

## ORIGINAL PAPER

# Alcohol consumption and the risk of self-reported perennial and seasonal allergic rhinitis in young adult women in a population-based cohort study

P. Bendtsen\*, M. Grønbaek\*, S. K. Kjær<sup>†‡</sup>, C. Munk<sup>†</sup>, A. Linneberg<sup>§</sup> and J. S. Tolstrup\*

\*Centre for Alcohol Research, National Institute of Public Health, Øster Farimagsgade Copenhagen, University of Southern Denmark, Denmark, <sup>†</sup>Danish Cancer Society, Institute of Cancer Epidemiology, Strandboulevarden Copenhagen, Denmark, <sup>‡</sup>Department of Gynecology and Obstetrics, Rigshospitalet, Blegdamsvej, Copenhagen, Denmark and <sup>§</sup>Research Centre for Prevention and Health, Glostrup University Hospital, The Capital Region of Copenhagen, Denmark

## Clinical and Experimental Allergy

### Summary

**Background** Alcohol consumption has been suggested to be associated with the development of allergic rhinitis (AR), but there is limited data on the topic.

**Objectives** The objective of this study was to investigate the association between alcohol consumption and the risk of developing AR among young women.

**Methods** Five thousand eight hundred and seventy Danish women aged 20–29 years participated in a prospective cohort study, and were free of seasonal and perennial AR at baseline (1991–1993). Alcohol consumption was assessed by a food frequency questionnaire. The main outcome measures were self-reported information on seasonal and perennial AR debuting during a mean follow-up period of 7.8 years.

**Results** During follow-up, 831 women developed seasonal AR and 523 women developed perennial AR, corresponding to 14% and 9%. Alcohol consumption was positively associated with the risk of developing perennial AR. The adjusted odds ratio (OR) for perennial AR was 1.78 (95% CI, 1.13–2.80) among women drinking more than 14 drinks/week compared with women drinking <1 drink/week. There was no association between alcohol consumption and seasonal AR. Having one or two parents with asthma was, after adjustment, significantly associated with the risk of developing seasonal (OR, 2.01; 95% CI, 1.65–2.45) and perennial AR (OR, 2.28; 95% CI, 1.70–2.74). Smoking was not associated with an increased risk of developing AR.

**Conclusion** In this population of young adult women, alcohol consumption was associated with an increased risk of developing perennial AR.

**Keywords** alcohol consumption, allergic rhinitis, epidemiology, prospective cohort study

*Submitted 21 September 2007; revised 28 December 2007; accepted 31 December 2007*

### Correspondence:

Janne Tolstrup, Centre for Alcohol Research, National Institute of Public Health, Øster Farimagsgade 5 A, DK-1399, Copenhagen, Denmark.  
E-mail: jst@niph.dk

### Introduction

Allergic rhinitis (AR) is an upper respiratory disorder affecting between 10% and 40% of the population worldwide [1, 2]. Over the last decades, the prevalence of AR has increased in westernized countries [3–8], including Denmark [9]. AR has a significant societal and economic impact in terms of increased work or school absenteeism, decreased work productivity and school performance, as well as decreased quality of life [10, 11]. In addition, it can contribute to other conditions such as sinusitis, otitis media, and sleep and learning problems [10, 12], and AR is strongly predictive of the development of asthma [7, 13].

The causes of AR are still unknown, but lifestyle and environmental factors associated with westernized, urba-

nized, and affluent lifestyles may play important roles [14]. Alcohol consumption is part of the western lifestyle and it has been proposed that alcohol consumption may be one of the factors contributing to the rise in AR. First, alcohol is a well-known trigger of hypersensitivity reactions, although the mechanisms underlying these reactions are unknown [15–18]. Second, there is evidence that alcohol influences the immune system in several ways [19–21]. Alcohol consumption impairs the T-helper (Th) lymphocyte type-1 cellular immune response that increases the susceptibility to bacterial infections such as tuberculosis and pneumonia. It has also been shown that alcohol induces a relative Th2 deviation as reflected by increased levels of some Th2-associated cytokines [22, 23]. Third, studies in patient populations have indicated a

positive correlation between alcohol consumption and total serum IgE [23, 24], and alcohol consumption during pregnancy has been associated with elevated levels of total IgE in the cord blood [25] and with an increased risk of early-onset atopic dermatitis in the offspring [26]. Furthermore, some [9, 19, 27–29], but not all, studies [30, 31] have found a positive association between alcohol consumption and the risk of IgE sensitization. Thus, it may be hypothesized that alcohol could be a potential risk factor for AR.

We aim at studying the association between alcohol consumption and risk of AR in a prospective cohort study of young adult women.

