



Development of the CoHa Extended 24-hour Dietary Recall Method for Microbiological Risk Assessment

Unhygienic food-handling practices are thought to play a significant role in foodborne illnesses. In this study, the 24-hour dietary recall method was modified to include information related to microbiological hazards in foods. Questions about temperature control, storage time, cross-contamination, and food preparation were included for all highly perishable food items. A small-scale survey was carried out with 42 voluntary elderly persons as a test population. The dynamic nature of microbiological hazards presents challenges for food consumption data needed in quantitative microbiological risk assessment. The concentration of microbes may vary in foods via different mechanisms, including growth during storage, death due to inactivation steps, and transfer from one food item to other. The food consumption data usually used in risk assessment often lack information on food handling by consumers.

Useful data for risk assessment were obtained about the consumption, storage and cooking practices of the respondents, even though self-reported behavior may

contain inaccuracies. This type of information can be used in both quantitative and qualitative risk assessments in order to evaluate the hazards to which consumers are exposed.

INTRODUCTION

Information on food consumption is an essential part of exposure assessment. Commonly, national food surveys are used as a source of data for risk assessment. However, national food surveys are usually conducted for nutritional study purposes and may thus be inapplicable for microbiological risk assessment (MRA). They lack vital information concerning the growth, inactivation, and cross-contamination of microbiological hazards. From the perspective of microbiological exposure assessment, information on how the food items have been handled and stored would be needed (9). One of the most accurate methods of collecting food consumption data on the population level, the 24-hour recall method (4, 20, 23), is also recommended by the European Food Safety Authority (EFSA) (11). The advantages of the 24-hour recall method include a low respondent burden and high accuracy, since the

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interviewer can ask the interviewee to specify the food eaten. It is also a relatively simple and quick method and therefore applicable for use with a large number of respondents (44).

Although information on hygiene behavior in consumer kitchens can be collected by using behavioral studies, the utilization of these studies is not without problems. Behavioral studies are often qualitative and thus are not applicable to quantitative exposure assessment. Quantitative studies on kitchen hygiene behavior exist, but have often been carried out in controlled environments and may therefore contain insufficient information (14, 28). Moreover, food consumption and preparation practices vary between countries, regions, and over time as a result of cultural differences (22). Therefore, country-specific, constantly updated information is needed.

Assessing the risks caused by consumer behavior is especially needed for quantitative MRA (QMRA), since a considerable proportion of food poisoning cases originate in households (10, 32, 38, 43), because of mishandling of food during preparation (32, 43). In the endpoint of a QMRA, the effect of the consumer on exposure is assessed through consumer phase modelling (CPM). CPM describes the time period between the purchase of a food product and its consumption, thus describing the exposure at the time of eating. Although CPM could provide important information on consumer exposure, the complexity of different handling and storage practices and lack of reliable quantitative data make the construction of a CPM difficult (27).

Most food consumption datasets include information on citizens of working age, and information on vulnerable groups is scarce. In Finland, people over 75 years old have typically been excluded from national food consumption surveys (17, 31). Food consumption in Finland has been investigated through Findiet surveys, which are repeated every five years by the National Institute for Health and Welfare (THL) as a part of the National FINRISK Study monitoring chronic disease risk factors (40). The age of the interviewees ranges from 25 to 74 years, leaving younger and older citizens unrepresented. However, the aging of the population is of growing concern in Western countries, including Finland. At present, there are over a million senior citizens (at least 65 years) in Finland, comprising 20% of the population and making the elderly a significant subpopulation. Furthermore, the share of the elderly in the population is rapidly growing (29), and is estimated by Elo et al. (8) to increase in Finland from 15% in 2000 to 25% in 2050.

A new, extended 24-hour recall method named CoHa (consumption and handling) was developed, taking (Q) MRA needs into account. In this study, the CoHa method was tested by interviewing volunteers over 65 years old and examining their food consumption and hygiene practices. Elderly people were chosen as a target group to represent a group that is vulnerable to foodborne diseases because of the likelihood of a weakened immune system and underlying

diseases (37). The CoHa method can be used to obtain information on food hygiene behavior in addition to food consumption, and this information could be used for MRAs, for example, through modeling bacterial growth by exploiting information on temperature, time, and other factors. To our knowledge, information on only isolated hygienic practices related to a narrow range of food products has so far been collected in Finland (25, 30).

