HOW DO QUANTITIES DRUNK PER DRINKING DAY AND THE FREQUENCIES OF DRINKING THOSE QUANTITIES CONTRIBUTE TO SELF-REPORTED HARM AND POSITIVE CONSEQUENCES?

PIA MÄKELÄ* and HELI MUSTONEN
STAKES, Helsinki, Finland

(Received 7 November 2006; first review notified 8 January 2007; in revised form 7 May 2007; accepted 16 July 2007; advance access publication 31 August 2007)

Abstract — Aims: This article examines how quantities drunk per drinking day (dose) and the frequency of drinking those quantities contribute to self-reported harm and positive consequences at the individual and population level. Methods: Participants were drinkers in a general population survey among Finns aged 15–69 years, conducted in 2000 (N = 1760, response rate 78%). Types of harm examined were self-reported worries over drinking control, negative consequences of individual drinking occasions, and external reactions to drinking. Results: Respondents who reported frequent drinking at very high doses (13 drinks and above for men, 8 and above for women) were in a league of their own with respect to the risk of harm. At the population level, the dose of 8–12 drinks accounted for most problems among men, and doses of 5–7 and 3–4 drinks among women. No gain in positive consequences was attached to drinking beyond the dose of 5–7 drinks among men and 3–4 drinks among women. Conclusions: The dose level at which the population-level risk was the highest was lower than the level at which the individual-level risk was the highest, due to a greater prevalence of drinking the lesser quantities. Future studies should pay more attention to the separate effects of dose as well as the frequency of drinking the particular doses per occasion at the individual level, and also, as to how the prevalence of these drinking patterns contributes to the population-level risk.

INTRODUCTION

The impact of heavy episodic drinking (HED)—also referred to as drunkenness or binge drinking—on many types of harm is increasingly recognized, both for harms at the individual and at the aggregate level (Bondy, 1996; Stockwell et al., 1996; Norström, 2002). Yet, much remains to be learnt about the significance of different extents of HED. For example, we know that the frequency of drinking 8 or more drinks is a better predictor of problems than the frequency of drinking 5 or more drinks (Hilton, 1987). However, it remains unclear how the risks add up at the population level, given that less extreme forms of HED are more common.

The so-called prevention paradox states that the bulk of adverse consequences may originate among moderate drinkers (by volume of consumption), even though the risk of adverse consequences is by far the highest among heavy drinkers. This is due to the higher number of moderate drinkers, and their somewhat elevated risk mainly arising from episodic heavy drinking (Kreitman, 1986; Stockwell et al., 1996; Gmel et al., 2001). Similarly, even though drinking very large quantities at a time (e.g. drinking 18 or more drinks) is associated with high risk, it remains rare, while less extreme quantities (e.g. 5–7 drinks) are associated with lesser risk, but are much more common. Gruenewald et al. (2003) have estimated that among American college students, the greatest risk of different types of self-reported alcohol-related problems at the population level was at the level of two drinks per day, not because of a particularly great risk from such drinking at the individual level but because of the great number of such drinking occasions. Hence, it is critical to ask what the ‘HED levels’ are that contribute most to problems at the population level, i.e. combine information on risk with that of prevalence. This is a central aim in the current paper.

The literature on drinking patterns reflects a long tradition of separating the two dimensions of drinking: different quantities drunk per occasion (dosage), and the frequency with which these occur (i.e. exposure to the different doses). This has often involved using graduated frequency measures (the frequency of drinking, e.g. 1–2, 3–4, 5–7, and 8 or more drinks) (Room, 1991). In the literature on the relationship between drinking and its consequences, these two dimensions have been overly reduced, often to a dichotomy (e.g. whether or not a person has drunk 5 or more drinks), to a maximum amount, or—in a good case—to the frequency of two different quantity levels (Kaupfer, 1984; Hilton, 1987; Room et al., 1995; Midanik, 1999; Rehm and Gmel, 1999).

One reason for the lack of more elaborate analyses is the absence of an unproblematic solution to how this should be done (Gruenewald et al., 2003). Problems related to multicollinearity may occur, if a large number of variables describing different frequencies of drinking different amounts of alcohol are included in one model. However, even more problematic is that usually the data on outcomes is at the individual level, i.e. they are summaries across many drinking occasions with many drinking levels, thus making it hard for researchers to draw inferences about which of the respondents’ drinking occasions have most contributed to the reported types of harm.