## Materials and methods

### *Study population*

We used data from a prospective cohort study, comprising women aged 20–29 years who were randomly sampled from the general female population in Copenhagen, Denmark. The study was initiated in 1991–1993 with the purpose of studying the natural history of human papillomavirus infection and cervical neoplasia. A detailed description of the study design has been published previously [32]. In the present study, we used data from the baseline examination in 1991–1993 and from the follow-up examination in 1999–2001. The women were followed up for a mean of 7.8 years (range 7–9 years).

From May 1991 to January 1993, 11 088 women participated in the baseline examination (response rate 68%) [33]. The women were personally interviewed about life-style factors, including smoking habits and socio-demographic factors. Furthermore, 9606 of the 11 088 women completed a food frequency questionnaire, which included questions about alcohol consumption. The follow-up was performed from November 1999 to May 2001, where 6763 of the women from the baseline examination were enrolled. The women were asked about perennial and seasonal AR by questionnaire. Women with seasonal or perennial AR at baseline were excluded ( $n = 893$ ), leaving 5870 women for further analysis.

### *Alcohol consumption*

The participants were asked to report their current average weekly consumption of beer (in bottles), wine (in glasses) and spirits (in units) at baseline. One bottle of beer contains 12 g of alcohol, and this is also considered to be the average amount of alcohol in the other types of drinks. The total weekly alcohol consumption was calculated by summing up the consumption of beer, wine and spirits. It was divided into the following groups: <1, 1–6, 7–13 and  $\geq 14$  drinks/week.

### *Seasonal and perennial allergic rhinitis*

Participants were asked at follow-up: 'Have you had seasonal allergic rhinitis, itchy eyes, or hay fever with seasonal variation?' and 'Have you had allergic rhinitis, itchy eyes, or hay fever without seasonal variation?' Women who responded positively to either question were asked whether the disease started in childhood or in adulthood, and for how many years they had had the disease. This information was used to exclude women with seasonal or perennial AR at baseline. The diagnoses, perennial and seasonal AR, were based on self-reported questionnaire data. To further validate the data, the women were asked whether a doctor had confirmed the diagnosis and, if so, which diagnostic test was used.

### *Other variables*

The following variables were considered as potential confounders: smoking status (categorized as never smoker, ex-smoker, one to nine cigarettes a day, 10–14, 15–19 or more than 20 cigarettes a day), follow-up time (7, 8, or 9 years), education (< 9 years, 10 years and 11 or more years), passive smoking and parental asthma. Passive smoking in childhood was defined as a confirmative answer to at least one of two questions: (1) 'How many smokers lived in your home when you were 0 to 7 years old?' and (2) 'How many smokers lived in your home when you were 8 to 16 years old?' The women were also asked whether their biological parents (one or both) had asthma. Parental asthma was defined as at least one biological parent with asthma.

### *Statistical analysis*

Data were analysed by logistic regression using the SAS/STAT statistical software package version 9.1 (SAS Institute Inc., Cary, NC, USA). Odds ratios (ORs) were computed with a 95% confidence interval (CI). ORs were computed for weekly alcohol consumption and analysis was adjusted for potential confounders at different levels in the analysis: (i) age adjusted, (ii) adjusted for age, follow-up time, education and smoking and (iii) further adjusted for passive smoking and parental asthma. Baseline characteristics of the women were presented as median values for the continuous variable (age) and proportions for the categorical variables (Table 1). To test whether there were differences in baseline characteristics between women who participated in the follow-up and those who did not, baseline characteristics according to follow-up status were compared by the Kruskal–Wallis test for continuous variables and by the  $\chi^2$  test for categorical variables. To examine the possibility that latent baseline symptoms of AR might affect some of the women's alcohol consumption, thereby biasing the results, additional analyses were

Table 1. Baseline characteristics of the study population according to alcohol consumption ( $n = 5870$ )

| Characteristics                                    | Alcohol consumption (drinks/week) |                  |                  |                  | <i>P</i> -value |
|----------------------------------------------------|-----------------------------------|------------------|------------------|------------------|-----------------|
|                                                    | <1                                | 1–6              | 7–13             | + 14             |                 |
| Women number (%)                                   | 977 (16.6)                        | 3694 (62.9)      | 961 (16.4)       | 238 (4.1)        |                 |
| Age in years (range)                               | 24.5 (21.7–27.3)                  | 24.9 (22.2–27.6) | 25.0 (22.2–27.8) | 25.7 (22.8–28.6) | < 0.001*        |
| Never smokers number (%)                           | 488 (50.0)                        | 1854 (50.2)      | 350 (36.4)       | 61 (25.6)        | < 0.001†        |
| Ex-smokers number (%)                              | 115 (11.8)                        | 357 (9.7)        | 99 (10.3)        | 21 (8.8)         |                 |
| Current smokers number (%)                         | 374 (38.3)                        | 1481 (40.1)      | 512 (53.3)       | 156 (65.6)       |                 |
| Exposed to passive smoking in childhood number (%) | 785 (81.7)                        | 2875 (79.0)      | 757 (80.8)       | 198 (84.6)       | 0.082†          |
| Parental asthma number (%)                         | 127 (13.0)                        | 420 (11.4)       | 104 (10.8)       | 42 (17.7)        | < 0.001†        |
| School education > 11 years number (%)             | 495 (50.7)                        | 2693 (73.0)      | 781 (81.4)       | 173 (72.7)       | < 0.001†        |