MATERIALS AND METHODS

No need for an ethical review was presumed, on the basis of The Finnish Advisory Board on Research Integrity (TENK) guidelines (39).

A questionnaire was developed to be used as an interview template. The questionnaire was based on 24-hour dietary recall, to which questions on food hygiene behavior were added. The questions were based on a guidance document on microbiological hazards from the Food and Agriculture Organization (FAO) and World Health Organization (WHO) of the United Nations (12). Based on this guidance, questions about temperature management (storage and cooling times and temperatures), cross-contamination (cleaning of utensils), and preparation of food were included. As the length of the interview should be kept short to reduce respondent burden and to minimize the costs (44), only the factors thought to be most important were included in the questionnaire. Furthermore, questions with anticipated socially acceptable answers were avoided.

The questionnaire was pilot tested with 19 participants among the employees of the Helsinki office of Finnish Food Safety Authority Evira. The pilot interviews were conducted during March and April 2016 at the facilities of Evira. Some minor modifications were made to the questionnaire based on the results of the pilot test. At the end of the pilot test, the interviewees were asked if they considered the interview too long.

Elderly persons (at least 65 years old) living independently in their own households, mainly in urban areas, were recruited on a voluntary basis for the interviews in the region of southern Finland. The participants were recruited by convenience sampling from applicants to the Sarcopenia Physical Frailty in older people: multi-component Treatment strategies study (1), and because not enough participants were obtained in this way, recruiting was also performed in the circle of acquaintances of the researchers. A total of 42 volunteers, 14 men and 28 women, participated in the study. Their ages ranged from 65 to 89 years, the average being 77 years and the median 76 years. Among the interviewees, 57% were more than 75 years old. The educational level of the respondents ranged from primary education (17%) and secondary education (10%) to tertiary education (74%). The participants did not know the content of the interview in advance. They were informed that the interview concerned “the usage and handling of food.”

The same interviewer carried out all the CoHa interviews. All but two interviews were carried out in the homes of participants. A picture booklet with pictures of three different portion sizes for each dish was used to evaluate the portion size consumed (41). Standard portion sizes from the Fineli database (35) were used for foods that were not included in the booklet, and household volume measures were used for foods that were difficult to evaluate by other means (such as milk in coffee/tea). Participants were able to check product information directly from the food package during the interview if the package was still available. In questions related to food microbiology, emphasis was placed on vegetables, meat and meat products, fish and fish products, and milk, since these are known to cause most of the cases of food poisoning in Finland (32).

Interviews were conducted between Monday and Friday, thus excluding Friday and Saturday from the recorded days. The distribution of the recorded weekdays was quite even; Sunday and Monday comprised 24% each, Wednesday and Thursday 17% each, and Tuesday 18% each of the recorded days. Participants were asked to recall their food consumption during the previous 24 hours. All data were collected between June and November 2016. Medicines and food supplements were excluded from the CoHa study for ease of handling of results. For background information, the

questions about the sex, age, level of education, and weight (self-reported) of the participants were asked. In addition, participants were asked how kitchen equipment was washed in their household and whether the temperature of the refrigerator had been measured with a thermometer. If the answer was yes, the temperature of the refrigerator reported by the participant was recorded. Questions about possible illnesses affecting immunity were not asked, as this would be considered unethical. No personal data was solicited or recorded. The length of the interview was measured to assess the respondent burden.

Food items were classified as perishable and unperishable, based on their water activity. The questionnaire was limited to food items with a water activity (a_w) value greater than 0.8, since pathogens can typically grow at (a_w) levels of 0.95-1, and some molds in a_w values of over 0.8 (7). Participants were asked to define food items as accurately as possible, including the brand of the food item. Interviews followed the structure presented in Fig. 1.

