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ORIGINAL ARTICLE

Association between variables used in the field substitution and post-stratification adjustment in the Belgian health interview survey and non-response

Johan Van der Heyden · Stefaan Demarest · Koen Van Herck · Dirk De Bacquer · Jean Tafforeau · Herman Van Oyen

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Abstract
Objectives Field substitution and post-stratification adjustment have been proposed to reduce non-response bias in population surveys. We investigated if variables involved in those techniques in the Belgian health interview survey 2004 are associated with non-response and assessed the impact of field substitution and post-stratification adjustment on the survey results.
Methods Data were obtained from all selected households ($n = 12.204$). The association between non-response and the selected variables was explored through multilevel logistic regression models with municipality and statistical sector as random effects.
Results All investigated variables were significantly related with non-response. Especially households that could not be contacted differed substantially from those who participated. Only post-stratification had a clear impact on the survey results.
Conclusions Even if variables used in the field substitution procedure of health surveys are strongly associated with non-response, the impact of field substitution on the survey results may be minimal, either because there was no bias of relevance or it was not captured. The usefulness of field substitution to correct for non-response bias in population health surveys seems to be quite limited.

J. Van der Heyden (✉) · S. Demarest · J. Tafforeau · H. Van Oyen
Scientific Institute of Public Health, Brussels, Belgium
e-mail: johan.vanderheyden@wiv-isp.be

K. Van Herck · D. De Bacquer
Department of Public Health, Ghent University, Ghent, Belgium

Keywords Health interview survey · Survey methodology · Non-response bias · Field substitution · Post-stratification

Introduction

A national health interview survey (HIS) is a basic component of a health information system. Many indicators used for international comparisons, such as those developed in the framework of the European Community Health Indicators Monitoring (ECHIM) (Kilpeläinen et al. 2008) are based on HIS results.

Although a HIS has several advantages, it has also important limitations. As the information is self-reported, the validity of the data is often questioned. The internal validity may be reduced due to recall bias, lack of knowledge of respondents of specific terminology, social desirability of certain answers, etc. Another problem relates to the fact that a survey does not provide information on the total population, but on a sample of respondents who are willing to participate. Extrapolation of the results to the whole target population may yield biased results if, due to a selective non-response, some population groups are over- or underrepresented in the sample, and if these groups behave differently with respect to the variables of interest.

Several studies have explored determinants of non-response in household surveys. A relationship has been shown with age, gender, civil status, race/ethnicity, household size, region, socio-economic status, place of residence, and type of dwelling (Burzykowski et al. 1999; Ekholm et al. 2010; Heerwegh et al. 2007; Helasoja et al. 2002; Korkeila et al. 2001; Mannetje et al. 2011; Schneider et al. 2012). Also personality appears to correlate with non-response (Marcus and Schutz 2005). The association with

health status is less clear-cut. One Danish study found that the health profile of non-participants is typically worse than that of participants (Drivsholm et al. 2006), whereas another study in the same country concludes that health status does not play a systematic role for non-response rates in HISs (Ekholm et al. 2010).

In Belgium, national HISs have been organized in 1997, 2001, 2004 and 2008. The national population register is used as the sampling frame. The sampling is done via a multistage stratified clustered design (Scientific Institute of Public Health 2005), involving a regional stratification (not proportional by population size), a provincial stratification (proportional by population size), a systematic sampling of municipalities (with probability of selection proportional by population size) per province, and a systematic sampling of households within the municipality based on a ranking of households by age of the reference person, household size and statistical sector (a homogenous area within a municipality with respect to morphological and social characteristics). In households with up to four household members everybody is selected. In larger households four people are selected via a procedure making use of the relationship with the reference person and the birthday of the household members. A detailed description of the methodology of the Belgian HIS has been published elsewhere (Van Oyen et al. 1997).

As in all surveys, also in the Belgian HIS non-response is an important concern. Non-response should be considered at two levels: unit non-response (i.e. failure to participate) and item non-response among participants. The focus of this paper is on the first one. Both in the design and management of the survey and the analysis of the results of the Belgian HIS, measures are taken to reduce the impact of unit non-response on the representativeness of the survey results.

