Reviewer’s report

Title: Time trends of non-alcoholic beverage consumption among adults in Germany, 1990-2011

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Reviewer: Bernadette Marriott

Reviewer's report:

Hello

This is an excellent article. As a reviewer, I have no recommended changes other than some minor English language edits which I have included in the document below. Great manuscript which will make a very good contribution to the global understanding of beverage intake!

Background

Sufficient intake of beverages, especially water, is required for most body functions and essential for human life. The German Nutrition Society (DGE e.V.) recommends that adults drink about 1.5 litres (L) every day, preferably water or non-alcoholic and non-caloric beverages (1). Daily intake of sugar sweetened and alcoholic beverages are explicitly not recommended. In Germany, data from the German National Nutrition Survey (NVS) II, conducted in 2005/2006 among individuals aged 14 to 80 years indicated a mean daily non-alcoholic beverage intake of about 2.3 L/day. Nearly half of the non-alcoholic beverage intake
in the population is water without significant differences in intake between men and women.

Coffee and black tea accounted for about one quarter, fruit juice for around 11% and soft drinks for 9% among men and 4% among women of the non-alcoholic beverage intake (2).

Similar results can be observed from the recent National Health Interview and Examination Survey (DEGS, 2008/11): For adults aged 30 years and older, water is the most frequently consumed non-alcoholic beverage, whilst juices and soft drinks are less important.

Nevertheless, men of all ages consume on average more sugar sweetened beverages (SSBs) than women (3). Based on data from the Federal Statistical Office of Germany, mineral water and soft drinks are the most consumed cold non-alcoholic beverages followed by fruit juices.

Between 1995 and 2015, the per capita consumption of mineral water increased from 98 L to
154 L and decreased to 148 L in 2017. Soft drink consumption rose from 92 L to 126 L until 2013 and then decreased to 116 L in 2017. The per capita consumption of fruit juices was around 40 to 42 L between 1995 and 2005 and decreased to 32 L by 2017. Over the same period, per capita consumption of alcohol decreased from 165 L to 131 L (4, 5).

A trend analysis on alcohol intake among German adults over two decades has been published recently (6), indicating that harmful alcohol consumption decreased among men and women from 1990 to 2011. However, information on trends in non-alcoholic beverage intake over this period of time is sparse. It is estimated that about a quarter of the daily energy intake of American adults resulted from non-alcoholic beverages (7), hence, the consumption of non-alcoholic energy containing beverages as part of the diet among adults in Germany may also
be substantial. Systematic reviews and meta-analysis suggests that SSBs can be an important source of individual energy intake and the consumption of energy dense soft drinks has an effect on body weight and cardiovascular risk factors (8-10).

For Germany, changes in the frequency of daily non-alcoholic beverage intake over the last two decades are unknown. Therefore, the aim of this analysis is to examine non-alcoholic beverage consumption trends from individual beverage intake information between 1990 and 2011 among adults living in Germany with special focus on gender, age and educational level.

Methods

Study design and population

Data from three cross-sectional German national health interview and examination surveys (GNHIESs) with information about health status, risk factors and health behaviour of the
German adult population were used (11). In a multistage sampling procedure 120 to 180 sample-points (study locations) were randomly selected. In a second step, in every sample point an age- and sex-stratified random sample of the population was selected from population-registries. The first survey (East/West Health Survey 1990-92,) was conducted as the last National Examination Survey within the German Cardiovascular Prevention Study in the former western part of Germany in 1990-1991 and analogous after reunification in former eastern Germany in 1991-1992 (in the following called EW, conducted between 1990-92) (12). The second survey, the German National Health Interview und Examination Survey 1998 (GNHIES98) was conducted between 1997-99 and the third survey between 2008-11 (DEGS). The data collection consisted of an interview with questions about diagnosed medical
conditions and medication, self-administered questionnaires asking among other items about sociodemographic characteristics and life style factors and health examinations (e.g. anthropometry, blood pressure, blood samples) (13-15).

