A comparison and evaluation of research methods used in consumer food safety studies

Elizabeth C. Redmond and Christopher J. Griffith

Food Research and Consultancy Unit, University of Wales Institute Cardiff (UWIC), Cardiff, South Wales, UK

Abstract

Worldwide incidence of food-borne disease has increased in recent years and data suggest that inadequate food-handling behaviour in the domestic environment may be an important factor. As a consequence of this, research into aspects of consumer food safety has been undertaken, especially in the UK and USA. The overall aims of conducting such research have been to investigate aspects of consumer food safety behaviour and to utilize information in the development of effective food safety education initiatives. In the past 25 years, 87 consumer food safety studies have been undertaken using different research methodologies; 75% utilized survey techniques (questionnaires and interviews), 17% were based on direct observation, and 8% utilized focus groups. The advantages and disadvantages of the different research methods used are discussed. Similarly, different forms of reliability and validity have been considered in the context of each research method used. A comparison of results from consumer food safety studies has shown that use of different research designs and approaches has resulted in differences in the findings about consumer food safety behaviour. Survey responses have provided a more optimistic portrayal of consumer food safety behaviour than data obtained from focus groups and direct observation. Although consumers have demonstrated knowledge, positive attitudes and intentions to implement safe practices, substantially larger proportions of consumers have been observed to implement frequent malpractices. This suggests that observational data provide the most reliable information denoting consumers' actual food safety behaviour and should be used preferentially with risk-based data for the design of communication strategies.

Correspondence
Elizabeth C. Redmond,Food Research and Consultancy Unit, University of Wales Institute Cardiff (UWIC), Colchester Avenue, Cardiff CF23 9XR, South Wales, UK. E-mail: eredmond@uwic.ac.uk

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Introduction

Each year, millions of people world-wide suffer from food-borne disease,[1] and illness resulting from consumption of contaminated food has become one of the most widespread public health problems in the contemporary world.[2] It has been estimated that between more than 1 in 10 and 1 in 12 people suffer from food-borne disease in the UK and USA each year.[3] The vast majority of food-borne disease cases in the UK are thought to be sporadic, with the domestic kitchen as a significant point of origin of many of these cases.

The prevention of food-borne disease involves co-operation of all stages of the food chain[4,5] and no one stage has sole blame or responsibility,[6] although the consumer has been described as the 'final line of defence'.[7] Multiple food safety skills are required by the consumer, with responsibilities extending from purchasing and receiving food products to processing and providing foods for themselves and for others.[8] Implementation of proper food-handling practices can prevent cases of food-borne disease,[9] and how consumers prepare food in the kitchen affects the risk of pathogen multiplication, cross contamination to other products, and pathogen destruction by thorough cooking procedures.

The acknowledgement of the importance of adequate consumer food-handling practices has recently been widely recognized.[10–13] Although information is available about manufacturing, processing and distribution processes in the food industry, the consumer remains the least studied link in the food chain. Information available about the consumer has been considered to be largely anecdotal.[14] A considerable amount of food preparation and handling occurs in the domestic environment, so research and consumer education

regarding the risk of food safety malpractices is an essential element of preventing food-borne disease.[15]

Information relating to domestic food-handling practices comes from two main sources: analysis of food poisoning outbreaks and consumer-based research studies.[16] Epidemiological studies of outbreaks have provided a considerable amount of quantitative data regarding contributory food-handling malpractices. The accuracy and availability of data is limited owing to recall difficulties of exact food consumption details and handling practices that may have been implemented some time before illness is reported. Retrospective analysis of such incidents of food-borne illness provides limited information about consumer food safety behaviour. Internationally, numerous consumer based research studies have attempted to evaluate aspects of consumers' food safety practices, with different strategies adopted for data collection, including questionnaire and interview surveys, focus group discussions and observation studies.

