Validation of questions designed for investigation of gastroenteritis

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Declarations of interest: none.

Abstract

Background: Health departments routinely investigate cases of gastroenteritis through interviews to determine the source of infection. However, validation studies of dietary questionnaires typically focus on quantities consumed and don't assess questions designed to identify sources of foodborne illness. We aimed to assess the accuracy and reliability of information collected by surveys of food history recall for gastroenteritis investigations.

Methods: A questionnaire was developed to investigate the sources of foodborne gastroenteritis in Australia, with questions on food exposures selected for validation. Fifty-five participants photographed all foods consumed and food receipts obtained during a seven-day observation period. These photographs were uploaded to an online survey or emailed to the researcher. Participants were contacted 14 days later for a telephone interview about foods consumed in the 7-day period. Questionnaire responses were compared to uploaded photographs. Kappa statistics (κ) and 95% confidence intervals were calculated. Sixty-two questions were assessed, including those targeting foods considered high-risk for foodborne gastroenteritis. Potential risk factors covered by these questions included: meats (poultry, beef, pork, and deli meats), the state of poultry purchased (raw versus precooked), and the number of meals eaten outside of the home.

Results: Several questions targeting high-risk foods were found to have substantial-to-almost perfect agreement (κ≥0.610) between what was eaten and what was reported by participants, with most questions showing at least a moderate level of agreement (κ=0.410-0.600). Questions regarding exposure to different types of meat showed a high level of consistency. The only question with poor participant recall (κ<0.000) was that relating to consumption of undercooked beef or veal.

Conclusion: Several questions designed for investigation of gastroenteritis were found to provide at least a moderate level of accurate and reliable recall, even after a delay until interview. These questions are suitable for investigating sources of foodborne gastroenteritis.

Keywords

Validation studies, food-borne diseases, questionnaires, mental recall

1. Introduction

Foodborne gastroenteritis was estimated to have cost the Australian economy $1.25 billion annually in 2000 (Abelson, Forbes, Hall, Applied Economics, & Department of Health and Ageing Australia, 2006). Epidemiologic investigations are often conducted to determine sources of infection, either as routine follow-up of notified cases of enteric infection, or during an outbreak investigation. Both types of investigation include interviewing affected individuals to determine foods eaten in the days prior to illness that may have caused illness, but questionnaires are rarely validated for food recall history. As the source of outbreaks are often identified, investigators tend to assume that questionnaires are reliable.

Validation of questions is important to verify the accuracy and reliability of results – an essential step if these results are to be used to influence public health policy and reduce the incidence of foodborne gastroenteritis. The incubation periods for most bacterial sources of gastroenteritis are generally around 1-10 days (Heymann, 2008). Therefore, exposure to potential sources may have occurred 1 – 2 weeks prior to patient interview and must be assessed over a period of several days. Investigations of sporadic gastroenteritis are especially challenging, with investigators relying on patient recall of exposure to many potential sources. This, combined with the time delay from onset of illness to the health department receiving a case notification and thence conducting an interview, leads to concerns around the accuracy and reliability of patient recall.

Studies have been conducted both prospectively and retrospectively to validate questionnaires regarding food and water consumption (Hankin, Rhoads, & Glober, 1975; Robertson et al., 2000), however these were specifically designed to test recall of food and water quantity and nutrient types. Recall of kitchen hygiene practices has also been validated using an observation versus self-report study design (Kendall et al., 2004). However, these studies did not validate questions related to food consumption in the context of an investigation into gastroenteritis, so the accuracy and reliability of these investigations remains unknown. All existing studies suggest a level of error in recall, which may have a significant impact on associations between foods and illness in source attribution studies (Mann, 1981). Mann (1981) conducted a prospective study investigating response error for two food items only, and suggested that this response error could be minimised through questionnaire design and interviewer-respondent interaction. While interviewer-respondent interaction is more challenging to address, questionnaire design can be assessed by conducting a validation study. This study aims to assess participant recall of questions designed for gastroenteritis investigation.