Two types of approaches can be discerned when trying to analyse the risks attached to different frequencies of drinking different doses of alcohol. In the first approach, in which Gruenewald et al. (2003) have done pioneering work, the number of drinks consumed on a single drinking occasion would be the central variable. The first task would be to estimate the within-individual drinking profiles, or the distribution of dosage over drinking occasions. The second task would be to estimate the risk of harm from drinking...
a given dose once. However, this is problematic when the same individuals report drinking at different dose levels. For example, an individual may report drinking 1–2 drinks daily within the reference period and 12 drinks once and experience one drinking-related problem, e.g. hangover. This respondent raises the risk estimate for a 1–2 drink dose, although the risk presumably arises from drinking the 12 drinks. Further, in Gruenewald et al. (2003)’s the approach, one assumption has been that the risk of drinking, say, 5 drinks 10 times equals 10 times the risk of drinking this amount once. This is likely to be a suitable assumption for negative consequences of individual drinking occasions, but less suitable for outcomes that result from longer-term heavy drinking.

This paper explores another approach, namely, whether it would be fruitful and possible to separate the effects of (the frequency of) drinking different doses as if they were separate risk factors, such as, tobacco smoking, blood pressure and drinking. That is, the frequency of drinking, for example, 1–2 drinks is treated as one variable, and the frequency of drinking 3–4 drinks as another. The analyses proceed in two steps, and in both steps, established epidemiological methods are used. First, risk functions are estimated with statistical regression models. Then, statistical adjustment can be used to separate the independent effects of different doses. Such an approach has been previously used successfully in mortality studies (Paljärvi et al., 2005). Second, we estimate the population attributable fraction (PAF), which is ‘the proportion by which the incidence rate of the outcome in the entire population would be reduced if exposure were eliminated’ (Last, 1995), i.e. the proportion of the outcome caused by a given dose level. Because this approach is more flexible in how the frequency of drinking different doses is related to risk, it is suitable also for studying how drinking patterns affect the risks that result from longer-term heavy drinking.

The kinds of harm that will be examined are: negative consequences of individual drinking occasions (e.g. quarrel or argument, scuffle or fight, regretting something said or done), worries over drinking control (‘control worries’ below; e.g. the use of greater quantities of alcohol than one would like to), and external reactions to drinking (e.g. warned by a doctor or criticism by partner, or at work). Additionally, some positive consequences of drinking (e.g. drinking helped in being funnier or less inhibited, or sorting out problems) are examined in order to address the question of how the kinds of positive effects that make people drink are related to amounts and frequencies of drinking.

MATERIALS AND METHODS

Data

The data came from the Finnish Drinking Habits Survey carried out in September–October 2000 by face-to-face interviews. The participants were a simple random sample among Finns aged 15–69 years excluding those living in the Åland Islands (0.5% of the population), the institutionalized (0.7%), and those whose place of residence was unknown (0.8%). There were 1932 respondents, with a response rate of 78%. Respondents reporting any consumption of any alcoholic beverages within the 12 months preceding the interview (N = 1760) were included in the current study. Weights calculated by post-stratification for sex, age, and geographical region were used in order to restore the population representation of the respondent sample. More elaborate corrections for the dropouts did not improve estimates of alcohol consumption (Mäkelä, 2003).

Measurement

Negative consequences of individual drinking occasions were measured by 7 questions, control worries by 4, external reactions to drinking by 4 for women and 5 for men, and positive consequences of drinking by 8 questions. The questions have often been used in previous Finnish analyses (Mäkelä and Mustonen, 1988, 1996, 2000). Appendix 1 gives the individual questions and answer options.

Four indices of consequences were constructed based on these four sets of questions by summing the values for individual questions; the values used are shown for each response alternative in Appendix 1. Among women, the question on criticism at work did not correlate with other questions in the index and was excluded (correlation with total: 0.1). Criticism towards the respondent’s drinking from different sources correlated satisfactorily (Cronbach’s alpha 0.6 among both men and women). Otherwise, correlations were good within indices (Cronbach’s alpha 0.7 or above). The index of negative consequences of individual drinking occasions was dominated by the items on regrets and quarrels, which contributed about two-thirds of the points on this index.

