

# Awareness of the Link between Alcohol Consumption and Cancer across the World: A Review

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## Abstract

Since 1988, the International Agency for Research on Cancer has classified alcohol as a Group 1 carcinogen, the highest level of risk. Growing evidence suggests that alcohol increases the risk of several types of cancer including breast, bowel, prostate, and liver, and accounts for a significant proportion of preventable cancers. Despite ample evidence of this relationship, public awareness is less clear. Following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, we reviewed 32 studies examining lay awareness of alcohol as a risk factor for cancer in 16 countries. Our results show that awareness appears to be low and varies internation-

ally; it is relatively higher in the United Kingdom, Morocco, and Australia. Methodologic differences in assessment obfuscate cross-country and cross-sample comparisons. In general, people are more likely to endorse alcohol as a risk factor when presented with a list of possible risk factors than when asked to list risk factors in an open-ended format. Attempts to increase awareness have been limited and constitute a significant public health need. We provide potential strategies to increase awareness, such as alcohol bottle labeling and fostering patient/physician discussions regarding the link. *Cancer Epidemiol Biomarkers Prev*; 27(4); 429–37. ©2018 AACR.

## Introduction

Alcohol accounts for 4.65% of the global burden of injury and disease, making it one of the most preventable causes of injury and death (1, 2), and an important behavioral risk factor for disease. Throughout the world, 38% of adults have consumed alcohol within the past 12 months (3). Importantly, alcohol has been shown to be a major behavioral risk factor for cancer in particular. Evidence concerning the carcinogenic effects of alcohol began to emerge in the early part of the twentieth century (4, 5), and epidemiologic studies and meta-analyses have since corroborated this association (6), thus motivating the International Agency for Research on Cancer (IARC) to classify alcohol as a Group 1 carcinogen (the highest category of risk) in 1988 (7). When alcohol is ingested and processed, it is converted into a chemical called acetaldehyde, a Group 1 carcinogen (8), which hinders DNA repair and thus increases cancer risk (9).

Epidemiologic data show that alcohol increases the risk of seven types of cancers including high prevalence cancers such as breast and bowel (10, 11) and is one of the principal risk factors for liver cancer (12). There appears to be a dose-response relationship between alcohol consumption and prostate cancer (13). Even small amounts of alcohol have been shown to increase risk; for example, bowel cancer risk is elevated by 9% for every 2 units (a unit is 10 mL or 8 grams; ref. 14) of alcohol a person consumes each day (15). Breast

cancer risk is also relatively higher among those who consume relatively small amounts of alcohol (16, 17). Nelson and colleagues (2013) (18) estimate that 31% to 51% of alcohol-related cancer cases occurred among women who consumed 20 grams or less (approximately 1.5 drinks) per day. All types of alcohol, including wine, beer, and spirits, increase cancer risk (19, 20).

Given the emergence of this evidence and the IARC's efforts to highlight the carcinogenic effects of alcohol, one might expect that awareness of this association would be widespread, and also linked to consumption. As a useful point of reference, over the past 50 years, greater awareness of the cancer risks associated with tobacco is thought to be a key factor in reducing the initiation and maintenance of tobacco use (21). It is less clear that people appreciate the effects of alcohol on cancer risk; it also seems likely that greater awareness might promote more informed decisions about consumption. The extent to which people feel at risk for cancer is likely to motivate behavior change designed to reduce that risk (22, 23); indeed, a recent meta-analysis observed a modest but significant ( $d = 0.23$ ) effect of risk perceptions on health behavior (24). If alcohol consumers appreciate the link between alcohol and cancer, they may feel more at risk and endeavor to reduce their consumption accordingly.

In this article, we investigated awareness of the link between alcohol and cancer across 16 countries in which awareness has been assessed. We also consider moderators of such awareness, including demographics and mode of measurement. Finally, we consider research and public health needs that emerge from this analysis.

