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ESTIMATION OF THE OCCURRENCE OF FOODBORNE SALMONELLOSIS IN HUNGARY

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While in developed countries research findings are available on the estimation of the realistic number of different diseases and their economic impact at social level, in Central and Eastern European countries these country specific data are neither sufficient nor reliable. This study partially fills the gap and gives a picture of the real number of foodborne salmonellosis in Hungary. In the spring of 2017, a survey about diarrhoeal and foodborne diseases was conducted by interviewing 1001 adults (over the age of 18). Our survey showed that approximately 18 times more individuals are suffering from *Salmonella* infection than it is assumed under the national and international epidemiological database. Based on our estimation, the annual number of foodborne salmonellosis may range from 91 242 to 105 606 in Hungary. In this paper a methodology has been developed to estimate the true occurrence of this disease. Our results can be used to calculate the costs-benefit ratios of future salmonellosis prevention programmes and inform decision-makers on the effectiveness of *Salmonella*-related measures in the area of food safety.

Keywords: food safety, occurrence estimation of *Salmonella* infections

The earliest significant studies on the social impacts of zoonotic foodborne diseases were conducted from the mid-1980s in the USA (Todd, 1985). Since then, food safety has become an issue of primary importance worldwide, including former socialist countries (Bánáti & Lakner, 2002), still, similar studies are scarcely available in these regions and none is presented in regard of Hungary.

Nontyphoidal salmonellosis – that is caused by all serotypes of *Salmonella* except for Typhi, Paratyphi A, B, and C in humans – can be transmitted directly or indirectly between animals (calves, pigs, chicken, turkeys, geese, ducks, free-living birds, pets, and rodents) and humans, by consuming contaminated foodstuffs or through contact with infected animals (Bauerfeind et al., 2016). The foodborne transmission route seems to be the first, accounting for 39% of all cases of illness, while human-to-human transmission is the second most important pathway (Havelaar et al., 2012). The severity of the disease in humans varies from slightly and moderately serious symptoms to life-threatening conditions. Decreased functioning of the immune system increases the risk of becoming diseased. As it is already known, *Salmonella* serovars that generally cause gastroenteritis are able to cause systemic disease in individuals with a primary or acquired immune deficiency (Pham & McScorley, 2015).

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Information on the number of cases is primarily provided by national health authorities and supervisory bodies (Roberts & Pinner, 1987; Lindqvist et al., 2001). Though these sources provide valuable information on the occurrence of salmonellosis, by its nature, they contain only the number of registered cases with more serious symptoms (Stroup & Teutsch, 1998). Less serious diseases that do not require medical treatment are known partially. However, reliable estimates of both the number of foodborne disease and its economic consequences help in assessing the effectiveness of any measures in the area of food safety (Mellou, 2013).

Research shows that the realistic number of cases can be calculated on the basis of the registered annual number of cases and a country- and pathogen-specific multiplier factor, which may change from 4 up to 28 or more (Boore et al., 2015). For example, in a study of the true number of campylobacteriosis and salmonellosis in Denmark, multipliers for underreporting of these diseases were 4.4 and 4.1, respectively (Havelaar et al., 2013). In the United Kingdom, similar factors should be applied to calculate the true incidence of these diseases: the multiplier for salmonellosis and campylobacteriosis are about 4.7 and 9.7 (Tam et al., 2012). In certain European countries, these factors seem to be higher: in Greece, multiplier advisable to correct the number of under-registered salmonellosis is 51.45 (Gkogka et al., 2011).

In Hungary, the average annual number of *Salmonella* infections is over 5300. Thus, it causes a significant economic impact on the society. Despite relevance of the subject, no study has been published using the estimated true number of salmonellosis for this country. The purpose of this study is to fill this gap in the literature and provide a realistic picture of this disease in the Hungarian population.

1. Materials and methods

1.1. Population survey

A survey on foodborne diseases was conducted in spring of 2017 in Hungary, in which 1001 adults (over the age of 18) were personally interviewed by using questionnaire. Based on previous international findings (Havelaar et al., 2013) it was assumed that the true occurrence of salmonellosis in Hungary might be many times the cases reported in the national database. A sample size of 1001 seemed to be sufficiently large to draw relevant conclusions.