Alcohol consumption was measured by graduated frequency questions. After an initial question on the maximum number of drinks consumed on any one day during the 12 months preceding the survey, the respondent was asked how often she or he drank 18 or more, 13–17, 8–12, 5–7, 3–4, or 1–2 drinks in a day, starting from the level indicated by the given maximum. It is not very common to have several separate drinking occasions in one day in Finland, and hence it may be assumed that this measure of drinks per drinking day approximates a measure of drinks per occasion. The average size of one drink in Finland is 1.5 cl or 12 grams of 100% alcohol. The frequency categories given were, with the numbers in parentheses indicating the categorization used in the analyses for men (first number) and women (second number): (1, 1) never; less than once a year; (2, 2) once or twice a year; (3, 3) 3–4 times a year; (4, 4) once during a couple of months; (5, 4) once a month; (6, 5) 2–3 times per month; once a week; (7, 5) 2–3 times a week; 4–5 times a week; daily. Categories had to be combined, and more so for women than for men, in order to have enough respondents in all frequency categories for all doses.

A second measurement of alcohol consumption, a so-called survey period measurement (Mäkelä, 1971; Simpura, 1987) was used for cross-validating the mean frequencies of drinking different doses. For this measure, the survey elicited the amounts consumed on all drinking occasions within a period of time preceding the interview. The length of the period varied between 1 week and 12 months, depending on the average drinking frequency of the respondent. The aim was to get information on the four previous drinking occasions (e.g. a frequency of “about once in 2 months” resulted in
a survey period of 8 months). The responses were then extrapolated to a scale of one year in order to get comparable figures across respondents. The downside of this measure is that respondents with different frequencies of drinking may be differentially affected by recall bias.

Method

Negative binomial models were fitted to the data, with the consequence indices—which can be thought of as estimates of the number of events that occurred to the respondent in the previous year—as outcome variables. Negative binomial models are otherwise similar to Poisson models, but they take into account over-dispersion. The categorized frequency of drinking a given dose was the main explanatory variable. The results were depicted as relative risks (RR) in different frequency categories, with the risk in the zero frequency category (those who never drank, e.g. a dose of 12–17 drinks) set as 1.0, separately for each dose.

In principle, we wanted to control for the frequency of drinking other doses than the dose under examination. However, this posed practical problems. When using continuous variables, a fixed relationship between the frequency of drinking and the given harm is assumed, which resulted in overadjustment (after adjustment, the risk at a high frequency of drinking a high dose was estimated to be systematically lower than at lower frequencies). The use of categorical frequencies, when several frequency categories were used, resulted in problems of multicollinearity, i.e. there were so many correlated parameters to be estimated that the estimates were highly unreliable. As a compromise, we controlled for the frequency of drinking other doses as dichotomized variables. This means that when modeling, for example, the effect of the frequency of drinking 5–7 drinks, we controlled for the main effects of frequent drinking at the levels of 1–2, 3–4, 8–12, and 13 or more drinks. Frequent drinking was defined as, among men, twice a month or more often, and among women as once every couple of months or more often. Additionally, age was controlled for by including it in the model as a categorical variable (15–34, 35–54, and 55–69 years).

The risk estimates were used to estimate the PAF for a given dose, e.g. 5–7 drinks:

$$\text{PAF}_{\text{dose}} = \frac{\text{SUM}[P_i(\text{RR}_i - 1)]/[1 + \text{SUM}[P_i(\text{RR}_i - 1)]]}{(1)$$

where the SUM is calculated over the different frequency categories i of drinking the given dose; P_i is the proportion of the sample in frequency category i; and RR_i is the relative risk in the category. The reference category, RR = 1, consists of those individuals who do not drink this dose at all. It should be kept in mind when interpreting the results that because all respondents included in the analyses were drinkers, the respondents in the reference category drank at least at one other dose level. Hence, the reference category consisted of different respondents for the different doses, i.e. we use a floating reference point. It is not possible to use one common reference category here: PAF_{dose} aims to estimate how many problems would be avoided if no one drank the given dose, and instead had the risk of the reference group; if, e.g. abstainers (who have no drinking-related harm) would be the common reference, then the incorrect conclusion would be that if no one ever drank 1–2 drinks (approximately 90% of drinkers currently do), nearly all harm would be avoided.

