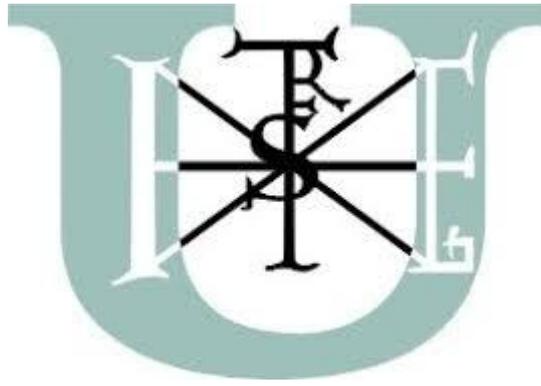


THESIS OF THE DOCTORAL DISSERTATION

Ágnes Gizella Gortva-Vajda

Budapest

2021



Szent István University

THESIS OF THE DOCTORAL DISSERTATION

**THE SOCIAL COST OF FOODBORNE SALMONELLOSIS IN
HUNGARY**

Ágnes Gizella Gortva-Vajda

Budapest

2021

Szent István University – Doctorial School of Food Sciences

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The candidate has fulfilled all the conditions prescribed by the doctoral school of Szent István University, the comments and suggestion at the thesis workshop were taken into consideration when revising the thesis, so the dissertation can be submitted to a public debate.

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1. INTRODUCTION AND OBJECTIVES

The Salmonellosis is considered to be one of the most significant food safety and public health problems, which are developed mostly due to the consumption of contaminated food and water, as well as poor hygiene. These diseases are caused by different *Salmonella* serotypes. Typical symptoms of the infection include diarrhea, vomiting, high fever, but mild fever and asymptomatic may also occur (Buzby et al. 1996).

In the last 10 years, the tendency of salmonellosis cases in the member states of the European Union has been stagnant (persistent not decreasing): while between 2010 and 2013, the number of confirmed cases had decreased from 101,052 to 82,694, by 2015 it rose again to over 90,000 (94,447 cases). A more significant decline was only seen in 2017, but then it was followed by another increase in 2018 (from 91,590 to 91,857 cases), causing some 3 billion Euros in damage to the member states of the international community (EFSA 2014, EFSA 2015, EFSA 2018).

Domestic data - with remarkable fluctuations - also confirm the increase in the incidence of salmonellosis: however, between the year of 2000 and 2009, the annual average number of illnesses was 8,767, compared with only 5,346 in subsequent years, but in 2018 the number of cases increased again. At that time, 13.1% more confirmed salmonellosis (4640 people) was registered compared to the previous year (4103 people) (KSH 2019).

Despite the importance of the topic, only a relatively small number of publications are available yet, that provide a substantiated estimate of the actual incidence of salmonellosis in each country and the magnitude of the losses involved. A similar calculation can also hardly be found in Hungary (Krisztalovics and Kasza, 2007). Based on these facts and the analysis of the international literature, it is certain that the actual number of cases significantly exceeds the reported cases.

The primary goal of my research was to provide a reliable estimate of the actual incidence of salmonellosis in relation to Hungary, as well as to draw a conclusion about the level of social costs based on the inventory of household, health care system and business losses. Based on the available domestic and international literature, as well as the experience gained during my research, I formulated the following hypotheses:

H1: In case of *Salmonella* infection, willingness to seek medical attention is affected by the severity of the symptoms (prolonged diarrhoea, abdominal pain etc.).

H2: The real number of domestic *Salmonella* infection cases is several times higher than registered in national and international databases.

H3: Consumers' risk aversion behaviour and willingness to pay for avoiding salmonellosis are significantly affected by certain demographic parameters.

H4: The cost of salmonellosis is primarily represents a burden on households and businesses' budgets. The social cost of this disease may reach several billion forints annually.

2. RESULTS

2.1. The true occurrence of foodborne salmonellosis in Hungary

A total of 245 of the interviewed 1001 (24.5% of all respondents) stated that had been suffering from diarrhoea in 2016. Our research showed that the occurrence of diarrhoeal symptoms was substantially higher for younger persons. Individuals aged 18-44 years presented 71% percent of those who had diarrhoea in 2016. Percentages of 45-65 years old or elder respondents were 22.9 and 6.1%, respectively. Among those suffering from diarrhoeal symptoms and having known the source of infection, the ratio of men was higher (2.3 vs. 1.25). Regarding the number of those seeking medical care (35 persons) and having confirmed infection (7 persons, 8.2% of 35), 1 case (0.1%) showed very serious symptoms.