2. *Methods*

A gastroenteritis questionnaire was created using questions from prior questionnaires where possible. The questionnaire was designed to collect information about several potential risk factors for infection including food exposures. The questionnaire was piloted on 16 participants (nine cases and seven controls) from Queensland, Australia, using the recruitment methods described in the CampySource Project Team's study protocol (Varrone et al., 2018), where a copy of the complete and final questionnaire can also be found. The study protocol outlines inclusion and exclusion criteria for cases and controls, which were adhered to for the pilot study. Following the pilot study, minor changes were made to the questionnaire for clarity. A subset of these questions was selected for validation, involving those relating to consumption of the highest-risk foods (chicken, other meats, and offal) (see Appendix A for included questions). Data from the pilot study also informed the delay between food consumption and interview.

2.1 Sample size

Initial sample size calculations indicated that approximately 125 participants were needed for this study. This sample size was calculated to provide 80% power to detect a kappa statistic of 0.200, assuming a 50% overall agreement probability, allowing for a 20% drop-out rate. However, preliminary analyses of the data suggested a much higher level of agreement for most questions. This allowed for a smaller total sample size.

2.2 Participant recruitment

Participants were recruited using social media, including Facebook and Twitter, via a personal account. Flyers were distributed around the University of Queensland's Herston campus and elsewhere. The lead researcher participated in radio interviews about the study to attract further participants.

Volunteers contacted the lead researcher via social media, email or telephone, and were then emailed participant information and consent forms. Once a signed consent form was returned, the participant received an email with a de-identified participant identification number and instructions on how to upload photographs to the online survey. Participants were selected using the criteria that they lived in Australia, owned and used a smartphone, and were 18 years or older.

2.3 Data collection

Two methods were used to collect detailed information on food history intake. Participants were asked to keep all receipts of food purchases for the observation period – this included grocery

shopping and take-away purchases. For the same time period, participants were also asked to photograph all food consumed and upload photographs to an online survey in Qualtrics along with a short description where necessary (Appendix B). Photographs of receipts were also uploaded via the Qualtrics survey. This information was collected for an observation period of one week, with participants interviewed using the survey questionnaire 14 days later to imitate the time delay experienced during public health investigations. During the pilot study it was determined that, on average, case interviews occurred 13.7 days after onset of illness (range 9-22 days). A single interviewer conducted all interviews, following the script found in Appendix A. Participants received an AU$20 gift voucher via email upon completion of the telephone interview. We made subtle modifications to the survey questionnaire during the study (Appendix C). Modified questions were analysed in their original and modified states.

2.4 Data analysis

Receipts and photographs of food were compared to the questionnaire answers for each participant to assess recall and determine the validity and reliability of the questions by the lead researcher. Information extracted included: number of days meat was eaten, number of days poultry was eaten, types of meat eaten (beef, lamb etc. as well as minced, kebab etc.), number of poultry meals eaten, number of meals eaten outside the home, and whether any meats were undercooked. Meals eaten outside the home were classified based on information provided in written descriptions, food packaging visible in photographs, and data collected from receipts.

Where we were unable to definitively ascertain the correct answer to a question based on a participant's photograph and description, the participant's response was excluded from analysis for that question. For example, this resulted in some participants being excluded from analyses on undercooked meat where the photograph was of a whole steak, taken prior to the meat being cut. In this instance, we were unable to determine the level of cooking the steak underwent. Determination of the extent to which meat was cooked was assessed visually.

Validity was assessed by categorising foods consumed and dining locations, and calculating percent agreements and kappa statistics using Stata (StataCorp, 2017). Weighted kappa statistics were calculated for questions with more than two possible answers. For these questions, all possible answers were weighted, with greater weights for participant responses that were closer to the correct result. Weights of zero were given only to those in total disagreement with the correct answer (i.e. the participant answered that they had eaten no poultry when they had in fact eaten it

every day during the study period). Foods consumed or dining locations visited by fewer than three participants were not deemed suitable for further analysis.

A sensitivity analysis was conducted on questions where a participant answered, “Don’t know/Not sure”. We compared the effects of changing this to the incorrect answer or excluding these participants for that question.

