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Injury Alcohol-Attributable Fractions: Methodological Issues and Developments

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Abstract

Background

Alcohol-attributable fractions (AAFs) are routinely used to estimate the burden of injury resulting from alcohol. Recent methodological advances allow AAFs to be estimated using national survey data. However, this requires assuming that the drinking patterns are equivalent to those used by epidemiological studies estimating the relative risk of injury. This study explores the implications of this assumption and presents an improved method of estimating injury AAFs.

Methods

Diary survey is used to describe individuals' drinking occasions and estimate AAFs. Statistical methods and numerical integration are used to combine the evidence on the risk of injury when intoxicated with the diary data. Alternative assumptions are chosen to explore the implications of using national survey data.

Results

Overall, an estimated 27% of road traffic accident (RTA) and 23% of non-RTA injuries in Britain are attributable to alcohol. AAF estimates for RTAs range from 54% to 2% and for non-RTAs from 36% to 8% in men aged 16-24 and women aged 55-64 respectively. Two potentially more realistic assumptions relating to the use of national survey data resulted in substantially lower AAF estimates for RTAs.

Conclusion

Current methods of estimating injury AAFs using national survey data are flawed for some harms, particularly RTAs, where the data is not consistent with the epidemiological literature. Our findings indicate that the burden of injuries from RTAs in England has been previously overestimated. Further research into the prevalence of risky behaviours when intoxicated is required to refine these methods and produce more robust burden of injury estimates.

Keywords: Alcohol consumption; road traffic accidents; motor vehicle accidents; injury; risk; attributable fraction

1. Introduction

Global Burden of Disease (GBD) estimates for 2010 show that almost 200,000 road traffic accident fatalities were the direct result of alcohol (Lim et al., 2012). This figure was derived using an estimated alcohol-attributable fraction (AAF) for road traffic accidents (RTAs). The AAF represents the proportion of a disease or harm that would disappear if the population was to stop consuming alcohol. For example, an AAF for death in an RTA of 20% implies that were the population to stop consuming alcohol, the total number of recorded deaths due to RTAs would be reduced by 20%. Due to the difficulty in observing the AAF directly, estimates are usually obtained indirectly by combining population level data on alcohol consumption with data on the relative risk of being fatally injured after consuming alcohol (Eide and Heuch, 2001).

Ridolfo and Stevenson (2001) produced some of the most widely used estimates of AAFs for RTAs by combining a relative risk of injury when driving with elevated blood alcohol content (BAC) with the prevalence of elevated BAC amongst randomly tested drivers in Australia. They used Australian data on drivers' BAC from 1996 and relative risk data estimated using accident data from 1983. Their findings have since been used to estimate the burden of fatalities and injuries resulting from RTAs in England (Jones et al., 2008), Scotland (NHS National Services Scotland, 2009) and Ireland (Martin et al., 2010) as well as globally (Rehm et al., 2009, 2004). However, since drinking patterns and driving practices may vary over time, and between countries, these findings may not be transferrable to other settings decades later. Furthermore, data such these are seldom available for large and representative samples and there was a need for alternative methods that take advantage of the available data.

For these reasons, research has been conducted to update the AAF estimates for injuries and to develop improved estimation methods. Taylor et al. (2011) developed novel methods in order to combine alcohol consumption data from national surveys with relative risk data obtained in a meta-analysis of primary studies, whilst taking account of between individual heterogeneity in the frequency of heavy drinking occasions. This approach has been used in more recent burden of

disease studies to estimate the extent of alcohol-attributable injuries (Shield et al., 2012a, 2012b) including the WHO GBD study 2010 (Lim et al., 2012). These estimated AAFs are typically substantially lower than previous estimates, for example, 10.4% for males aged 30 – 44 years in fatal RTAs (Shield et al., 2012a), compared with up to 50% for this subgroup in previous studies (NHS National Services Scotland, 2009; Rehm et al., 2004).

Whilst national survey data used in these studies is widely available it does have limitations when compared with the roadside testing data of previous studies (Ridolfo and Stevenson, 2001). The calculation of injury AAFs makes use of relative risk estimates derived in studies which compare the rates of fatal or non-fatal injuries amongst groups of people who did and did not drink alcohol (Lloyd, 1992; Taylor et al., 2010). However, participation in these studies is often conditional on engaging in some type of risky behaviour, for example, driving a car in the case of injury in an RTA. However, although national surveys often provide data on alcohol consumption, they do not usually provide data on drinking and driving. In order to apply the methods developed by Taylor et al. (2011) it is necessary to assume that the proportion of time that a person is intoxicated, given their reported consumption, is the same as the proportion of time intoxicated while driving. In other words, that the likelihood of drinking alcohol and the likelihood of driving are independent.