As found, in case of those respondents who did not consult a doctor, the most frequent reason was that they had slighter symptoms to which they did not attach great importance (32.9%). Another frequent reason (20.3%) was that they did not want to spend time away from away from work.

To evaluate the strength of relationships between the willingness to seek medical care and the severity of symptoms, correlation analysis was used. Our results showed that the correlation was statistically significant between these variables ($r=-0,344$, $p=0,002$). (The direction of this relationship was negative because of the inverted scaling of the two variables.)

2.2. Estimated number of foodborne salmonellosis

Results obtained from the Normal Approximation Method showed that the ratio of cases with diarrhoeal symptoms fell between 21.8 and 27.1%. Ratio of those in the sample, whose disease was due to food consumption, was 8.5% (CI 95: 6.8-10.2%). To calculate a pathogen and country-specific multiplier factor for foodborne salmonellosis, the self-reported data and national epidemiological data were used.

Due to the lack of detailed summary report on the ratio of the infectious diseases in Hungary in 2016, we used the 2015 statistics as a basis of the calculation (EPINFO, 2016), which may results bias considering that the question of the consumer survey referred to 2016. In 2015, a total number of 20 395 enteric infectious was reported by the NCE which equals to 0.275% 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 number 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% (CI 95: 6.8-10.2%) thought their case was related to food consumption. As around 70% of food related diseases are caused by viruses, 1% are caused by parasites and the other are mainly due to bacterial infections (Bresee et al. 2002; Fonseca és Ravishankar, 2007), it was supposed that that only 2.5% (CI: 1.5%; 3.5%) 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 0.9% (CI: 0.3%; 1.5%) – got foodborne *Salmonella* infections.

Based on these results, we may conclude that approximately 18 times (CI 95%: 6; 30) 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 if salmonellosis. It should be mentioned that information on the sources of *Salmonella* infections is not available in the national database. In our work it was assumed that NCE-registered cases are foodborne.