All participants were informed about study objectives and data protection handling. Verbal consent was witnessed and formally recorded in the first and second survey. Subjects in the third survey provided written informed consent prior to their participation. The surveys were conducted according to the Federal and State Commissioners for Data Protection guidelines.

DEGS was approved by the local ethics committee at Charité-Universitätsmedizin Berlin in October 2008 (ethics approval application document number: EA2/047/08). The implementation of the EW and GNHIES98 conforms to the principles of the Helsinki Declaration.
Since the final National Examination Survey of the Cardiovascular Prevention Study was part of the EW and included a study population aged 25 to 69 years, the analyses are restricted to this age range. The overall response rates ranged from 70% in 1990-92 to 61% in 1997-99 (12, 16). For DEGS the sample consists of 4,193 first-time participants (42% response) and 3,959 persons, who had already participated in GNHIES98 (62% response). Non-participants were asked to complete a short questionnaire including information on socio-demographic and health-related characteristics (14). The comparison between responders and non-responders of DEGS and between the overall net sample and the resident population of Germany demonstrated a high degree of representativeness (17).
In all surveys, dietary data were collected using self-administered food frequency questionnaires; however, there were differences in the obtained data across the surveys in food groups, reference time, intake frequencies and information on portion sizes. To compare the information across surveys we could only use frequency information of non-alcoholic beverage intake since portion sizes were not asked in GNHIES98. There were some differences in assessment of beverage intake: in EW, beverage intake was assessed using the question "How often do you consume beverages?" Participants reported their consumption of fruit and vegetable juices, soft drinks, mineral water, coffee, and tea. The frequency categories were "never", "once a month or less", "2-3 times a month", "about once a week", "several times a week", "(almost) daily". In GNHIES98, data on frequency of beverage intake
during the past 12 months were collected for fruit and vegetable juices, tap and mineral water, soft drinks (including cola, soda, tonic water, lemonade), coffee, and black tea using the categories "never", "once a month or less", "2-3 times a month", "about once a week", "several times a week", "daily or almost daily" and "more times a day". In DEGS, the questionnaire has a different order of non-alcoholic beverages compared to EW and GNHIES98. A detailed description of the dietary assessment method in DEGS has been published previously (18). In brief, the frequency of beverage intake during the last 4 weeks were assessed for fruit juices, vegetable juices, tap and mineral and flavoured water, sugar-containing soft drinks (including cola, soda, tonic water, lemonade, iced tea, energy drinks), coffee, and black, green, herbal and fruit tea. The answering categories were "never", "once a month or less", "2-3 times a month", "1-2 times a week", "3-4 times a week", "5-6 times a
week", "once a day", "twice a day", "three times a day", "4-5 times a day" and "more than 5 times a day". To examine trends over time from surveys with different dietary collection methods we standardized the information of non-alcoholic beverages across surveys and summarized the beverages to the groups "fruit and vegetable juice", "soft drinks", "water", and "coffee". The trends for tea intake, including all kinds of tea, were limited to EW and DEGS because the questions about tea in the GNHIES98 were different. The reported frequency categories in all three surveys were recoded into monthly frequencies and then categorized as "none" (never), "occasional" intake (less than 4 times a month/once a week to several times/week, but not daily), and "frequent" intake (almost daily or more). Age was categorized in age groups (25-34 y, 35-44 y, 45-54 y, 55-69 y). The education level was defined in accordance with the International Standard Classification of Education
(ISCED, version 1997) and categorized as low (9 or 10 years: lower secondary), medium (11-13 years: upper secondary), and high (14 or more years: higher education) (19).

Analysis

From EW 1990-92 to DEGS 2008-11, a total of 18,666 adults were interviewed and examined (1990-1992: n=7,466 in, 1997-99: n=5,825, 2008-11: n=5,375). Participants with missing responses to all non-alcoholic beverage items (overall n=210; 1990-1992 n=1, 1997-99 n=141, and 2008-11 n=68) were excluded from the analysis. Men and women with missing information for one beverage item were included, resulting in slightly different n for single beverage items.