RESULTS

Table 1 shows the distribution of drinkers for the different frequency categories by dose. For example, 41% (100 – 59 = 41) of men reported having drunk 13–17 drinks on one occasion at least once in the previous 12 months. The average frequencies show that among both men and women, drinking occasions with only one to two drinks are by far the most common. However, high doses of alcohol were drunk relatively frequently particularly among men. They reported drinking 8–12 drinks, on average, every six weeks, 13–17 drinks more than 4 times per year, and over 18 drinks nearly 3 times a year. Thus, they reported drinking eight or more drinks nearly 16 times per year, which is more than once per month. Women reported drinking 5 or more drinks on average 7 times a year.

The frequency of the heaviest drinking occasions may seem high. The results could be cross-validated using ‘survey period measure’ (see Measurement section). The graduated frequency measure gave much higher estimates for the frequency of light drinking occasions (Table 1), suggesting that very light drinking occasions are better reported in summary fashion and more easily forgotten when individual drinking occasions should be recalled. However, estimates for heavy drinking occasions were surprisingly similar. Finnish men quite simply drink heavily.

The negative consequences of individual drinking occasions and external reactions from drinking were rarer than were control worries and positive consequences. The mean values were 0.89, 0.32, 2.31, and 2.14, respectively (with maximum values of 14, 5, 12 and 8, respectively).

Risk of consequences for different doses at the individual level

Among men, the risk of suffering negative consequences of individual drinking occasions, such as quarrels or accidents, did not change systematically with the frequency of drinking 1–2, 3–4 or 5–7 drinks (Fig. 1). Drinking 8–12 and, particularly, 13–17 and 18 or more drinks increased the risk considerably. The risk was elevated already when drinking 8–12 drinks, on average, every six weeks, 13–17 drinks more than 4 times per year, and over 18 drinks nearly 3 times a year. Thus, they reported drinking eight or more drinks nearly 16 times per year, which is more than once per month. Women reported drinking 5 or more drinks on average 7 times a year.

Control worries were among both men and women more common at high than at low to moderate frequencies of drinking at all dose levels, even 1–2 drinks. Again, it was the frequent drinking of large amounts that resulted in highest risk.

Men’s frequency of drinking up to 5–7 drinks did not have much to do with the risk of external reactions to drinking, while the drinking of 8 or more drinks increased the risk at even rather low frequencies. Again, the risks were, by far, the highest for drinking 13 or more drinks frequently. Among women, the regular drinking of even 3–4 drinks was...
Fig. 1. Men’s risk† of different types of consequences as a function of frequency of drinking†† different doses. *P<0.05, **P<0.01, ***P<0.001. P-value is for the test of whether the given level of drinking as a whole (all frequencies) can be dropped from the model, i.e. for whether drinking this quantity affects risk of harm. † The predicted mean consequence index. Age and drinking other doses, as dichotomies, have been adjusted for, and predictions are for reference categories (age group 15–34 years, and for the non-frequent categories of the other dose levels). ††Frequencies as times per year, month or week: 1: <1/yr, 2: 1–2/yr, 3: 3–4/yr, 4: 6/yr, 5: 1/mth, 6: 2–4/mth, 7: 2+/wk.

Fig. 2. Women’s risk† of different types of consequences as a function of frequency of drinking†† different doses. *P<0.05, **P<0.01, ***P<0.001. P-value is for the test of whether the given level of drinking as a whole (all frequencies) can be dropped from the model, i.e. for whether drinking this quantity affects risk of harm. † The predicted mean consequence index. Age and drinking other doses, as dichotomies, have been adjusted for, and predictions are for reference categories (age group 15–34 years, and for the non-frequent categories of the other dose levels). ††Frequencies as times per year or month: 1: <1/yr, 2: 1–2/yr, 3: 3–4/yr, 4: 6–12/yr, 5: 2+/mth.
Table 1. Distribution (%) of non-abstaining respondents to different categories of frequency of drinking by dose level