Food intake data were classified according to the food classification system of the Finnish national food composition database, Fineli (35). In further analyses, food items were classified according to their instructed storage temperature (refrigerated or not), whether they were highly perishable and whether the food item had a best-before or

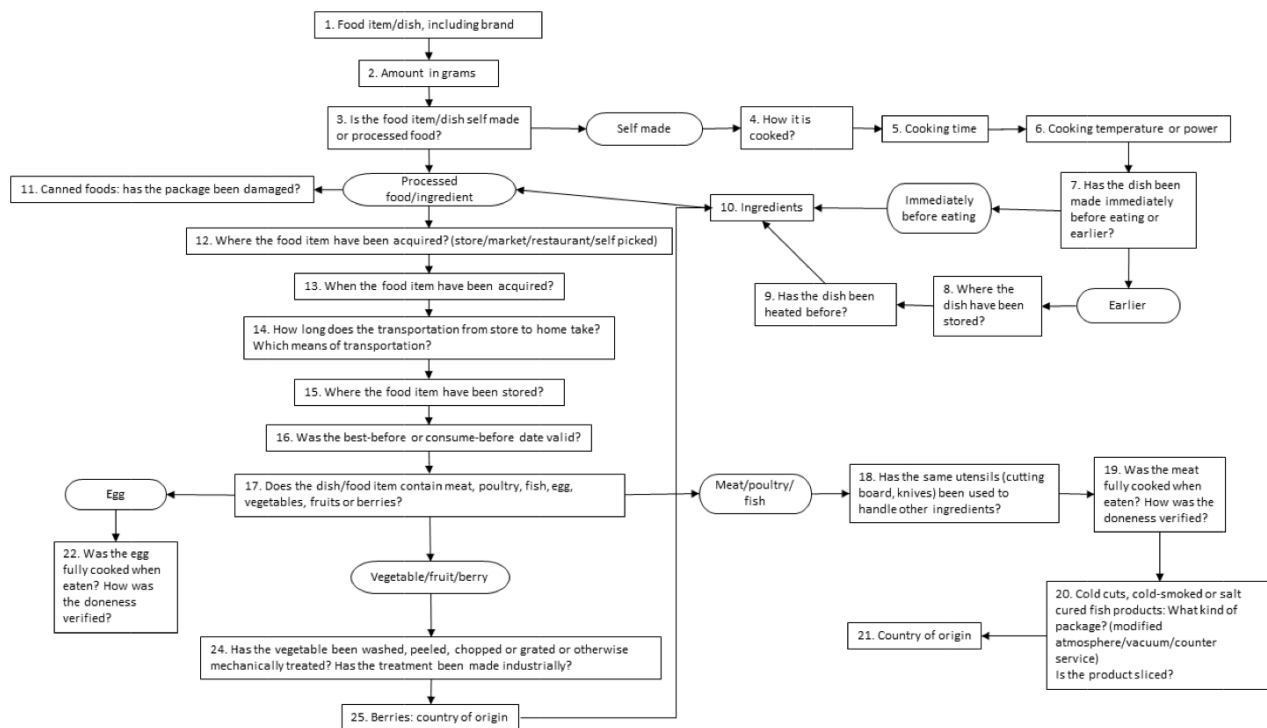


Figure 1. The course of the interview. 4, 5, 8, and 15: Multiple answers are possible to create a time-temperature interval. 8 and 15: For example, refrigerator, freezer, and room temperature.

consume-before date. IBM SPSS Statistics 24 was used to calculate standard deviations for food consumption data and to test for normality (Kolmogorov-Smirnov test and Shapiro-Wilk test). The unequal variance *t*-test for unpaired samples was used to test for differences in food consumption between the participants of the CoHa study and the elderly in the Findiet 2012 study (16), and between the participants of the CoHa study and the working-age groups in the Findiet 2012 study (16). The comparisons were made for each food group separately. For example, the *t*-test was calculated between men who had been eating cereals in the CoHa study (mean 353 g/day, sd 232 g/day) and elderly men who had been eating cereals and cereal products in the Findiet 2012 (16) study (mean 305 g/day, sd 164 g/day). The answer rate (the proportion of respondents providing an answer other than “not known”) was calculated for each question with 95% confidence intervals (95% CI), using Microsoft Excel 2013 software.