All statistical analyses were performed with survey procedures for complex samples taking into account the cluster design effect in SAS release 9.4 (SAS Institute, Cary, NC, USA).
account for the unequal sampling probabilities and non-response, the statistical analyses were weighted with a survey specific weighting factor adjusting for differences in demographic characteristics from the official German population according to sex, age, education, federal state, and community type (17). Additionally, the weighting factor for DEGS 2008-11 considered the reparticipation probability of GNHIES98 participants. Since 1990 the age structure of the German population has changed considerably and analysis between 1990-92, 1997-99 and 2008-11 were standardised to the age structure of the population on 31 December 2010.

For descriptive analysis, age-standardized frequencies and 95% confidence intervals (CI) were calculated for gender, age groups and education level. Age-standardized trends over time were calculated with logistic regression models. Statistical hypothesis were tested at $\alpha=$
Results

Table 1 summarizes the age-standardized frequencies of non-alcoholic beverage intake across the three surveys. The proportion of adults with a frequent fruit juice intake increased from 21.1 % (95%-CI: 20.8-23.0 %) in 1990-92 to 27.2 % (25.6-29.0 %) in 2008-11. Furthermore, the percentage of adults who never consume fruit juice increased from 10.5 % (9.6-11.4 %) to 18.1 % (16.8-19.6 %) in 1997-99 and dropped to 15.8 % (14.6-17.1 %) in 2008-11. The proportion of adults with frequent soft drink intake markedly increased between 1990-92 and 1997-99 from 10.0 % (9.0-11.1 %) to 19.4 % (17.8-21.0 %) and was 18.7 % (17.3-20.3 %) r in 2008-2011. Similarly, the proportion of an occasionally soft drink intake rose from 40.8 % (39.3-42.4 %) to 47.1 % (45.4-48.8 %) in 1997-99 and was similar in
2008-11, whereas the percentage of adults who never consumed soft drinks decreased from

49.1 % (47.4-50.9 %) to 34.0 % (32.4-35.6 %) in 1997-99 and was similar in 2008-11. From

1990-92 to 2008-11 the daily intake of water increased from 59.1 % (56.8-61.4 %) to 87.6 % (86.2-88.9 %); whereas the percentage of adults who occasionally consumed water decreased from 33.9 % (32.3-35.6) to 10.5 % (9.3-11.8 %) and the percentage of adults who reported not drinking water also decreased from 7.0 % (6.0-8.0 %) to 1.9 % (1.5-2.4 %) in 2008-11. The proportion of adults with frequent coffee intake decreased between 1990-92 and 1997-99 and increased between 1997-99 and 2008-11. The percentage of adults who occasionally consumed coffee decreased and the percentage of non-consumers of coffee increased over time. Between 1990-92 and 2008-11 the proportion of none and frequent tea intake increased,
whereas the proportion of occasional tea intake decreased.

Table 2 presents the trends of adults consuming almost daily or more fruit and vegetable juice by sex, age group and education. The percentage of a frequent juice consumption increased among men significantly from 19.4 % (17.9-21.0 %) in 1990-92 to 26.9 % (24.7-29.2 %) in 2008-11 and slightly, but not statistically significant from 24.4 % (22.7-26.1 %) to 27.6 % (25.3-30.0 %) among women. Across the surveys, the proportion of men who consume juice frequently increased, except in the 35-44 and 55-69 year age groups. No differences between surveys were found in all age groups among women. The proportion of men who consume juice frequently increased over time in the middle and upper education groups, but not in the low education group. For women, an increase is only seen in the low education group.
An increase in frequent soft drink consumption is mainly seen among men between 1990-92 and 1997-99 and remained unchanged until 2008-11 (Table 3). Among women, no obvious change over time is observed. In 2008-11, 25.2 % (22.9-27.7 %) of men were twice as likely as women to be frequent soft drink consumers (12.1 %, 10.5-13.9 %). The proportion of men who consume soft drinks on a daily and more frequent basis is increased in all age and educational groups between 1990-1992 and 1997-1999 and remained almost constant thereafter. For women, a similar trend is only observed in the age group 25 to 34 years. In 1997-99 and 2008-11, men in the high education group consumed daily soft drinks less often than men in the middle and lower education groups. This gradient is not found in 1990-92. Between 1990-92 and 2008-11 the proportion of women with a frequent soft drink intake increased in the lower education group and decreased significantly in the high education
The frequency of almost daily or more water intake rose steadily among men and women, in all age and educational groups between 1990-1992 and 2008-11 (Figure 1 and 2). Overall, women are more likely to consume water on a daily basis. In the period 1997-99 and 2008-11, the proportion of men in the high education group with frequent water consumption is much higher than among men in the low education group. Among women, this gradient is only seen in 2008-11. 1990-92 shows no differences in the proportion of frequent water intake between different educational level groups.