This may not be an appropriate assumption, but its potential impact on the resulting injury AAF estimates has never been examined. Additional limitations may also influence the resulting injury AAF estimates and therefore the burden of injury attributed to alcohol. These include the limited information on the number and scale of heavy drinking occasions available in most national surveys. The ideal drinking data would describe the amount consumed on every drinking occasion, in order to be consistent with the drinking occasion level data used to derive injury relative risks. Average weekly consumption or the frequency of drinking X+ number of drinks does not provide sufficient information to construct complete occasion based drinking patterns (Gmel et al., 2011).

The purpose of this study is threefold; firstly to extend the methods of Taylor et al. (2011) to better take account of the heterogeneity in drinking patterns between individuals using diary data.

Secondly, to derive updated AAF estimates for two categories of injury in England, RTAs and non-RTA injuries, using England specific drinking data. Thirdly, to conduct an exploratory analysis of the potential implications of the assumption that drinking and driving are independent. The analysis was conducted using two alternative assumptions to provide insights into the uncertainty in the burden of injury estimates resulting from this assumption.

2. Methods

2.1. Overview

The indirect method of estimating AAFs for a given disease or injury involves combining alcohol consumption data for the target population with the estimated relative risk of harm due to alcohol consumption within the target population using the formula in Eq. 1. In Eq. 1, p_i is the proportion of the population in consumption group i and RR_i is the relative risk of injury or disease for an individual at this level of alcohol consumption. The group labelled i = 0 represents abstainers. The alcohol consumption measure required depends on the outcome of interest. For some chronic harms, such as pancreatitis, the appropriate measure of alcohol consumption may be the average quantity of alcohol consumed per week (Irving et al., 2009). For acute harms, however, which result from intoxication, an appropriate measure of alcohol consumption would be data on the quantities of alcohol consumed on every occasion in some time interval, such as a year.

$$AAF = \frac{\sum_{i=1}^{k} p_i(RR_i - 1)}{\sum_{i=0}^{k} p_i(RR_i - 1) + 1}$$

(1)

2.2. Survey data

This study makes use of British data from the National Diet and Nutrition Survey (NDNS) 2000/2001 (Office for National Statistics Social and Vital Statistics Division, 2002). The NDNS is a nationally representative cross-sectional survey of adults aged between 19 and 64, living in private households in Great Britain and contains both a questionnaire and a diary component. The questionnaire, administered through face-to-face interview, records respondents' demographics, health and

lifestyle information and includes quantity-frequency (QF) questions to measure their usual alcohol consumption. The diary was prospective over 7 days and required respondents to weigh and record all items of food and drink consumed during the diary period. For alcoholic beverages, respondents recorded details of the beverage (such as 'beer, strong bitter, canned'), the time of day and the weight of the serving, obtained using scales provided to the respondent, from which the grams of alcohol was derived. In the NDNS 2000/01 there were a total of 1,724 individual survey respondents who completed both the 7-day diary as well as the survey questionnaire. For a summary of the NDNS 2000/01 data used in this analysis, see the supplementary material, which can be found by accessing the online version of this paper (see Appendix A).

2.3.   Drinking occasions

Using the NDNS 2000/2001 data it is possible to group individual drinks and obtain a dataset of the drinking occasions that took place over the 7-day period, for a representative sample of the British population, as we have shown elsewhere (Hill-McManus et al., 2013). The occasion-based drinking patterns can be described using three 'drinking measures' that contain enough information to approximately recreate an individual's annual drinking occasions. Shown in Table 1, these measures are the average number of weekly drinking occasions, n, the average quantity consumed during a drinking occasion, μ, and the standard deviation in the quantity consumed during a drinking occasion, σ.

