover' Acta Physiologica Scandinavica 1978: volume 104, issue 2, pages 180 to 187
15. Lacey J and others. 'A multidisciplinary consensus on dehydration: definitions, diagnostic methods and clinical implications' Annals of Medicine 2019: volume 51, issues 3 to 4, pages 232 to 251
16. Taylor K. 'Adult Dehydration' 2022 (viewed on 4 August)
17. Evans GH and others. 'Optimizing the restoration and maintenance of fluid balance after exercise-induced dehydration' Journal of Applied Physiology (1985) 2017: volume 122, issue 4, pages 945 to 951

# Annexe A. Protocol

## Review question

The review question is:

1. What is the minimum amount of alcohol derived from alcoholic beverages needed to cause dehydration in adults?

This rapid evidence summary will identify and synthesis experimental primary studies (for example, randomised controlled trials, randomised cross-over trials) investigating the minimum amount of alcohol needed to cause dehydration in adults.

## Eligibility criteria

| | **Included** | **Excluded** |
|---|---|---|
| Population | All adults (at least 18 years of age) | Non-human studies<br>Children (less than 18 years of age) |
| Settings | Real world or laboratory settings | |
| Context | Not applicable | |
| Exposure | Alcohol (of any form) taken orally | |
| Outcomes | Dehydration as defined by study authors. Examples of potential measures of dehydration include plasma osmolality, urine output, urine osmolality, plasma urea:creatinine ratio, and clinician-defined dehydration | |
| Language | English language | Non-English language studies |
| Date of publication | Any | |
| Study design | Randomised controlled trials<br><br>Experimental studies | • observational studies<br>• editorials<br>• letters<br>• opinion pieces<br>• guidelines<br>• reviews |
| Publication type | Published, peer-reviewed primary research studies | |

# Identification of evidence

Medline, Embase and Web of Science will be searched to identify any existing evidence related to the review question, published prior to 28 July 2023. See Search strategy.

Screening on title and abstracts will be undertaken in duplicate by 2 reviewers for 10% of the potentially relevant studies, with the remainder completed by one reviewer. Full text screening will follow the same process. Disagreement will be resolved by discussion or with a third reviewer. Due to time constraints formal critical appraisal of included studies will not be undertaken.

# Synthesis of evidence

Data will be extracted straight into narrative summaries of included studies by one reviewer. Variations across populations and subgroups, for example cultural variations or differences between ethnic or social groups will be considered, where evidence is available.

# Search strategy

## Database: Ovid MEDLINE(R) ALL <1946 to 28 July 2023>

1. Dehydration/ (14,690)
2. dehydrat*.tw,kf. (50,558)
3. hypohydrat*.tw,kf. (599)
4. (diuresis or diuretic*).tw,kf. (54,791)
5. exp Diuretics/ (83,590)
6. exp Diuresis/ (21,236)
7. (urine adj3 (output* or produc*)).tw,kf. (10,170)
8. Urine/ (38,046)
9. or/1-8 (225,380)
10. (alcohol* adj5 (beverage* or drink* or consume* or consuming or consumption or intake*)).tw,kf. (96,835)
11. exp Alcohol Drinking/ (78,100)
12. exp Alcoholic Beverages/ (23,243)
13. (beer* or wine or wines or spirits or liquor* or liqueur*).tw,kf. (44,674)
14. exp Ethanol/ad (13,498)
15. (blood ethanol or blood alcohol).tw,kf. (7,483)
16. Blood Alcohol Content/ (736)
17. Ethanol/bl (8,749)
18. (ethanol* adj5 (beverage* or drink* or consume* or consuming or consumption or intake*)).tw,kf. (11,450)
19. or/10-18 (198,210)
20. 9 and 19 (1,346)
21. exp animals/ not humans.sh. (5,141,635)
22. 20 not 21 (1,198)

