Bayesian estimation of proportions in the analysis of unavailability of health care in Slovakia

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Abstract

Availability of health care affects the quality of life of the population and unmet needs for health care is an important indicator of poverty or social exclusion. The paper deals with estimating the proportion of the population of the Slovak Republic who cannot afford necessary medical treatment mainly because of lack of money, but also for other reasons. In analysis, two sources of data were used: sample survey EU SILC and sample survey EHIS, both conducted by the Statistical Office of the Slovak Republic. Since these sources of information were simultaneously used, it was appropriate to apply Bayesian methods.

Keywords: *health care, EU SILC – European Union Statistics on Income and Living Conditions, EHIS – European Health Interview Survey, Bayesian estimation of the proportion*

JEL Classification: C83, I140

1 Introduction

One of the current problems the European Union is dealing with is to reduce the number of people at risk of poverty and social exclusion. To map the current state, the indicator AROPE has been developed. In addition to this indicator, an inaccessibility of health care primarily for financial reasons may be considered as a sign of poverty. It is known (see Barnay (2016)), that there exists causal relationship between health status and the probability of being employed, which strongly influences the social situation. There is no doubt that health depends (among other things) on health care (see Nováková and Chinoracká (2015)).

The level of health care in the EU is regularly monitored through a database of the World Health Organization (WHO), fixed annually by the European Health Consumer Index (EHCI). According to this criterion, the standard of health care in Slovakia has been on a declining trend since 2013. For 2016 the value of EHCI was 678, which ranks Slovakia at number 23 among the 35 European countries (according to Björnberg (2016)).

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We have dealt with those indicators of access to the health care, which result directly from the social situation of the recipients of healthcare: the inability to meet the need for health care for financial reasons, for a big distance of provider or too long waiting period. In Chaupain-Guillot and Guillot (2015), some other determinants of unmet needs for medical and dental care are analysed.) We used the database of sample surveys EU SILC and EHIS, in which indicators of unavailability of health care for the said reasons are mapped. To estimate the proportion of the population who suffer from a deficit in some of mentioned areas, we used the data from EHIS in Section 2, in which we also identified some of the factors affecting the degree of inaccessibility of healthcare. In Section 3, we specified the analysis by application of Bayesian methods. For modelling the prior distribution, data from EU SILC were used.

2 Analysis of the unavailability of health care based on a database EHIS

The legal framework for developing the European Health Interview Survey (EHIS) is the Regulation (EC) No 1338/2008 of the European Parliament and of the Council of 16 December 2008 on Community statistics on public health and health and safety at work. Detailed specification of the data and metadata to be provided is pursuant to the Commission Regulation (EU) No 141/2013 of 19 February 2013 (according to Eurostat, 2013). We used the part of the questionnaire UN (**U**nmet **n**eeds for health care), which included questions:

UN1a: Have you experienced delay in getting health care in the past 12 months because the time needed to obtain an appointment was too long?

UN1b: Have you experienced delay in getting health care in the past 12 months due to distance or transport problems?

UN2: Was there any time in the past 12 months when you needed the following kinds of health care, but could not afford it?

A. medical care

B. dental care

C. prescribed medicines

D. mental health care (by a psychologist or a psychiatrist for example).

(In following, we use the abbreviations UN1a, UN1b, UN2a, UN2b, UN2c, UN2d for the listed variables). For all questions, respondents could choose one of the three options: “yes”, “no” or “no need for care” (in UN2c the last option was “no need for prescribed medicines”).

Besides the above mentioned variables, we dealt with some other variables that might come into consideration as factors affecting the access to health care: sex, age, region, degree of urbanisation, educational attainment, self-declared labour status, status in employment, net

monthly equivalised income of the household and self-perceived general health. For each of them, we conducted test for independence between them and the above listed variables from the group UN. Each test was performed twice: in the first case all three possible answers to the questions of the group UN were taken into account; in the second case we analysed only two different answers – "yes" or "not yes", so that we merged second and the third answers into one group. This was done with respect to create the indicator comparable with some of the indicators of EU SILC. No doubt, that the more valuable information is provided by the first case, as we can detect the proportion of those who could not meet needs for healthcare out of those who really needed it. Obviously, in the second case, the sample proportions are smaller: the difference depends on the number of respondents, who said they had not need the health care in particular questions (it does not hold for the question UN2d, which requires special analysis). To compare the different kinds of proportions for each question from the group UN, they are shown in Table 1.