Table 1

The variables used to describe individual occasion based drinking patterns

Variable	Description
n	The predicted number of weekly drinking occasions
μ	The average quantity of alcohol consumed during a drinking occasion, obtained using the QF mean weekly consumption and n, the predicted number of weekly drinking occasions
σ	The predicted standard deviation of the quantity consumed during a drinking occasion
x	The quantity of alcohol consumed during a drinking occasion
$\varphi(x;\mu,\sigma)$	The probability distribution of consuming quantity x during an occasion, given mean occasion consumption μ and standard deviation σ

As a single 7-day period may not be representative of an individual's typical weekly drinking occasions, in our earlier study we estimated the usual weekly drinking patterns for this survey sample using a series of regression models (Hill-McManus et al., 2013). The coefficients from these regressions have been used to predict the average number of weekly drinking occasions, *n*, and the standard deviation in the quantity consumed during a drinking occasion, *σ*. Rather than imputing the average quantity consumed during a drinking occasion, *μ*, this was estimated by dividing the mean weekly consumption, estimated using the survey QF questions, by *n*. The distribution *φ* describes the distribution of the amount drunk during an occasion for an individual (i.e., x) and is assumed to follow a normal distribution with individual-specific *μ and σ.*

2.4. Injury relative risk

The extensive literature of case-control and case-crossover studies investigating the relationship between single occasion drinking and the risk of suffering an acute harm, resulting in injury or death, has been synthesised in a meta-analysis (Taylor et al., 2010). The acute harms considered included, amongst others, road-traffic accidents (RTAs), falls, assaults and bicycle accidents. Taylor et al.

(2010) grouped the harms into two categories: RTAs and all non-RTA injuries. The estimated relative

risk (RR) functions are reproduced in Eq. (2a) and Eq. (2b), where LN(RR) is the natural logarithm of

the relative risk and x is the grams of alcohol consumed prior to the occurrence of the injury and C is

a constant equal to 0.0039997100830078. Using Eq. (2a) and Eq. (2b) it is possible to estimate the

relative risk of injury following a drinking occasion for any level of consumption.

$$\text{RTA: LN(RR)} = 3.29 \times 10^{-4} \times (x + C)^2 \tag{2a}$$

$$non-RTA\text{: LN(RR)} = 2.19 \times 10^{-1} \times (x + C)^{0.5} \tag{2b}$$

2.5. Annual relative risk

The general procedure for calculating the average annual relative risk of injury is described in Taylor

et al. (2011). This involves computing the relative risk of injury for every drinking occasion and taking

the average, weighted by an estimate of the duration a person is intoxicated as a result of the

alcohol that they consumed in a drinking occasion. Hence, higher consumption occasions will result

in longer periods of intoxication and receive a greater weight. All the time spent not intoxicated is

considered to be an occasion with a relative risk of one. Therefore, if T is the total number of hours

in a year (i.e., 8760), $t_{intox}(x)$ is the number of hours intoxicated after consuming x grams of alcohol,

n(x) is the number of occasions in a year in which x grams of alcohol were consumed and RR(x) is the

relative risk of injury while intoxicated after consumed x grams of alcohol, then the annual relative

risk for a single individual can be estimated using Eq. 3.

$$RR_{annual} = \frac{1(T - \sum_x t_{intox}(x)\,n(x)) + \sum_x RR(x) t_{intox}(x)\,n(x)}{T} \tag{3}$$

From our earlier analysis of the NDNS data from 2000/2001 (Hill-McManus et al., 2013), described

above, we have an estimated probability distribution for the quantity of alcohol consumed, given by

$\varphi(x;\mu,\sigma)$. Therefore, in Eq. (3), we can replace the number of occasions of x grams, n(x), with the

estimated number of annual occasions, N, multiplied by the probability of consuming at that level, $\varphi(x;\mu,\sigma)$, for an individual with a predicted μ and σ, as is shown in Eq. (4).

$$n(x) = N\,\varphi(x;\mu,\sigma)$$

(4)

To obtain an estimated duration of intoxication, for an occasion in which x grams of alcohol are consumed, we rearranged the Widmark formula used to estimate a person's blood alcohol content (BAC) (Posey and Mozayani, 2007; Watson et al., 1981). By setting the BAC to be zero, we can use Eq. (5) to estimate the time, in hours, it would take for an individual's BAC to drop to zero from the time they consumed a given quantity of alcohol, x. In Eq. (5), r is the Watson-r value, W is the individual's body weight (in kg) and β is the elimination rate of alcohol by the liver.

$$t_{intox}(x) = \frac{x}{rW\beta}$$

(5)