Younger age groups were not included in the survey for two main reasons: on the one hand, it was assumed they could not answer to our specific questions (up to 10 years in particular). On the other hand, according to scientific literature (Szalka et al., 2005), incidence of salmonellosis among young adults and middle-aged persons may be similar to those reported among younger age groups, but the diagnostic activity and willingness to seek medical care when having health problems are lower in these age groups.

Beside age, the respondents were selected on the basis of demographic parameters such as gender and living location. For these parameters the sample is representative to the Hungarian population according to the general census published by the Hungarian Central Statistical Office (HCSO, 2016). 47.4% of the respondents were male and 52.6% were female. Level of education, economic status, size of the household, type of residence (village, town, capital), and level of income were also recorded (Table 1). Those living in towns were over-represented (64.0 cf. 52.6%), while persons who have not attained an upper secondary

educational qualification (7.2 cf. 15.9%) and those living in villages (13.2 cf. 29.5%) were under-represented.

Table 1. Survey respondents by age, educational level, level of income, and type of residence, % (n=1001)

Age		Level of education		Level of income		Type of residence	
		Primary school	2.7	Low	2.2	Capital	22.8
18–44	46.7	Vocational school	35.7	Below average	14.6	Town	64.0
45–64	32.3	Secondary school	7.2	Average	65.1	Village	13.2
65 years or older	21.1	University, college	54.3	Above the average	17.1		
				High	1.0		

Source: own data based on population survey conducted in 2017

1.2. Registered number of salmonellosis in the Hungarian population

The annual number of salmonellosis cases is registered by the National Center for Epidemiology (NCE) in Hungary. To calculate the average number of salmonellosis per year, time series data provided by NCE between 2012 and 2016 were used (NCE, 2016).

1.3. Approximate country and pathogen-specific multiplier factor

A passive surveillance system, such as the Hungarian, characteristically underestimates the real number of infected persons. This, of course, results in underdiagnoses and underreporting of different enteric diseases. To assess the ratio of those having suffered from salmonellosis, and therefore to calculate a specific multiplier for underreporting, respondents were firstly asked about whether they had experienced any diarrhoeal symptoms in 2016. If their answer was affirmative, they were then asked about the possible causes and sources of these health problems. Some questions were designed to assess the willingness to seek medical care in case of having diarrhoea, while others were used to estimate the ratio of confirmed salmonellosis.

1.4. Definitions

Case definitions of fever and diarrhoea were given in the questionnaire. Based on scientific literature (Ogoina, 2011), fever was defined as elevated body temperature above 38 °C. Diarrhoea was described as a condition when having at least three loose liquid bowel movements each day (WHO, 2017). Confirmed *Salmonella* infections: included only those cases where the respondent had been informed by a general practitioner of the disease.

Foodborne origin: in real life, the source of salmonellosis is often based on the assumption of the diseased person or the general practitioner. In the survey, deciding whether a case was foodborne was based on personal judgement.

1.5. Data quality

When conducting the survey, to filter out those who were probably not affected by either salmonellosis or any other illnesses related to food consumption, trap questions were used.

1.6. Uncertainty analysis

To certain questions in the survey beside "Yes/No", "Not certain" and "I do not remember" were also possible answers to choose. However, in case of these type of answers to calculate the margin of error is not evident. In order to define the confidence interval (CI) for the percentages of those who stated they had diarrhoeal symptoms due to food consumption, the so called Normal Approximation Method was used. This method describes uncertainty in binomial samples (Wallis, 2003). First, answers were transformed to 1 ("Yes") or 0 ("No", "Not certain" or "I do not remember"). Considering the target of our analysis, estimating the margin of error for clear "Yes" answers was primarily important.