The purpose of conducting consumer food safety studies has been to ascertain how consumers handle food in their homes, determine what consumers know about food safety, and why some safe food-handling practices are implemented and others are not. The overall aims of the majority of studies that have been undertaken have been to provide information for the development of effective communication strategies to promote safe food-handling practices.[17–23]

Measurement of consumer knowledge, attitudes and behaviour can provide a basis for planning health promotion programmes.[24] Foster and Kaferstein[25] have stated that only when existing attitudes and practices regarding food safety are known is it possible to plan effective strategies to encourage and strengthen desirable behaviours and discourage unsuitable ones. Adoption of social cognition models to health-related issues has enabled the relationship between attitudes, beliefs and behaviour in relation to behavioural change to be identified.[26]

This paper aims to evaluate information obtained about consumer food safety behaviour according to research methods implemented for data collection. The advantages and disadvantages of different approaches used will be discussed in light of the reliability and validity of research methodology. Similarities and disparities between knowledge, attitudes, intentions, self-reported practices and specific food-handling actions in domestic food preparation will be identified according to the research method used with subsequent implications. Findings will be discussed in the context of the potential microbiological risks attributed to specific food-handling errors.

Methods

An extensive search of previous literature was conducted to locate published and unpublished consumer food safety studies. Electronic searches of computerized library databases and screening of reference lists from relevant research papers and reports facilitated the identification of many published studies. Internet browsers were utilized to search the World Wide Web and many unpublished international studies were obtained using the 'Foodsafe' listserv. Attendance at international food-safety-related conferences and personal communication with experts in the field also resulted in the acquisition of the results of several unpublished studies.

Inclusion and exclusion criteria for reviewed consumer food safety studies

Studies included in the discussion evaluated consumers' knowledge, attitudes, beliefs and intentions, self-reported practices and actual hygiene behaviours relating specifically to food preparation in the domestic kitchen. Only studies that were an assessment of individual consumers and targeted consumer groups were included for review. Persons classed as consumers included anyone who prepared food on a regular basis but who was not a professional food handler.

Research has shown that actual observed food preparation behaviours of trained food handlers may be better than that of consumers[27] and, therefore, results of studies concerning trained persons from the food industry were excluded as they could bias common findings and conclusions within the review. Additional studies that were excluded were those predominantly based on risk perceptions of other aspects of food safety such as pesticide residues or bovine spongiform encephalopathy (BSE).

Results and discussion

Research methods used for food safety studies

A variety of methods of data collection has been used for the evaluation of domestic food safety behaviour. The use of different research methods to assess consumer food safety in terms of knowledge, attitudes, self-reported practice and actual behaviour can be compared to provide a more complete representation of why consumers implement or fail to implement certain food-handling behaviours and not others. Information collected from different individual sources, using different survey designs and approaches, may provide incomplete or inconsistent data. Differences in study design and methodology have been thought to explain differences between prevalence estimates of high-risk food-handling and consumption behaviours between research studies.[28]

The majority of social research approaches for data collection can be categorized as qualitative (ethnographic) or quantitative (positivism) methods. Fundamental distinctions between the two approaches are emphasized by methods of analysis and interpretation of data; one method deals with numbers, whereas the other is concerned with words.[29] Quantitative techniques include questionnaire and structured interview methodologies, and are appropriate when the issue is known about, relatively simple and unambiguous, and amenable to valid and reliable measurement.[30] Such methods generate data that can be presented numerically and which can be subject to statistical analysis.[31] Qualitative research utilizes unstructured interviewing and focus group techniques as a means of data collection. Overall aims of this type of research are generally to study people in the natural social settings and are essential for exploring new topics and obtaining an insight into complex issues.[30] However, such techniques produce data that are not so readily open to statistical interpretation.[31] Observation of psychomotor activities can be recorded using qualitative and quantitative methods, the choice of which is largely dependent upon required outcomes.

Research methods used for collection of consumer food safety data include self-completion questionnaires, interviews (collectively known as surveys), focus groups and observation studies. Data shown in Table 1 denote the proportions of studies completed according to research methodology. Use of interviews was found to be the most common method for obtaining information on consumer food safety, accounting for 48% of studies, followed by self-completion questionnaires that accounted for 27% of studies. Research using focus groups accounted for 8% of studies and use of the direct observation technique accounted for 17% of studies.