Hence, the final formula for estimating an individual's annual relative risk of injury is given by Eq. (6). The summations over all occasions have been replaced by integrals since we are now using a continuous probability distribution for the quantity consumed in an occasion. The integrals cannot be solved analytically and we therefore used numerical methods to estimate their values. The integrals were approximated at single integer values of x, using the cumulative density function, for values of x between 1 and 100 grams. The 100 gram upper bound is chosen since the risk functions become unstable for occasions exceeding 100 grams (Taylor et al., 2010). Therefore, the 100 gram occasion is assigned the sum of the probabilities for 100 grams upwards. This process and the numerical integration are described in detail in the supplementary material, see appendix A. The result of this analysis is annual relative risk (either for RTAs or non-RTAs) for an individual given their predicted weekly occasion based drinking patterns, from which we can use Eq. (1) in order to estimate injury AAFs.

$$RR_{annual} = \frac{\left[1\left(\mathrm{T} - \mathrm{N}\int_1^\infty \varphi(x;\mu,\sigma)t_{intox}(x)\,dx\right) + \mathrm{N}\int_1^\infty RR(x)\varphi(x;\mu,\sigma)t_{intox}(x)\,dx\right]}{T}$$

(6)

2.6.   Drink driving

By using this approach of calculating the annual relative risk by weighting according to the proportion of the time spent sober relative to intoxicated it has been implicitly assumed that the probability of drinking is independent of the probability of all other activities, such as sleeping, being away from the home or driving. Therefore, in the case of RTAs, it is assumed that if an individual is intoxicated for 1% of the year, then this person is intoxicated for 1% of the time that he or she spends driving. As far as we are aware this assumption is neither supported by data nor acknowledged in the research literature (e.g. Taylor et al. (2011)). We have conducted two sensitivity analyses to explore the possible uncertainty in the estimated AAFs for RTAs. The alternative assumptions are selected to be plausible but are otherwise arbitrary and serve only to explore the possible impact of the assumption on the final AAF estimates. Sensitivity analyses have been conducted for RTAs only, since these estimates are likely to be most sensitive to the assumptions imposed in this analysis.

Sensitivity analysis 1

This analysis considers that the more a person drinks the less likely they are to drive. The proportion of time spent driving whilst intoxicated is still assumed to be proportional to the proportion of time spent intoxicated overall, but with an added constant of proportionality that is reduced for high consumption occasions. It was assumed that the proportions were equal if less than 24 grams of alcohol were consumed (equivalent to 3 UK units), half the proportion if between 25 and 80 grams (80 grams is equivalent to 10 UK units) of alcohol were consumed and one tenth the proportion if more than 80 grams of alcohol was consumed. Therefore, if an individual is intoxicated for 1% of the year, then they are intoxicated for 1% of the time when driving after drinking less than 25 grams of alcohol, 0.5% after drinking between 25 and 80 grams and 0.1% after drinking over 80 grams.

Sensitivity analysis 2

This analysis used data on drink driving in an attempt to apply a more realistic assumption regarding the amount of time an individual drives intoxicated. The British Crime Survey asks respondents 'In

the last 12 months how often, if at all, have you driven when you think you may have been over the legal alcohol limit?'. NDNS survey respondents have been randomly apportioned between drink driving groups according to the responses to this question provided in the 2010/11 survey (UK Department for Transport, 2011), shown in Table 2.

Table 2
British Crime Survey reported drink driving 2010/11

Drink drive frequency	% of population	% Driving time intoxicated
Once or twice a week	1%	12.79%
Once or twice a month	1%	2.95%
Once every couple of months	1%	0.98%
Once or twice in the last 12 months	5%	0.25%
Not at all	92%	0%

The drink drive frequencies in Table 2 were converted into an estimated proportion of driving time spent intoxication using the average driving time of an hour per day, converted to 365 hours per year, and an annual number of trips of 610 (UK Department for Transport, 2010). It was further assumed survey respondents have reported thinking that they are over the limit only after consuming more than 3 UK units, equivalent to 24 grams of alcohol. All drinking occasions over 3 units were adjusted such that they matched to appropriate proportion for an individual, while for intoxication from 3 units or less it was assumed that driving occurred in an equal proportion to intoxication overall.

3. Results

The estimates of the injury AAFs based on the NDNS 2000/01 survey data, for each injury category, are presented in Table 3. The AAFs estimated from this sample for the whole population are 27% for RTAs and 23% for non-RTA injuries. Average annualised relative risk estimates were determined for gender and age subgroups, and are presented in Table 4, along with the corresponding estimate of the AAF. The averaged relative risks only include drinkers, and as such represent the average risk of injury over all drinkers in each subgroup, relative to the average risk of a non-drinker in the population. All the results have accounted for the individuals' survey weight.