Expected agreement was calculated to show the amount of agreement that can be expected due to chance alone (i.e. if the participant was guessing the answer rather than remembering). Kappa statistics are calculated based on the difference between the expected agreement and actual or observed agreement. Strengths of agreement for kappa levels are displayed in Table 1.

Table 1. Kappa levels and their respective strength of agreement (Landis & Koch, 1977).

Kappa Statistic	Strength of Agreement
<0.000	Poor
0.000 – 0.200	Slight
0.210 – 0.400	Fair
0.410 – 0.600	Moderate
0.610 – 0.800	Substantial
0.810 – 1.000	Almost Perfect

3. Results

3.1 Participants

Of the 57 volunteers that began the study, two (3.5%) dropped out prior to undertaking the telephone interview. Of the 55 participants, 12 (22%) were male. Participant ages ranged from 19 to 64 years (median = 27) (Table 2).

Table 2. Number of participants per age group.

Age group (years)	No. participants
18-25	21
26-35	24
36-45	4
46+	6

3.2 Data

A total of 62 questions were assessed, 41 of which were found to have a high level of consistency (Tables 3 and 4). This includes questions targeting foods considered high-risk for foodborne gastroenteritis in general. Most questions showed moderate level of agreement (κ=0.410-0.600) or higher, with many found to have substantial-to-almost perfect agreement (κ≥0.610). Questions addressing risk factors where too few participants (<3) were exposed were excluded from analysis (Appendix D).

The sensitivity analysis for questions with a "Don't know/Not sure" answer displayed similar results using both approaches. However, changing answers to be incorrect was more conservative so we have included results from calculations using this method (Tables 3 and 4).

Table 3. Level of exposure recall to food items eaten and dining locations visited during the observation period (questions with two possible answers).

Question	n/N	Expected agreement (%)	Actual agreement (%)	Kappa (95%CI)	Number incorrectly said "no"	Number incorrectly said "yes"
Restaurant	23/29	67.18	100.00	1.000 (1.000-1.000)	0	0
Kebab shop	3/18	72.22	100.00	1.000 (1.000-1.000)	0	0
Liverwurst	3/55	89.69	100.00	1.000 (1.000-1.000)	0	0
Pate pork	3/55	89.69	100.00	1.000 (1.000-1.000)	0	0
Meat & poultry	50/55	83.47	100.00	1.000 (1.000-1.000)	0	0
Pork offal	3/55	89.69	100.00	1.000 (1.000-1.000)	0	0
Undercooked pork	3/55	89.69	100.00	1.000 (1.000-1.000)	0	0
Outside home	43/47	79.31	97.87	0.897 (0.699-1.000)	1	0
Pate	3/55	88.07	98.18	0.848 (0.555-1.000)	0	1
Poultry purchased raw & fresh	9/17	50.17	88.24	0.764 (0.457-1.000)	1	1
Salami	14/55	62.94	90.91	0.755 (0.552-0.958)	3	2
Poultry purchased precooked	5/22	64.88	90.91	0.741 (0.403-1.000)	1	1
Beef other*	26/54	50.07	85.19	0.703 (0.514-0.893)	4	4
Beef*	40/55	27.85	87.27	0.698 (0.492-0.904)	5	2
Poultry at home	38/46	71.27	91.30	0.697 (0.420-0.975)	2	2
Pork other	38/55	54.51	85.45	0.680 (0.479-0.882)	6	2
Pork*	42/55	61.02	87.27	0.673 (0.452-0.895)	5	2
Poultry	48/55	77.79	92.73	0.673 (0.374-0.971)	2	2
Pork mince	18/55	58.48	85.45	0.650 (0.431-0.869)	6	2
Chicken with bones	22/54	51.71	81.48	0.616 (0.403-0.830)	5	5
Outside home (other fast food)	24/32	53.13	81.25	0.600 (0.336-0.864)	6	0
Ham	18/55	52.83	80.00	0.576 (0.357-0.795)	3	8
Beef mince	36/55	49.16	74.55	0.499 (0.288-0.711)	12	2

