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Use of record-linkage to handle non-response and improve alcohol consumption estimates in health survey data: A study protocol

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Abstract (300)

Introduction

Reliable estimates of health-related behaviours, such as levels of alcohol consumption in the population are required to formulate and evaluate policies. National surveys provide such data; validity depends on generalisability but this is threatened by declining response levels. Attempts to address bias arising from non-response are typically limited to survey weights based on socio-demographic characteristics, which do not capture differential health and related behaviours within categories. This project aims to explore and address non-response bias in health surveys with a focus on alcohol consumption.

Methods and analysis

The Scottish Health Surveys (SHeS) aim to provide estimates representative of the Scottish population living in private households. Survey data of consenting participants (92% of the achieved sample) have been record-linked to routine hospital admission [Scottish Morbidity Records (SMR)] and mortality [from National Records of Scotland (NRS)] data for surveys conducted in 1995, 1998, 2003, 2008, 2009 and 2010 (total adult sample size around 40,000), with maximum follow-up of 16 years. Also available are census information and SMR/NRS data for the general population. Comparisons of alcohol-related mortality and hospital admission rates in the linked SHeS-SMR/NRS with those in the general population will be made. Survey data will be augmented by quantification of differences to refine alcohol consumption estimates through the application of multiple imputation or inverse probability weighting. The resulting corrected estimates of population alcohol consumption will enable superior policy evaluation. An advanced weighting procedure will be developed for wider use.

Ethics and dissemination

Ethics approval for SHeS has been given by NHS MREC and use of linked data has been approved by the Privacy Advisory Committee to the Board of NHS National Services Scotland and Registrar General. Funding has been granted by the MRC. The outputs will include four or five public health and statistical methodological international journal and conference papers.

Primary Subject Heading: Public health

Secondary Subject Heading: Addiction: Health policy; Mental health.

Keywords

Mental health; Health informatics < BIOTECHNOLOGY & BIOINFORMATICS; Hepatology < INTERNAL MEDICINE; Substance misuse < PSYCHIATRY; PUBLIC HEALTH; STATISTICS & RESEARCH METHODS

Word count: 3816 (max 4000)

Introduction

The large scale of social harms linked to alcohol is increasingly recognised, with alcohol abuse the most widely perceived social issue in Scotland.[1] Alcohol-related hospital admissions have quadrupled and death rates nearly tripled since the beginning of the 1980s[1] – relative increases which are the steepest in western Europe,[2] with detrimental repercussions for the wellbeing of the wider population. In response to the escalating problem, the Scottish Government (SG) has launched a strategic approach to reducing alcohol-related harm and helping to address associated health inequalities. The approach encompasses a comprehensive range of interventions, service development, and regulatory change – including the possibility of minimum unit pricing of alcohol – aimed largely at the whole population, alongside targeted interventions.[3] Given that alcohol harm is clearly linked to alcohol consumption at the individual[4-5] and population level,[6] the Strategy aims to reduce population mean consumption, proportions exceeding weekly and daily sensible drinking guidelines, and the prevalence of dependent drinkers and ultimately reduce alcohol-related harm. The SG has tasked National Health Service (NHS) Health Scotland (HS) to lead a portfolio of studies - "Monitoring and Evaluating Scotland's Alcohol Strategy" (MESAS)[1]. As well as ultimate reductions alcohol-related harms, a key outcome for the MESAS evaluation is whether alcohol consumption is reduced[3]. However, reliable ascertainment of alcohol consumption – which is useful in intervention planning as well as in evaluation – is problematic.

Alcohol retail sales data provide the most valid and reliable means of estimating total population alcohol consumption[7], but are limited to overall per capita consumption and do not give any information on the amount consumed by individual sub-groups (demographic, socioeconomic or geographic) or on patterns of drinking (e.g. binge drinking); they also exclude alcohol purchased abroad and home brewed, and cannot distinguish transactions made by visitors and residents. In contrast to sales data, health surveys, such as the Scottish

Health Survey (SHeS)[8-14], provide estimates of population mean alcohol intake, drinking patterns, and differential intake across sub-groups.