## Methods

We conducted a systematic review of peer-reviewed published articles according to standard Preferred Reporting

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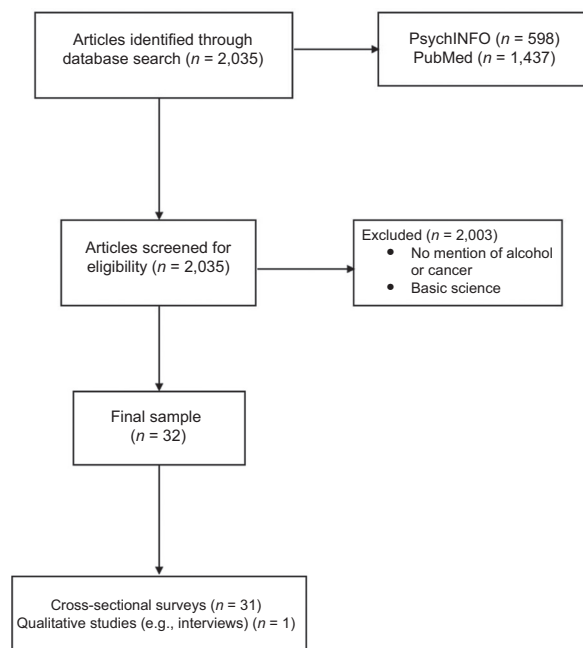
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Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The first author (J.K. Scheideler) conducted a keyword search using two medical and social science databases, PubMed and PsychINFO. Search terms of alcohol, cancer, and awareness were utilized in a variety of combinations ("alcohol" AND "cancer," "awareness," "knowledge," "risk perceptions," "beliefs"). A total of 2,035 articles were identified in the search. Articles were included if they assessed awareness or knowledge of cancer and alcohol, or the risk factors for cancer. Upon manual exclusion of titles and abstracts from the identified articles, 2,003 articles were excluded due to no mention of alcohol or cancer, or because they focused on basic science questions rather than awareness. The final pool included a total of 32 articles/surveys that assessed awareness of cancer and risk factors for cancer across 16 different countries, published between 1991 and 2017. This information is summarized in Figure 1.

## Summary of Findings

Levels of awareness of alcohol as a cancer risk factor across all countries in which it has been assessed are summarized in Table 1. Overall, awareness appeared to be highest in United Kingdom, Morocco, and Australia, although still relatively modest. In Table 2, we categorize studies by whether they prompted respondents with a list of cancer risk factors or offered an open-ended response option. Most studies assess awareness in just one country. An important exception is a study conducted in the late 1990s in five European countries (Italy, Belgium, France, Portugal, and Spain). Most countries had a high rate of reporting alcohol reduction as a strategy for cancer prevention (all above 75.8%; ref. 25). However, aware-



**Figure 1.** The summary of the eligibility criteria for inclusion into the review.

ness of alcohol as a carcinogen, particularly among women in those same countries, appeared to be much lower. Measurement differences must therefore be considered as a major limitation of this literature, an issue to which we return later. Another exception is a study conducted by researchers from the Cancer Research United Kingdom (CRUK) organization between 1999 and 2001. They assessed awareness of risk factors for different health ailments (including breast cancer) in 10,724 educated women between the ages of 17 and 30 from 23 countries. A majority of respondents (57%) endorsed heredity as a risk factor for breast cancer, followed by smoking (18%), and stress (11%). However, only 8% of respondents endorsed the remaining lifestyle factors, and only 3% of women identified alcohol as a risk factor for breast cancer (26).

## Awareness and risk perceptions in Europe

Several studies have been conducted in individual European countries at different points in time. One study in Greece explored perceptions of cancer etiology and prevention strategies among college-age students between October 1991 and February 1992. In general, alcohol was identified as a risk factor for cancer only among those who also smoked. Respondents reported the hematologic cancer risk to be 26% among those who both drank and smoked, followed by esophageal (22.1%), brain (14.1%), and liver cancer (3.2%) (27). In Italy in 1998, 86.7% of adults cited reducing alcohol consumption as a measure one could take to reduce cancer risk (28), as did 81% of adults in Spain in 2002 (29). This finding resonates with what La Vecchia and colleagues observed in the aforementioned cross-country survey, namely, that awareness appears to be higher when asking about alcohol as a cancer prevention technique than as a risk factor.

In a more recent survey conducted in 2011, over 90% of Danish and Swedish adults recognized smoking, indoor tanning, and ionizing radiation as risk factors for cancer (among 13 listed), but 56% of Danish and 52.6% of Swedish adults were not aware that alcohol was a risk factor (30). In 2013, only 24.6% of Portuguese adults referred to alcohol as a risk factor for oral cancer in face-to-face interviews (31).