1. A first set of measures relates to the prenotification, the burden for the respondents, incentives for participation, the number and timing of attempts to access the sample unit and the motivation, training and follow-up of the interviewers. It is generally agreed that appropriate measures with respect to those items contribute to a reduction of non-response (Groves et al. 2002), but it is difficult to quantify their effect.
2. A second measure is field substitution of the non-participating households. Through the systematic sampling procedure, three replacement households are taken (the next three in the population register), with similar characteristics in terms of age of the reference person, household size and statistical sector. The four households with similar characteristics form one cluster. If a household cannot be contacted or refuses participation, it is replaced by the next household from the same cluster. It is assumed that households within a cluster are replaceable for each other, as they are look-alikes for these three parameters.
3. A third measure is the calculation of post-stratification weights at individual level based on a comparison of the distribution of the realized sample in terms of age, gender, household size and province with the same distribution in the total population, available from the National Register. The use of post-stratification weights is in the first place required to correct for the unequal selection probability of households and individuals, e.g. due to the regional stratification, which is not proportional by population size. At the same time it corrects for a bias of the sample distribution due to a selective non-response in function of the four variables that are used for the calculation of the weights.

The underlying assumptions for the two last measures are that (1) non-response depends on the indicated characteristics and (2) the relation between those characteristics and any outcome of the survey (health outcome, health determinant, service use) is the same for respondents and non-respondents.

In this paper, we use data from the Belgian HIS 2004 to investigate the first assumption. If age, gender, household size, statistical sector and province are associated with non-response, it makes sense to use those variables in the field substitution and/or the post-stratification procedure. We also want to identify if non-response is related to factors that were not taken into account in the replacement scheme and the post-stratification, but for which information is available for both respondents and non-respondents, more specifically the nationality and the type of residence of the household. The overall aim is to assess if a crucial condition is fulfilled for the usefulness of the measures that are taken to reduce the impact of non-response on the representativeness of the results in the Belgian HIS and to identify which weaknesses still exist that may bias the results. Furthermore, we want to assess the impact of those measures on the survey results.

Refusal by sample units and failure to contact sample units can both contribute to survey non-response bias. However, the nature of the contribution can be rather different in the two cases as they represent different concepts. Refusing and hard-to-contact households may have different characteristics (Lynn and Clarke 2002). Determinants of non-response (including both failure to contact and refusal) are therefore not only investigated in general, but also for failure to contact (among all selected households) and refusal (among those who were successfully contacted) separately.

Methods

Data

Data were used from the Belgian HIS 2004. The study included all selected households ($n = 12{,}204$), with the exception of households for which the address indicated in the national register did not exist, households that did not live on the indicated address and households that were non-eligible for inclusion (Table 1). To the latter category belonged households with their official address in a prison, a psychiatric institution or another collective household (except home for elderly).

Eligible households were contacted either by telephone or at the doorstep. Households could only be considered as non-contactable if no contact could be established after at least five contact attempts, of which at least one was at doorstep, at least one was during the weekend and at least two were outside working hours during the week (Scientific Institute of Public Health 2005). Interviews were carried out in the three national languages (Dutch, French and German) and in English.

From the national register we obtained information on age, gender and nationality of the reference person, household size and residency (province, municipality and statistical sector). Nationality was regrouped in three categories: (1) Belgian, (2) nationality from another EU country, USA or Canada and (3) other nationalities (mainly Moroccan and Turkish). Information on the type of residence of the household was obtained through two questions in the household questionnaire. A first one distinguished if the residency was a house alone, a semi-detached house or a terraced housed, flat or community building. A second question classified the residency as being located in a low density area or high density area. In case of non-response this information was provided by the interviewer.

Statistical analyses

Three outcome indicators were considered, all of them at household level: failure to contact, refusal (among those for whom a successful contact had been established) and non-response (combining the two). Multilevel logistic regression was used with three levels: municipality, statistical sector and household.