Question	**UN1a**	**UN1b**	**UN2a**	**UN2b**	**UN2c**	**UN2d**
Proportion (1st case)	6.26 %	1.42 %	2.21 %	6.95 %	4.89 %	1.80 %
Proportion (2nd case)	4.83 %	1.06 %	1.68 %	4.95 %	3.39 %	0.29 %

Table 1. Proportions of respondents, who did not receive particular (according to the question) care out of those who needed the care (1st case) and out all respondents (2nd case). Source: EHIS 2014, authors´ own elaboration.

As we can see, the highest proportions relate to unavailability of dental care (for more details see Tchicaya and Lorentz (2014)) and too long waiting time (detailed analysis of this indicator is in Muzik and Szalayova (2013)).

It came out, that the results in detecting factors influencing proportions in both cases were not significantly different except that the last question UN2d, where in the first case the strong dependence appeared, while in the second case the p-values of the independence tests were mostly higher than 0.5. This may be caused by the content of the question – many people do not want reveal the need for mental care.

Considering the limited extent of the text, we only present the most interesting results of the first case (three different answers to questions from the group UN). Among the above listed factors, the strongest influence on the UN variables have self-perceived general health (HS1), self-perceived labour status (MAINSTAT), region (REGION), net monthly equivalised income of the household (HH INCOME) and educational attainment

(HATLEVEL). For all of them, the p-values of independence tests were less than 0.01 (for both cases). Table 2 shows the proportion of those respondents who said their health care needs have not been satisfied out of those who needed it, for each level of mentioned factors. According to http://ec.europa.eu/eurostat/en/web/products-manuals-and-guidelines/-/KS-RA-13-018, the meanings of factors´ variations[3] are as follows:

HS1 (self-perceived general health):

1 very good
2 good
3 fair
4 bad
5 very bad

MAINSTAT (self-perceived labour status):

10 carries out a job or profession, including unpaid work for a family business or holding, an apprenticeship or paid traineeship, etc.
20 unemployed
31 pupil, student, further training, unpaid work experience
32 in retirement or early retirement or has given up business
33 permanently disabled
35 fulfilling domestic tasks
36 other inactive person

REGION (according to NUTS II):

1 Bratislava
2 West Slovakia
3 Middle Slovakia
4 East Slovakia

HHINCOME (net monthly equivalised income of the household):

1 below 1st quintile
2 between 1st quintile and 2nd quintile
3 between 2nd quintile and 3rd quintile
4 between 3rd quintile and 4th quintile
5 between 4th quintile and 5th quintile

[3] Variations that did not occurred are not listed.

HATLEVEL (educational attainment based on ISCED-2011 classification):

0 early childhood development, pre-primary education
1 primary education
2 lower secondary education
3 upper secondary education
4 post-secondary but non-tertiary education
5 tertiary education; short-cycle
6 tertiary education; bachelor level or equivalent

In Table 2, the largest number of each row is highlighted. As we can see, the largest proportions are for each factor (except for REGION) in the most vulnerable categories: people with bad or very bad health, permanently disabled people or people fulfilling domestic tasks, people with the lowest income and people with the lowest educational attainment. All these attributes meets especially the Roma segment of the population, which accounts for approximately 7.5 percent of the population (more detailed analysis is in Bartošovič (2016) or Bobakova et. al. (2015)). As for the factor REGION, the results were surprising for us. Despite predictions that in Bratislava region live people with the highest income, it turned out that many of them cannot afford health care. As we can see from Šoltés and Gajdošík (2016), there exist some other variables that may cause such relation among regions.