In the only study we found conducted in Ireland, 42% of respondents cited alcohol when asked to list the top five risk factors. Moreover, 37% of respondents were aware that all types of alcohol increase cancer risk (32). In the United Kingdom in 2001, when given a list of oral cancer risk factors, 19.4% of adults viewed alcohol as a risk factor (33). Sanderson and colleagues found that more United Kingdom adults believed excessive alcohol intake to be a greater risk factor for heart disease than cancer in 2002 (34), and an earlier study conducted in 2004 found that 33% of U.K. adults endorsed alcohol as a risk factor when prompted with a list (35).

The current state of awareness in the United Kingdom was assessed in a survey conducted by CRUK. In July 2015, 2,100 English adults were asked to identify health conditions they believed resulted from drinking too much alcohol in an open-ended response format. Then, the participants were prompted with a list of seven health conditions (e.g., cancer, heart disease, diabetes, high cholesterol, liver disease, being overweight or obese, and arthritis) and were asked to identify which ones they believed could result from drinking too much alcohol. When given the open-ended response option, 12.9% identified cancer as a potential outcome of drinking too much alcohol. However,

**Table 1.** Summary of studies conducted including methods, participant demographics, and sample size

| Year surveyed (not published) | First author | Country            | Recognition of abstinence as a cancer prevention strategy | Recognition of alcohol as a risk factor                   | Question format (open-ended vs. listed) | Gender surveyed | Cancer type explored | Age group       | Sample size |
|-------------------------------|--------------|--------------------|---|---|---|-----------------|----------------------|-----------------|-------------|
| 1988                          | Hill         | Australia          | 8%  | N/A   | List                                    | Both            | All                  | 16+             | 3527        |
| 1988-1989                     | Baghurst     | Australia          | N/A   | 35%   | Open-end                                | Both            | All                  | 18+             | 1095        |
| 1989                          | Hall         | Australia          | N/A   | 0%  | Open-end                                | Both            | None                 | 18-65           | 500         |
| 1990                          | Horowitz     | USA                | N/A   | 13%   | List                                    | Both            | Oral                 | 18+             | 41104       |
| 1991-1992                     | Makris       | Greece             | N/A   | 26% Blood<br>22.1% Esophagus<br>14.1% Brain<br>3.2% Liver | List                                    | Both            | All                  | 18-25 (college) | 1136        |
| 1996                          | Kristeller   | USA                | N/A   | 1.3/5   | List                                    | Both            | Specified            | 25-83           | 1095        |
| 1999                          | Nichols      | USA                | N/A   | 8%  | Open-end                                | Female          | All                  | 10-13           | 62          |
| 1999                          | La Vecchia   | Italy              | N/A   | 86.7%   | List                                    | Both            | All                  | 16+             | 5579        |
| 1999-2000                     | La Vecchia   | Belgium            | 75.8%   | N/A   | List                                    | Both            | All                  | 16+             | 5579        |
| 1999-2000                     | La Vecchia   | France             | 84%   | N/A   | List                                    | Both            | All                  | 20+             | 5579        |
| 1999-2000                     | La Vecchia   | Spain              | 82%   | N/A   | List                                    | Both            | All                  | 16+             | 5579        |
| 1999-2000                     | La Vecchia   | Portugal           | 83.5%   | N/A   | List                                    | Both            | All                  | 16+             | 5579        |
| 1999-2001                     | Peacey       | North. Europe      | N/A   | 17.8%   | List                                    | Female          | Disease              | 17-30           | 2547        |
| 1999-2001                     | Peacey       | East. Europe       | N/A   | 15%   | List                                    | Female          | Breast               | 17-30           | 2285        |
| 1999-2001                     | Peacey       | South.Europe       | N/A   | 15%   | List                                    | Female          | Breast               | 17-30           | 2372        |
| 1999-2001                     | Peacey       | Asia               | N/A   | 5.8%  | List                                    | Female          | Breast               | 17-30           | 1255        |
| 1999-2001                     | Peacey       | Africa/South Amer. | N/A   | 12.3%   | List                                    | Female          | Breast               | 17-30           | 1145        |
| 1999-2001                     | Peacey       | Amer USA           | N/A   | 10.1%   | List                                    | Female          | Breast               | 17-30           | 1120        |
| 2001                          | West         | UK                 | N/A   | 19.4%   | Open-end                                | Both            | Oral                 | 16+             | 3384        |