The statistical sector is a key variable in the procedure of the substitution of households. To assess differences in response rate by statistical sector, the median odds ratio (MOR) as proposed by (Larsen and Merlo 2005; Merlo et al. 2006) was estimated as direct epidemiological interpretation of small area variance in the logistic regression. The MOR translates the variance in the widely used OR scale, which has a consistent and intuitive interpretation. In very simple terms the MOR could be interpreted as the increased (median) odds of non-response if a household was to change area (e.g. municipality or statistical sector). If the MOR was equal to 1, there would be no difference among areas in response rate. If there were important differences by area, the MOR would be large. MORs were calculated both for municipality (MOR_{mun}) and statistical sector (MOR_{stat}). The MOR_{mun} assesses the difference when moving to another municipality and the MOR_{stat} assesses the difference when moving to another statistical sector within the same municipality.

The analyses were performed in two steps. In a first model only geographical variables were included. Municipality and statistical sector were entered as random effect parameters, province as a fixed effect at the level of the municipality. In a second model we added characteristics of the household and the households' residence as fixed effects at the level of the household and verified to which extent the addition of these variables altered the associations observed in the first model.

Second degree fractional polynomial smooth plots (tested powers: -2, -1, -0, 0, 0.5, 1, 2, 3) were generated presenting the probability of household participation by age and sex of the reference person, based on a multinomial logistic regression model.

Finally we selected some health outcomes in different health-related domains and investigated to which extent estimates and their association with an important determinant (education) vary in function of four different scenarios: (1) use of none of the two measures, (2) use of post-stratification weights only, (3) use of field substation

Table 1 Status of selected households, Belgian health interview survey, 2004

Status	Number of households	% of households	Sum of household members
Address non existing	143	1.1	209
Household not living on indicated address	811	6.1	1,144
Household non eligible	114	0.9	147
Household non contactable	1,539	11.6	2,423
Household refused to participate	4,135	31.2	8,053
Household agreed to participate	6,530	49.2	13,655
Total	13,272	100.0	25,631

only, (4) use of both measures. All analyses were carried out with Stata/SE 10.1 (Stata Company 2007). For the regression models we used linearization-based variance estimators (Kish and Frankel 1974).

Results

Overall, 12.6 % of the households invited for participation could not be contacted, 33.9 % refused and 53.5 % participated. In Table 2, a univariate distribution of household characteristics is presented for the three types of households: those who could not be contacted, those who refused and those who participated.

Table 3 presents the results of the multilevel logistic regression for non-response in general, combining failure to contact and refusal. Model 1 explores geographical variations in non-response, without taking into account household characteristics. From this model we conclude that there are important differences in non-response rate by

Table 2 Distribution of background characteristics of eligible households (in %) by participation status, Belgian health interview survey, 2004

	Non contactable ($n = 1.539$)	Refusing ($n = 4.135$)	Participating ($n = 6,530$)
	(%)	(%)	(%)
Sex reference person			
Male	59.1	57.3	62.5
Female	40.9	42.7	37.5
Age group reference person			
<24 years	6.6	2.7	3.2
25–44 years	40.8	20.4	28.7
45–64 years	24.2	25.9	28.1
65 years+	28.4	50.9	40.0
Nationality reference person			
Belgian	78.6	90.1	89.5
Other EU countries—USA/Canada	15.0	7.5	7.5
Other countries	6.4	2.4	3.0
Household size			
1	66.1	45.6	42.4
2	20.6	38.9	36.3
3	5.1	3.8	4.7
4+	8.2	11.8	16.6
Type of residence			
House alone	9.7	20.3	27.6
Semi-detached house	8.4	13.1	15.0
Terraced house. flat or community building	81.9	66.6	57.4
Residential area			
Low density	43.4	55.7	63.9
High density	56.6	44.3	36.1
Province of residence			
West-Vlaanderen	2.1	4.0	6.2
Antwerpen	8.1	8.8	8.9
Vlaams Brabant	5.9	7.6	4.5
Oost-Vlaanderen	6.4	10.3	6.9
Limburg	3.1	5.3	7.0
Brussels	52.6	34.1	29.3
Brabant wallon	1.4	2.2	3.3
Hainaut	7.0	10.2	11.4
Liège	5.7	8.2	8.9
Luxembourg	4.9	6.4	9.6
Namur	3.1	2.9	4.1