However, a degree of error is unavoidable with such survey-based measures for two main reasons:[15] distorted self-reporting of intake (which tends to be under-reported for a variety of reasons including systematic underestimation and social desirability bias) and under-representation of groups associated with heavy drinking – men, younger individuals and those from deprived backgrounds, who have higher alcohol consumption than average, tend to be under-represented in surveys[15]. The SHeS suggests no association of alcohol intake with area deprivation[16] – for example, in 2008, 27% of men living in the most deprived quintile according to Scottish Index of Multiple Deprivation (SIMD) self-reported consumption which exceeded binge drinking thresholds compared with 25% of those in the least deprived quintile.[1] However, the rate of alcohol-related mortality[17] and hospital admissions[18] are much higher in those living in the most deprived areas than in the least deprived areas: in 2009 alcohol-related mortality rates in the most deprived SIMD quintile (48 per 100,000 population) was 6 times that in the least deprived quintile (7 per 100,000 population); hospital admissions in 2009/10 were 7.5 times as high[1]. We would thus expect alcohol consumption estimates to be higher with greater deprivation and question the lack of such an association apparent from survey data.

The discrepancy may be explained by one or more of the following: genuinely greater levels of alcohol-related harm among the more deprived for equivalent levels of consumption;[5] differential underestimation of self-reported consumption; a greater spread of drinking patterns within the most deprived areas *i.e.* a greater proportion of heavy drinkers *and* non-drinkers[19] – as indicated by SHeS data[1] – which averages the higher and lower consumption out in those communities when considering per capita consumption, potentially masking variation within deprivation strata; or differential sampling bias (either due to lower unit response levels in the most deprived areas or a similar response level across quintiles

missing more extreme drinkers in the most deprived quintile relative to those in the least deprived quintile). It is also possible the association between alcohol consumption and harm differs between survey responders and non-responders, reflecting, for instance, differential patterns of consumption such as greater concentration of harmful binge drinking among non-responders for equivalent levels of overall consumption, or adverse combinations of different risk factors.[20]

Comparison with UK sales data previously suggested that survey underestimation of alcohol intake may be as great as 50%,[15] and elevated sales estimates in recent years do not support SHeS-based time trends of reductions in alcohol consumption[21] (Table 1). The apparent discrepancy could be explained, at least in part, by progressively increasing survey underestimation of alcohol intake as response levels have fallen – as low as 61% in 2008 at the household level compared with 81% in 1995 (Table 1) – if the surveys have become increasingly less representative, especially for those living in deprived areas.[22] The inconsistency of drinking estimates from Scotland's surveys is thus of increasing concern as apparent population trends in consumption are potentially misleading. Addressing the issue is of wider importance for policy design and evaluation which rely on accurate and consistent monitoring of trends in population health.

Correction for under-representation of specific population subgroups can be made by procedures such as inverse probability weighting (IPW)[23] assuming data are 'missing at random' (MAR – see Statistical methodology section/Appendix). However, the increasingly low response levels remain problematic if respondents and non-respondents with the same socio-demographic characteristics behave differently, for example in terms of health-related behaviours. The SHeS reports use IPW based on limited socio-demographic characteristics but, since non-participation is likely to be related to heavy drinking,[15] this invalidates IPW based solely on socio-demographic characteristics and the MAR assumption: simply increasing the weight given to the young, deprived male respondents does not address the

problem since those sampled are unlikely to be representative of the population of this subgroup of heavy drinkers.

Previous work on impacts of unit non-response based on studies with varying response rates has generally found those of lower socioeconomic status in terms of employment,[24] income,[25] education[26] and area deprivation[27] are under-represented. Younger age groups,[28] men, single individuals and those with poorer health status[29] also tend to be under-represented, though this can vary.[28 30] Although estimates of association such as those between socioeconomic position and health outcomes are not generally distorted[29 31] (there are exceptions[26]), prevalence of behaviours related to poor health tend to be under-estimated. In an Australian study, participants experienced 10% greater survival relative to the general population[32] and a Finnish record-linkage study found that the risk of death was underestimated.[31] Where previous work on impacts of survey non-response has focussed on alcohol, in both a Canadian survey (47% response)[25] and a New Zealand survey (50% response)[27] among others[33-34] alcohol consumption was found to be under-estimated. A Danish survey-based cohort study found that the relatively healthy and affluent participants tended to be have lower risks of alcohol overuse and tobacco-related disease outcomes relative to non-participants.[29] The "triangulation" of survey and sales data on alcohol to harmonise the survey-based consumption distribution with sales-derived per capita consumption has been demonstrated.[35]