| 2002                          | Sanderson    | UK                 | N/A   | N/A   | Open-end                                | Both            | All                  | 16-75           | 1747        |
| 2002                          | Garcia       | Spain              | 81%   | N/A   | N/A                                     | Both            | All                  | 15+             | 1438        |
| 2003                          | Inoue        | Japan              | N/A   | 21.7%   | List                                    | Both            | All                  | 20+             | 2000        |
| 2003                          | Hawkins      | USA                | 3.8%  | N/A   | Open-end                                | Both            | All                  | 18+             | 5589        |
| 2004                          | Redeker      | UK                 | N/A   | 33%   | List                                    | Both            | AI                   | 15+             | 4233        |
| 2004                          | Messina      | USA                | N/A   | N/A   | List                                    | Both            | Colorectal           | 50+             | 1093        |
| 2004                          | Bowden       | Australia          | N/A   | 22.4%   | List                                    | Both            | All                  | 18+             | 2700        |
| 2006                          | Spector      | USA                | N/A   | N/A   | Open-end                                | Female          | Breast               | 35-74           | 32          |
| 2005                          | AICR         | USA                | N/A   | 33%   | List                                    | Both            | All                  | 18+             | 1010        |
| 2007                          | AICR         | USA                | N/A   | 37%   | List                                    | Both            | All                  | 18+             | 1022        |
| 2007-2008                     | MacTiernan   | Australia          | N/A   | 57.5%   | List                                    | Both            | All                  | 18+             | 2094        |
| 2008                          | El Rhazi     | Morocco            | N/A   | 81%   | List                                    | Both            | All                  | 18+             | 2891        |
| 2009                          | AICR         | USA                | N/A   | 46%   | List                                    | Both            | All                  | 18+             |             |
| 2009                          | Cotter       | Australia          | N/A   | 48%   | List                                    | Both            | Disease              | 18-65           | 1255        |
| 2011                          | Lagerlund    | Denmark            | N/A   | 43.3%   | List                                    | Both            | All                  | 30+             | 3000        |
| 2011                          | Lagerlund    | Sweden             | N/A   | 47.4%   | List                                    | Both            | All                  | 30+             | 3070        |
| 2011                          | Gosein       | Trinidad           | N/A   | 12.4%   | List                                    | Female          | Breast               | 40+             | 441         |
| 2012                          | Bowden       | Australia          | N/A   | 36.6%   | List                                    | Both            | All                  | 18+             | 2700        |
| 2012                          | Naanyu       | Kenya              | N/A   | 47.5%   | Open-end                                | Both            | Breast               | 18+             | 1335        |
| 2013                          | AICR         | USA                | N/A   | 38%   | List                                    | Both            | All                  | 18+             | 1026        |
| 2013                          | Monteiro     | Portugal           | N/A   | 24.6%   | Open-end                                | Both            | Oral                 | 18-96           | 1116        |
| 2013                          | Buykx        | Australia          | N/A   | 47.4%   | List                                    | Both            | All                  | 18-91           | 2482        |
| 2013                          | Buykx        | Australia          | N/A   | 55.3%   | List                                    | Both            | All                  | 20-29           | 365         |
| 2015                          | Ryan         | Ireland            | N/A   | 42%   | Open-end                                | Both            | All                  | 18-74           | 748         |
| 2015                          | Buykx        | England            | N/A   | 46.9% (when given a list)<br>12.9% (when open-ended)      | Both                                    | Both            | All                  | 18+             | 2100        |
| 2015                          | AICR         | USA                | N/A   | 43%   | List                                    | Both            | All                  | 18+             | 1108        |
| 2016                          | Merten       | USA                | N/A   | 86% (liver)   | Given                                   | Both            | All                  | 18-25           | 728         |
| 2017                          | AICR         | USA                | N/A   | 39%   | List                                    | Both            | All                  | 18+             | N/A         |

when prompted with the list of diseases, 46.9% selected cancer as a potential health consequence (36).