Table 3 Multilevel model for proportion of non-response of households, health interview survey, Belgium, 2004

Terms	Model 1 [OR (95 % CI)]	Model 2 [OR (95 % CI)]
Fixed effects at level of household		
Age		
< 25 years		1.00
25–44 years		0.89 (0.71–1.11)
45–64 years		0.97 (0.77–1.22)
> 64 years		1.04 (0.84–1.30)
Sex reference person		
Male		1.00
Female		0.99 (0.91–1.09)
Nationality reference person		
Belgian		1.00
EU—USA/Canada		1.25 (1.08–1.45)
Other countries		1.00 (0.79–1.25)
Household size		
1		1.45 (1.25–1.68)
2		1.32 (1.14–1.52)
3		1.09 (0.92–1.28)
4+		1.00
Type of residence		
House alone		1.00
Semi-detached house		1.11 (0.96–1.28)
Terraced house. flat or community building		1.44 (1.27–1.64)
Area of residence		
Low density area		1.00
High density area		1.20 (1.08–1.33)
Fixed effects at level of municipality		
Province of residence		
West-Vlaanderen	1.00	1.00
Antwerpen	1.31 (0.86–1.98)	1.40 (0.93–2.09)
Vlaams Brabant	2.94 (1.90–4.55)	3.11 (2.05–4.74)
Oost-Vlaanderen	2.31 (1.52–3.50)	2.45 (1.64–3.65)
Limburg	1.17 (0.78–1.77)	1.35 (0.90–2.01)
Brussels	2.24 (1.52–3.30)	1.74 (1.20–2.53)
Brabant wallon	1.03 (0.61–1.72)	1.02 (0.62–1.69)
Hainaut	1.49 (1.01–2.20)	1.51 (1.04–2.19)
Liège	1.27 (0.85–1.91)	1.33 (0.90–1.97)
Luxembourg	1.02 (0.68–1,52)	1.16 (0.79–1.71)
Namur	1.19 (0.72–1.95)	1.33 (0.82–2.15)

Random effect parameters

	Variance (SE)	MOR (+95 % CI)	Variance (SE)	MOR (+95 % CI)
Municipality	0.462 (0.040)	1.91 (1.81–2.02)	0.429 (0.039)	1.87 (1.77–1.98)
Statistical sector	0.439 (0.042)	1.88 (1.78–2.00)	0.446 (0.043)	1.89 (1.79–2.01)
Log likelihood	−7,928.0533		−7,848.3936	

province. We observe higher rates of non-response in Vlaams Brabant, Oost-Vlaanderen and Brussels as compared to West-Vlaanderen, the province with the lowest non-response rate. Furthermore, there are substantial differences in non-response by municipality and by statistical sector.

After adjusting for individual household characteristics (model 2) the geographical variations in non-response hardly change, although the OR for non-response in Brussels (compared to West-Vlaanderen) drops from 2.24 (95 % CI 1.52–3.30) to 1.74 (95 % CI 1.20–2.53) indicating that some of the differences can be explained by specific characteristics of the households in the Brussels' region. It appears indeed that a higher non-response is observed among households from other EU or industrialized countries (OR 1.25; 95 % CI 1.08–1,45 versus Belgian citizens), one person households (OR 1.45; 95 % CI 1.25–1.68 versus households with at least 4 household members), households living in terraced houses, flats and community buildings (OR 1.44; 95 % CI 1.27–1.64 versus households living in a house alone) and households living in high density areas (OR 1.20; 95 % CI 1.08–1.33 versus households living in a low density area).

Table 4 presents separate analyses for failure to contact (among all selected households) and refusal (among the households that could be contacted). Only model 2 is presented, as the geographical differences hardly change after the inclusion of household characteristics. For both indicators there are important geographical differences, but they are more pronounced for failure to contact than for refusal. The results also give more insights into provincial differences in non-response. The higher non-response in Brussels is mainly a problem of failure to contact and the higher non-response in Oost-Vlaanderen is a problem of refusal. In Vlaams Brabant both contribute more or less equally.