\*Kruskall–Wallis test.

† $\chi^2$  test.

performed using a time window where participants who developed AR in the first two years after the baseline examination were excluded. A sensitivity analysis where only women with a physician-confirmed diagnosis were considered as having AR was also performed. For tests of linear trend, we treated the median value within categories of alcohol intake as a continuous variable.

A possible interaction between alcohol consumption and parental asthma was analysed by including interaction terms in the statistical model test, where a model without interaction terms was compared with a model containing a term for the interaction between alcohol consumption (in four categories) and parental asthma (yes/no) by a log likelihood test. Furthermore, we tested for interaction between alcohol intake and smoking, which, as for alcohol intake and parental asthma, was performed by comparing a model including the interaction term to a model without the interaction term.

The criterion for statistical significance was 5%.

## Results

During a mean follow-up of 7.8 years, 831 (14%) of the 5870 women developed self-reported perennial AR and 523 (9%) developed self-reported seasonal AR.

Table 1 shows the population characteristics according to alcohol consumption. The women had a median alcohol consumption of 3.5 alcoholic drinks/week (fifth to 95th centiles, 0.3–12.6). There were more smokers in the higher alcohol categories than in the lower categories. For example, the prevalence of smoking was 38% among non-drinkers and 66% among those who drank 14 or more drinks/week. Women with an alcohol consumption of 14 or more drinks/week were more likely to be predisposed in terms of parental asthma than women in the lower alcohol drinking categories, for instance, the proportion with parental asthma was 18% among women drinking 14 or more drinks/week compared with 11% among women drinking 1–6 or 7–13 drinks/week. Women

with an alcohol consumption of < 1 drink/week were less likely to have more than 11 years of education than women with a higher alcohol consumption. The proportion with more than 11 years of education was 51% among women with an alcohol consumption of < 1 drink/week, whereas it was more than 72% among women in the other alcohol categories. For age and passive smoking, there was no difference. Women who did not participate in the follow-up tended to be less educated ( $P < 0.001$ ) and were more frequently smokers ( $P < 0.001$ ) than women who participated in the study. For age and alcohol intake there were no statistically significant differences between the two groups.

Alcohol consumption was not associated with the risk of developing self-reported seasonal AR (Table 2). By contrast, there was a dose-dependent increase in the ORs of self-reported perennial AR according to alcohol consumption; for example, the OR adjusted for age, smoking, education and follow-up time was 1.13 (95% CI, 0.86–1.48) for drinking 1–6 drinks/week and 1.85 (95% CI, 1.18–2.91) for drinking 14 or more drinks/week. The ORs changed very little after further adjustment for passive smoking in childhood and parental asthma, and the results remained statistically significant for women drinking 14 or more drinks/week (OR, 1.78; 95% CI, 1.13–2.80) (Table 3).

We performed a linear trend test for perennial AR, which showed that for every additional drink per week the fully adjusted risk of perennial AR increased by 1.03 ( $P = 0.01$ ).

Parental asthma was significantly associated with developing seasonal and perennial AR. Women with the predisposition had an adjusted OR = 2.01 (95% CI, 1.65–2.45) for developing seasonal AR and an adjusted OR = 2.28 (95% CI, 1.70–2.74) for developing perennial AR compared with women without parental asthma.

Smoking more than 15 cigarettes/day was associated with a significantly decreased risk ( $P < 0.001$ ) of seasonal AR (OR, 0.60; 95% CI, 0.48–0.75), but not perennial AR

Table 2. OR (95% CI) by logistic regression for seasonal AR according to alcohol consumption among 5870 women

| Alcohol consumption (drinks/week) | Number of cases | Model 1*         | Model 2†         | Model 3‡         |
|-----------------------------------|-----------------|------------------|------------------|------------------|
| < 1                               | 134             | 1 (reference)    | 1 (reference)    | 1 (reference)    |
| 1–6                               | 530             | 1.05 (0.85–1.29) | 1.05 (0.85–1.29) | 1.01 (0.82–1.25) |
| 7–13                              | 131             | 0.99 (0.76–1.28) | 0.99 (0.76–1.28) | 0.98 (0.75–1.29) |
| + 14                              | 36              | 1.10 (0.74–1.64) | 1.10 (0.74–1.64) | 1.15 (0.76–1.73) |
| <i>P</i> for trend§               |                 | 0.90             | 0.54             | 0.66             |

\*Adjusted for age.