Lamb	16/55	62.55	80.00	0.466 (0.203-0.729)	8	3
Chicken kebab	4/55	86.51	92.73	0.461 (0.014-0.908)	2	2
Turkey	9/55	79.97	89.09	0.455 (0.111-0.800)	6	0
Chicken without bones	43/55	61.79	78.18	0.429 (0.162-0.696)	8	4
Undercooked meat	5/47	75.96	85.11	0.380 (0.017-0.744)	2	5
Lamb other	11/55	69.09	80.00	0.353 (0.047-0.659)	6	5
Chicken mince*	11/55	74.55	81.82	0.286 (-0.030-0.601)	8	2
Deli meats*	7/16	49.22	62.50	0.262 (-0.194-0.717)	2	4
Undercooked beef/veal	3/47	82.48	80.85	-0.093 (-0.200-0.014)	3	6

*Participant answered "Don't know/Not sure".
n=total number of participants that consumed the food item/ate at the dining location.
N=total number of responses analysed per question.
"Other" meat subtypes are those not specified. This would include steaks, roasts etc.
"Outside home" refers to any dining location outside of the home. "Outside home (other fast food)" refers to fast food/takeaway outlets excluding kebab shops or restaurants/cafes.

Table 4. Level of exposure recall to food items eaten and dining locations visited during the observation period (questions with >2 possible answers).

Question (>2 answers)	N	Number possible answers	Expected agreement (%)	Actual agreement (%)	Weighted kappa (bootstrapped 95%CI)*	Number under-estimated	Number over-estimated
Number of meals eaten outside the home	17	4	54.90	94.12	0.870 (0.701-1.000)	3	0
Number of meals eaten that included poultry	55	4	63.33	81.82	0.504 (0.320-0.649)	14	12
Number of days where no meat/poultry was eaten	15	8	77.39	92.37	0.663 (0.227-1.000)	3	3
Number of days where no poultry was eaten	15	8	71.73	85.70	0.494 (0.176-0.812)	4	4
Number of days where meat/poultry was eaten	38	8	67.51	87.21	0.606 (0.385-0.828)	8	11
Number of days where poultry was eaten	38	8	70.33	81.56	0.379 (-0.185-0.572)	15	14

N=total number of responses analysed per question.
*Bootstrapped 95%CIs underwent 1000 replications.

In Table 4, questions on the number of meals eaten included four possible answers: 0 meals, 1-2 meals, 3-4 meals, 5 or more meals. Questions on the number of days a food item was eaten included eight possible answers (0-7 days).

One question relating to consumption of undercooked beef or veal had poor participant recall ($\kappa<0.000$; Table 3). For this question, nine of the 47 participants included in analysis answered incorrectly. Five other questions only achieved a slight-to-fair level of recall ($\kappa=0.000$-0.400). Four of these related to food exposures (undercooked meat, lamb (other), deli meats, and chicken mince; Table 3), and the remaining question had more than two possible answers (Table 4). Four questions had 95% confidence intervals including $\kappa=0.000$.

Questions most often answered incorrectly were those asking for the number of days poultry was eaten, the number of days meat/poultry was eaten, and the number of meals eaten that included poultry (Table 4). Participants both under- and overestimated their intake of these foods. The biggest difference occurred in the question asking if beef mince was eaten (Table 3), with 12 participants incorrectly stating they had not consumed beef mince versus only two incorrectly stating that they had consumed this item.

Most of the questions excluded from analysis due to a small number of people exposed were those regarding offal, pate and types of undercooked meat (except beef or veal).

3.1 Effects of questionnaire modifications

Before modifications were made, recall of overall deli meat consumption was fair ($\kappa=0.262$). However, after modifying the questionnaire to ask about individual deli meats, a higher level of recall can be seen across all deli meat options, with the lowest of these being ham ($\kappa=0.576$).

Where changes were made to questions regarding the number of days where meat or poultry were eaten, level of recall is lower. However, as these questions have a total of eight possible answers and a small sample size, they require further investigation to better compare and assess validity.