Table 3
Estimated alcohol-attributable fractions for injury

Subgroup	Alcohol-attributable fraction	
	RTA	non-RTA
Total population	25%	21%
Male	36%	29%
Female	12%	14%

Table 4
Average drinker annualised relative risk and AAFs for injury by age and gender subgroup

Gender / Age Band	RTA injuries			non-RTA injuries		
	RR	SE	AAF	RR	SE	AAF
Male						
Age Bands						
16-24	2.16	(0.19)	54%	1.57	(0.07)	36%
25-34	1.70	(0.11)	41%	1.48	(0.05)	32%
35-44	1.69	(0.15)	41%	1.47	(0.06)	32%
45-54	1.42	(0.12)	30%	1.36	(0.05)	26%
55-64	1.32	(0.07)	24%	1.30	(0.04)	23%
Female						
Age Bands						
16-24	1.71	(0.21)	42%	1.39	(0.08)	28%
25-34	1.15	(0.03)	13%	1.19	(0.02)	16%
35-44	1.10	(0.03)	9%	1.14	(0.02)	13%
45-54	1.03	(0.01)	3%	1.10	(0.01)	9%
55-64	1.02	(0.00)	2%	1.08	(0.01)	8%

Regarding the age and gender specific AAFs, the overall trend is for the AAF for each category of acute harm to be highest amongst men and in the youngest age groups, decreasing as age increases. For RTA injuries, in the youngest male subgroup aged 16-24, roughly 54% of injuries are a result of alcohol consumption, while the corresponding figure for females is 42%. This rapidly falls as age increases, to 41% and 13% in the next age group for males and females respectively. In the oldest age group, ages 55-64, the AAFs are 24% for males and only 2% for females. A similar but less dramatic trend is observed for non-RTA injuries, starting at 36% and 28% in the youngest age group for males and females respectively with the male AAF dropping to 23% and the female to 8% in the oldest age group.

3.1. Sensitivity analyses

The first sensitivity analysis considers driving to be less likely following heavy drinking occasions, but that the proportion of drive time intoxicated is related to the proportion of the year intoxicated. The second sensitivity analysis attempts to use additional data on drinking and driving in England in order to estimate the proportion of time a person drives intoxicated. The results are shown in Figure 1 separately for age and gender subgroups.
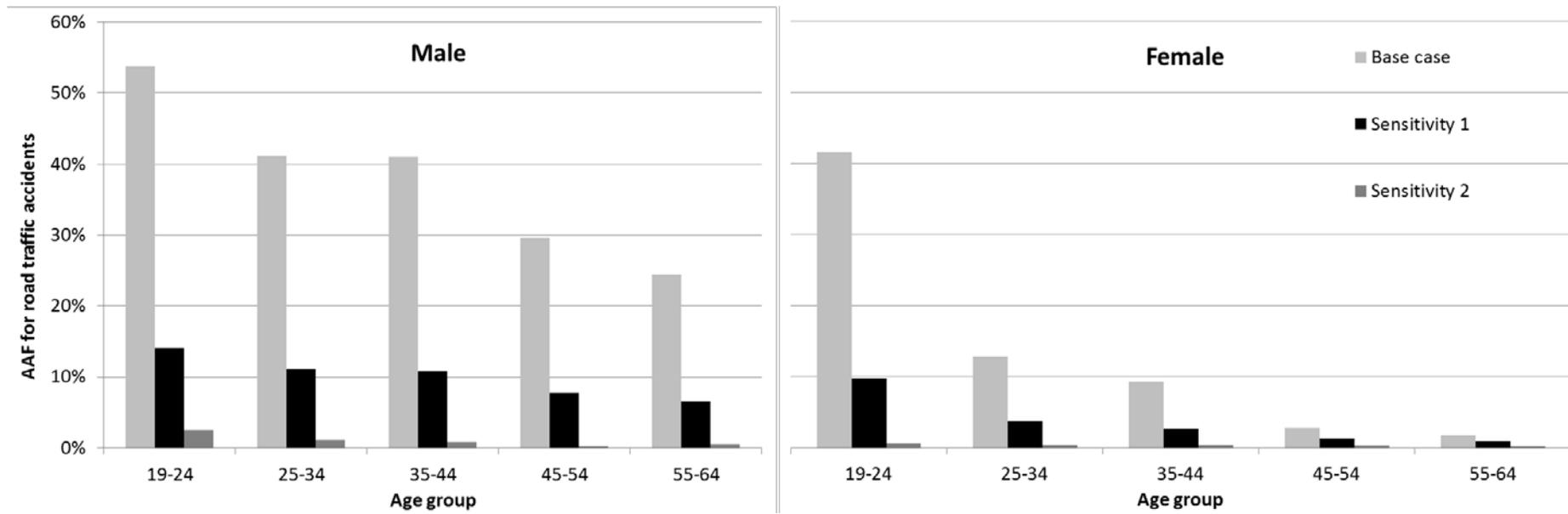
Figure 1: Results of two analyses using alternative assumptions for the probability of driving intoxicated