As an example of method utilization, the effect of consumer behavior on levels of *Salmonella* spp. in meat (food category “meat total”) was demonstrated. The initial concentration of *Salmonella* spp. in fresh meat was set to 1 or 40 CFU/g, representing the lower and upper concentrations found in these products (16). Cross-contamination was set to a concentration of 1 CFU/g for cooked products, as the transfer rate of *Salmonella* from surfaces to meat is low (24). Growth during transportation and storage was modeled by use of the online ComBase Predictor growth model for *Salmonella* spp. (2). The actual recorded time-temperature intervals for each ingredient were utilized, including short storage periods at room temperature, for example during meal preparation. As the purpose of this example was to demonstrate the possibilities for using the data, rather than to provide a realistic consumer phase model, heat transfer was assumed infinite, i.e., it was assumed that the temperature of the food item changed stepwise as the temperature of the environment changed. Intrinsic factors of pH and a_w for fresh and cooked meat were set to 6.0 and 0.99, respectively (13, 19). A lag phase was not included in the estimation. The temperature range of the ComBase Predictor model for *Salmonella* spp. begins from 7°C. No growth was assumed at temperatures below 5°C (26). To calculate the exposure, each predicted concentration was multiplied by the actual recorded portion consumed.

RESULTS

In the CoHa study, 439 different food codes and 1,525 food items were recorded. Mean intakes and the proportion of users of different food categories are presented in *Tables 1 and 2*. To check the validity of the new method and to examine differences between age groups, the results were compared to information on elderly (65–74 years) and working-age (25–64 years) consumers, available from the Findiet 2012 study (17). Among men in the CoHa study, no statistically significant differences were found in comparison to

either the elderly or working-age group of the Findiet study (*Tables 1 and 2*). Among women, statistically significant differences in consumed portions of different food categories were found in the food categories of alcoholic beverages, egg dishes, fish dishes, and potatoes when compared to the elderly group, and the food categories egg dishes, fish dishes, milk dishes, and potatoes when compared to the working-age group, of the Findiet study. For men, only a small range of food categories was analyzed because of scarcity of data.

Respondent burden was assessed by measuring the length of the interview. The average interview took 62 minutes (median 58 minutes), ranging from 30 minutes to about 100 minutes. In the pilot survey, in which the respondents were working-age, the average length of the interview was 51 minutes, ranging from 15 minutes to somewhat more than an hour. The respondents of the pilot survey did not consider the interview too long or tiresome, except for one respondent.

The answer rates (i.e., answers other than “not known”) for each question are presented in *Fig. 2*. The responses provide information not only on knowledge and practices, but also on the level of uncertainty. The highest answer rates were for questions related to storage practices. In about 80% of the cases, the interviewee knew about the storage of the food item in question. The place of purchase and transportation from there to home, as well as cooking practices, were also well known (in about 70% of the cases). The packaging of meat products (vacuum/modified atmosphere, etc.) was known in about 60% of cases. The country of origin (only asked for berries and animal-based products) and best-before dates were not inspected from the packaging information or not remembered by most of the interviewees. Some product characteristics were not determined with additional questions, but were instead included in the classification of the foods, examples of such characteristics include the slicing of cold cuts.

The growth of *Salmonella* spp. in meat and meat dishes during storage was used as an example to demonstrate how the data obtained in this survey could be used in risk assessment. A total of 65 food items (19 ingredients and 46 dishes) belonging to the food category “meat total” had information on both the storage period and temperature. Storage periods varied from less than one day to up to one week. The average refrigerator temperature was 6°C, ranging from 3 to 9°C. The concentrations of *Salmonella* spp. varied on average from 20 (1 CFU/g scenario) to 800 (40 CFU/g scenario) CFU/g (median 2 to 90 CFU/g). The highest predicted concentration was 6,500 CFU/g, with an initial concentration 40 CFU/g. Only a small number of respondents could provide information on both the cooking time and temperature. Thus, quantitatively assessing the inactivation rate of *Salmonella* spp. in food was difficult. However, if cross-contamination with 1 CFU/g after cooking was assumed (even though no such occasions