Discussion

Between 1990-92 and 2008-11, the proportion of adults with a frequent intake of juice, soft drinks and water as well as tea has increased in the German adult population. The increase in
frequent soft drink intake was more pronounced between 1990-92 and 1997-99 compared to the later period. Only the proportion of a frequent coffee intake decreased in the 1990s and increased between 1997-99 and 2008-11. Daily consumption of juice rose among men in general and in the middle and upper education groups, whereas this trend could only be seen in the lower education group among women. In the 1990s, frequent soft drink intake increased among adults as well, especially among men of all age and education groups and among women of the low educated groups. Furthermore, daily water intake increased among men and women, in all age and educational groups.

Water, especially consumed as tap water, is easily accessible and fulfils the fluid needs of healthy individuals. Plain water contributes up to 80% of the total beverage intake in adults.
and is the main water source for all age groups (20). In Australia and selected European countries (France, Italy, Spain) water was the most consumed beverage for men and women (21, 22). Data from the Federal Statistical Office of Germany presented an increase in the per capita consumption of mineral water by 50% from 1995 to 2015 (5). In our data the proportion of adults who consume water daily or more increased up to 30 percentage points.

Recent changes in supply of mineral water with diverse gas content (no, medium, high) and the availability of specifically waters with flavour or fortified with vitamins as well as machines which carbonate plain water by adding carbon dioxide to generate sparkling water resulted in more attractive non-alcoholic and non-caloric products. Water as the first choice to quench thirst is widely communicated in the population and recommended in guidelines, so
it may also be that people independent of gender, age and education are more aware of this message (1).

In 2008-11, one fifth of the German population reported a daily intake of soft drinks. This is a similar dimension compared to data from the Behavioural Risk Factor Surveillance System (BRFSS), which indicates a prevalence of regular soda drinks ≥ 1 times daily by 17%, 21% among men and 14% among women (23). For Germany in 2005/2006 the mean daily consumption of soft drinks was on average 224 g among men and 88 g among women as reported by the NVS II and decreased with increasing age, so the oldest participants showed the lowest consumption of soft drinks (2). This is in line with our observation on the prevalence of daily intake: In 2008-11, proportionally, twice as many men compared to women consumed soft drinks almost daily or more, the highest daily consumption among men
and women was found in the youngest age group (25 to 34 years) and becomes lower in higher age groups. This age dependent gradient is also described in detail in a systematic assessment.

of individual-level beverage intake data and country-level beverage availability data (24), this might be a reason why intake of total sugars as a percentage of energy decreased over lifespan (25). Frequent soft drink intake in lower educated compared to the higher educated groups seen in our data is consistent with findings from other surveys which compared heavy consumption of SSBs among low education and low income groups compared to high education and high income groups (26).

The increase in the proportion of daily soft drink intake from 1990-1992 to 1997-99 especially among men in all age groups and all education levels could be due to the fact that
diverse products of SSBs entered the market during this period. In the US, from 1977 to 2001 larger portion sizes and increasing number of SSB servings were reported (7). For Germany, official statistics indicate an increase until 2013 and a levelling off or a slight decrease in the per capita consumption of soft drinks since then (5). From 1999 to 2012 in the US and from 1995 to 2011 in Australia a decrease in SSB consumption as well as for Australia a downward trend in availability of refined sugars and intake of added sugars was reported (27, 28). Possibly the growing evidence on carbohydrate intake and the possibility of chronic disease prevention published by the German Nutrition Society in 2006 (29) could have led to increasing consciousness about SSB consumption as part of the daily diet. Although reliable data are missing, increasing health consciousness is especially found among women and in the high educated groups (30), in which the prevalence of daily SSB intake in
our data dropped by 50%.