4. Discussion

4.1 General discussion

In this study, we found that participants showed consistently high levels of recall for most potential risk factors when asked what and where they had eaten over the course of a seven-day observation period. In general, when giving the incorrect response, the participants tended to not recall eating a particular food item rather than to incorrectly state that they had done so, although this was not

consistent across different food items. This high level of recall is an important finding, especially following the delay to interview of 14 days. This delay is often unavoidable when conducting public health investigations, so knowing participant recall is somewhat reliable 14 days after consumption indicates that the findings of these investigations are still valid, although likely to bias towards the null.

A previous study by Gertler, Czogiel, Stark, and Wilking (2017) identified that a longer delay to interview decreases accuracy when participants were asked what foods were eaten during a particular meal. Gertler et al. (2017) found that for each additional day of delay, false-negative recall increased by 8%, false-positive recall increased by 3%, and indecisive recall increased by 12%. This has the potential to be a significant issue in public health investigations, which mostly use a case-control study design to identify risk factors for disease. Controls are usually interviewed regarding diet history of the previous seven-to-ten days with no delay, so according to Gertler et al. (2017), these data should be more robust. Cases, however, are subject to a delay depending on how long it takes from the time cases become infected, exhibit symptoms, seek medical attention, undergo laboratory testing and are thence reported to a health department (Gilpin et al., 2006). It can be argued that once ill, cases may reflect upon foods consumed prior to developing symptoms. However, the impact this may have on recall is immeasurable.

Studies have shown a large variation in time delay for gastroenteritis case notifications and interviews. Gallay et al. (2008) conducted a case-control study on sporadic campylobacteriosis in France with a median delay of 15 days to interview from onset of illness for cases (range 5-44 days). Similar studies have allowed case interviews to be conducted up to 30 days after onset of illness (Stafford et al., 2007; Unicomb, Dalton, Gilbert, Becker, & Patel, 2008).

Outbreak investigations also experience significant delays to case interview, with only 54.2% of (193/356) gastroenteritis outbreaks in New Zealand in 2001 being reported to the appropriate public health service within one week of onset of illness (Thornley, McDowell, Lopez, & Baker, 2002). This report found the median delay ranging from 1-36.5 days depending on the type of outbreak (common event, institutional, community-wide etc.). Other outbreak investigations have reported cases being interviewed more than four weeks after onset of illness (Merritt, Miles, & Bates, 1999; Wilson, 2005).

Large errors in recall can affect the results of a case-control study in several ways. Firstly, if a food that is poorly recalled – such as beef mince in our study – is a source of gastroenteritis, it is unlikely to be identified as such because this error will bias towards the null. Of the participants who ate beef

mince in our study, 33.3% reported a false-negative. Conversely, items such as ham, of which 32.7% of participants reported a false-positive, may bias away from the null if controls with a shorter recall period were more likely than cases to correctly recall not eating the food.

Eating beef has previously been identified as a risk factor for gastroenteritis in both sporadic and outbreak settings (Finch & Blake, 1985; Gallay et al., 2008; Unicomb et al., 2008; Vogt & Dippold, 2005). However, most studies did not detect a significant association (Bell, 2013; McMahon & Mahmood, 1993). Based on the level of underreporting of beef mince consumption in our study, this might reflect recall bias towards the null. Veal is less commonly eaten and difficult to identify in case-control studies.

Interestingly, participants in our study had poor recall ($\kappa<0.000$) when asked if they had eaten undercooked beef or veal. Poor recognition of undercooked meat has been identified in the past (Lando & Chen, 2012; Røssvoll et al., 2014), with half (2/4) of the potential risk factors with a higher level of false-positive than false-negative reports in our study assessing recall of undercooked meats. All three participants that ate undercooked beef or veal incorrectly reported they hadn't. Conversely, only 13.6% (6/44) of those that did not eat undercooked beef or veal reported that they had. This demonstrates a difficulty in accurately assessing undercooked meats as a risk factor when relying on participant recall. However, our assessment of meat items as being undercooked was purely subjective, as photographs were visually examined and thermometer readings were not requested as part of this study. The purpose of this study was to assess recall only and not to determine the public's understanding of terms. Studies have shown a lack of knowledge in the general public when determining meat doneness. Most people have been found to judge when meat is ready to eat based on colour, which can be deceptive (Kendall et al., 2004; Røssvoll et al., 2014). This may result in misclassification for questions asking about undercooked meats.