Table 1 Methods of data collection used in consumer food safety studies ($n = 87$ studies)

Method of data collection	Frequency of use *n* (% of total studies)	Frequency of use *n* (% of total studies)
Self completion questionnaires		23 (27%)
Postal	9 (10%)	
Self administered	12 (14%)	
Online	2 (2%)	
Interviews		42 (48%)
Telephone	18 (21%)	
Face to face	24 (28%)	
Focus groups		7 (8%)
Observational studies		15 (17%)

Adapted from Redmond and Griffith.[32]

Data presented in Table 2 indicate that the majority of studies using the interview technique and self-completion questionnaires have been undertaken in USA (46%) and UK (42%), and most of the data collected using observation of consumer food safety behaviours have been from the UK. Additional observational studies have been carried out in USA and Australia. Focus groups studies used in the present discussion were conducted in the UK (England and Wales) and USA.

Sample size of all consumer food safety studies

The issues of sample size and sampling are crucial to the external validity of results obtained from all research methods. External validity relates to the generalizations of research results to the wider population of interest[30] (see Table 5). Determination of the sample size is largely determined by theoretical sampling

Table 2 Origin of studies using different research methodologies

Location	Self-completed questionnaires *n* (% of total study type)	Interviews *n* (% of total study type)	Focus groups *n* (% of total study type)	Observation *n* (% of total study type)
UK and Northern Ireland	9 (39%)	18 (43%)	4 (57%)	10 (67%)
USA	11 (48%)	19 (45%)	3 (43%)	4 (27%)
Canada	0 (0%)	1 (2%)	0 (0%)	0 (0%)
Southern Ireland	0 (0%)	1 (2%)	0 (0%)	0 (0%)
Italy	1 (4%)	0 (0%)	0 (0%)	0 (0%)
Australia	0 (0%)	1 (2%)	0 (0%)	1 (6%)
New Zealand	2 (9%)	2 (5%)	0 (0%)	0 (0%)
Total	23 (100%)	42 (100%)	7 (100%)	15 (100%)

Table 3 Survey sizes of consumer food safety studies for different research methods used

	Total no. of consumers assessed per study type (n^1)	Total numbers of studies reviewed (n^2)	Mean no. of consumers assessed per study type ($n^1 + n^2$)
Telephone interviews	13 298 839	19	699 939
Face-to-face interviews	43 413	24	1 809
On-line questionnaires	2 807	2	1 404
Postal questionnaires	4 559	9	507
Self-administered questionnaires	2 540	12	212
Observation studies	1 244	15	83
Focus groups[a]	472–590	27 (53 groups)	67–84 (~8 groups)

[a]Assuming that between 8 and 10 respondents attend each focus group.[35]

requirements and practical limitations such as time and cost.[33] It is considered to be easier to produce biased results when using a small sample, however, use of large samples may obscure weak design methods and participant variables.[34] Sample sizes used for consumer food safety studies ranged from 40 to 13 221 077 respondents (see Table 3). Analysis of the size of consumer food safety studies has shown that the largest number of consumers reached was by means of telephone interviews obtaining responses from 100 to 13 221 007 respondents. Use of face-to-face interviews was conducted using between 84 and 10 172 consumers, postal questionnaires between 82–869 consumers, and self-administered questionnaires between 62 and 824 consumers. Studies using focus groups and observation were based on fewer consumers than surveys.