†Adjusted for age, smoking, education and follow-up time.

‡Adjusted for age, smoking, education, follow-up time, passive smoking in childhood and parental asthma.

§Test of linear trend was performed by including the median value within categories of alcohol intake as a continuous variable.

OR, odds ratio; CI, confidence intervals; AR, allergic rhinitis.

Table 3. OR (95% CI) by logistic regression for perennial AR according to alcohol consumption among 5870 women

| Alcohol consumption (drinks/week) | Number of cases | Model 1*         | Model 2†         | Model 3‡         |
|-----------------------------------|-----------------|------------------|------------------|------------------|
| < 1                               | 73              | 1 (reference)    | 1 (reference)    | 1 (reference)    |
| 1–6                               | 324             | 1.19 (0.91–1.55) | 1.13 (0.86–1.48) | 1.14 (0.87–1.49) |
| 7–13                              | 94              | 1.34 (0.97–1.84) | 1.26 (0.90–1.75) | 1.28 (0.92–1.77) |
| + 14                              | 32              | 1.91 (1.22–2.97) | 1.85 (1.18–2.91) | 1.78 (1.13–2.80) |
| <i>P</i> for trend§               |                 | < 0.01           | 0.01             | 0.01             |

\*Adjusted for age.

†Adjusted for age, smoking, education and follow-up time.

‡Adjusted for age, smoking, education, follow-up time, passive smoking in childhood and parental asthma.

§Test of linear trend was performed by including the median value within categories of alcohol intake as a continuous variable.

OR, odds ratio; CI, confidence intervals; AR, allergic rhinitis.

Table 4. OR by logistic regression for seasonal and perennial AR according to smoking status (*n* = 5870)

| Smoking status      | OR for seasonal AR* | OR for perennial AR* |
|---------------------|---------------------|----------------------|
| Never smokers       | 1 (reference)       | 1 (reference)        |
| Former smokers      | 0.84 (0.65–1.08)    | 1.01 (0.74–1.38)     |
| < 15 cigarettes/day | 0.87 (0.72–1.06)    | 1.05 (0.90–1.33)     |
| ≥ 15 cigarettes/day | 0.60 (0.48–0.75)    | 0.90 (0.70–1.16)     |
| <i>P</i> for trend† | < 0.001             | 0.24                 |

\*Adjusted for age, alcohol consumption, education, follow-up time, passive smoking in childhood and parental asthma.

†Test of linear trend (among current smokers only) was performed by including the median value within categories of alcohol intake as a continuous variable.

OR, odds ratio; AR, allergic rhinitis.

(Table 4). The interaction tests for alcohol intake and smoking status were not significant for either perennial AR (*P* = 0.73) or seasonal AR (*P* = 0.37). To further examine the association between perennial AR, alcohol consumption and smoking, we stratified analyses by smoking status (current smoker/non-current smoker). The stratified analysis showed that generally there was a trend towards higher alcohol consumption, which implied an increased risk for perennial AR. The results were statistically insignificant, except among current smokers drinking more than 14 drinks/week, where the OR for developing peren-

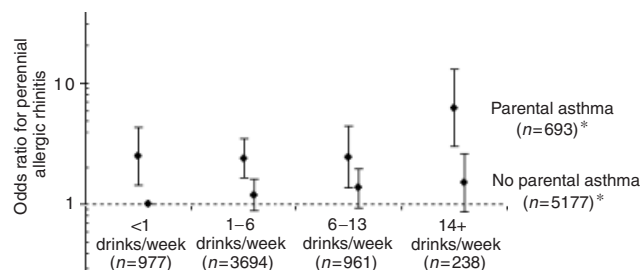


Fig. 1. Adjusted odds ratios for perennial allergic rhinitis according to parental asthma. Women without parental asthma drinking <1 drink/week are used as the reference group. \*Adjusted for age, education, follow-up time and passive smoking in childhood.

nial AR was 2.17 (95% CI, 1.17–4.04) compared with current smokers drinking <1 drink/week.