## Database: Embase <1974 to 28 July 2023>

1. *dehydration/ (7,781)
2. dehydrat*.tw,kf. (61,987)
3. hypohydrat*.tw,kf. (686)
4. (diuresis or diuretic*).tw,kf. (76,237)
5. *diuretic agent/ (16,528)
6. exp *diuresis/ (11,404)
7. (urine adj3 (output* or produc*)).tw,kf. (16,576)
8. *urine/ (26,852)
9. or/1-8 (192,222)
10. (alcohol* adj5 (beverage* or drink* or consume* or consuming or consumption or intake*)).tw,kf. (135,820)
11. drinking behavior/ (56,065)
12. exp alcoholic beverage/ (34,978)
13. (beer* or wine or wines or spirits or liquor* or liqueur*).tw,kf. (56,145)
14. alcohol/ad, do, po [Drug Administration, Drug Dose, Oral Drug Administration] (3,278)
15. (blood ethanol or blood alcohol).tw,kf. (9,956)
16. (ethanol* adj5 (beverage* or drink* or consume* or consuming or consumption or intake*)).tw,kf. (15,816)
17. or/10-16 (236,720)
18. 9 and 17 (1,944)
19. (exp animal/ or nonhuman/) not exp human/ (7,115,783)
20. 18 not 19 (1,654)

## Web of Science Core Collection

(all editions: Science Citation Index Expanded, Social Sciences Citation Index, Arts and Humanities Citation Index, Conference Proceedings Citation Index – Science, Conference Proceedings Citation Index – Social Science and Humanities, Book Citation Index – Science, Book Citation Index – Social Sciences and Humanities, Emerging Sources Citation Index, Current Chemical Reactions, Index Chemicus)

Date: 31 July 2023

TS=((alcohol* NEAR/4 (beverage* or drink* or consume* or consuming or consumption or intake*))) OR TS=((beer* or wine or wines or spirits OR liquor* or liqueur*)) OR TS=("blood alcohol") OR TS=((ethanol* NEAR/4 (beverage* or drink* or consume* or consuming or consumption or intake*)))

AND

TS=(dehydrat*) OR TS=(hypohydrat*) OR TS=((diuresis or diuretic*)) OR TS=((urine NEAR/2 (output* or produc*)))

1,202 results

# Annexe B. Data extraction tables

ml: millilitres, kg: kilograms, mOsmol: milliosmoles per kilogram of water, mmol: millimoles, SD: standard deviation, SE: Standard error

| Study | Participant characteristics | Methods | Outcome |
|---|---|---|---|
| Bendtsen and others 1999 (1) | 7 healthy volunteers, 5 men and 2 women, all social drinkers, mean (SD) age = 36(11) years. | Experimental study, aim was to investigate the influence of drinking water on the excretion profile of ethanol. All participants required to abstain from alcohol for 24 hours prior. Participants consumed 1,000ml beer (44 grams ethanol) in 30 minutes. Urine specimens collected every 30 minutes for 6 hours. At 120 minutes post-alcohol participants required to drink either 500ml or 1,000ml tap water. | Though not the primary aim of the study, a drop in urine osmolality and urine creatinine was seen for the first 90 minutes after intake of beer due to diuresis, then these measures increased until water intake at 150 minutes. |
| Ek and others 1953 (12) | Healthy men and women, sample size not specified (at least 16 participants, age not specified). | Experimental study, within-subject control. Experiments separated by at least 2 days. Compared the effects of beer, beer without hops, malt extract, hops solution, water-brandy mixture, and water control (all at 666ml volumes) on urine volume, urinary sodium and urinary potassium. | Beer (both with and without hops) gave rise to a higher diuresis and a higher urinary sodium excretion than a corresponding amount of water. A brandy-water mix to produce equivalent alcohol/volume as the beer did not produce significantly different diuresis or sodium excretion compared to water. Findings not reported in full. |
| Eisenhofer and others 1983 (2) | 8 men, 6 were social drinkers and 2 usually abstinent from alcohol, age range 22 to 45 years.<br><br>(Note: the study included 2 experiments – details in this table are just for those on ethanol relevant to the review outcomes.) | Experimental study, within-subject control. Thirst induced with intravenous hypertonic saline infusion twice at least one week apart, once with prior ethanol consumption (20% vol/vol with orange juice at 0.5 to 1 ml/kg doses over 10 minutes) and once without (orange juice only). Outcomes measured for 5 hours post ethanol/placebo. | Ethanol caused thirst to be experienced later compared with orange juice (mean (SD) minutes 70<br>(37) versus (vs) 44(29), p<0.02) and at higher plasma osmolalities (mean(SD) mOsmol per kg 293(5) vs 286(4), p<0.01).<br><br>The thirst response to saline was blunted in the ethanol condition for the first 2.5 hours, then increased compared to control in the latter 2.5 hours. |
| Hobson and others 2010 (3) | 12 men, social drinkers, mean(SD) age = 23(4) years. | Experimental study, 4 experimental trials, randomised cross-over design. Each trial involved initial exercise in hot, humid conditions to create dehydration. Participants were then provided fluid to rehydrate (2 trials), or were fluid restricted to remain dehydrated (2 trials). In each of those 2 conditions participants were given either 1,000ml alcohol free beer or 960ml alcohol free beer with 40ml 100% ethanol. Blood and urine samples collected hourly for 4 hours. | No difference in urine output when hypohydrated (negative fluid balance) between alcoholic (mean(SD) 261(138) ml) and non-alcoholic (174(61) ml) beer (p=0.057). There was a difference when euhydrated (neutral fluid balance) (1279(256) vs 1121(148) ml alcohol and non-alcohol respectively; P<0.001).<br><br>Serum osmolality was higher 1 hour after drinking in both alcohol trials (mean(SD) 303(5) and 298(5) mOsmol per litre) than in their non-alcohol, equivalent hydration trials (290(8) and 284(5) mOsmol per litre hypohydrated and euhydrated, respectively; P<0.001). |