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Dose level</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1–2</td>
<td>3–4</td>
<td>5–7</td>
</tr>
<tr>
<td>1: none or less than once a year</td>
<td>15</td>
<td>25</td>
<td>27</td>
</tr>
<tr>
<td>2: 1–2 times a year</td>
<td>6</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>3: 3–4 times a year</td>
<td>6</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>4: 1 in two months</td>
<td>8</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>5: once a month</td>
<td>11</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>6: 2–4 times a month</td>
<td>34</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>7: 7–8 times a week or more</td>
<td>20</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>All, %</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>N</td>
<td>871</td>
<td>871</td>
<td>871</td>
</tr>
<tr>
<td>Mean times per year</td>
<td>45.4</td>
<td>19.6</td>
<td>13.4</td>
</tr>
<tr>
<td>Mean times per year, survey period measure</td>
<td>28.0</td>
<td>11.2</td>
<td>11.4</td>
</tr>
</tbody>
</table>

Risk for different doses at the population level

While the risk of different types of harm and positive consequences generally increased with an increasing dose at the individual level, the same was not true at the population level, i.e. when taking into account the prevalence of each quantity—frequency category by calculating PAF (Table 2). These are shown in Table 2 with and without adjusting for drinking at other dose levels. The effect of adjustment was to lower the level of the AF estimates, but the rank order of the different doses was not much affected. Relative risk estimates from comparisons of mean rates of harm produced similar AFs as the unadjusted figures in Table 2 (data not shown). In the following, we base our interpretations on the adjusted estimates.

For the 1–2 drink dose, the estimated PAFs were negative. The interpretation and reason for this is that if drinking 1–2 doses would stop, then, instead of being exposed to the risk attached to drinking 1–2 drinks, these respondents would be assumed to be exposed to the risk of the reference category, i.e. to a higher risk due to these other respondents drinking higher doses. That is, a 1–2 drink dose is 'protective' when compared to the risk level among those who drink larger amounts.

The dose that resulted in most problems depended on both the type of consequence and sex. Among men, the dose that accounted for the most negative consequences was 8–12 drinks. A 5–7 drink dose resulted in the most positive consequences.

Among women, a 5–7 drink dose accounted for a large part of the problems at the population level. For control worries as well as for positive consequences, a 3–4 drink dose seemed to have the most impact.

DISCUSSION

We set out to examine what kind of HED is associated with most harm at the individual level on the one hand, and at the population level on the other. At the individual level, the results were mostly as expected. The risk of harm generally increased with increasing dosage and frequency. Perhaps, the
clearest result on individual risks was that the respondents reporting frequent drinking of the highest doses, 13 or more drinks among men and 8 or more among women, formed a league of their own with respect to the risk of harm. Differences between other frequency and dose categories were dwarfed in comparison to the difference between these heaviest consumers and other respondents.

However, the effect of dose versus frequency depended on the gender and outcome studied. In some cases, like for control worries among women, the frequency of drinking appeared more important than quantity. An increase in the number of drinks consumed did not increase positive consequences beyond a dose of 5–7 drinks among men and 3–4 drinks among women.

At the population level, the most harmful dose among men was 8–12 drinks depending on the consequence, while among women it was 5–7 or 3–4 drinks. Hence, even if the risks at the individual level were much higher for a dose of 18 or more drinks than for a dose of 8–12 drinks among men, and higher for 13 or more drinks than for 5–7 drinks among women, the latter lower doses contributed a greater share of harm at the population level, due to their higher prevalence.

Most positive consequences were accounted for by a dose of 5–7 drinks among men and 3–4 drinks among women. It may be concluded that according to the respondents’ subjective experience of positive and negative consequences of drinking, there is no gain in drinking more than 5–7 drinks among men and 3–4 drinks among women, but rather, what changes beyond this level is that experiences of negative consequences become more common.

**Generalizability and comparison to other studies**

Our results cannot be generalized to other populations, because both the risk functions and, particularly, the exposure distributions are population-specific. Our results differ radically from those reported by Gruenewald *et al.* (2003) for American college students using a different method (see introduction section). According to their results, the greatest population risk of such harm as hangovers, missing a class, unplanned sex and driving under the influence, was related to drinking only 2 drinks among men and women combined. There are several possible reasons for the differences in results. First, it is very likely that the different methodology is one significant cause for the difference. One of the main differentiating factors is the floating reference point used here, but the effect of this difference is difficult to assess unless the different methods are applied to the same data. This was beyond the scope of this paper. We will return to the issue of methodology below.