Age and gender of the reference person are related to failure to contact and refusal in an opposite way. An increasing age of the reference person and a female reference person are associated with a lower probability of not being able to contact the household, but also with a higher probability of refusal. Both effects level out, resulting in only slight variations in participation rate in function of the age, which is clearly demonstrated in Fig. 1.

The nationality of the reference person only marginally influences the refusal rate, but citizens from other EU countries and other industrialized countries are more difficult to contact than Belgians. This is not the case for households with a reference person from other countries (mainly Maghreb countries and Turkey). Small households, and especially one person households, are much harder to contact, but once a contact has been established they do not refuse more often than larger households. Households living in a terraced house, flat or community building are more difficult to contact and refuse more than households living in a house alone.

Table 5 demonstrates how some selected health-related survey estimates and their association with education and region vary according to different scenarios. For most of the selected indicators the use of post-stratification weights has a substantial impact on the prevalence of the estimate. Field substitution on itself has very few impacts. There is no change of relevance for point estimates. Only in combination with weights there are some minor changes regarding associations.

Discussion

In this study, we assessed the usefulness of strategies to deal with non-response bias in the Belgian HIS. Compared to other national HISs, non-response in the Belgian HIS is quite high (Aromaa et al. 2003). Moreover, non-response seems to increase. Between 1997 and 2008 the household refusal rate, calculated as the number of households who refused participation among those who were contacted, has risen from 39 to 45 % (Scientific Institute of Public Health 2012). Even though this trend needs to be interpreted with caution, because in 2004 and 2008 there has been an oversampling of older people, the non-response in the Belgian HIS is worrying, but not an isolated phenomenon. Many other surveys face the same problem (Ekholm et al. 2009; Galea and Tracy 2007).

Many tools have been described to reduce unit non-response rates (Groves et al. 2004), but usually it is very difficult to assess how useful these are. Field substitution and weighting adjustments have been described as ways to reduce non-response in household surveys (Vehovar 1999; MacDonald et al. 2009; Kessler et al. 1995). However, a necessary condition for those measures to be effective is that there is an association between potential predictors of unit non-response involved in those strategies, and the actual non-response. Although Vives et al. (2009) found that both methods produce a comparable effect on prevalence estimates (Kessler et al. 1995), it is likely that a combination of both strategies is more successful than each one separately.

The sampling frame for the selection of households in the Belgian HIS is the national register. Information from the national register is used to implement the field substitution and weighting adjustments. To evaluate the potential of those measures to reduce non-response bias, it is essential to know if the variables that are involved in those procedures (age, gender, household size, province as regional indicator, statistical sector as indicator of both the place of residence and socio-economic status) are effectively associated with the participation status.

Our results confirm that in the Belgian HIS province, statistical sector and household size are significantly associated with non-response. At first sight this seems not the case for age and gender, but when analysing this separately for failure to contact and refusal it appears that also

Table 4 Multilevel models for proportion of non-contactable households and refusal rate, health interview survey, Belgium, 2004