We examined the joint effects of parental asthma and alcohol consumption on the risk of developing perennial AR, with women without parental asthma and drinking <1 drink/week used as a reference (Fig. 1). For all levels of alcohol consumption, women with parental asthma had a higher risk for perennial AR than women without parental asthma. The highest risk was observed among women with parental asthma drinking 14 or more drinks/week who had an OR = 6.28 (95% CI, 3.07–12.86) compared with women without parental asthma drinking <1 drink/week (Fig. 1). Repeating the analysis with

women without parental asthma drinking 14 or more drinks/week as reference group showed that women with parental asthma drinking 14 or more drinks/week had an OR = 4.18 (95% CI, 1.86–9.40). A test for overall interaction between parental asthma and alcohol consumption was performed, but we found no interaction on the multiplicative scale ( $P = 0.33$ ).

We repeated the analyses where only women with a diagnosis confirmed from the hospital or doctor were taken into account. Using this more strict definition of perennial AR resulted in fewer cases ( $n = 405$ ). However, the results showed the same tendency as for all cases ( $n = 523$ ), but the ORs were generally attenuated and had broader confidence intervals. For example, women with a confirmed diagnosis who drank more than 14 drinks/week had an adjusted OR = 1.47 (95% CI, 0.86–2.51) compared with women drinking < 1 drink/week.

We also analysed data after implementing a time-window where all cases developing in the first 2 years after baseline were excluded from the analysis ( $n = 53$ ). The risk of perennial AR associated with drinking 14 or more drinks/week were unchanged (OR, 1.78; 95% CI, 1.10–2.88).

## Discussion

In this prospective cohort study of 5870 young adult women, we found that alcohol consumption was associated with an increased risk of developing perennial AR, but not with the risk of developing seasonal AR. Smoking was associated with a decreased risk of developing seasonal AR, but not with the risk of developing perennial AR. Having one or two parents with asthma was significantly associated with developing perennial and seasonal AR.

The strength of this study lies in the prospective design and the large sample size. The study was conducted in a representative sample, and selection and recall bias were minimized because of the prospective design.

Information on alcohol consumption was obtained by self-reports, which may imply some underreporting. But because data were collected prospectively and without prior knowledge of the hypothesis under study, any such misclassification is probably non-differential, i.e. unrelated to perennial and seasonal AR. Hence, the obtained results are most likely conservative. Misclassification of outcome is possible, because information on perennial and seasonal AR was obtained by self-report and allergy tests such as skin prick testing (SPT), or specific IgE measurements were not performed. Thus, some persons with non-AR may have been classified as having AR. However, we have no reason to believe that any such misclassification would be related to alcohol consumption and thus would cause bias in the observed results. Furthermore, we performed sensitivity analyses only including women with a history of doctor-confirmed

diagnosis and observed results similar with the main results, which may indicate that misclassification is not a cause of major bias. Nevertheless, future studies should include allergy tests to examine whether the effect of alcohol is related to the allergic or non-allergic rhinitic phenotype.

The prevalence of seasonal and perennial AR was 22.5% and 15.3%, which corresponds to the prevalence found in other studies [4, 7, 34].

The proportions of developing self-reported seasonal and perennial AR over a mean time period of 7.8 years were 14% and 9%, respectively. These findings are relatively high but could be explained by the fact that the study population is relatively young and living in an urban area; both factors have been linked to higher risks in other primarily cross-sectional studies [7, 35, 36].

Some studies have found that smoking is associated with increased serum total IgE concentrations [37–39]; thus it may be hypothesized that smoking could be a potential risk factor for AR. In spite of this, most studies found either no association between smoking and AR or even an inverse association [40–43]. Accordingly, we found that heavy smokers were less likely to develop seasonal AR than never smokers, and this was not affected by excluding early cases. There was no association between smoking and perennial AR. Nihlén et al. [36] found that smoking habits were not associated with the incidence of AR. In other studies, smoking has been linked with reduced allergic sensitization [40–43], and Bugiani et al. [44] found that active current smoking exposure was negatively associated with AR (OR, 0.76; 95% CI, 0.69–0.84). In line with this, a prospective cohort study by Linneberg et al. [42] found that smoking was negatively associated with the risk of allergic sensitization assessed by SPT positivity (adjusted OR, 0.45; 95% CI, 0.21–0.98). However, this relationship appears to vary between different allergens [37]. Jarvis et al. [41] found that current smokers were at an increased risk of sensitization to house dust mite allergen (OR, 1.29; 95% CI, 1.11–1.50) than never smokers, but at a decreased risk of sensitization to grass (OR, 0.76; 95% CI, 0.67–0.88) and cat allergens (OR, 0.69; 95% CI, 0.59–0.80).