Overall, the alternative assumptions resulted in substantially lower AAF estimates for RTAs. In the

first sensitivity analysis, the AAFs are reduced by roughly a factor of 4 and there is a slightly lower

age gradient. Using the data on the frequency of drinking driving from the British Crime Survey,

much smaller AAF estimates were obtained, range from 0.2% to 2.5% over the age and gender

subgroups.

3.2.   Between study comparison

We provide a comparison of these results, including the base case and sensitivity analyses, with

those of two other studies for RTAs only, in Table 5. The other sources are Taylor et al. (2011) from

which we present both their base case estimates and a sensitivity analysis, and Ridolfo and

Stevenson (2001). Ridolfo and Stevenson (2001) are the estimates that were used in the most recent

burden of injury study for England (Jones et al., 2008). Compared with these, our base case findings

are considerable higher, and would result in higher estimated alcohol-attributable harm due to

RTAs.

Table 5

Between study comparison of AAF estimates for injury

Gender / Age Band		Study name and year					
	This study: base case	This study: SA1	This study: SA2	Taylor et al. (2011)	Taylor et al. (2011) SA3	Ridolfo & Stevenson (2001)
Year	2000/2001	2000/2001	2000/2001	2008	2008/01-02	1996
Country	England	England	England	Canada	Canada/US	Australia[†]
Male						
Age Bands						
16-24	52.5%	14.1%	2.5%	22.0%	57.0%	37.0%
25-34	39.7%	11.1%	1.2%	16.0%	37.0%	37.0%
35-44	42.0%	10.8%	0.9%	16.0%	37.0%	37.0%
45-54	24.9%	7.7%	0.3%	15.0%	22.0%	37.0%
55-64	26.9%	6.5%	0.5%	16.0%	19.0%	9.0%
65-74	-	-	-	16.0%	19.0%	9.0%
Female						
Age Bands						
16-24	41.8%	9.8%	2.5%	13.0%	18.0%	18.0%
25-34	14.8%	3.8%	1.2%	2.0%	4.0%	18.0%
35-44	10.4%	2.7%	0.9%	2.0%	4.0%	18.0%
45-54	3.5%	1.3%	0.3%	3.0%	3.0%	18.0%
55-64	2.0%	1.0%	0.5%	3.0%	3.0%	0.0%
65-74	-	-	-	3.0%	3.0%	0.0%

*Taylor et al. (2011) used different age groupings to these, see the supplementary material for the matching of different age group AAFs

†Derived using Australia specific data, but applied worldwide, including England (Jones et al., 2008) and Scotland (NHS National Services Scotland, 2009)

Compared with the base case findings from Taylor et al. (2011) our results are also considerably higher, by roughly a factor of 2 for most subgroups. However, the authors acknowledge limitations in the data regarding the scale of heavy drinking occasions and conduct sensitivity analyses which examine alternative assumptions. Their third sensitivity analysis is considered by the authors to be a "real-life" scenario and produced estimates that are comparable to our own, differing mainly for young female drinkers. Both sensitivity analyses that we have conducted produce AAF estimates lower than in any of these studies. The first analysis does not differ substantially from the base case estimates from Taylor et al. (2011) but the results of the second analysis are far smaller than any other estimates.

4. Discussion

This study has shown how occasion based drinking data from diary surveys can be combined with relative risk estimates in order to estimate AAFs for injuries. However, it has also identified a substantial source of uncertainty in such estimates. Overall, it was found that approximately 27% of RTA injuries and 23% of non-RTA injuries are attributable to alcohol. The average relative risks of injury and resulting AAFs vary considerable by age and gender subgroup. AAFs are greater for men than women and in the younger age groups for both RTA and non-RTA injuries, ranging from 54% to 2% for RTAs and from 36% to 8% for non-RTAs. It has been shown that AAF estimates for RTAs are highly sensitive to the assumption of the independence of drinking and driving and two alternative assumptions significantly reduced the AAF estimates.