Pilot work conducted by the group based on the 1995 SHeS with follow up[36] to 2001 aimed to investigate whether respondents were representative of the Scottish population in terms of all-cause mortality and coronary heart disease (CHD) incidence or mortality.[37] Standardised rates of incidence and mortality were calculated by sex for respondents aged 40–64 at the time of the survey and a comparison dataset was created based on population estimates and event registers for the entire Scottish population. Male participants in SHeS had lower than expected mortality from CHD and women higher incidence of CHD. Differences were seen for all levels of deprivation but were more pronounced in the most deprived areas and were geographically patterned. This work demonstrated that even with a relatively high response level, participants differ from the population they are intended to represent and reflect a

potentially serious bias in health surveys.[37] Separately, in an attempt to resolve the effect of alcohol abstainers in deprived areas, some re-analysis of SHeS data involved removing those who had not drunk in the previous week.[1] While this yielded some of the expected deprivation gradient in alcohol consumption, it was not enough to explain the inequalities in alcohol-related harm, indicating the need for further exploration of the discrepancy between consumption estimates and harms among the most disadvantaged groups (fuller investigation of this is currently being pursued in a related project and potentially can be considered in an extension of this project).

The aim of this project is to inform the monitoring and evaluation of the Scottish Government's Alcohol Strategy by exploiting existing record linked and population data resources and using advanced statistical methodology to quantify and address unit non-response induced imprecision of national health survey-based estimates of alcohol consumption (weekly intake; binge drinking; problem drinking) in the population of Scotland by age, sex, area deprivation and geographical region. Whilst some attempt shall be made to account for distortion of survey-based estimates due to self-report bias, the main focus of this project is on departure from representativeness, particularly that arising from unit non-response.

Methods and analysis

SHeS are cross-sectional cluster-sampled surveys designed to provide data at both national and regional level about the health of the population living in private households in Scotland (Table 1)[8-14]. Scotland is one of very few countries to have created longitudinal information by way of record-linkage of survey data. Individual SHeS data are confidentially linked to prospective and retrospective routine hospital admission data [Scottish Morbidity Records (SMR)] and mortality [from the National Records of Scotland (NRS; formerly the General Register Office of Scotland)].[36 38-39] Despite declining overall survey response levels, the percentage consenting to linkage is high and has remained above 85%.[36] The database is maintained by Information Services Division (ISD) of NHS Scotland, and audits have shown

that SMR data are around 90% accurate in identifying the correct diagnosis,[40] and SMR completeness is around 99%.[41]

Also available are administrative mortality and hospital admission data for the general population, as well as population estimates derived from routine data.

Robust protocols for identifying individuals with medical conditions attributable to alcohol have been defined and published by NRS/Office of National Statistics and ISD and are used to publish official statistics on alcohol mortality[42-43] and morbidity[18] respectively. Through partnership with the market research agencies Nielsen Company and CGA Strategy,[22] we have privileged access to alcohol sales data at the national level for Scotland.

Linked Scottish Health Survey-Scottish Morbidity Record/deaths

We plan to use the 1995, 1998, 2003, 2008, 2009 and 2010 SHeS records linked to SMR and NRS records, providing a maximum follow-up of around 16 years with adult sample sizes consenting to linkage of 7363, 8305 and 7425 for 1995, 1998 and 2003 respectively, and around 5560, 6400 and 6230 for 2008, 2009 and 2010 respectively. From the SHeS-SMR/NRS we have age, sex, area deprivation, health board region and estimates of weekly intake (including an indicator of heavy drinking), binge drinking and problem drinking (all from the survey-component; the latter two measures are available from 1998 onward) and individually linked alcohol-related hospitalisation and mortality. We are missing all information on the SHeS non-responders but we can infer their characteristics in terms of age, sex and deprivation based on population estimates (see step 3 below).