2. Results and discussion

2.1. Self-reported data on foodborne infections

A total of 245 of the interviewed 1001 individuals (24.5% of all respondents) stated they had been suffering from diarrhoea in 2016 (Fig. 1). Our research showed that the occurrence of diarrhoeal symptoms was substantially higher for younger persons. Individuals aged 18–44 years represented 71.0% of those who had diarrhoea last year. Percentages of 45–65 years old or elder respondents were 22.9 and 6.1%, respectively. Information on the frequency of diarrhoea in case of children and young people under 18 years of age was not available, as these age groups were not included in the population survey.

As found, among those suffering from diarrhoeal symptoms, the ratio of men was higher. Percentages of women and men who had known the source of their infection was food, were 2.3 and 1.2, respectively. Regarding the number of confirmed cases, 4 women (0.4%) and 3 men (0.3%) were affected by confirmed salmonellosis and only 1 of them (0.1%) said she had very serious symptoms.

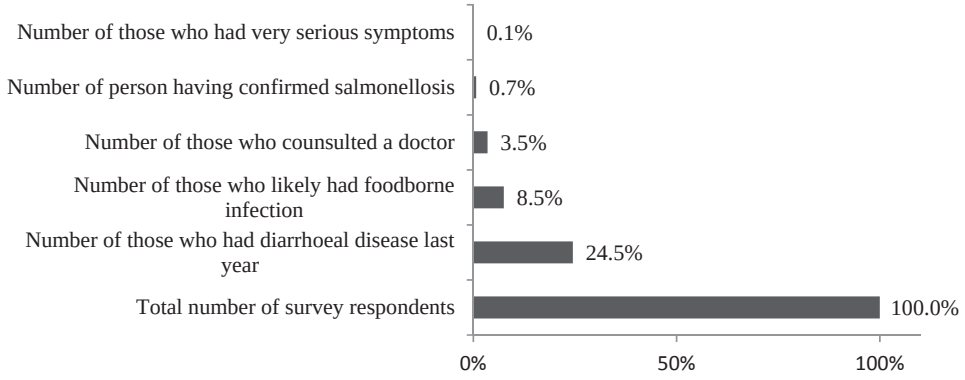

Fig. 1. Percentages of all survey respondents and those who were suffering from diarrhoeal disease (n=1001), %
Source: own data based on population survey conducted in 2017

Among those getting diarrhoeal symptoms (24.5% of total respondents), the number of persons who had symptoms after food consumption was 85 (34.7% of total diarrhoeal cases). As found, ratio of those who went to seek medical care when experiencing diarrhoea of any

kind or origin (including foodborne cases) was only 1 in 7 (35 out of 245 respondents). Number of registered and confirmed salmonellosis was 7, which represented only 8.2% of those who reported having health problems likely due to food consumption.

In case of those respondents who did not consult a doctor, the most frequent reason was that they had slighter symptoms and did not attach great importance to them (39.2%). Another frequent reason (20.3%) was that they did not want to spend time away from work (Fig. 2).

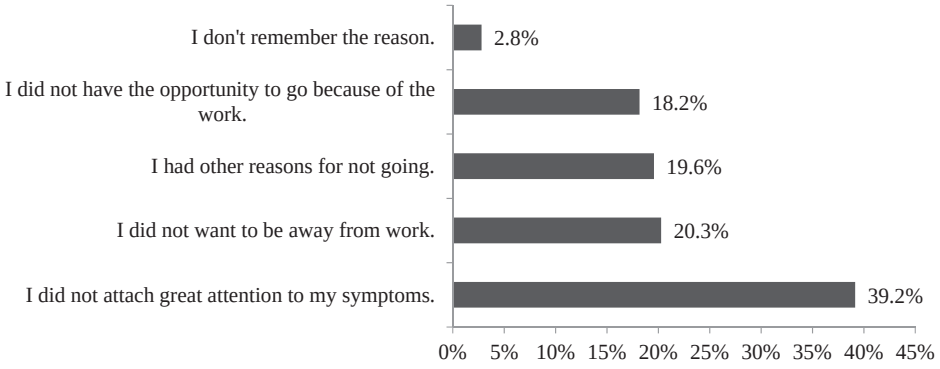

Fig. 2. Result of multiple-choice questions: most common causes for refusing to consult a doctor when having diarrhoeal symptoms, %
Source: own data based on population survey conducted in 2017

Regarding those respondents who were affected by any diarrhoeal symptoms or confirmed salmonellosis, in the ratio of those who went to seek a practitioner, gender differences were not significant at 95% confidence level ($P<0.05$). Thus, data was considered as a single set.