Certain genetic factors are associated with the risk of AR [36, 45]. We found that women with parental asthma had an OR = 2.01 (95% CI, 1.65–2.45) for developing seasonal AR and an OR = 2.28 (95% CI, 1.70–2.74) for developing perennial AR compared with women without parental asthma. The predisposition in terms of parental asthma was significant for developing perennial allergic disease. In line with this, several other studies have shown that parental asthma is a strong predictor of allergic diseases and that the risk of developing AR is higher among subjects with parental asthma. In Dold et al.'s [45] study of German schoolchildren, parental asthma was a strong risk factor for AR (OR, 2.5; 95% CI, 1.6–4.0). This

supports the hypothesis that AR is a multifactorial disease brought about by different familial and environmental influences [45, 46].

There are few known modifiable risk factors for AR. Hence, it would be of considerable interest if alcohol were causally related to the development of perennial AR. It can help introduce new insight into some of the biological mechanisms of AR and, from a diagnostic point of view, the findings can bring in new knowledge in the clinical setting where alcohol is not usually considered to be a risk factor for AR. Alcohol is a powerful immunomodulatory drug with various effects on the immune system [20]. There are different hypotheses regarding the association between alcohol and allergic diseases, and the particular biological mechanisms by which alcohol consumption can lead to AR and increased levels of IgE and AR are not fully understood. The effect of alcoholic drinks on IgE responses could be due to ethanol [23]. But acetaldehyde, which is an intermediate in the metabolism of alcohol and appears to be the primary mediator of alcohol-intolerance reactions, could also play an aetiological role and help in explaining why alcohol increases the risk of allergy [19, 47]. Individuals that are intolerant to alcohol appear to have an impairment in the enzyme that converts acetaldehyde to acetic acid, and this reduced activity of the enzyme acetaldehyde dehydrogenase results in increased levels of acetaldehyde [18]. Israel *et al.* [48] found that acetaldehyde–protein adducts, which are recognized as foreign to the immune system, were found in high amounts in Caucasians with adverse reactions after alcohol consumption.

The present results were obtained in a cohort of women. It should be recognized that there is evidence to suggest that women, as compared with men, may be more susceptible to some of the deleterious effects of alcohol [49]. These differential effects are believed to be due to gender differences, e.g. higher body fat/water ratio or reduced liver mass/body weight ratio in females, or lower first-pass metabolism in females. Therefore, it would also be of interest to examine gender differences in the possible effects of alcohol on the development of rhinitis.

Alcohol consumption is widespread and allergic disease has a high prevalence, especially in western countries where atopic diseases can affect as much as 40% of people throughout their life, and the incidence is increasing. Danish women are among the most heavily drinking women in the world, so if a link between alcohol consumption and raised risk for perennial AR can be confirmed, public health implications may be significant.

It is a new finding that alcohol consumption increases the risk of perennial AR among younger women, and it clearly deserves further investigation. If the association represents a causal finding, further studies should focus on the biological mechanism and on whether lifestyle factors and genetic variations may influence susceptibil-

ity to the effects of alcohol consumption. There are many unanswered questions in the area and, in general, we need more information about risk factors for allergic diseases. Further developments within this area could increase our understanding of the effects of alcohol on the immune system as well as in the mechanisms of allergic diseases.

## Acknowledgements

*Competing interests:* None declared.

*Ethics approval:* The study was approved by the Ethical Committee of Copenhagen and Frederiksberg Municipality, Denmark (V.100.1665/90).