General population data

From NRS we have mid-year population estimates based on the decennial census (96% enumeration level), mortality, birth, immigration and emigration data. We have population denominators in all survey years for the whole of Scotland and corresponding alcohol-related hospitalizations (SMR) and deaths (NRS) in the general population data – all by age, sex,

area deprivation and region – from those years through to 2010 as numerators for comparison with the survey data (see step 1 below).

Statistical methodology

We propose to compare survey data and population data to examine how representative the respondents to the SHeSs are in terms of alcohol-related hospitalizations and deaths to inform the improvement of survey-based estimates of alcohol consumption (Figure 1). This involves comparing linked records for the survey samples with combined census records, mortality and hospital admission data for the entire population by socio-demographic sub-groups. These comparisons inform on departures from representativeness mainly arising from bias induced by non-response. In the core set of analyses, we shall produce corrected alcohol consumption estimates, assessing the differential effects of varying response levels. We shall additionally develop an advanced correction procedure that can be tailored for different population subgroups and survey response levels for application to other surveys with record-linkage capacity. Finally, we shall inter-relate corrected survey-based consumption estimates and national alcohol sales data to ascertain self-report bias and obtain further refined estimates.

In missing data scenarios there are a number of possible missingness mechanisms. Data can be missing completely at random (MCAR), missing at random (MAR) or missing not at random (MNAR). If missingness depends on the observed data but not on the unseen data, the missing observations are MAR. In this case, the individuals with complete data (the 'complete cases') are no longer representative and analysing complete cases gives biased estimates. However, under MAR we can take the predictors of missingness into account in analyses using techniques such as multiple imputation (MI)[44]. Imputation is the substitution of some value for a missing data item. Among the imputation techniques available, MI is considered to be superior as it makes reliable estimation of variances and confidence intervals relatively easy. Once all missing values have been multiply imputed, the datasets

can then be analysed using standard techniques for complete data and combined using standard rules.

Alternatively, if the missingness depends on unobserved data (even after taking account all the information in observed data), the observations are MNAR. In this case, we have to incorporate sensitivity analyses – such as a pattern mixture approach – into MI. A pattern mixture model allows different imputation models for each pattern of missing values under specified MNAR mechanisms with the potential for very general application.[45] We aim to achieve this in Step 6 (below) by changing the imputations to allow them to represent likely differences in the associations between alcohol consumption and alcohol-related hospitalizations and deaths in those with observed compared with those with missing alcohol consumption data, by modifying the model intercept term before imputing.

The novel methodological approach we shall use is based on several assumptions: non-response in the (unlinked) SHeS dataset is MNAR; up to Step 5 (below) we are assuming that given alcohol-related hospitalizations and deaths for responders and non-responders, non-response in the SHeS-SMR dataset is MAR; step 6 goes one stage further, assuming alcohol-related harm is greater for non-responders than responders for a given level of consumption and attempts to account for this differential relationship.

We propose to:

1. Compare rates of alcohol-related hospitalizations and deaths in the SHeS-SMR/NRS responders with corresponding rates in the general population for each socio-demographic category combination (age, sex, area deprivation and health board region).
2. From 1, estimate the probability of alcohol-related hospitalizations and deaths in the non-responders to the SHeS by each socio-demographic combination (Figure 2).
3. From the denominator data of the general population, identify the number of missing respondents within each socio-demographic combination group in the survey.

4. From 1 and 2, simulate the observations for non-responders with the corresponding alcohol-related hospitalization and death probabilities in each socio-demographic combination group. To our knowledge, this has not been previously been done.

5. Multiply impute unknown alcohol consumption in the simulated 'non-responders' based on socio-demographic characteristics and alcohol-related hospitalizations and deaths under the assumption that the consumption data are MAR.

6. Change the alcohol consumption imputations to reflect the likely difference between responders and non-responders in alcohol consumption for a given probability of alcohol-related hospitalizations and deaths using a pattern mixture model approach which assumes that the consumption data are 'missing not at random' (MNAR) given the observed data. The effects of a range of differences will be explored, assuming, for instance, that the risk of mortality is 10% or 20% higher in the non-responders than the responders for equivalent levels of alcohol consumption.