Outcome	Non contactable [OR (95 % CI)]	Refusing [OR (95 % CI)]
Fixed effects at level of household		
Age		
< 25 years	1.00	1.00
25–44 years	1.02 (0.77–1.35)	0.87 (0.66–1.14)
45–64 years	0.64 (0.48–0.85)	1.18 (0.91–1.54)
> 64 years	0.32 (0.24–0.42)	1.57 (1.21–2.03)
Sex reference person		
Male	1.00	1.00
Female	0.74 (0.65–0.85)	1.13 (1.03–1.25)
Nationality reference person		
Belgian	1.00	1.00
EU—USA/Canada	1.57 (1.29–1.91)	1.06 (0.90–1.25)
Other countries	1.16 (0.87–1.54)	0.87 (0.67–1.15)
Household size		
1	4.07 (3.18–5.21)	0.93 (0.79–1.09)
2	2.05 (1.58–2.65)	1.07 (0.92–1.25)
3	0.94 (0.69–1.29)	1.06 (0.89–1.26)
4+	1.00	1.00
Type of residence		
House alone	1.00	1.00
Semi-detached house	1.33 (1.02–1.75)	1.08 (0.93–1.25)
Terraced house. flat or community building	1.64 (1.30–2.08)	1.38 (1.20–1.58)
Area of residence		
Low density area	1.00	1.00
High density area	1.08 (0.92–1.26)	1.19 (1.06–1.33)
Fixed effects at level of municipality		
Province of residence		
West-Vlaanderen	1.00	1.00
Antwerpen	1.43 (0.74–2.78)	1.36 (0.91–2.03)
Vlaams Brabant	2.61 (1.36–5.01)	2.84 (1.87–4.32)
Oost-Vlaanderen	1.65 (0.87–3.15)	2.42 (1.63–3.61)
Limburg	1.67 (0.87–3.22)	1.23 (0.83–1.84)
Brussels	3.10 (1.73–5.54)	1.37 (0.94–2.00)
Brabant wallon	1.25 (0.55–2.82)	0.97 (0.59–1.60)
Hainaut	1.80 (0.99–3.27)	1.40 (0.97–2.04)
Liège	1.40 (0.74–2.65)	1.28 (0.87–1.90)
Luxembourg	1.61 (0.86–3.04)	1.06 (0.72–1.57)
Namur	2.78 (1.33–5.78)	1.09 (0.67–1.88)
Random effect parameters		

	Variance (SE)	MOR (+95 % CI)	Variance (SE)	MOR (+95 % CI)
Municipality	0.540 (0.065)	2.02 (1.86–2.20)	0.418 (0.041)	1.85 (1.75–1.97)
Statistical sector	0.652 (0.059)	2.16 (2.02–2.32)	0.416 (0.050)	1.85 (1.73–2.00)

those factors are important determinants. These results support the hypothesis that it is useful to make use of those variables in strategies to reduce non-response bias in the Belgian HIS.

After adjustment for age, gender, household size, statistical sector and province an independent association is also found between non-response on the one hand, and nationality, type of residence and area of residence on the

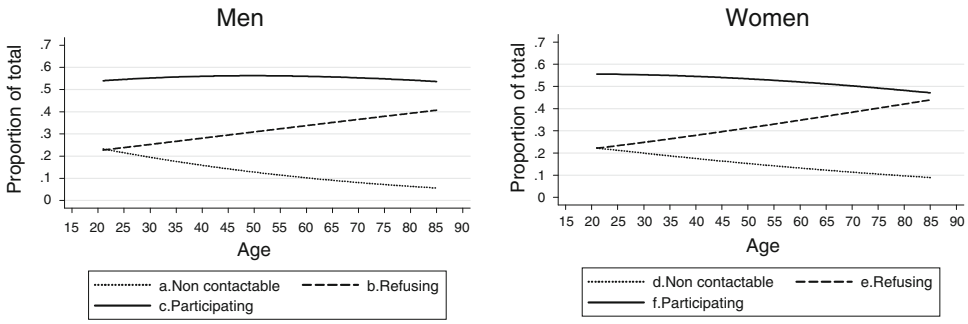

Fig. 1 Second degree fractional polynomial smooth plot of the probability of household participation by age and sex of the reference person, based on a multinomial logistic regression model. Health interview survey, Belgium, 2004. Powers of best fit: *a* (1, 2); *b* (1, 3); *c* (0.5, 2); *d* (1, 2); *e* (1, 1); *f* (0.5, 2)

Table 5 Estimates of health outcomes and age and gender adjusted associations between those health outcomes and education and region according to different scenarios of field substitution and use of post-stratification weights (PSW), health interview survey, Belgium, 2004