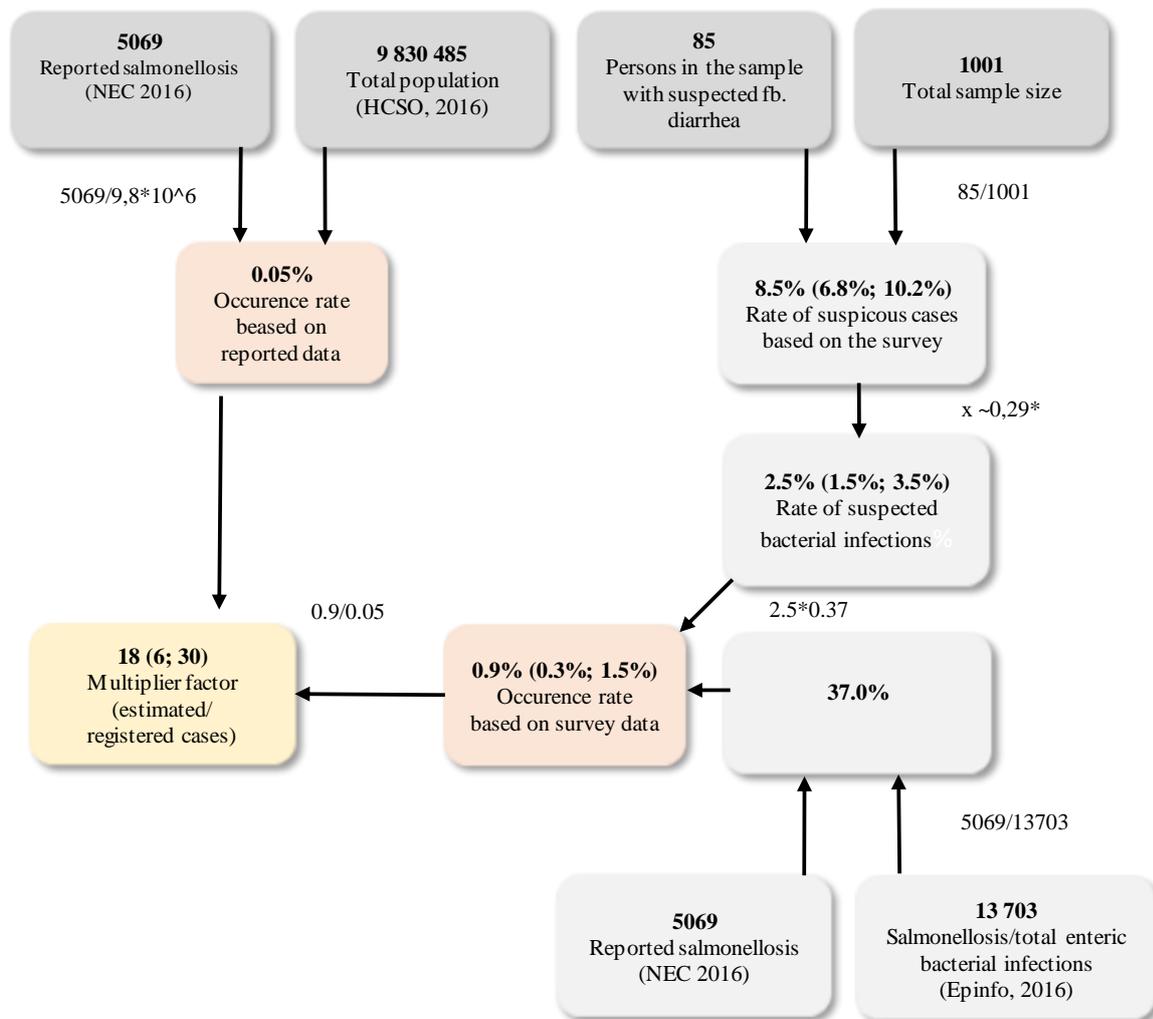


Fig. 1 Estimation of the occurrence of foodborne salmonellosis cases compared to the reported cases

*According to international literature, approximately 70% of these food-related diseases are caused by viruses, 1% is parasitic and the rest is bacterial (Breese et al. 2002, Fonseca and Ravishankar, 2007)

2.3. Consumers' willingness to pay for avoiding *Salmonella* infection

Number of persons interviewed was 1001, of which 464 participants gave relevant answer (out of 580 who gave any answer to this question) to our WTP question ('How much would you pay for avoiding a *Salmonella* infection? Salmonellosis is an infection, which generally causes diarrhoea, cramps, shivering and relatively high fever with a recovery time of 3-4 days.'). Our results show that mean of consumer WTP for avoiding *Salmonella* infection was 17 684 Ft. The value of median and mode were 5541 and 10.000 Ft, respectively.

As found, 73 persons totally rejected to pay for avoiding salmonellosis. By contrast, 1 person would have given even 500.000 Ft to prevent the illness. Those who did not accept the idea to pay often stated that "health is cannot be expressed in monetary value". However, 43.3% of the

respondents would have given to give 2500-10 000 Ft to avoid salmonellosis personally or in their family.

2.3.1. Main factors affecting Hungarian consumers' WTP

One-way ANOVA analysis showed that WTP was influenced by several demographic parameters. However, statistically significant results were obtained in case of the type of residence ($p=0.035$) and the regions ($p=0,044$). There were huge differences between the WTP of persons living in different regions: as found, lower WTP was mentioned by persons living in Central and Northern Hungary or Southern Great Plan. Considering the type of residence, those mentioning at least 50 000 Ft or higher WTP value, were originated from country towns or the capital city.

Furthermore, our analysis showed that previous (more severe and still evocable) illnesses also influenced consumers' WTP ($p=0,001$). Those who did not experience any diarrhoeal symptoms during the year preceding our survey, more often mentioned lower (less than 100 000 Ft) WTP values. It is important to notice that sex, the level of education and scientific qualification did not have effect on consumers' judgment. To see the presumed relationship of these variables with WTP, correlation analysis was used. Positive and negative weak correlation could also be found (sex: $r=0,144$, $p=0,004$; level of education and scientific qualification: $r=-0,167$, $p=0,004$). Correlation between the level of income and WTP could not be justified ($p=0,053$). Correlation between economic status and WTP was also not found ($p=0,054$), even if higher values were more often mentioned by persons with higher economic status.

2.3.2. Underlying factors that influence consumers' WTP

Beside demographic variables, we were also interested in the effect of other attributions. Thus, a factor analysis was also performed. This method is applied to reduce the number of correlated variables and turn them into factors, while making social-economic surveys easier to understand. Results from this analysis showed that our variables which significantly characterize our respondents can be described by 4 factors (explaining 67.15% of the total variance). The first factor was the 'complexity of household' (consisted of the number of children under the age of 15 and size of the household). The second group was called 'susceptibility' (it included the age group and disease in the previous year). The third and the fourth factors were the 'role in the family' and 'life style, attitude to life'. From the demographic parameters, the latter contained only the level of income.