Factor	**Variations of factor**						
HS1	**1**	**2**	**3**	**4**	**5**		
UN1a	3.41	4.08	8.38	*10.95*	6.29		
UN1b	0.00	0.78	1.71	2.89	*5.88*		
UN2a	1.23	0.91	2.47	5.22	*5.63*		
UN2b	3.84	4.83	8.90	*14.29*	9.09		
UN2c	1.88	2.29	4.71	*12.02*	10.69		
MAINSTAT	**10**	**20**	**31**	**32**	**33**	**35**	**36**
UN1a	5.76	7.33	2.60	6.92	9.74	*11.11*	4.22
UN1b	0.83	1.20	0.00	2.10	*3.66*	0.00	1.82
UN2a	1.06	6.31	1.11	2.23	*7.29*	2.94	1.85
UN2b	4.95	17.89	3.23	6.82	15.38	*20.00*	5.29
UN2c	2.27	13.99	1.38	4.97	*13.92*	9.38	4.17

REGION	**1**	**2**	**3**	**4**		
UN1a	7.00	5.75	4.21	*8.85*		
UN2a	*5.49*	1.48	2.06	1.83		
UN2b	*19.03*	4.11	5.05	6.75		
UN2c	*12.57*	1.98	5.36	4.56		
HHINCOME	**1**	**2**	**3**	**4**	**5**	
UN2a	*4.65*	2.65	1.80	1.32	0.74	
UN2b	*16.93*	6.81	5.32	3.65	3.48	
UN2c	*12.17*	4.10	4.09	2.54	1.81	
HATLEVEL	**1**	**2**	**3**	**4**	**5**	**6**
UN2b	*16.13*	12.01	6.62	9.30	4.31	3.50
UN2c	*14.71*	10.10	4.07	6.74	1.09	1.69

Table 2. Sample proportions (%) of respondents who´s health care needs have not been satisfied out of those respondents who needed health care.

Source: EHIS 2014, authors´ own elaboration.

3 Application of Bayesian methods for estimating the proportion of people, who are not receiving medical care for some selected reasons

Bayesian statistical inference is the alternative to the sampling-theory statistics. If there exists, besides the sample data, some additional information on the analysed variable, Bayesian approach can be used to make estimation more precise.

The main difference between the classical and the Bayesian approach is that the estimated parameter in Bayesian statistics is not an unknown constant, but it is considered as a random variable. Along with the sample data, there exists another piece of information, on the base of which the prior distribution of variable is created. Including sample data into analysis, the distribution transforms into posterior distribution, serving as a background for inference conclusions. If the prior and the posterior are of the same type, together with the sample distribution, they create *conjugate family*. For estimating the proportion π, the conjugate family binomial/beta is often used. In the case, the hyper-parameters of posterior distribution $Be(\alpha';\beta')$ satisfy (see Bolstad (2004))

$$\alpha' = \alpha + x \tag{1}$$

$$\beta' = \beta + n - x \tag{2}$$

(α, β are hyper-parameters of prior distribution and *x* denotes number of occurrence of event out of *n* trials). The Bayesian point estimation of parameter π is the posterior mean:

$$E(\pi / \mathbf{x}) = \frac{\alpha + x}{\alpha + \beta + n}. \tag{3}$$

Our goal was to estimate the proportions of people, who cannot receive the medical care, more precisely than it was in Section 2. In order to do so, we used as a prior information data from the P-file (Personal Data) of sample survey EU SILC, in which some of the questionnaire´s questions are similar to the questions in the survey EHIS. This refers to following questions:

PH040: Unmet need for medical examination or treatment,

PH050: Main reason for unmet need for medical examination or treatment,

PH060: Unmet need for dental examination or treatment,

PH070: Main reason for unmet need for dental examination or treatment.

The respondents had to choose answers "yes" or "no" to the questions PH040 and PH060 and one following options to questions PH050 and PH070:

1 Could not afford to (too expensive)

2 Waiting list

3 Could not take time because of work, care for children or for others

4 Too far to travel/no means of transportation

5 Fear of doctor/hospitals/examination/ treatment

6 Wanted to wait and see if problem got better on its own

7 Didn't know any good doctor or specialist

8 Other reasons

Although the questions look similar to those in the EHIS questionnaire, their exact formulation and cross connection divided respondents into different groups than it is in EHIS. After logical analysis, we managed to develop an indicator that has the same content in both surveys: We monitored the proportion of respondents (out of all respondents) who did not meet the need for medical care for one of the three reasons: "Could not afford to" (1), "Waiting list" (2) and "Too far to travel/no means of transportation" (4). Each of them has strong relation to social situation of the respondent.

To create the prior distribution, we used data from EU SILC 2005 – EU SILC 2015 for evaluating corresponding proportions; they are shown in Table 3.