We shall look separately at each round of the survey to see how the decline in non-response affects the estimates of alcohol consumption. An advanced correction procedure, likely to involve weighting, will be developed that can act differently for different subgroups (especially by deprivation) and survey response levels for application to other surveys with record-linkage capacity.

Further work

Consideration will be given to alternative approaches. These will include use of the SHeS-SMR/NRS to build an imputation model for alcohol consumption, which would then be extrapolated to impute consumption for the entire population; this would be done with caution since we would be imputing a high fraction of the data. We shall perform validity checks on any systematic difference between survey participants as a whole and those not consenting to linkage. For instance, we can make overall comparisons of reported alcohol consumption and drinking patterns as well as sociodemographic factors. Additionally, we can potentially use sensitivity analyses to address any differential consumption-outcome associations among

deprivation categories, *i.e.* allowing for the possibility of genuinely greater levels of alcohol-related harm among the more deprived for equivalent levels of consumption.[5] Sensitivity parameters would be identified from literature reviews as well as detailed discussion with co-applicants with experience in the alcohol field and other experts who could give critical feedback on proposed sensitivity parameters. Integration of corrected survey estimates of alcohol consumption with sales data will allow further refining of estimates.[35] There is a risk that the socio-demographic variables alone will not provide sufficient data for the response model for alcohol consumption. If modelling problems occurred indicating this as a limitation, we would seek the addition of marital status, which is associated with alcohol-related harm[20] and is available from hospital admissions, death certificates and population census records. Should our proposed approach of simulating age, sex and area data for non-responders fail, a method for IPW with MNAR would be considered.[46] Analyses may be complicated by the apparent dichotomy in the drinking behaviour of the most deprived groups who are the most likely not to drink at all, or to drink little within the moderate drinking category but also the most likely to drink at harmful levels.[19] We shall address this by considering a separate variable representing very heavy alcohol consumption, for which missing data would be directly imputed in addition to the other alcohol estimates. We shall also consider the incorporation of estimates of alcohol consumption among those admitted to hospital based on previously developed methodology.[47]

Implications

An optimal means of ensuring survey representativeness is attainment of high levels of response (based on an accurate and up-to-date sampling frame). While this has been achievable in the past, great efforts are required in survey conduct to maintain response levels of around two-thirds in the SHeS at the present time. Our proposed approach forms an important additional strategy to addressing non-response which is applied at the analysis stage.[48] The key innovations of this approach are the simulation of observations for non-responders, and the explicit incorporation of differential associations for non-responders and responders for any given age / sex / deprivation / region combination by factoring in an alternative hospital admission/mortality rate for the non-responders by implementation of a

pattern mixture-based approach. The latter attempts to find plausible sensitivity analyses of departures from data being MAR and fits with the paradigm of 'principled sensitivity analysis',[49] much discussed in the statistical literature but little implemented in practice.

Evaluation of public health policy such as strategies to tackle alcohol problems in Scotland (and beyond) will benefit from enhanced knowledge with the improved estimates of alcohol consumption and prevalence of harmful drinking and dependency we aim to offer. The detection of changes in behaviour and harms in specific groups such as deprived groups and hazardous drinkers necessary to evaluate effectiveness of, for instance, minimum unit pricing of alcohol relative to general duty rises will be supported. The accuracy of the assertion that there is a small proportion of the population who drink very heavily and who are responsible for the vast majority of harms may also be elucidated.

There is potential general application of this work beyond alcohol to other survey-derived information – tobacco, diet and physical activity, for instance. Data from population surveys are used extensively and methodological improvements are of interest to a wide international audience. The advanced correction procedure we aim to create will potentially be applicable to existing and future surveys for improved addressing of non-response bias wherever there is the capacity to record-link surveys with administrative health data. Presently, linkage of survey data to routine health records represents a cost-effective means of generating valuable longitudinal data but is performed in very few countries. In exploiting such linkage to improve conventional survey-based estimates, our work will demonstrate the extended utility of record linkage, providing further impetus for its wider uptake internationally. Simulation of demographic variables for survey non-responders is not necessary in countries with unique population identifiers and comprehensive linkage (such as the Nordic countries) with the ability to follow-up all individuals regardless of response status. The multiple imputation of survey data for non-responders and the pattern mixture aspects of our proposed methodology would nevertheless be applicable in these settings. The prospect of increasing the validity of survey data is increasingly valuable in the context of decreasing survey response, as well as increasing fiscal austerity.