| Study | Participant characteristics | Methods | Outcome |
|---|---|---|---|
| | | | Suggestive of diuretic action of alcohol being blunted in hypohydrated conditions. |
| Irwin and others 2012 (4) | 12 men, previous alcohol drinkers, mean(SD) age = 23(4) years. | Three experimental studies, randomised cross-over design separated by at least 7 days. One trial in dehydrated state caused by exercise, 2 trials in euhydrated state. Set volume of alcohol (vodka mixed with orange juice) given at a volume sufficient to case a rise in blood alcohol level of 0.050%. Outcomes monitored for 4 hours. | Peak urine output occurred 60 minutes post alcohol ingestion on all trials, with significantly higher volumes during the euhydration trials compared to the dehydration trial at 60 and 120 minutes post alcohol consumption ($p<0.05$). |
| Jones and others 1990 (13) | 80 healthy men, mean (SD) age across the 6 experiments ranged from 24.6 (3.2) to 53.6 (2.4) years.<br>Doses of alcohol administered (gram/kilogram) in each experimental condition with their respective sample sizes and body weight [kilograms (standard deviation)]:<br><br>0.51 (N = 16); 83.8 (13.1)<br>0.68 (N = 12); 73.5 (7.7)<br>0.68 (N = 12); 80.9 (6.5)<br>0.68 (N = 12); 80.9 (6.5)<br>0.68 (N = 12); 84.2 (9.9)<br>0.85 (N = 16); 79.9 (8.0) | Experimental study, no control condition. Six experiments, all involving neat whiskey; 0.51 grams per kg over alcohol 15 minutes (1 experiment), 0.68 grams per kg alcohol over 20 minutes (4 experiments), 0.85 grams per kg alcohol over 25 minutes (1 experiment).<br><br>Urine volumes collected at hourly intervals for 9 hours. | Peak production of urine was associated with the highest dose of alcohol and occurred between 60 and 120 minutes, however large inter-individual variations. |
| Kawano and others 2004 (5) | 14 men with mild to moderate hypertension, age range 37 to 67 years, current alcohol intake range 30 to 105ml per day. | Experimental study, within-subject control. 3 phases: control phase = 3 days of non-alcoholic drinks added to dinners, alcohol phase = 7 days alcoholic drinks added to dinners (1ml per kg ethanol in the form of vodka, lime and water), recovery phase = 3 days of nonalcohol drinks added to dinners. Most outcome measures not relevant to this review however urine collections for 24 hours were carried out each study day. | No change in urine output in early phase of alcohol period, but urine output increased significantly on days 4 to 6. Biphasic changes in urinary sodium excretion were observed during the alcohol period, decreasing from 112.8 mmol per day during control period to 97.6 mmol per day on day 2, then increasing to 130.8 mmol per day on day 4. There were no significant changes in urinary excretion of creatinine or potassium. |
| Kawano and others 1996 (6) | 16 men with mild to moderate hypertension, mean(SE) age = 54(1) years, habitual alcohol drinkers (mean(SD) alcohol intake 66(6)ml per day). | Experimental study, within-subject control. Assessed the effects of salt and alcohol on 24-hour blood pressure and heart rate. Alcohol experiment relevant to this review, due to outcome measure of 24 urine collection. 2 phases: control phase = 3 days of non-alcoholic drinks added to dinners, alcohol phase = 7 days alcoholic drinks added to | Urine output and urinary sodium excretion did not differ between the control and alcohol phases of the experiment. |