2.4. Cost of illness at social level

2.4.1. Cost of foodborne salmonellosis in the health care system

Cost of the treatments and sequelaes

In 2016, approximately 12 000 persons sought medical care with suspicion of salmonellosis. Based on the information received from National (NEAK) and literature data (EMMI 2017), the cost of the medical treatment (such as GP treatment, hospitalization, patient transport, treatment of the sequelaes) of these cases reached 97.4 million Ft for the healthcare system.

2.4.2. Cost of salmonellosis in the households

Cost of medication

Based on our calculation, the cost of medication in case of salmonellosis was around 2592 Ft per person in 2016. The estimated number of total cases was 91 818 (CI 95: 30 606; 1530 30). Consequently, the total cost of medical treatment was at about 238.0 million Ft (CI 95: 79.3; 396.9) at household level during this year.

Loss of well-being

The welfare and well-being losses can be inferred by multiplying the „amount offered” in exchange for avoiding of a disease, and the estimated number of the cases. To calculate this amount of money, WTP analysis (Willingness to pay) was used. As mentioned, the average WTP was 17 684 Ft (the median and modus reached 5541 and 10 000 Ft, respectively). Considering the average value, the loss of well-being was estimated to be 1.62 billion Ft (CI 95: 541.2; 2.7 billion). Calculating with the median, the losses are also significant (508.8 million Ft, CI 95: 169.6; 847.9 million Ft).

Loss of income due to the disease of an employee or a child under the age of 12 in the family

The average gross wage per capita per was around 8773 Ft (263 200/30) in 2016. Considering the rate of employment (66.5%) and the fact that 51.3% of the persons with registered salmonellosis (5101) belonged to the economically active age groups, number of those taking sick-leave was estimated to be 1741. Calculating with 5-day absence from work, the reduced

level of the income per day (-30%) and the estimated number of diseased employees, the loss of income due to salmonellosis was estimated to be 22.9 million Ft ($1741 \times 8773 \times 5 \times 0.3$).

To take care of diseased children under the age of 12 (2353), 1651 persons (2353×0.665) might have to be stay at home. 1565 of them (2353×0.665) received state aid (3291 Ft per day per capita) for taking care of their children. However, 87 persons (130×0.665) lost 100% percent of their income when they were absent from work because of their children's disease. According to our calculation, the loss of income when children (0-11 years old) fall ill, was around 42.9 million Ft ($1565 \times 5 \times (8773 - 3291)$). When taking care of older children (12-14 years old), the loss reached at about 3.8 million Ft ($87 \times 5 \times 8773$). Based on our estimation, the total loss of income due to the salmonellosis of working family members (22.9 million Ft) and the illness of children (42.9 and 3.8 million Ft) was around 69.6 million Ft in 2016.

2.5. Loss of enterprises

2.5.1. Cost of sick-leave

In case of confirmed salmonellosis, the amount was sick leave was 70% of the gross salary per day (263 200/30, that was 8773). Consequently, the total estimated value of sick leave that employers paid was around 53.3 million Ft ($1741 \times 8773 \times 5 \times 0.7$).

2.5.2. Productivity losses

The decrease in productivity losses may also occur when children fall ill but their parents have to go to work (and they deal with children after work). Assumed that 66.5% of the infected persons (or their parents) was employed and 3392 of them were absent from work (1741 due their own salmonellosis, 1651 for taking care of their children) the productivity decreased in 57 667 cases ($(5101 \times 18) - 3392$, that is 61 059 - 3392). In those cases where salmonellosis was confirmed, productivity losses were not taken into consideration. As the Hungarian GDP per capita per day was estimated to be 38 186 Ft and recovery from salmonellosis took generally 5 days, the productivity losses of employers could reach approximately 11.0 billion Ft ($38\ 186 \times 57\ 667$) (CI 95: 3.2 billion; 18.8 billion Ft).

2.6. Estimated total cost of foodborne salmonellosis at social level

By summarizing the partial results of the calculations described above, we can estimate the real social cost of salmonellosis for 2016. It should be noted that this calculation still does not include

certain additional losses that may have occurred indirectly in each sector (such as product recall costs, damage due to loss of market reputation, cost of additional tasks for official food chain supervision). The estimated total cost of food-borne salmonellosis in the health care system, the economic sector and households is calculated at an average WTP (17,684 Ft) to 13.1 billion Ft (4.1 billion Ft; 22.1 billion Ft), while WTP calculated at its median value (5,541 Ft) to 12.0 billion Ft (3.7 billion Ft, 20.2 billion Ft). According to both approximation, the costs are mainly borne by businesses and households due to redundancies and reduced working capacity. Calculated with a higher welfare loss (17,684 Ft), households bear 14.8% of the losses, enterprises 84.5%, and counting with a lower welfare loss, the rates of the losses would be 6.8% and 92.4%.