Ethics and dissemination

Ethics and dissemination

Ethics approval of the SHeS have been given by the NHS Multi-Centre Research Ethics Committee (MREC03/0/19 for 2003; 07/MRE09/55 for 2008; 08/MRE09/62 for 2009-2011; reference numbers prior to 2003 are unavailable) and the supply and use of linked data has been approved by the Privacy Advisory Committee to the Board of NHS National Services Scotland and Registrar General (PAC 47/12; IR2012-01837). Funding for this work has been granted by the Medical Research Council Methodology Research Panel under the Population and Patient Data Sharing Initiative for Research into Mental Health (MR/J013498/1).

The outputs of the research will include a series of papers which are likely to include:

Public health papers:

1. A baseline assessment of the differential alcohol-related admissions/mortality in the survey samples relative to the general population;
2. Reporting of refined alcohol estimates;
3. Combination with sales data to ascertain self-report bias among responders, and further refine estimates.

Statistical methodological papers:

1. The novel application of pattern mixture modelling for refining survey estimates using record-linked data.
2. Establishing a correction methodology based on the non-response level which can be applied to future surveys.

Data sharing statement

The SHeS[8-14] and combined SHeS-SMR[36 38-39] have been created through substantial investment and are used extensively as the bases of secondary analysis by the research community; release of these anonymised resources is determined by ISD. The value added by this work is the corrective procedure methodology which will be published and hence

available to researchers to replicate the enhanced data created by this project, as well as produce similarly enhanced data from others record-linked surveys. Given this, neither is it possible for us to share, nor is there is no benefit to the research community of having access to the specific file created.

ARTICLE SUMMARY

Article focus

▪ To explore and address non-response bias in the health surveys, with a specific focus on alcohol consumption.

Key messages

▪ National health surveys provide estimates of behaviours in the population – such as levels of alcohol consumption – which inform health policies, but validity depends on their representativeness of the general population. Declining response levels mean that surveys may be becoming less representative.

▪ This project aims to compare data from Scottish Health Surveys record-linked to administrative health data sources with corresponding general population data to resolve non-representativeness by using differentials to derive probabilities of alcohol-related hospitalizations and deaths in non-responders; the numbers missing from surveys will be identified by demographic sub-group to simulate observations for non-responders with corresponding alcohol-related harm probabilities and then multiply impute alcohol consumption.

▪ More accurate alcohol consumption estimation will lead to improved evaluation of interventions and enhanced information for policy. We shall ultimately devise a general application correction factor which will offer a valuable boost to survey-based research.

Strengths and limitations of this study

▪ The strengths of this work are the reliable utilisation of existing linked survey records and the extension of comparisons of responders and non-responders from basic socio-demographic variables to health outcomes.

▪ The limitations include the possibility of distortion from non-consent to record linkage of survey responders which could explain some of the disparities between alcohol-related harm outcomes in the survey samples relative to the general population; however, this only affects 7%-15% of respondents and is unlikely to greatly distort findings. With incomplete (around 96%) enumeration level, there is also uncertainty about the representativeness of the Census; although there is a concern that resultant under-estimation of the population denominator estimates (but not of the alcohol-related hospitalisation and mortality) may lead to artificially elevated alcohol-related harm estimates (particularly for the most disadvantaged groups), this will be minimised by the limited extent of the population non-enumeration (around 4%).

The scale of mismatch between survey and population estimates may vary over time because of differences in self-reporting (*e.g.* greater home drinking or more binge drinking) making it increasingly difficult for respondents to estimate their consumption as well as differential non-response levels. Thus although we may derive a correction method for a particular year, it is potentially invalid to apply it in future years. However, the differential non-response factor is likely to be predominant. Socioeconomic characteristics may change between the time of survey and the hospitalisation or death event according to the social selection thesis,[50] but this is likely to account for only a very small number of individuals.

Competing interests statement

GM is a member of the Scottish Government-funded MESAS evaluation. The remaining authors declare that they have no competing interests.