TABLE 1. Mean amounts of different food categories consumed by respondents of the CoHa study (age 65–87), and comparison with the corresponding food categories in the latest Findiet study for the elderly age group (age 65–74) (17). Mean amounts are presented for consumers only

Food class	Men							Women							
	CoHa study, age 65–87 (n = 14)			Findiet study, age 65–74 (n = 210)				P-value	CoHa study, age 66–89 (n = 28)			Findiet study, age 65–74 (n = 203)			P-value
	Proportion of consumers, %	Mean amount (g)	Sd	Proportion of consumers %	Mean amount (g)	Sd	Proportion of consumers, %		Mean amount (g)	Sd	Proportion of consumers %	Mean amount (g)	Sd		
Alcoholic beverages	14	478	257	31	377	430	*	14	305	230	15	196	153	< 0.05	
Beverages	100	993	592	100	1130	532	*	100	1227	874	100	1242	518	*	
Cereals and cereal products	100	353	232	100	348	200	> 0.05	100	305	164	99	279	141	> 0.05	
Egg dishes	14	78	32	19	64	51	*	18	92	72	21	45	31	< 0.05	
Fat and fat products	86	38	44	81	37	28	*	75	28	21	78	24	19	*	
Fish dishes	43	147	95	49	128	94	> 0.05	32	204	176	42	110	100	< 0.05	
Fruit and berry dishes	79	423	377	89	301	213	*	96	320	241	98	294	197	*	
Meat dishes	93	180	155	99	234	145	> 0.05	86	197	131	92	163	107	> 0.05	
Milk dishes	93	457	347	97	415	278	*	96	297	169	97	367	214	> 0.05	
Miscellaneous	36	28	17	42	15	17	*	25	39	9	43	20	31	*	
Potatoes	29	181	94	63	139	85	*	25	141	70	57	81	52	< 0.05	
Sugar and confectionery	71	17	15	65	20	26	*	54	33	40	62	14	16	*	
Vegetable dishes	86	224	154	82	177	147	> 0.05	93	200	160	95	178	132	*	

*Sample size not sufficient or data not normally distributed to allow *t*-test to be performed.

were recorded in this study), the average concentration would be 100 CFU/g (median 10 CFU/g, ranging from 1 to 3,400 CFU/g). The corresponding doses were on average 3,700 CFU (median 400 CFU, ranging from 15 to 102,000 CFU).

DISCUSSION

The advantages of conducting a full QMRA, including a model for the consumer phase, have been widely recognized (12). However, assessing the risk associated with consumer behavior has proven to be difficult, since consumers cannot be controlled by laws or regulations. The CoHa study attempted to improve the means of obtaining information on consumer behavior by modifying the 24-hour recall method to acquire more precise data for (Q)MRA.

The advantage of the CoHa method is that it obtains quantitative data on the amounts of foods eaten combined

with quantitative data on storage times and the handling of food. Data obtained using the CoHa method can be utilized in risk assessments to determine hazards related to consumer behavior in multiple ways. First, data on storage times and temperatures can be utilized in estimating the levels of pathogens at the time of consumption, through growth modeling. Details on a food product (such as the salt content) and packaging (such as modified atmosphere packaging) can also be utilized in growth modeling. Second, microorganisms may cause cross-contamination through direct contact between different foods or indirectly, through kitchen surfaces, utensils, or hands. The CoHa method provides a means to assess the frequency of these types of mishandlings. In addition, the concentration of microorganisms can be decreased through heating or certain preservation methods. The use of storage

TABLE 2. Mean amounts of different food categories consumed by respondents of the CoHa study (age 65–87), and comparison with the corresponding food categories in the latest Findiet study for the working-aged age group (age 25–64) (17). Mean amounts are presented for consumers only