2.2. Estimated number of diarrhoeal foodborne cases

Results obtained from the Normal Approximation Method showed that the number of the persons with diarrhoeal symptoms fell between 218 and 272, which equals to 21.8% and 27.1% of the total number of respondents (Table 2). Number of those who had diarrhoeal symptoms likely due to food consumption fell between 70 and 100 (28.7 and 40.7%). In order to calculate the multiplier factors, the self-reported data were used.

2.3. Estimated number of salmonellosis

The aim of this research was to determine a country and pathogen-specific multiplier factor that helps the estimation of the total annual number of salmonellosis in Hungary including the latent part.

Table 2. Low and high estimates of diarrhoeal, foodborne cases based on survey results (median and 95%CI)

Total sample (N=1001)	$P_{self\text{-}reported}$	$P_{estimated}$*	
		Low estimate	High estimate
Proportion of those who had diarrhoeal disease last year	245	218	272
Proportion of those whose diarrhoea was likely foodborne	85	70	100
Proportion of those whose infection was likely foodborne and consulted a GP	35	26	44
Proportion of persons having confirmed salmonellosis**	7	–	–
Proportion of those who had very serious symptoms**	1	–	–

*: 95% CI, z=1.96, alfa=0.05
**: These cases were confirmed medically. Therefore, estimating the margin of error was not reasonable.
Source: own data based on population survey conducted in 2017

Due to lack of a detailed summary report on the ratio of infectious diseases in Hungary in 2016, we used the 2015 statistics as a basis for the calculation (EPINFO, 2016), which may result in some bias considering that the questions of the consumer survey referred to 2016. In 2015, a total number of 20 395 enteric infections was reported by the NCE, which equals to 0.2075% of the total population (a total number of 9 830 485 in 2016, according to HCSO (2016)). Our survey, however, indicated that 24.5% of the respondents experienced likely infection. Assuming that we might replace the missing 2016 data with the numbers of the published report of 2015 without compromising the reliability significantly, this indicates that only 0.84% of those people who felt ill supposedly due to any enteric illness appeared in the official statistics as a case. Of the survey respondents 8.5% thought their case was related to food consumption. As around 70% of food-related diseases are caused by viruses (Bresee et al., 2002; Vasickova et al., 2005), it was supposed that only 2.5% of the respondents was suffering from bacterial foodborne infections. Based on the ratio appearing in national statistics (NCE, 2016), it was also assumed that 37% of these persons – that is 0.96% – got foodborne *Salmonella* infections. Our survey showed that 0.7% of the cases were confirmed. In contrast, according to the national database (NCE, 2016), only 0.05% of the total population had confirmed salmonellosis. Based on these results, we may conclude that the number of confirmed cases could be 14 times more than the reported salmonellosis (Fig. 3). We can also conclude that approximately 18 times more individuals are suffering from *Salmonella* infection than it is assumed under the national and international epidemiological database. In other words, only 5.5% (1 out of 18) of those who felt ill due to foodborne infection turned to a doctor and was reported as a case to statistical data collection in regard of salmonellosis (Fig. 4).

Based on the survey results, 8.2% of the respondents had diarrhoeal symptoms probably due to food consumption and had medically confirmed salmonellosis. Note that only a part of these cases is registered by the NCE (Krisztalovics & Kasza, 2007; Kasza et al., 2011). At the same time, since information on sources of *Salmonella* infections is not available in the national database, it was assumed that the NCE-registered cases in the database are all foodborne.