| Study | Participant characteristics | Methods | Outcome |
|---|---|---|---|
| | (Note: the study included 2 experiments – details in this table are just for those on ethanol relevant to the review outcomes.) | dinners (1 ml/kg ethanol in the form of vodka, lime and water). | |
| Lawson and others 1977 (7) | 14 men, mean age 22 years, social alcohol drinkers | Experimental study, within-subject control. Experimental phase: participants drank 0.8g alcohol per kg body weight over 90 minutes (whiskey with diet 7-up 1:2 ratio). Control phase: diet 7-up with trace of whiskey sufficient to impart alcoholic taste but not to raise blood alcohol levels, and food colouring. Water intake, urine output and fluid balance assessed for the following 4 hours, amongst other less relevant outcomes for this review. | No significant differences in urine output at baseline. Urine volumes consistently greater after alcohol vs after placebo. When fluid intake was compared between alcohol and control conditions across whole 4 hours of follow-up, no significant difference. When time-period broken down, there was a significant increase in water intake in the first 90 minutes after alcohol vs placebo, but no difference for the remaining 2.5 hours. Eleven out of 14 participants had a negative fluid balance after alcohol (mean -228ml), 1 out of 14 had a negative fluid balance after placebo (mean +269ml). |
| Linkola and others 1978 (14) | 7 healthy men, age 25 to 35 years, volunteered for the experiments performed under controlled clinical conditions. | Participants' diets and fluid intake was manipulated priori to ingestion of alcohol to standardise food and fluid ingestion across all participants. After which, participants received 15%; weight per volume ethanol 10 ml per kg. Blood samples were taken from all participants throughout the day following ingestion of ethanol. | Ethanol concentration was associated with greater plasma arginine vasopressin concentrations. Participants with nausea and vomiting and the worst hangover symptoms demonstrated the greatest concentration of plasma arginine vasopressin. |
| Maughan and others 2016 (8) | 85 men randomised, 13 lost to follow up (reasons provided), 72 participants completed follow up. Mean(SD) age = 25(4) years.<br><br>3 study sites (Bangor, Loughborough, Stirling; UK). | Investigated the effects of 13 different commonly consumed drinks on urine output and fluid balance. Each participant undertook the experiment a maximum of 4 times with water (control) and 3 other randomly assigned test drinks (from 13 options): 1,000ml volume over 30 minutes. Only one of the test drinks was alcoholic – lager beer (Carling). A 'beverage hydration index' was calculated = volume of urine produced after drinking, expressed relative to the standard volume produced after equivalent volume of still water. | The alcohol content of the lager did not appear to increase diuresis over the other drinks. 'Beverage hydration index' (volume of urine produced after drinking, expressed relative to the standard volume produced after equivalent volume of still water) – no significant difference compared to water control condition. |
| Polhuis and others 2017 (9) | 20 men underwent randomisation, 18 were completed for follow-up. Median age = 69 years (range 65 to 75 years). | Randomised diet-controlled crossover trial with 6 interventions: beer, non-alcoholic beer, red wine, non-alcoholic red wine, spirits, or tap water. Each intervention separated by at least 7 days. During first 30 minutes of lunch, beer and non-alcoholic beer – 3 x 250ml volume, wine or non-alcoholic red wine 3 x 93ml, spirits or tap water – 3 x 36ml (not blinded – taste and smell differences apparent). Standard diet with 3 different energy levels depending on participant body weight was supplied during the trial to minimise dietary confounding. Primary | The authors report higher cumulative urine output with wine and spirits compared to non-alcoholic red wine and tap water during the first 4 h ($p<0.003$ and $<0.001$, respectively), however the quoted effect sizes of 0.25ml and 0.18ml seem implausibly small and may reflect a unit error.<br><br>The authors report no difference in cumulative urine output with wine and spirits compared to non-alcoholic red wine and tap water after 24 hours ($p>0.40$, $p>0.10$), and that |