Many previous burden of disease studies have relied on the work of Ridolfo and Stevenson (2001), using data from the 1980s and 1990s, which is now arguably out of date and not appropriate for estimating the current worldwide burden of injury. More recent studies have applied methods developed by Taylor et al. (2011) that enable national survey data to be used in the calculation of AAFs. This study has adapted and extended Taylor et al.'s (2011) methods to accommodate a more complete description of an individual's drinking patterns; in this case derived from diary data. By comparison, our analysis has produced similar results for non-RTA injuries but substantially larger AAF estimates for RTA injuries. This is primarily a result of having individual estimates not only of the frequency of heavy drinking occasions, as was available to Taylor et al. (2011), but also the different levels of consumption during such drinking occasions. Where Taylor et al. (2011) have used alternative survey data to simulate realistic drinking patterns (referred to as '"real-life" scenario') as a sensitivity analysis, they have obtained AAF estimates for RTAs that are very similar in scale to those obtained from this study, which provides some validation of our estimates.

There is, however, an additional limitation to these methods which is particularly problematic in the case of injuries from an RTA. This derives from the use of national survey data which makes it necessary to assume that drinking and driving are independent events. We conducted two sensitivity analyses in order to explore the consequences of alternative assumptions on the estimates of the AAFs for RTAs. The results

suggest that Taylor et al.'s (2011) methods may substantially overestimate the alcohol-attributable burden of injuries resulting from RTAs. To demonstrate the impact in terms of the burden of injury, we used person-specific hospital admissions data presented by Jones et al. (2008) for 2005. Our base case AAFs for RTAs imply 7,024 alcohol-attributable injuries, compared with 4,050 estimated in Jones et al. (2008). The sensitivity analysis estimates of Taylor et al. (2011), although they relate to Canada, would imply 6,315 alcohol-attributable injuries, close to our base case estimate. However, the findings from our own sensitivity analyses, applying what may be more realistic assumptions regarding drinking and driving, produce much lower estimates of alcohol-attributable injuries of 1,864 and 275.

Alcohol-attributable injuries make a significant contribution to the overall health burden from alcohol, and obtaining reliable estimates is therefore an important research objective. We suggest that there are two avenues of further research that could advance this field and improve burden of injury estimates, both requiring primary data collection. Firstly, roadside testing of large representative samples would produce the alcohol consumption data conditional on driving consistent with the data epidemiological studies used to estimate risks. We are not aware of the existence of such data and expect that obtaining representative samples would pose considerable challenges. Secondly, data on the prevalence of drinking and driving and its variation across demographics, as well as for different levels of consumption would facilitate more accurate AAF estimates using the methods presented in this paper.

There are several limitation to this study, either inherent in the data that was used or in the methods themselves. First and foremost, the NDNS data was collected in 2000/01 and as drinking patterns, other risk factors and the social context (e.g. car or road safety) evolve over time this may change the AAFs. Other data limitations include under-recording of alcohol consumption in survey data and the possible differential level of recording compared with clinical studies. It is well known that on average survey respondents under-record their alcohol consumption substantially, by as much as 50% (Meier et al., 2013). However, the clinical studies used to derive relative risk relations (Taylor et al., 2010) have used alternative methods of recording alcohol consumption of either, asking about drinking prior to injury which is likely to have better recall rates and result in less under-recording (Stockwell et al., 2008, 2004), or by roadside testing for which

under-recording is less problematic. This difference in coverage is likely to put a downward bias on our estimates.

This study has shown how occasion based drinking data, which captures both the frequency and range in quantities across occasions, can be used to estimate AAFs for injuries. However, it has also shown that these methods are flawed for some harms, particularly RTAs, when drinking data from national surveys are not consistent with those collected by epidemiological studies which estimate the relative risks of injury. Sensitivity analyses indicate that the burden of injuries from RTAs in England has been previously overestimated. Further research into the prevalence of risky behaviours when intoxicated is required to refine these methods and produce more robust burden of injury estimates.

Appendix A

Supplementary material associated with this article can be found, in the online appendix, at http://

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