2.7. NEW SCIENTIFIC RESULTS

1. My research revealed factors that influence the willingness to seek medical care in case of diarrhoeal diseases. It has been found that severity of the symptoms has a significant effect on consulting a general practitioner. In case of rather severe cases, the probability of seeking medical care is higher. It was also found that the long-term absence from work has also a significant but negative effect on seeking medical care.
2. Based on the results of population survey with 1001 participants, I found that the actual incidence of salmonellosis is almost 18 (95% CI: 6, 30) times higher than the cases registered in the Hungarian epidemiological database. This is lower, compared to a previous national study and an international research on the Hungarian estimated incidence (De Knecht et al. 2014, Krisztalovics and Kasza, 2007) but higher compared to the result of De Jong and Ekdahl, 2006. The difference in the results may have been due to the fact that in the national and international literature the methodology for establishing country-specific and pathogen-specific multipliers differs significantly.
3. Based on the results of my research, it can also be stated that the willingness of domestic consumers to pay for a voiding salmonellosis is significantly influenced by the severity of their previous (past year) diarrheal diseases and place of residence (region and type of residence). Relationships between WTP and sex, level of education or scientific background were also significant but weak. As to the other demographic parameters, I was not able to justify the assumption that the level of income and the economic status significantly influence consumers' WTP.

4. Based on my calculations, the annual social cost is at around 13.1 billion (4.1; 22.1 billion HUF) in Hungary. I found that significant proportion of the costs is born by the businesses due to reduced ability to work and productivity losses, respectively (11.1 billion Ft (CI 95: 3,3 billion; 18.8 billion). The losses of households are also significant (1.9 billion Ft, CI 95: 690.2; 3.2 billion Ft).

3. CONCLUSIONS AND RECOMENDATIONS

In more developed countries a large number of studies has been published on the impact of various foodborne diseases, including the social-economic aspects of salmonellosis. In Hungary, similar studies – which dealt with the costs of salmonellosis at different level – was not available so far. Based on the available literature, as well as the experience gained during my research, I formulated several hypotheses that may help to assess the real cost of foodborne salmonellosis and allow to analysis the cost-benefit of various prevention programmes. The conclusions drown by the results are described below.

My research revealed factors that influence the willingness to seek medical care in case of diarrhoeal diseases. It has been found that severity of the symptoms has a significant effect on consulting a general practitioner. In case of rather severe cases, the probability of seeking medical care is higher. When having only slight symptoms, people do not attach importance to the disease. It was also found that the long-term absence from work has a significant but negative effect on seeking medical care. The attitude of seeking medical care is indicative and shows that not only asymptomatic but symptomatic cases can often be hidden before the reporting system.

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Based on the results of my research, it can also be stated that the willingness of domestic consumers to pay for a voiding salmonellosis is significantly influenced by the severity of their previous (past year) diarrheal diseases and place of residence (region and type of residence). Relationships between WTP and sex, level of education or scientific background were also significant but weak. As to the other demographic parameters, I was not able to justify the assumption that the level of income and the economic status significantly influence consumers' WTP. The 'complexity of households' and 'susceptibility proved to be the primarily important underlying factors in WTP responses.

Based on my calculations, the annual social cost is at around 13.1 billion (4.1; 22.1 billion Ft) in Hungary. I found that significant proportion of the costs is primarily born by the businesses due to reduced ability to work and productivity losses, respectively (11.1 billion Ft (CI 95: 3.3

billion; 18.8 billion). The losses of households are also significant (1.9 billion Ft, CI 95: 690.2; 3.2 billion Ft).

In the light of my research results, it can be estimated that the total social cost of foodborne salmonellosis in Hungary is very high. Therefore, in a later study it would be worthwhile to compare the tools and costs of international prevention programmes and compare their impact on the number of cases. This diverse international experience would be helpful in order to develop further reduction measures, taking into consideration domestic conditions. It would be important to increase consumer awareness, as a significant proportion of food-borne diseases occur in households. In terms of the total burden of food-borne salmonellosis, the cost of a complex national programme covering the entire food chain would be lower than the social costs that would result from the absence of such a programme. However, this analysis not in the scope of this present dissertation.

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