Fruit juice is an important source of vitamins and minerals, and usual intake of 100% fruit juice consumption is associated with better diet quality (31). Trends in mean daily fruit juice consumption collected from three European dietary surveys and within NHANES indicate a decrease in fruit juice among European countries (Spain, Italy, France) from 2007 to 2016, and in the US from 1999-2012 (21, 28). For Germany the NVS II 2005/2006 showed a decrease in mean daily consumption of fruit juices with increasing age with the oldest participants demonstrating the lowest consumption of fruit juices and nectars (2). However, the upward trend in the proportion of daily juice intake seen in our data seems unusual, but not unexpected. The increase of adults who daily consume juice was accompanied by the public
health campaign '5 a day', which started in Germany in the beginning of the 1990s. '5 a day' recommends eating five portions of fruit and vegetables every day, and it is possible to replace one portion by a smoothie or a glass of 100% fruit or vegetable juice (32).

Furthermore, the first smoothies were produced mid-2000 to 2010 and have become increasingly popular since then. Smoothies are beverages made by raw fruit or vegetables with other added ingredients. They have a healthy image and were advertised to have a nutritional benefit and to improve the diet. In our observations, daily juice intake increased especially among men and middle and high educated groups, but also among women in the low educated groups. It could be that especially these groups changed their beverage consumption pattern from certain alcoholic beverages to non-alcoholic beverages:

between 1995 to 2015 there was a decrease in per capita consumption of beer from 135.9 L to 105.9 L (5) and also national health survey data show a decline in harmful alcohol
consumption among men and women between 1990-1992 and 2008-11 (6). In the Spanish food consumption survey a strong increase in non-alcoholic beverage consumption has been observed since 1964 (33). Also, data from the longitudinal part of the German National Nutrition Monitoring (NEMONIT) indicate that men and women increased their non-alcoholic beverage consumption over a 6-year period between 2005 and 2013 (34). We assume that the implementation of the '5 a day' public health policy as well as the easy access and availability of smoothies and the decrease in beer intake could have resulted in a compensation of alcoholic with non-alcoholic beverages with a healthy image. These changes, could have resulted in an increasing consumption frequency in fruit juice in 2008-11 compared to the 1990s.

To our knowledge, this is the first detailed description of trends over two decades of daily
intake of juice, soft drinks and water among German adults using nationally representative data sources. However, some potential limitations of our results should be considered. A major limitation of comparing the three surveys is that the food frequency information is different in some aspects and a comparison of the three surveys could be based only on the frequency of daily intake. Therefore, beverage intake could not be quantified in a comparable way (e.g. mean daily amounts). This limits the conclusions that can be drawn from the analysis. A more general limitation is that information of beverage consumption was based on self-reported consumption and respondents might not answer unbiased. In general, recall bias is a serious limitation in the collection of dietary and beverage intake data and under-reporting or selective reporting of consumption is common. Due to social desirability, less healthy
beverage intake, such as soft drinks, could be underreported or healthy beverages like water overestimated. Furthermore, although we used a survey specific weighting factor adjusting for differences in demographic characteristics from the official German population, it cannot be ruled out that the effects over time within the ISCED categories can be also explained by the different age distributions within the groups. Finally, cross-sectional studies are useful to report frequency of beverage consumption and changes in beverage patterns (20).

Conclusion

In conclusion, in contrast to the population wide trends in alcohol consumption, which are decreasing among German adults, the frequency of daily intake of juice, soft drinks and water is increasing. An increase of water consumption is in line with the dietary recommendations.
to choose water as the first choice to quench thirst. Nevertheless, a daily intake of fruit juice
and soft drinks, which have high sugar contents, is explicitly not recommended by dietary
guidelines. Exploring non-alcoholic beverage intake over time may help to design better
targeted prevention measures.

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