#### Awareness in Australia

In 1988, when given a list of preventive behaviors for cancer, only 8% of Australian adults reported believing that reducing or eliminating alcohol from their diet could result in a lower risk of cancer (37). In the same year, when respondents

were asked to identify the health ailments associated with alcohol, not one respondent listed cancer (38). In another study, 35% of South Australian adults reported alcohol consumption as a risk factor for 3 types of cancers when given an open-ended response option (39). A telephone survey conducted from 2007 to 2008 found that 57.5% of respondents (60.9% men; 55.6% women) reported that alcohol increased the risk of cancer and 39.6% (45.1% men; 36.7% women)

**Table 2.** Summary of whether survey gave participants a list of carcinogens or used an open-ended response option (prompted vs. unprompted)

| Directly provided alcohol as RF   | Open-ended questions   |
|---|--|
| 42% (Ryan et al., 2015)   | 24.6% (Monteiro et al., 2015)  |
| 56.7% Denmark; 52.6% Sweden (Lagerlund et al., 2015)  | 2.9% (Naanyu et al., 2015)   |
| 36.6% (Bowden et al., 2014)   | 11.33% (Hawkins et al., 2010)  |
| 81% (El Rhazi et al., 2014)   | 3.75% - when asked to specify cancer reduction strategies (Hawkins et al., 2010) |
| 12.4% (Gosein et al., 2014)   | Alcohol not mentioned (Spector et al., 2009)                                     |
| 58% (MacTiernan et al., 2014)   | Alcohol not mentioned (Hall et al., 1992)  |
| 48% (Cotter et al., 2013)   | 8% (Hill et al., 1991)   |
| 33% (Redeker et al., 2009)  | 12.9% (Buykx et al., 2016)   |
| 10.1%, USA; 17.8%, Northern Europe; 15%, Eastern Europe; 15%, Southern Europe; 5.8%, Asia; 12.3%, Africa and South America (Peacey et al., 2006). | 8% (Nichols et al., 2006)  |
| 21.7% (Inoue et al., 2006)  |  |
| 19.4% (West et al., 2006)   |  |
| 81% (Garcia et al., 2005)   |  |
| 92.2% (La Vecchia et al., 2000)   |  |
| 86.7% (La Vecchia et al., 1999)   |  |
| 1.3/5 = average rating (Kristeller et al., 1996)  |  |
| 26% - only for people who drink and smoke (Makris et al., 1994)   |  |
| 46% (Hill et al., 1991)   |  |
| 46.9% (Buykx et al., 2016)  |  |
| 86% (Merten et al., 2016)   |  |

regarded beer consumption in particular as a risk factor when given a list of risk factors (40). A later survey (2009) found that 48% of adults were aware that drinking causes cancer and 51% were aware that reducing alcohol consumption prevents cancer when prompted with a list (41).

Every second year from 2004 to 2012, data assessing perceptions of the link between alcohol and cancer were collected in Southern Australia. In 2004, 22.4% of respondents rated alcohol as either "very" or "extremely" important for increasing cancer risk. This percentage increased to 36.6% of respondents in 2012 (42). In 2013, awareness increased to 47.4%, with the highest perceptions among respondents between the ages of 20 and 29 at 55.3% (43). Although perceptions do seem to reflect increasing awareness, nearly half of the survey population still failed to acknowledge alcohol as a risk factor for cancer.

#### Awareness in the United States

There has been considerably less research attention to the level of awareness of alcohol as a risk factor for cancer in the United States and the small number of relevant studies suggests awareness is low. In the 1990 National Health Interview Survey, only 13% of respondents indicated awareness that alcohol was a risk factor for oral cancer (44). Data from the 2003 Health Information National Trends Survey found that 11.9% of respondents mentioned "don't drink alcohol/drink less alcohol" as a cancer prevention strategy when asked to list cancer prevention strategies. Participants who mentioned "eat better/better nutrition" as a strategy were prompted for more specific information. Of those participants, only 3.8% cited "alcohol reduction" (45).

The American Institute for Cancer Research distributes the Cancer Risk Awareness Survey to a random sample of American adults every 2 years. This survey asks respondents if they believe alcohol has a significant effect on whether or not the average person develops cancer. In 2005, 33% of adults indicated that alcohol was a risk factor for cancer. This belief gradually increased to 37%, in 2007 and to 46% in 2009. Awareness decreased to 38% in 2013, but then increased in 2015 to 43%. The most recent 2017 Cancer Risk Awareness Survey Report

found that awareness is currently at 39% (46). The margin of error for this survey has been  $\pm 3\%$  from the years 2005 to 2017, suggesting that awareness has not changed appreciably and remains relatively modest.