Credibility of research findings

Reducing the possibility of obtaining inaccurate research findings requires attention to be given to two particular emphases on research design: reliability and validity. Reliability has been defined as 'the degree to which measurements are consistent' and validity has been defined as 'the extent to which the procedure measures what it is intended to measure'.[36] Adequate reliability is considered to be a precondition to validity,[37] and is required to give researchers confidence in data and prevent collection of worthless and misleading data. Several parameters of reliability may need to be assessed to judge the overall reliability of a research instrument. Such parameters are defined in Table 4. For research to be considered valid, it must be based on fact

Table 4 Forms of reliability required during implementation of different research methods used to collect information about consumer food safety

			Requirements for different research methods			
Reliability parameters	Meanings	Example of implementation	Questionnaires	Interviews	Focus groups	Observation
Test-retest reliability	Determination of consistency of responses to a scale when a sampled population is tested once and then again some time later.[30,34]	Administration of a survey to the same population on two occasions or repetition of observed food preparations by the same participants over a short period of time.	✓	✓	✗	✓
Internal consistency	Assessment of the consistency of results across items within a test.[38]	Use of Cronbachs alpha or split half for analysis of a food safety survey to ensure that responses are consistent.	✓	✓	✗	✗
Inter-observer reliability	Determination of the extent to which the results obtained by two or more observers/ interviewers agree for similar or same populations.[30]	Observation of a videoed food preparation session by more than one observer – comparison of results.	✗	✓	✗	✓
Intra-observer reliability	Measurement of a variation which occurs within an observer as a result of multiple exposures to the same stimulus.[39]	Observation of a videoed food preparation session on more than one occasion by the same observer – comparison of results.	✗	✗	✗	✓
Parallel-forms or alternate forms of reliability	Assessment of the consistency of two tests constructed in the same way from the same domain.[38]	Obtaining observational data detailing consumer food-handling practices using direct observation and video recordings on separate occasions.	✓	✓	✓	✓
Repeatability.	Refers to the stability of results from a measuring instrument (e.g. survey, observational checklist) on d different occasions.[34]	Recording of the same observed behaviours on a predetermined checklist or the same psychological responses on a survey on more than one occasion – followed by a comparison of results.	✓	✓	✗	✓

or evidence.[40] Measurement of a variety of forms of validity is described in Table 5. Different forms of reliability and validity will be discussed in the context of each research method used for collection of data about consumer food safety.

Data collection using survey techniques

For the purposes of collecting information about consumer food safety, interviews and questionnaires have been the predominant methods of data collection, accounting for 65 (75%) of the studies analysed. Social surveys involve a quantitative method of collecting information from a population sample, usually by personal interviews or by self-completion questionnaires. Although providing valuable information, questionnaire and interview data is largely reliant upon self-reported practices and consumer knowledge. Discrepancies between self-reported practices and actual food-handling behaviours have been reported previously.[11,42–44] Studies using questionnaires and interviews for assessing hygiene behaviours have found evidence of a tendency for over-reporting of behaviours perceived to be 'good'.[42,44,45] In light of such findings the traditional household questionnaire used alone for assessment of hygiene behaviours has been considered to be limited in its efficacy, scope and accuracy.[42] A limitation regarding data obtained from surveys includes the ability to make generalizations about specific food safety practices. For example, although surveys have shown that large proportions of consumers have reported to cook food effectively, different cooking methods have been shown to influence heating efficacy.[19] This suggests that surveys should investigate knowledge, attitudes and self-reported practices of specific cooking methods needed to achieve safe cooking temperatures for different foods, as opposed to generic practices.

Forms of reliability and validity required for the development and implementation of surveys are determined in Tables 4 and 5. Most types of reliability can be applied to consumer food safety survey techniques. Consideration of all types of validity stated in Table 5 are required when carrying out consumer food safety surveys to ensure the measurement tool (the questionnaire or interview schedule) measures what it intends to measure.[46] For example, if information regarding consumer knowledge of hand-washing and hand-drying practices is sought, validity must be assessed to ensure that information regarding a related variable is not being measured instead.