Estimate	No PSW No field substitution [% (95 % CI)]	Only field substitution [% (95 % CI)]	Only PSW [% (95 % CI)]	Both PSW and field substitution [% (95 % CI)]
Poor to moderate perceived health	26.8 (25.7–27.9)	27.1 (26.3–28.1)	23.0 (21.4–24.5)	23.1 (21.8–24.3)
Handicap in mobility	8.6 (8.0–9.3)	8.8 (8.2–9.3)	4.8 (4.1–5.4)	4.9 (4.3–5.5)
Diabetes	4.3 (3.9–4.8)	4.7 (4.3–5.1)	3.1 (2.6–3.7)	3.5 (3.0–3.9)
Daily smoker	26.9 (25.8–28.0)	26.6 (25.7–27.5)	27.9 (26.1–29.7)	27.6 (26.1–29.1)
No contact with specialist <1 year	46.0 (44.9–47.1)	46.2 (45.4–47.2)	50.3 (48.5–52.1)	49.6 (48.1–51.0)
Use of prescribed medicines in past 2 weeks	53.7 (52.6–54.7)	54.8 (54.0–55.7)	46.0 (44.3–47.7)	47.3 (45.9–48.8)
OR lowest[a] versus highest[b] educational group	OR (+95 % CI)	OR (+95 % CI)	OR (+95 % CI)	OR (+95 % CI)
Poor to moderate perceived health	2.95 (2.46–3.55)	3.01 (2.59–3.51)	3.06 (2.29–4.10)	3.31 (2.61–4.21)
Handicap in mobility	2.31 (1.71–3.14)	2.89 (2.24–3.72)	2.05 (1.23–3.43)	2.94 (1.87–4.62)
Diabetes	2.15 (1.54–3.02)	2.17 (1.67–2.82)	3.66 (2.22–6.05)	2.92 (1.94–4.38)
Daily smoker	2.00 (1.65–2.43)	1.95 (1.66–2.30)	2.05 (1.52–2.77)	2.09 (1.63–2.69)
No contact with specialist <1 year	1.61 (1.39–1.87)	1.63 (1.44–1.84)	1.50 (1.18–1.90)	1.47 (1.21–1.79)
Use of prescribed medicines in past 2 weeks	0.93 (0.79–1.10)	1.06 (0.92–1.21)	1.03 (0.80–1.33)	1.03 (0.83–1.28)
OR Wallonia versus Flanders	OR (+ 95 % CI)	OR (+ 95 % CI)	OR (+ 95 % CI)	OR (+ 95 % CI)
Poor to moderate perceived health	1.45 (1.27–1.65)	1.43 (1.28–1.60)	1.45 (1.19–1.76)	1.52 (1.30–1.79)
Handicap in mobility	0.94 (0.75–1.17)	1.00 (0.83–1.20)	1.00 (0.70–1.42)	1.08 (0.81–1.44)
Diabetes	1.46 (1.14–1.88)	1.49 (1.22–1.81)	1.46 (0.99–2.16)	1.51 (1.12–2.06)
Daily smoker	1.13 (0.99–1.29)	1.12 (1.01–1.25)	1.09 (0.89–1.32)	1.09 (0.93–1.28)
No contact with specialist <1 year	0.72 (0.65–0.79)	0.73 (0.67–0.80)	0.67 (0.57–0.78)	0.66 (0.58–0.75)
Use of prescribed medicines in past 2 weeks	1.41 (1.25–1.58)	1.43 (1.30–1.58)	1.37 (1.16–1.61)	1.37 (1.19–1.58)

[a] No diploma or only primary education

[b] Tertiary education

other hand. Information on the nationality is included in the national register. The number of non-Belgians is probably too small (only 8.3 % in 2004) to be used in the field substitution, but may be included in the weighting adjustment. Even though there appears to be a strong association between non-response, on the one hand, and area and type of residence, on the other hand, information on those characteristics is only useful for substitution and non-response weighting adjustment if it is available at population level and can be obtained for all households in the sampling frame. This is currently not the case in Belgium. In each case it is quite informative to find out that lower

response rates are found among households from other EU countries, the US or Canada, persons living in high density areas and persons living in a terraced house, flat or community building. In the prenotification, the training of interviewers and the contact strategy specific attention should be paid to measures to increase the participation of households with those characteristics.

The results that are described in this study are confirmed by the findings in the literature, especially the much stronger relationships that are found with non-contact. In general, this is related to characteristics that are indicative of the at-home pattern of the household, the presence of physical impediments and the call pattern of the interviewers (Groves and Couper 1998).