On the base of evaluated proportions, we created the prior beta distribution. By maximum likelihood method we estimated parameters ($\alpha = 15.466, \beta = 746.788$) and performed Kolmogorov-Smirnov test to verify the appropriateness of the distribution. Since the p-value was more than 0.99, the distribution $Be(15.466;746.788)$ fitted well and might be used as a prior. In the data from EHIS, there were 297 respondents ($x = 297$) out of all 5490 ($n = 5490$), who had not met need for health care for one of the mentioned reasons. Thus, according to (1) and (2) we evaluated parameters of posterior distribution $Be(\alpha';\beta')$: $\alpha' = 312.466$, $\beta' = 5939.788$, so according to (3) the Bayesian point estimation of the proportion is $\hat{\pi}_B = 0.0500$. This value is smaller than the point estimation based only on sample data (EHIS) 0.0541 and bigger than prior mean 0.0203. It means, that according to the data from survey EHIS, 5.41 % out the whole population is not provided medical care for one of mentioned reason. The estimation of proportion based only on the prior information (EU SILC) is smaller (2.03 %) and when both surveys are used, we get the value 5.00 %.

YEAR	(1)	(2)	(4)	(1)+(2)+(4)	SAMPLE SIZE	PROPORTION
2005	324	44	24	392	12868	0.0305
2006	278	42	33	353	12630	0.0279
2007	109	46	18	173	12570	0.0138
2008	67	71	41	179	13645	0.0131
2009	84	81	60	225	13580	0.0166
2010	80	101	47	228	13907	0.0164
2011	89	149	43	281	13261	0.0212
2012	112	135	35	282	13502	0.0209
2013	92	135	23	250	13044	0.0192
2014	114	130	32	276	13187	0.0209
2015	102	154	52	308	13535	0.0228

Table 3. Proportions of respondents with unmet need for (at least) one of the reasons: "Could not afford to", "Waiting list" and "Too far to travel/no means of transportation".
Source: EHIS 2014, authors´ own elaboration.

Let´s compare interval estimations (on confidence level 95 %): The classical confidence interval based on normal approximation, is (4.81 %; 6.01 %). Prior beta distribution gives interval (1.15 %; 3.14 %) and Bayesian credible interval is (4.47 %; 5.55 %). We may

conclude that on confidence level 95 %, for more than 4.47 % up to 5.55 % of population the medical care is not available for lack of money, for too big distance from provider of medical care or for too long time they have to wait for the care.

Conclusion

One of the signs of poverty is unavailability of the health care for (mainly) financial reasons, but also for other reasons, which are related with social situation of people. By analysis of data from survey EHIS 2014 we estimated, that 6.26 % of those, who needed health care, don´t receive it because of too long distance from provider, 1.42 % because of long waiting period, 2.21% because they cannot afford it. Lack of money is reason, why 6.95 % of population do not receive dental care, 4.89 % cannot receive prescribed medicine and 1.80 % do not receive mental care, despite they need it. Analysis of factors influencing unavailability of health care shows, that the groups of people who are the most threatened by unmet need for health care (as well as dental care or mental care) or they cannot afford the prescribed medicines, are the most vulnerable groups: people with bad health, permanently disabled people, people with the lowest income and people with the lowest educational attainment. In many cases (see Table 2) the proportion of such people is bigger than 10 %. This is really a serious situation and the government should design such arrangements that would help to these most vulnerable groups.

In order to make estimations more precise, we analysed another source of similar data – P-files from EU SILC which was used as a prior information for Bayesian estimation. Unfortunately, the formulations of the questions are slightly different from those of survey EHIS, so we could only analyse the proportion of people, who cannot receive medical care for one of three reasons: lack of money, to long distance or too long waiting time. As the proportions in EU SILC were smaller than the proportions evaluated from EHIS, the Bayesian estimation was smaller (5.00 %), than the classical point estimation on the base of EHIS (5.41 %). If we realize that Slovakia has about 5 400 000 people, of which 84.7 percent has 15 or more years (the age of EHIS´s respondents), estimated share indicates that more than 220 000 inhabitants have no access to health care for mentioned reasons. This is a serious fact deserving attention of the competent authorities.

Acknowledgements

Realization of the paper was supported by a grant agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic VEGA. Project: VEGA no. 1/0548/16 *The progress of the SR in achieving of the strategy Europe 2020 in the area of poverty and social exclusion.*

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