| Study | Participant characteristics | Methods | Outcome |
|---|---|---|---|
| | | outcome: difference in cumulative urine output at 4 and 24 hours post consumption of the drinks between the 3 alcoholic drinks vs 3 non-alcoholic. | beer and non-alcoholic beer did not differ at any time point (p > 0.70).<br>No significant differences were reported in urine osmolality, urinary sodium or potassium between the interventions. |
| Shirreffs and others 1997 (10) | 6 healthy men, occasional alcohol drinkers, mean (SD) age = 36(9) years. | Experimental study, within-subject control. All participants completed 4 trials - exercise induced dehydration (cycling in heat – climatic chamber), followed by beverage ingestion (drinks containing 0, 1, 2 or 4% alcohol consumed over 60 minutes in a volume equivalent to 150% of estimated sweat loss), then monitoring of fluid balance for 6 hours. Trials separated by 7 days. | Peak rate of urine production was 1 hour later in the 4% alcohol condition (1 hour period occurring 2 hours after beverage consumption) vs the 0, 1, and 2% alcohol conditions (1 hour period occurring 1 hour after beverage consumption), p=0.024. In all trial conditions, urine production neared basal levels by the end of 6 hours follow up. No significant differences between interventions in cumulative urine volume at any time point, or whole body net fluid balance. Increase in blood and plasma volume was lower at 1 hour post rehydration was in the 4% vs 0% alcohol condition. The authors conclude alcohol has a negligible diuretic effect when consumed in dilute solution after moderate hypohydration, and that there was no difference in rehydration recovery between 0,1, and 2% alcohol conditions, but slower recovery in the 4% alcohol condition. |
| Wijnen and others 2016 (11) | 13 men recruited, 2 did not complete the study due to illness (influenza). Occasional alcohol drinks (less than or equal to 14 alcohol consumptions per week). | Experimental, randomised cross-over design. Each participant completed 5 experimental trials: exercise-induced mild dehydration (1% body mass loss), followed by beverage consumption (5 beverage conditions - non-alcoholic beer, 2% beer, 5% beer, tap water, and a commercially available sports rehydration drink; volumes equal to 100% of sweat loss), then 5 hours fluid balance monitoring. Trials separated by at least 7 days. | Urine production significantly higher for 5% beer vs isotonic sports drink at 1 hour post rehydration (mean[SD] 299[143]ml vs 105[67]ml, p<0.01). Net fluid balance negative in all trial conditions at 5 hours post rehydration. Fluid retention (retained fluid divided by ingested fluid) was 21% (5% beer), 36% (2% beer), 36% (non-alcoholic beer), 34% (water) and 42% (isotonic sports drink). |

# About the UK Health Security Agency

UKHSA is responsible for protecting every member of every community from the impact of infectious diseases, chemical, biological, radiological and nuclear incidents and other health threats. We provide intellectual, scientific and operational leadership at national and local level, as well as on the global stage, to make the nation heath secure.

UKHSA is an executive agency, sponsored by the Department of Health and Social Care.



Prepared by Stefano Brini, Naomi Carter, Jennifer Hill, Elizabeth Kumah, Maheen Qureshi and Serena Carville, August 2023.

For queries relating to this document, contact: enquiries@ukhsa.gov.uk

Published: December 2025
Publishing reference: GOV-16954 (CPHR010i)

Suggested citation: Brini S, Carter N, Hill J, Kumah K, Qureshi M and Carville S. Minimum amount of alcohol to cause dehydration: a rapid evidence summary. UKHSA; 2025.



UKHSA supports the UN Sustainable Development Goals