It is striking that the distribution by household characteristics differs especially between participating and not contactable households. When comparing the distribution of the characteristics of participating and refusing households, the differences are far less clear (Table 2). Further efforts to reduce non-response bias in the Belgian HIS should therefore focus in the first place on households that are difficult to contact: one person households, households with a reference person aged between 25 and 44 years, households from other EU countries, the US or Canada, living in a high density zone, especially Brussels and/or living in a terraced house, flat or community building. Also in the UK it has been observed that separating refusal bias and non-contact bias is useful and has implications for the development of appropriate field strategies to combat non-response bias (Lynn and Clarke 2002; Kessler et al. 1995).

Our study did not allow investigating directly the association between non-response and education. Earlier studies linking data from the HIS 2001 and the Belgian census have, however, indicated, both at an aggregated and individual level, that the response rate is negatively correlated with the educational attainment (Lorant et al. 2007; Demarest et al. 2012). The substantial variation of response rates by neighbourhood, operationalised in our study via the statistical sector, may therefore partially be due to socio-economic differences at area level. The relation between area deprivation and non-response has also been observed elsewhere (Goodman and Gatward 2008).

The amount of bias introduced by non-response depends on both the proportion of the sample that fails to respond and the extent to which non-responders systematically differ from the entire population (Schneider et al. 2012). Through field substitution and adjustment weights it is aimed to obtain estimates that are more representative for the target population than this would have been the case without applying those measures. However, as there is no certainty that responders and non-responders with the same background characteristics are also similar in terms of outcome measures of the survey, the impact of those measures on the representativeness of the results remains unknown. More research is needed that compares outcome measures of health surveys between responders and non-responders with similar background characteristics, e.g. by linkage of survey results with other registers.

The comparison of estimates of health outcomes and their association with education and region according to different scenarios is interesting, and although it does not provide information on the true magnitude of bias, it illustrates potential changes in effect estimates indicative of bias, if these methods are used. Especially the impact of field substitution appears to be limited. Taking into account that the use of field substitution makes the field work organisation more complex, it may be questioned if the effort is worthwhile. This depends of course on the variables that are involved. If more specific socio-economic information could be used, such as education or income, the impact could be bigger.

Measures to reduce non-response bias should also be taken with caution. In one study it was even observed that in the sole case of smoking, substitution seemed to have further biased survey estimates (Vives et al. 2009). Often the literature focuses on the impact of non-response bias on prevalence estimates. Van Loon et al. (2003) found that even though non-response leads to bias in prevalence estimates, it did not cause bias in the examined associations.

In this article, we mainly focused on household non-response. To assess the representativeness of the survey results, there is also need to consider non-coverage, individual non-response within a participating household and item non-response.

Non-coverage occurs when the sampling frame omits some units of the survey population either accidently or deliberately (Barriball and While 1999). In the Belgian HIS only a few population groups are excluded from participation: prisoners, persons living in a psychiatric institution and persons living in a big convent (Scientific Institute of Public Health 2005). Illegal residents cannot be sampled as they are not included in the national register, but they constitute a small fraction of the total population. The field work of the HIS is spread over a whole calendar year. Samplings are done quarterly, assuring that the time lag between the selection of the sampling and the actual field work is kept as short as possible. It is therefore concluded that the coverage of the survey is quite sufficient.

Also the impact of intrahousehold refusal can be ignored. In the HIS 2004, 97.7 % of the eligible household members agreed to participate. It is important to mention that, when a selected person is not able to participate, a proxy interview is possible for that person.

Finally, also the level of unit response in the Belgian HIS is quite high. Previous research based on the results

from the HIS 1997 concluded that the influence of item-level missing data on the HIS results is negligible (Burzykowski et al. 1999).

Conclusion

Household non-response remains the major threat for the external validity of survey results. It is reassuring that there is evidence that the household characteristics that are taken into account in procedures to reduce non-response bias are indeed linked with non-response, but there is no guarantee that the association between those characteristics and the outcome measures of interest is similar for responders and non-responders. For all selected indicators, the impact of field substitution both on point estimates and associations was marginal. This means that either there was no bias of relevance or it was not captured. The usefulness of field substitution to correct for non-response bias in population health surveys seems to be small.

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