In our study, stronger levels of recall were especially evident when participants were asked about their dining locations during the observation period. This recall was substantial-to-almost perfect across all location options. The only exception being "outside home (other fast food)", which fell just short of substantial recall ($\kappa=0.600$).

Overall, questions with these stronger levels of recall had incorrect answers in both directions, with varying proportions of false-positive and false-negative recall across potential risk factors. In a case-control study, if the proportion of false-positive and false-negative reports were consistent across cases and controls it would result in bias toward the null. As such, items identified as statistically

significant risk factors for gastroenteritis by case-control studies that use these questions could be presumed valid, but some may still be missed.

Implications for public health practice include a need to consider recall bias in calculations of study power. Bias toward the null can result in risk factors of lower prevalence being found to be statistically insignificant and be overlooked by public health policies and prevention strategies. Interviewers should be trained to assist with recall. A need for more rapid case notification is also evident, with delay to interview having an important impact on case data collected.

4.2 Limitations

Participant recruitment via social media likely resulted in selection of a younger study population compared to the whole population, as shown by our median age being 27 years. Eighty-one percent of study participants were in the age range 18-35 years, so results may be more representative of recall in this age group than the whole population. Volunteer bias may have resulted in a more food-aware population, possibly increasing the overall level of recall. The process of photographing food may have resulted in better recall of what participants had eaten. Our study also had a much higher proportion of female (78%) than male participants, so our results may be more representative of women's level of recall than the whole population's. Due to the small sample size, several questions require further investigation to better assess validity.

Visually assessing whether meats are undercooked is an imperfect measure of food safety. Ideally, internal thermometer readings should be collected to better ascertain which meats were thoroughly cooked (Lando & Chen, 2012). This would also eliminate the need to exclude those who did not provide a clear photograph of each meat item. Additionally, a process of uploading food consumption data that requires less participant interaction with the data would help to minimise priming.

The impact of delay to interview cannot be determined using real-life case data. Consequently, it is impossible to compare the effect this delay will have in a case-control study, where cases are recruited retrospectively. Cases may reflect on foods they deem to be a risk for illness once symptoms begin, which may improve recall. It is not feasible to measure if this will result in similar recall to that of a control, who is interviewed without a delay.

Nevertheless, our findings should be considered when designing questionnaires for future gastroenteritis investigations and interpreting their results. Efforts were made to minimise bias where possible, with participants unaware of the food items of interest for the study and a single interviewer used for all telephone interviews.

5. Conclusions

Public health investigations are conducted in many countries to determine the source of common illnesses. Gastroenteritis is a significant health issue, and source tracing can be beneficial for prevention. For this reason, it is important that the tools used are robust.

Our study suggests that even following a 14-day delay in interview, cases can recall if they were exposed to certain food items with reasonable accuracy. Most of the questions assessed were found to provide at least a moderate level of accurate and reliable recall. This indicates that results from studies using these questions can be considered reliable. Dining locations were especially well remembered, with poor recall found only in the consumption of undercooked beef and veal. Further investigation is required for foods with a low level of consumption.

Acknowledgements

Funding:

Funds for participant gift vouchers were provided by Curtin University.

While undertaking studies, LV is supported through an Australian Government Research Training Program (RTP) Scholarship.

MDK is supported by a National Health and Medical Research Council Fellowship (GNT1145997).

Declaration of interest

None.

Ethics approval

Curtin University's Human Research Ethics Committee (ethics ID: HRE2016-0464). The University of Queensland's Human Research Ethics Committee (ethics ID: 2017001121/HRE2016-0464). The Northern Territory Department of Health and Menzies School of Health Research's Human Research Ethics Committee (ethics ID: 2017-3016).

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