Food class	Men							Women						
	CoHa study, age 65–87 (n = 14)			Findiet study, age 25–64 (n = 585)			P-value	CoHa study, age 66–89 (n = 28)			Findiet study, age 25–64 (n = 710)			P-value
	Proportion of consumers %	Mean amount (g)	Sd	Proportion of consumers %	Mean amount (g)	Sd		Proportion of consumers %	Mean amount (g)	Sd	Proportion of consumers %	Mean amount (g)	Sd	
Alcoholic beverages	14	478	257	37	499	519	*	14	305	230	21	298	405	> 0.05
Beverages	100	993	592	100	1538	718	*	100	1227	874	100	1608	734	*
Cereals and cereal products	100	353	232	98	337	195	> 0.05	100	305	164	99	269	142	> 0.05
Egg dishes	14	78	32	25	63	52	*	18	92	72	23	50	37	< 0.05
Fat and fat products	86	38	44	84	39	33	*	75	28	21	84	28	23	*
Fish dishes	43	147	95	39	127	116	> 0.05	32	204	176	42	95	72	< 0.05
Fruit and berry dishes	79	423	377	81	267	234	*	96	320	241	92	272	221	*
Meat dishes	93	180	155	96	268	158	> 0.05	86	197	131	93	175	115	> 0.05
Milk dishes	93	457	347	98	482	371	*	96	297	169	99	408	284	< 0.05
Miscellaneous	36	28	17	58	27	33	*	25	39	9	55	32	59	*
Potatoes	29	181	94	58	129	72	*	25	141	70	49	90	56	< 0.05
Sugar and confectionery	71	17	15	75	29	33	*	54	33	40	81	25	32	*
Vegetable dishes	86	224	154	85	174	151	> 0.05	93	200	160	95	183	142	*

*Sample size not sufficient or data not normally distributed to allow *t*-test to be performed.

information was demonstrated in the example of *Salmonella* spp. in meat. This showed the importance of including consumer behavior in risk assessment, as the initially low levels of the pathogen, unlikely to be capable of causing disease, multiplied significantly.

Some attempts have been made to construct consumer phase models for risk assessment purposes. A food frequency questionnaire formatting of the questions is more common than 24-hour recall (5, 6, 15, 20, 36). However, for acute exposure assessment, 24-hour recall is often more suitable than a frequency questionnaire (4, 20, 23). Most of these studies have had a relatively narrow focus, such as on a single or a few food ingredients, such as vegetables (18, 20), chicken (3, 15, 36), and RTE foods (33). In contrast, the CoHa method gathers information on all the foods capable of maintaining microbial growth. With the very narrow focus

of the study, some risky behavior might be unobserved and the risk would thus appear smaller than it is in reality. Some studies have also examined a wider range of foods, similarly to the CoHa study (5).

Based on the answer rates, it appears that the CoHa method is best suited for obtaining information on storage times and temperatures. Most participants could recall when they had bought the food item and knew where it had been stored. However, in some cases, the participants had not acquired the food items themselves, and the information therefore could not be obtained. Most participants could also provide detailed information on the product characteristics (for example, whether cold cuts of meat had been sliced industrially). In contrast, most participants had not looked at the packaging labels and were thus unable to give detailed information on the country of origin or best-before date.