Second, there may be differences in the connection between drinking patterns and risk of harm between US college students and Finns due to factors such as norms of conduct when drinking, and the contexts of drinking. This may be reflected in results, particularly when the risks are estimated for men and women combined (as Gruenewald *et al.* did) versus separately (as was done here). Third, the observation that the greater parts of harm are accounted for by higher dosage occasions in Finland than among US college students is a natural result of Finnish men drinking considerably larger doses of alcohol, on average. For example, the annual frequency of drinking 8 or more drinks was 16 among Finnish men and approximately 6–7 among male American college students. Our cross-validation using a completely different measure of drinking suggests, as does conventional wisdom, that even though the Finnish estimates are high, they are not likely to be strongly biased. Among women, the difference was smaller but in the other direction: the annual frequency of drinking 5 or more drinks was 7 among Finnish females and approximately 10 among American female students.

We could only examine the risk of a limited number of consequences whose prevalence can be examined using a survey. It is possible that results on more serious and rare consequences of drinking would have been different.

---

### Table 2. Attributable fractions at different dose levels, by type of harm or benefit and sex

<table>
<thead>
<tr>
<th>Type of harm or benefit</th>
<th>Individual drinking occasions</th>
<th>Control worries</th>
<th>External reactions</th>
<th>Positive consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Other levels not controlled</td>
<td>Other levels controlled</td>
<td>Other levels not controlled</td>
<td>Other levels controlled</td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–2</td>
<td>−35</td>
<td>−26</td>
<td>−30</td>
<td>−25</td>
</tr>
<tr>
<td>3–4</td>
<td>7</td>
<td>12</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>5–7</td>
<td>−3</td>
<td>1</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>8–12</td>
<td>33</td>
<td>36</td>
<td>41</td>
<td>36</td>
</tr>
<tr>
<td>13–17</td>
<td>41</td>
<td>36</td>
<td>29</td>
<td>23</td>
</tr>
<tr>
<td>18+</td>
<td>27</td>
<td>23</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>13+</td>
<td>50</td>
<td>50</td>
<td>33</td>
<td>30</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–2</td>
<td>−10</td>
<td>−26</td>
<td>−22</td>
<td>−30</td>
</tr>
<tr>
<td>3–4</td>
<td>41</td>
<td>23</td>
<td>42</td>
<td>31</td>
</tr>
<tr>
<td>5–7</td>
<td>59</td>
<td>43</td>
<td>47</td>
<td>33</td>
</tr>
<tr>
<td>8–12</td>
<td>41</td>
<td>26</td>
<td>29</td>
<td>18</td>
</tr>
<tr>
<td>13+</td>
<td>14</td>
<td>6</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>
Similarly, the risk of other, less serious consequences not included in this study might have been elevated at lower dose levels, a potential example being sexual risk-taking. Also, if we had been able to include all heavy drinkers and alcoholics, who often do not respond to surveys, and are partly excluded from the sampling frame, the results might have looked somewhat different.

Implications for policy
Our results can be related to Finnish prevention efforts. The most basic element of Finnish alcohol policy has been to prevent per capita consumption from growing. The success of this effort cannot be claimed to be very good, as the level of per capita consumption has increased from about 2 litres per inhabitant in 1960s to 8.4 litres in 2006. However, our results—showing that harm originated from all dosage levels above 1–2 drinks per drinking day—confirm that controlling the level of per capita consumption, rather than focusing on heavy drinking occasions only, is still a good aim. A further reason for this is that drinking patterns at the population level are very much slower to change than the average volume of consumption, and hence an increase in consumption all too often leads to an increase in heavy drinking occasions.

In Finland, ‘at risk’ HED is defined as consumption of more than 5 drinks (60g) for women and 7 drinks for men per occasion on a weekly basis. By international comparison, these limits may be considered high, but a recommendation to never drink, for example, more than 5 drinks a day for men and 4 drinks for women would not be taken very seriously and could be counterproductive. In the light of our results, it can also be most fruitful—in addition to trying to keep the volume of consumption from increasing further—to aim at reducing particularly these heaviest drinking occasions, i.e. 5 or more drinks per drinking day among women, and 8 or more drinks among men.