The following studies examined awareness among specific samples of participants in the United States. Kristeller and colleagues (1996) asked diagnosed cancer patients whether they believed alcohol was a potential cause of their cancer, on a scale from 1–5, with 5 representing the highest risk (47). The mean was 1.3. In the aforementioned study that assessed awareness in 23 countries, Peacey and colleagues (2006) found that only 10.1% of American college students believed alcohol was a risk factor for cancer (26). When sixth-grade girls in Wisconsin were asked to list potential causes of cancer in February 1999, 91% listed smoking as a cause for cancer but only 8% listed alcohol (48). Awareness appears particularly low among youth, which is important given that adolescents are exposed to alcohol marketing more than any other age demographic (49), and given that alcohol is the drug most frequently misused by youth (50, 51).

Another study found that fewer than 50% of adults in New York identified alcohol consumption as a risk factor for colorectal cancer. In 2004, current smokers less frequently cited smoking, alcohol use, and eating meat cooked at very high temperatures as increasing the risk for colorectal cancer than never or ex smokers (52). A qualitative study in a cohort of women from North Carolina found that no one associated alcohol with breast cancer risk. In fact, one participant stated, "I don't really associate alcohol with breast cancer. I don't think there's ever been an alcohol link..." (53). These findings suggest, not surprisingly, that participants respond differently when given open-ended questions than when prompted with a predetermined set of risk factors.

Most recently (2016), cancer risk factor knowledge was assessed with a Mayo Clinic of Jacksonville survey among 758 undergraduate and graduate students (ages 18–25) at a university in the Southeast region of the United States. Eighty-six percent of participants correctly identified that alcohol leads to an increased risk of liver cancer. However, awareness of the

association between alcohol and head/neck and breast cancer was low (<50%; ref. 54).

#### Awareness in other countries

Awareness varies considerably in other countries where surveillance has been more limited. A survey conducted in 2011 found that 12.4% of Trinidadian women identified alcohol as a risk factor for breast cancer (55). In Western Kenya, data collected from face-to-face interviews in 2012 assessing knowledge and beliefs about breast cancer causes, presentation, and treatment showed that 52.5% of respondents had no knowledge of potential breast cancer risk factors. Among the remaining respondents, 12.3% endorsed heredity, 11.9% types of food, 6.9% witchcraft and curses, 3.6% family planning methods, and 2.9% endorsed the use of alcohol and tobacco as risk factors for breast cancer (56). In a 2003 survey in Japan, 21.7% of adults considered alcohol as a risk factor (57). Moroccan adults appear to be the most aware, as 81% accurately identified alcohol as a risk factor in 2008 (58). However, it is important to note that it is difficult to fully generalize findings from these countries given that only one study per country was conducted.

#### Moderators of awareness

Several of the aforementioned studies identified factors that could moderate the perceived relationship between alcohol consumption and cancer risk. Importantly, measurement and analysis of moderators vary greatly across studies, so the findings we report here are simply illustrative. Although people with lower levels of education are less likely to cite red meat, salt, and bacon as dietary risk factors for cancer (37), there does not appear to be a relationship between education and identification of alcohol as a risk factor. In one study, respondents with a personal history of cancer were less likely to identify alcohol as a risk factor compared to those with a family history of cancer (59). There is evidence to suggest that females are more likely than males to recognize alcohol as a risk factor for cancer in certain countries. Women more frequently report healthy behaviors (e.g., alcohol reduction) as a cancer prevention mechanism in Spain (29), and rate alcohol as an important risk factor for cancer in Australia (42). In one exception, men have been shown to be more likely than women to identify beer as a risk factor in Australia (40).

Awareness of alcohol as a risk factor has been found to be associated with being younger in the United Kingdom (33). Respondents under the age of 30 are more likely to identify alcohol as a cancer risk factor (37) and knowledge that alcohol causes cancer has been shown to be higher in people below the age of 45, specifically between the ages of 20 and 29 in Australia (43, 40) and the United States (47).

Smoking status also appears to moderate awareness. One study showed higher awareness among nonsmokers (33); awareness was lowest in current smokers. Smokers have been shown to be less likely to mention alcohol reduction as a way to reduce cancer risk compared to former and never smokers in Spain (29) and the United Kingdom (35). This is particularly notable given that smokers are more likely than nonsmokers to consume alcohol (60, 61).