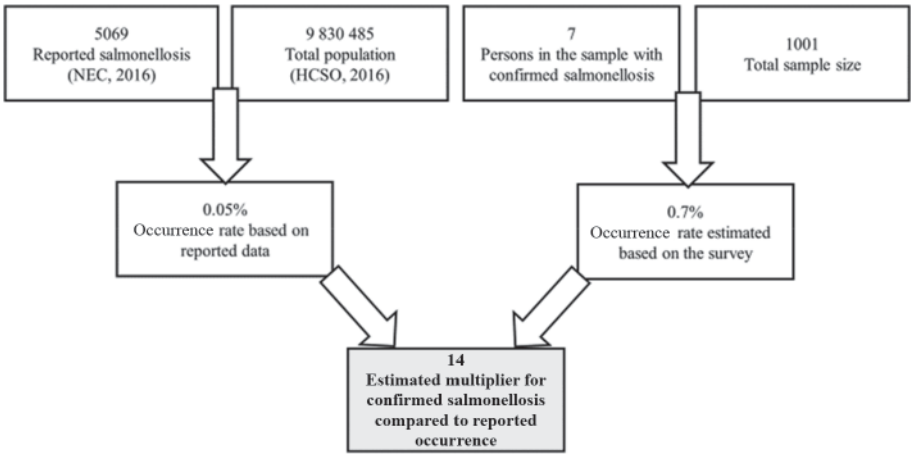

Fig. 3. Deriving multiplier for confirmed salmonellosis compared to reported cases
Source: own data based on population survey conducted in 2017

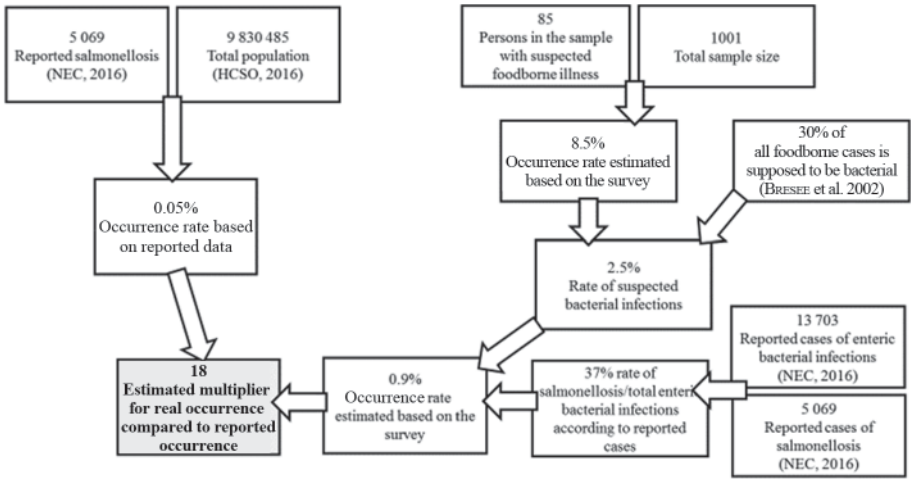

Fig. 4. Deriving multiplier for estimated occurrence of suspected foodborne salmonellosis compared to reported cases
Source: own data based on population survey conducted in 2017

The number of salmonellosis between 2012 and 2016 was 5336 in average annually (NCE, 2016). The minimum number of NCE-registered cases was 5069 (in 2015), while the maximum number of cases was 5867 (in 2012). In the light of the above, by using the multiplier factor for *Salmonella* infections defined earlier in this section, the estimated total (reported and latent) number of foodborne salmonellosis may range from 91 242 to 105 606 per year.

3. Conclusions

The results of the survey indicate that most of the individuals seek medical care only if their symptoms are serious (long lasting diarrhoea with high fever and abdominal pain). On the basis of the representative survey we were able to conclude that approximately 18 times more persons might be suffering from *Salmonella* infection per year compared to the number recorded in the national epidemiological database in Hungary. Compared with previous researches, this factor for salmonellosis in Hungary is higher than previously published by De Jong and Ekdahl, (2006), but lower than estimated by Havelaar and co-workers (2013), which was 66.7. It should be noted that the population under 18 years was not included in the survey. It should also be added that source of salmonellosis is not declared in the national statistics.

The calculation method presented in this paper can assist field-related research and policy making. However, it is important to remark that lack of previous studies related to foodborne salmonellosis in Hungary may limit the conformity of our model as a suitable means to provide predictive estimates on the true number of foodborne salmonellosis.

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