## References

- Bauchau V, Durham SR. Epidemiological characterization of the intermittent and persistent types of allergic rhinitis. *Allergy* 2005; **60**:350–3.
- Settipane RA, Charnock DR. Epidemiology of rhinitis: allergic and nonallergic. *Clin Allergy Immunol* 2007; **19**:23–34.
- European Allergy White Paper. 1997. UCB Institute of Allergy, Brussel.
- Galassi C, De Sario M, Biggeri A *et al.* Changes in prevalence of asthma and allergies among children and adolescents in Italy: 1994–2002. *Pediatrics* 2006; **117**:34–42.
- Howarth PH, Holmberg K. Allergic rhinitis: an increasing clinical problem. *Allergy* 1995; **50**:4–5.
- Sly RM. Changing prevalence of allergic rhinitis and asthma. *Ann Allergy Asthma Immunol* 1999; **82**:233–48.
- Verlato G, Corsico A, Villani S *et al.* Is the prevalence of adult asthma and allergic rhinitis still increasing? Results of an Italian study. *J Allergy Clin Immunol* 2003; **6**:1222–38.
- Latvala J, von Hertzen L, Lindholm H, Haahtela T. Trends in prevalence of asthma and allergy in Finnish young men: nationwide study, 1966–2003. *BMJ* 2005; **330**:1186–7.
- Linneberg A, Petersen J, Nielsen NH *et al.* The relationship of alcohol consumption to total immunoglobulin E and the development of immunoglobulin E sensitization: the Copenhagen Allergy Study. *Clin Exp Allergy* 2003; **33**:192–8.
- Simons FE. Learning impairment and allergic rhinitis. *Allergy Asthma Proc* 1996; **17**:185–9.
- Nathan RA. The burden of allergic rhinitis. *Allergy Asthma Proc* 2007; **28**:3–9.
- Roberts G, Hurley C, Lack G. Development of a quality-of-life assessment for the allergic child or teenager with multisystem allergic disease. *J Allergy Clin Immunol* 2003; **111**:491–7.
- Linneberg A, Nielsen NH, Frolund L, Madsen F, Dirksen A, Jorgensen T. The link between allergic rhinitis and allergic asthma: a prospective population-based study. The Copenhagen Allergy Study. *Allergy* 2002; **57**:1048–52.
- Nolte H, Backer V, Porsbjerg C. Environmental factors as a cause for the increase in allergic disease. *Ann Allergy Asthma Immunol* 2001; **87**:7–11.
- Linneberg A, Berg ND, Gonzalez-Quintela A, Vidal C, Elberling J. Prevalence of self-reported hypersensitivity symptoms following intake of alcoholic drinks. *Clin Exp Allergy* 2007; **38**:145–51.