Finally, we considered how per capita consumption might be related to awareness using the data reported above. We used data collected between 2008 and 2010 by the World Health Organization, which assessed the total amount of alcohol per

capita consumption (liters of pure alcohol) in each country among adults over the age of 15 (62). The point estimates for the 16 countries for which we possessed awareness data were then correlated using Spearman's  $\rho$  with a three-level categorical variable we created on the basis of best estimates of awareness (low, < 50%), 2 (medium, 50%–60%), and 3 (high, >60%). The correlation was not significant ( $\rho = 0.37$ ,  $P = 0.15$ ). Of course, this analysis was limited by a small sample, by the fact that awareness estimates were not always collected in the same year as consumption, and by differences in measurement of awareness across countries. However, this analysis suggests preliminarily that countries with higher consumption do not necessarily also have higher awareness of the alcohol–cancer link.

#### Variability in measurement approach

There were important differences in how each of the studies reviewed here operationalized and measured knowledge and awareness about alcohol as a risk factor and cancer prevention target. Despite awareness being low overall, the studies that directly provided alcohol as an option to respondents yielded higher awareness than those in which respondents were instructed to give an open-ended response in which they listed risk factors *de novo*. Studies that provided alcohol as an option yielded endorsements that alcohol is a risk factor for cancer ranging from 5.8% to 81%. However, in the studies that asked open-ended questions, generally fewer than 25% endorsed alcohol as a risk factor. The lack of consistency in data collection across studies makes comparisons difficult. As mentioned previously, another difference that may affect these findings is that some studies ask about cancer more generally, whereas others ask about specific types of cancer. These differences are reported in Table 2.

## Discussion

In a review of 32 studies and surveys conducted across 16 countries, we found a great deal of variability in awareness about the link between alcohol consumption and cancer risk. Awareness appeared to be highest in the United Kingdom, Morocco, and Australia, although awareness in these countries is still modest from a public health standpoint. A major limitation in the literature is that there are important methodological differences among the studies, particularly in the way awareness is measured. In general, although awareness appears to be increasing in many countries, at least half or more of the population does not consider alcohol to be a risk factor for cancer. Furthermore, although awareness has steadily increased in many countries over the past three decades, it appears to have leveled off more recently. This outcome may be a function of prevalent beliefs in health benefits of alcohol (particularly red wine; ref. 63). Although studies have shown that resveratrol (a compound found within the skin of grapes and in red wine) may hold disease-protective properties, and is generally safe in doses up to 5 grams per day (64), clinical trials in humans have yet to provide conclusive evidence that resveratrol in red wine prevents cancer (65).

#### Regional cancer incidence attributed to alcohol consumption

Praud and colleagues (2016) report that 5.5% of the total number of cancer cases globally are attributed to the

consumption of alcohol. Regionally, of these cases, the alcohol-attributed incidence rates for cancer vary, with the Western Pacific region (e.g., Australia; Japan) having the highest rate of incidence (7.1%), followed by the European (e.g., Belgium; United Kingdom; 5.4%), South-East Asian (e.g., Indonesia; 5.2%), African (e.g., Kenya; 4.8%), the Americas (e.g., North and South America; 4.2%), and Eastern Mediterranean (e.g., Morocco; 0.8%) regions (66). Some of these data resonate with our findings. For instance, the Eastern Mediterranean region has the lowest incidence rate and the awareness in Morocco is high. On the other hand, countries within the Western Pacific and European regions have a much higher cancer incidence rate, yet their awareness is also relatively high. This could potentially be due to the fact that more information is available in those countries, given the high incidence rate. We attempted to correlate consumption with awareness in the 16 countries for which we had sufficient data, and did not observe a significant correlation, suggesting that countries with higher consumption do not have higher awareness.

#### Potential strategies to increase awareness

In 2010, the World Health Organization passed a global strategy to reduce alcohol-related harm (67). A major goal of this strategy is to increase awareness about the health effects of alcohol, along with knowledge of policies and interventions (68). Many policy initiatives have since been proposed, including labeling alcohol bottles with cancer-risk warnings (69), which has historically shown to be effective for raising awareness of the health effects of tobacco (70–72). Warning labels may also influence attitudes towards and intentions to consume alcohol (73). However, there remains a dearth of research examining whether warning labels on alcohol bottles have the potential to result in behavior change, and little work has explored the effect of cancer messages in particular. The most efficacious interventions for reducing the health burden of excessive alcohol use are taxation, control of physical availability, and restriction of advertising and marketing, as identified by the World Health Organization (74). It is unclear how these interventions might also affect awareness.