Notes on methodology
The current paper presented a new way of assessing the risks of harm at different frequencies of drinking different doses of alcohol, based on tools from a basic epidemiological toolkit. The simultaneous assessment of the effects of dosage and frequency proved informative. Compared to methods employed previously, the current method allowed the possibility to assess risk functions flexibly with regard to functional form. This provided the opportunity to study the connection between drinking patterns and consequences of longer-term drinking. Reactions from others as well as worries over drinking control—which can be considered as dependence symptoms—were examples of such consequences. Literature on the connection between this type of harm to the frequency of drinking different quantities of alcohol has so far been practically non-existent.

The possibility to adjust for drinking other doses was one motivation for using the new method, but it posed practical problems. Due to problems with multicollinearity, adjustment for drinking other doses could only be done using dichotomized variables, which might be insufficient. The adjustment for other doses as dichotomies lowered the estimated risks, but at a crude level, the population level risks were relatively similar with and without adjustment for drinking other doses.

Another difficulty that emerged with the new method was that no common reference point could be used, and the change in the composition of the reference group makes the interpretation of the results complicated. Ideally we would want a reference group that would show us how the risk would change if, e.g. the people who sometimes drink 1–2 drinks did not drink this amount at all but retained all their other drinking occasions. In principle, the risk in this optimal reference group with fewer drinking occasions should be smaller than the observed risk. This optimal reference group would only be available in a controlled experiment. Here, this comparison was done via a statistical model where we compared people who drink 1–2 drinks sometimes to those who do not (but who drink more). We ended up with an estimated ‘protective effect’, which indicates that the reference group deviates from an ideal one.

We would welcome other studies on this subject, e.g. simulation studies, before the methodology used in this paper is applied more widely. The methodological conclusion is still that no fully satisfactory method has yet been proposed for assessing the combined effects of dose and frequency on harms at the individual level, and for combining data on risk and prevalence to yield estimates of risk at the population level. We hope that this study provokes discussion and research that will further improve the ways in which the important questions laid out in the introduction can be studied. It could also be hoped that surveying the frequency of drinking high doses such as 13–17 and 18 or more drinks would become more common in other countries as well so that the results on their frequency and importance with respect to harm could be better compared.

APPENDIX 1. QUESTIONS POSED ON CONSEQUENCES OF DRINKING

Negative consequences of individual drinking occasions
‘Next I shall mention some situations which may arise when using alcohol. How often during the past 12 months have you found yourself in similar situations when drinking . . . quarrel or argument; scuffle or fight; accident or injury; loss of money or other valuable items; damage to objects or clothing; driving a car under the influence of alcohol; regretted something you have said or done?’. The response alternatives were (0) ‘never’, (1) ‘once or twice’ and (2) ‘3 or more times’. Maximum value for index: 14.

Control worries
Do you ever feel that you use alcohol more often than you actually would like to? Do you ever feel that you use greater quantities of alcohol than you actually would like to? How often do you find yourself drinking more than you have initially planned to? How often have you found that you have not been able to stop drinking once you have started? Response categories were (0) ‘never’, (1) ‘seldom’, (2) ‘now and then’ and (3) ‘often’. Maximum value for index: 12.
External reactions to drinking
Has it occurred during the last 12 months that . . . some of your friends have thought you should drink less or exercise a little more caution in drinking; you have been criticized for your drinking by someone near to you; you have been warned for your drinking by someone at work (for men only); your wife/husband/partner has left you or threatened to leave you because of your drinking? Response alternatives were (0) no and (1) yes. Maximum value for index: 4 (women) or 5 (men).

Positive consequences of drinking
Have you felt in the course of last 12 months that drinking has helped you to . . . sort out problems in your relations to those nearest to you; express your feelings better than ordinarily; get closer to someone of the opposite sex; sort out problems related to your job; be funnier and wittier; be less inhibited in the company of others; learn to know someone better; have fun? Response alternatives were (0) no and (1) yes. Maximum value for index: 8.

REFERENCES