- 16 Nihlen U, Greiff LJ, Nyberg P, Persson CG, Andersson M. Alcohol-induced upper airway symptoms: prevalence and comorbidity. *Respir Med* 2005; **99**:762–9.
- 17 Vally H, de Klerk N, Thompson PJ. Alcoholic drinks: important triggers for asthma. *J Allergy Clin Immunol* 2000; **105**:462–7.
- 18 Vally H, Thompson PJ. Allergic and asthmatic reactions to alcoholic drinks. *Addict Biol* 2003; **8**:3–11.
- 19 Linneberg A, Hertzum I, Husemoen LL, Johansen N, Jorgensen T. Association between alcohol consumption and aeroallergen sensitization in Danish adults. *Clin Exp Allergy* 2006; **36**:714–21.
- 20 Cook RT. Alcohol abuse, alcoholism, and damage to the immune system – a review. *Alcohol Clin Exp Res* 1998; **22**:1927–42.
- 21 Kazbariene B, Kalibatas J, Krikstaponiene A, Zabulyte D, Monceviute-Eringiene E. Alterations of human immune system functions in relation to environmental contamination, gender and alcohol consumption intensity. *Cent Eur J Public Health* 2007; **15**:13–7.
- 22 Gonzalez-Quintela A, Vidal C, Lojo S *et al.* Serum cytokines and increased total serum IgE in alcoholics. *Ann Allergy Asthma Immunol* 1999; **83**:61–7.
- 23 Gonzalez-Quintela A, Vidal C, Gude F. Alcohol, IgE and allergy. *Addict Biol* 2004; **9**:195–204.
- 24 Dominguez-Santalla MJ, Vidal C, Vinuela J, Perez LF, Gonzalez-Quintela A. Increased serum IgE in alcoholics: relationship with Th1/Th2 cytokine production by stimulated blood mononuclear cells. *Alcohol Clin Exp Res* 2001; **25**:1198–205.
- 25 Bjerke T, Hedegaard M, Henriksen TB, Nielsen BW, Schiotz PO. Several genetic and environmental factors influence cord blood IgE concentration. *Pediatr Allergy Immunol* 1994; **5**:88–94.
- 26 Linneberg A, Petersen J, Gronbaek M, Benn CS. Alcohol during pregnancy and atopic dermatitis in the offspring. *Clin Exp Allergy* 2004; **34**:1678–83.
- 27 Gonzalez-Quintela A, Gude F, Boquete O *et al.* Association of alcohol consumption with total serum immunoglobulin E levels and allergic sensitization in an adult population-based survey. *Clin Exp Allergy* 2003; **33**:199–205.
- 28 Linneberg A, Nielsen NH, Madsen F, Frolund L, Dirksen A, Jorgensen T. Factors related to allergic sensitization to aeroallergens in a cross-sectional study in adults: the Copenhagen Allergy Study. *Clin Exp Allergy* 2001; **31**:1409–17.
- 29 Vidal C, Armisen M, Dominguez-Santalla MJ, Gude F, Lojo S, Gonzalez-Quintela A. Influence of alcohol consumption on serum immunoglobulin E levels in atopic and nonatopic adults. *Alcohol Clin Exp Res* 2002; **26**:59–64.
- 30 Assing K, Bodtger U, Linneberg A, Malling HJ, Poulsen LK. Association between alcohol consumption and skin prick test reactivity to aeroallergens. *Ann Allergy Asthma Immunol* 2007; **98**:70–4.
- 31 Bakos N, Scholl I, Szalai K, Kundi M, Untersmayr E, Jensen-Jarolim E. Risk assessment in elderly for sensitization to food and respiratory allergens. *Immunol Lett* 2006; **107**:15–21.
- 32 Kjaer SK, van den Brule AJ, Bock JE *et al.* Human papillomavirus – the most significant risk determinant of cervical intraepithelial neoplasia. *Int J Cancer* 1996; **65**:601–6.
- 33 Munk C. Younger women and smoking – a longitudinal study of the trend in smoking prevalence and determinants of smoking and initiation and cessation among nearly 14,000 Danish women. Institute of Cancer Epidemiology, Danish Cancer Society, University of Copenhagen, Copenhagen: Denmark, 2001.
- 34 van de Ven MO, van den Eijnden RJ, Engels RC. Atopic diseases and related risk factors among Dutch adolescents. *Eur J Public Health* 2006; **16**:549–58.
- 35 Krause T, Koch A, Friberg J, Poulsen LK, Kristensen B, Melbye M. Frequency of atopy in the Arctic in 1987 and 1998. *Lancet* 2002; **360**:691–2.
- 36 Nihlen U, Greiff L, Montnemery P *et al.* Incidence and remission of self-reported allergic rhinitis symptoms in adults. *Allergy* 2006; **61**:1299–304.
- 37 Jarvis D, Luczynska C, Chinn S, Burney P. The association of age, gender and smoking with total IgE and specific IgE. *Clin Exp Allergy* 1995; **25**:1083–91.
- 38 Oryszczyn MP, Annesi I, Neukirch F, Dore MF, Kauffmann F. Relationships of total IgE level, skin prick test response, and smoking habits. *Ann Allergy* 1991; **67**:355–8.
- 39 Miyake Y, Miyamoto S, Ohya Y *et al.* Relationship between active and passive smoking and total serum IgE levels in Japanese women: baseline data from the Osaka maternal and child health study. *Int Arch Allergy Immunol* 2004; **135**:221–8.
- 40 Baldacci S, Modena P, Carrozzi L *et al.* Skin prick test reactivity to common aeroallergens in relation to total IgE, respiratory symptoms, and smoking in a general population sample of northern Italy. *Allergy* 1996; **51**:149–56.
- 41 Jarvis D, Chinn S, Luczynska C, Burney P. The association of smoking with sensitization to common environmental allergens: results from the European community respiratory health survey. *J Allergy Clin Immunol* 1999; **104**:934–40.
- 42 Linneberg A, Nielsen NH, Madsen F, Frolund L, Dirksen A, Jorgensen T. Smoking and the development of allergic sensitization to aeroallergens in adults: a prospective population-based study. The Copenhagen Allergy Study. *Allergy* 2001; **56**:328–32.
- 43 Wuthrich B, Schindler C, Medici TC, Zellweger JP, Leuenberger P. IgE levels, atopy markers and hay fever in relation to age, sex and smoking status in a normal adult Swiss population. SAPAL-DIA (Swiss study on air pollution and lung diseases in adults) team. *Int Arch Allergy Immunol* 1996; **111**:396–402.
- 44 Bugiani M, Carosso A, Migliore E *et al.* Allergic rhinitis and asthma comorbidity in a survey of young adults in Italy. *Allergy* 2005; **60**:165–70.
- 45 Dold S, Wjst M, von Mutius E, Reitmeir P, Stiepel E. Genetic risk for asthma, allergic rhinitis, and atopic dermatitis. *Arch Dis Child* 1992; **67**:1018–22.
- 46 Litonjua AA, Carey VJ, Burge HA, Weiss ST, Gold DR. Parental history and the risk for childhood asthma. Does mother confer more risk than father? *Am J Respir Crit Care Med* 1998; **158**:176–81.
- 47 Eriksson CJ. The role of acetaldehyde in the actions of alcohol (update 2000). *Alcohol Clin Exp Res* 2001; **25**:15S–32S.
- 48 Israel Y, MacDonald A, Niemela O *et al.* Hypersensitivity to acetaldehyde–protein adducts. *Mol Pharmacol* 1992; **42**:711–7.
- 49 Ward RJ, Coutelle C. Women and alcohol susceptibility: could differences in alcohol metabolism predispose women to alcohol-related diseases? *Arch Womens Ment Health* 2003; **6**:231–8.