Another suggested strategy is to increase awareness by fostering discussions regarding alcohol and cancer among general practitioners and their patients. Only one in six adult consumers in the United States report speaking with a healthcare practitioner about their alcohol use (75). Wellard and colleagues (2016) suggest that there is a lack of awareness or limited understanding of the link amongst general practitioners themselves in New South Wales and South Australia. In addition, the authors found that these discussions about alcohol only took place when it appeared to be causing salient detrimental effects to the patient (76). Therefore, educating healthcare practitioners about the carcinogenic effects of cancer may be an important step to increase public awareness.

The "Alcohol and Cancer" campaign was developed in 2010 in Western Australia and is the first of its kind to raise awareness of the relationship of heavy drinking and cancer in women 18–60 years old. The campaign integrated TV, internet, poster, and print advertisements with graphic images relaying that alcohol is carcinogenic. Subsequent survey evaluations of this campaign found that knowledge of the link significantly increased. However, drinking behavior did not change after the campaign (77). Nev-

ertheless, mass media campaigns may hold promise to effectively increase awareness.

Research might explore whether policy differences between countries limit the extent to which future initiatives could be successfully employed. Future research on patient–physician communication, particularly regarding lifestyle risk factors, could address discussion of alcohol as a risk factor for cancer. Intervention campaigns that highlight the risks of alcohol should also convey prevention strategies that one can take to decrease risk of alcohol-attributable cancer, such as physical activity. Current research shows that the association between alcohol intake and cancer mortality risk might be greatly reduced among individuals who meet the standard physical activity recommendations (78).

#### Lessening defensiveness toward messaging

Upon learning information that may threaten their attributes or lifestyle, people often become defensive, and find fault with the information (79, 80). As people learn more about the link between alcohol and cancer, there is a chance that they may become defensive toward these types of health messages, given that alcohol is a ubiquitous social staple throughout the world. Furthermore, knowledge of alcohol as a risk factor for cancer could compound the fatalistic belief that "everything causes cancer" (81). Thus, simply increasing awareness about the carcinogenic effects of alcohol may be insufficient; it may also be necessary to confront lay skepticism and defensiveness in response to such messages.

One promising approach to reduce such defensiveness offered by the social psychological literature is to provide opportunities to focus on one's most important values or what is called "self-affirmation" (82, 83). When people engage in self-affirmation prior to threatening health messages, they process the messages more carefully and with less defensiveness, and express greater interest in changing their behavior (84–86).

Accordingly, Klein and colleagues asked female alcohol consumers to read an article detailing the breast cancer risks associated with alcohol consumption. Prior to reading the article, half wrote an essay about a cherished value with examples of how they had acted in a way consistent with this value in the past, constituting a self-affirmation. Compared with a nonaffirmed control group, participants showed more attentional bias to threatening material in the article (87), expressed higher feelings of vulnerability to getting breast cancer (88), and reported more steps they would take to reduce their alcohol consumption (ref. 89; see also ref. 90). Moreover, among participants who believed that cancer messages were ambiguous, acceptance of this alcohol/cancer message was relatively higher (91). Feelings of vulnerability were found to mediate the effects of self-affirmation on intentions to reduce alcohol consumption (92). These findings suggest that using self-affirmation and other defensiveness reduction strategies prior to the delivery of messages about the risks of alcohol could be a promising avenue to increasing receptivity. These are of course highly intensive, individual-level approaches and less intensive ones are necessary.

Receptivity of messages is clearly important to raise awareness given the evidence that when people learn about the alcohol and cancer link, they are more likely to support alcohol-restrictive policies, such as increasing the price of alcohol, placing warning labels on alcohol containers, and reducing alcohol outlets

(93, 94). Research exploring how different cultures respond to different messages is essential toward the end of constructing the most influential messages. These recommendations align with the recent statement of the American Society of Clinical Oncology that increasing research and communication efforts regarding the association between alcohol and cancer is a major priority both in oncology and public health (95).

## Conclusion

Mounting scientific evidence identifies alcohol as a significant risk factor for cancer. The current review suggests that global awareness of this link varies greatly across the world, and is rather modest overall. To attenuate the effects of alcohol on cancer morbidity and mortality, and on public health more generally, we encourage further research on potential strategies to reduce defensiveness to threatening health messages and to increase awareness of this important but underappreciated link.

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No potential conflicts of interest were disclosed.

## Disclaimer

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