Authors' contributions

LG was involved in the conception of the study design, literature search, and prepared the first draft of the manuscript; GM and IRW contributed to all sections of the paper; SVK contributed to all sections and the literature search; EG and LR contributed to the introduction and further work sections; AHL was involved in the conception of the study design, literature search and contributed to all sections. All authors read and approved the final manuscript.

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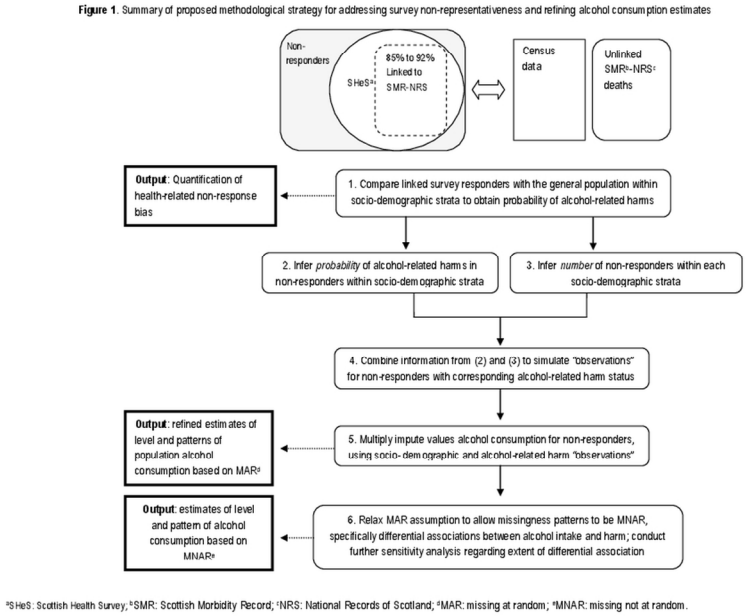
Table 1: Response levels and alcohol consumption estimates in men in the Scottish Health Surveys, retail-based consumption estimates and population male alcohol-related mortality in Scotland 1995 to 2011

Survey data						National retail data	National mortality data
Survey Year	Household response level	Adult response level	Achieved adult sample	Consent to linkage	Mean alcohol units per week in men	Total volume of pure alcohol sold (1000L)[c]	Number of male alcohol-related deaths[e]
1995	81%	84%	7,932	93%	20.1[a]	41,712	531
1998	77%	76%	9,047	92%	19.8[a]	43,770[d]	755
2003	67%	54%	8,148	91%	19.8[b]	47,175	1,056
2008	61%	54%	6,465	86%	18.0[b]	50,346	971
2009	64%	56%	7,531	85%	17.5[b]	50,842	837
2010	63%	55%	7,245	86%	16.0[b]	50,524	909
2011	66%	56%	7,544	86%	15.0[b]	48,746	815

[a] the 1995 and 1998 surveys were prior to the significant change in the way in which alcohol consumption estimates were derived and are for men aged 16 to 64 only thus are not comparable with those for 2003 onward;
[b] the estimates for surveys from 2003 onward are for men aged 16 and over;
[c] Source: Nielsen/CGA Strategy sales in Scotland dataset (off-trade sales in 2011 adjusted to account for the loss of discount retailers);[21]
[d] Data not available for 1998 - estimate interpolated from available figures for 1995 and 2000;
[e] Source: General Register Office for Scotland figures for 2011.[51]



Summary of proposed methodological strategy for addressing survey non-representativeness and refining alcohol consumption estimates
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Figure 2: Estimating the probability of alcohol-related hospitalisation/mortality in Scottish Health Survey non-respondents from alcohol-related hospitalisation/mortality data on respondents and on the general population of Scotland

$$P(\text{a-r h}^{a} \text{ in the non-respondents})^{b} = \frac{[P(\text{a-r h}^{a} \text{ in the general population})^{b} - \text{survey response proportion} * P(\text{a-r h}^{a} \text{ in the respondents})^{b}]}{(1 - \text{survey response proportion})}$$

[a] a-r h: alcohol-related harm - hospitalisation or mortality from alcohol-related causes
[b] P(*x*): Probability of *x*

127x90mm (300 x 300 DPI)