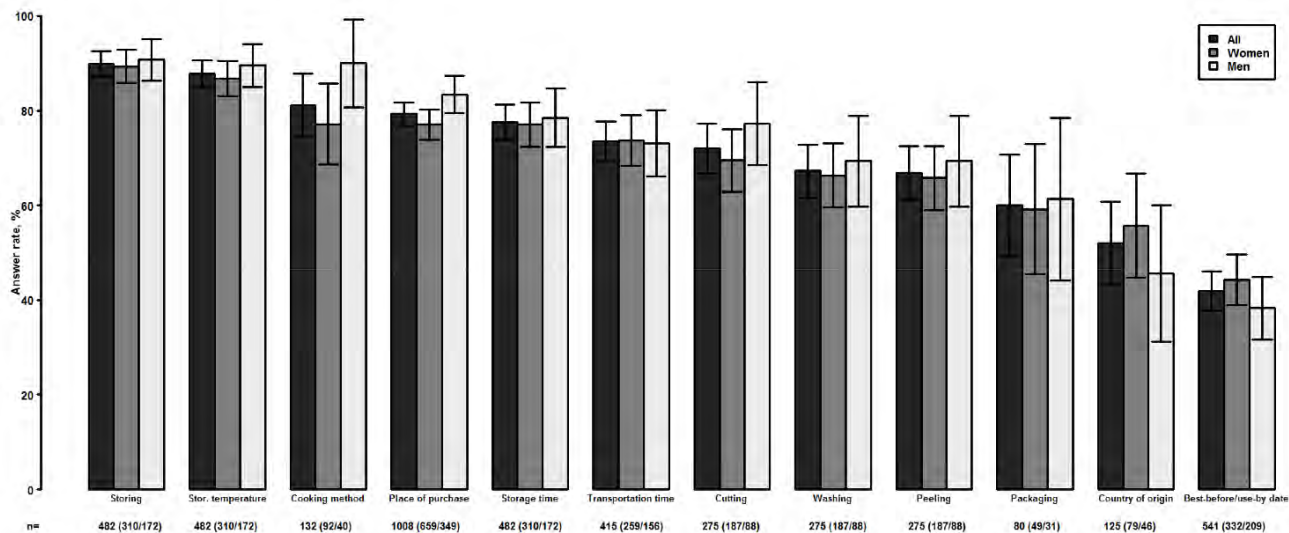


Figure 2. The proportion of participants (%), with 95% CI, able to provide an answer for each question related to food storage, cooking practices, temperature, or product characteristics, separated according to gender.

No major differences were found between genders when confidence intervals were taken into account. The questions included in the CoHa survey must be carefully assessed, as a large number of questions increases the respondent burden, and if consumers cannot give explicit answers, the usefulness of these questions is limited.

In the CoHa study, home interviews were preferred because they allowed for checking of missing information, even though the interview can also be carried out in other environments. All the interviews described in this article except two were conducted in the participants' homes. This allowed participants to check information on food items that could otherwise have been forgotten, such as best-before dates or the manufacturer. Best-before dates or consume-before dates and other information could often be verified, since the participants showed the food package to the interviewer. Furthermore, for elderly persons, it might be difficult to travel away from home to be interviewed. Thus, for many elderly persons, it was an easier option that the interviewer came to them, which may have increased the participation rate. However, some respondents felt uncomfortable allowing a stranger into their homes. This must be taken into account when arranging the interviews so that an alternative place for the interview can be provided.

Questionnaires have been criticized for producing biased data in behavioral studies (34). Interview methods rely on the participant's memory, which may cause inaccuracies, especially in elderly persons (42). The advantage of the 24-hour recall method is that it is easier to remember the events of the previous day than those of a longer time ago (4). However, some of this advantage may be lost by asking for details about

food items that might have been purchased up to months ago. Also, previous studies have found that observational studies provide a more realistic view of consumer behavior than surveys (21). In the CoHa study, the questions were formulated neutrally to avoid biased answers. Furthermore, some information can be obtained only through self-reporting.

The present CoHa study was carried out with a small and unrepresentative sample. A larger and representative study should be carried out for risk assessment purposes. With better representativeness, the CoHa method could be used to collect data on consumer behavior related to risk assessment with a moderate time span and respondent burden. The advantage of the CoHa method is that as the questions are open (i.e., the foods that are focused upon are not predetermined), it is possible to note hazardous behavior that might otherwise be undetected. In addition, the CoHa method provides information on both consumption and behavior for multiple food groups. This allows the results to be used cost efficiently for multiple purposes. The data obtained in a CoHa study can be very detailed and accurate, which is preferred in (Q)MRA. The information obtained with the CoHa method would also be of use in food risk assessment concerning chemical hazards or in nutritional studies, which are currently facing similar difficulties with data quality to MRA. However, the CoHa method is laborious to carry out with a large number of respondents. Therefore, the method would be best suited to studying vulnerable groups in order to obtain more detailed data on their possibly hazardous behavior, particularly if their food consumption or behavior is assumed to differ from that of the overall population.

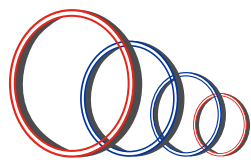
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DEADLINES:

2 October 2018 – Symposia and Roundtables

15 January 2019 – Technical and Poster Abstract Submissions

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