Questionnaires

Self-completion questionnaires were used to obtain information on consumer food safety for 27% of surveys reviewed. This method of data collection allows the ability for unambiguous quantitative data to be collected,[30] and there is a requirement for the format to be kept relatively simple and straightforward owing to little control over respondents' interpretation of questions.[47]

The most common methods for distribution of self-completion consumer food safety questionnaires are postal and self-administration. Postal questionnaires accounted for the 36% of the questionnaires distributed. Sending questionnaires through the post allows respondents from wide geographical areas be reached at relatively low cost. However, use of this method does not allow adequate control over external influences and verification of who actually completes the questionnaire. Response rates for postal questionnaires tend to be low,[37] for example, the response rate for a postal questionnaire administered in USA was 43%.[17] Self-administered questionnaires accounted for 48% of consumer food safety questionnaires studied. Although time consuming, this method ensures a high response rate, accurate sampling and minimum interviewer bias.[37] Examples of questionnaires administered for completion during college lectures in USA[48] or in conjunction with other research projects in UK[19,49] have obtained ≈100% response rate. In recent years, the use of the Internet as a means for conducting self-complete surveys has increased in popularity. Although access to the Internet is increasing, not all households may have access to the web and this may therefore create sample biases.[50] Online surveys accounted for 9% of consumer food safety surveys reviewed.

Questionnaire data is known to be valuable in terms of identifying what people know[51] and perceive about food safety. Some consumer food safety studies have shown that questionnaires have also been used as a measurement tool for assessing the consistency of

Table 5 Forms of validity required during implementation of different research methods for collection of information on consumer food safety

Validity parameters	Meanings	Example of implementation	Requirements for different research methods			
			Questionnaires	Interviews	Focus groups	Observation
Internal validity	Good internal validity occurs when any differences of measurements observed between groups are attributed solely to the hypothesised effect under investigation.[41]	Ensure measurements are a good estimate of what they are expected o measure, e.g. inadequate food preparation practices are due to (eg) inadequate knowledge of correct practices rather than lack of equipment.	✓	✓	✓	✓
External validity	The extent that results can be generalised to populations, situations and conditions.[40]	If results of a study can be applied to a wider population then a study has external validity/good generalizability, eg. food-handling actions of targeted groups of consumers.	✓	✓	✓	✓
Face validity	The extent to which a method measures what it is intended to measure; acceptability of a format to a target group.[41]	Visually assess a food safety survey or observational checklist to ensure food safety issues are addressed.	✓	✓	✓	✓
Content validity	Evaluation of the content of a test to ensure that it is representative of the area which it is intended to cover.[34]	Visually assess a food safety survey or observational checklist that (for example) is determining efficacy of hand decontamination and ensure hand-washing and hand drying issues are addressed.	✓	✓	✓	✓
Criterion validity (includes concurrent and predictive validity and diagnostic validity)	Determination of the correlation of a scale with another measure of the trait under study, ideally, by a 'gold standard' which has been used and accepted in the field.[39]	Comparison of a newly devised food safety survey/observational checklist with older surveys/checklists known to have good criterion validity.	✓	✓	✓	✓
Construct validity (includes criterion-related, convergent, concurrent and discriminant validity)	Agreement with other tests in the way that is expected; used when a 'gold standard' is not available.[41]	Comparison of results from one study with another (for example) perceptions of hand-washing from a structured survey with focus groups findings of the same subject.	✓	✓	✓	✓
Precision validity/ responsiveness to change	The ability of an instrument to detect small changes in an attribute/ measurement of the association between the change in an observed score and the change in a true value of the construct.[30]	Capability for the improvement/ deterioration of (for example) a specific food safety attitude or behaviour to be detected using a survey or observational checklist.	✓	✓	✗	✓

responses between sampled populations over periods of time. For example, a survey undertaken in New Zealand[52] was a 'conceptual replication' of a previous study.[53] Results showed a high level of consistency between the two studies, suggesting that there was a testable, baseline level of food safety understanding in the community.[52]

Interviews

Use of face-to-face interviews for data collection accounted for the largest proportion (48%) of consumer food safety surveys under discussion. Out of these interviews, 16/24 (67%) were conducted in the respondent's own home, for example, interviews conducted in the UK in 1998 used 'in-home' interviewing methods.[54] Alternative locations for face-to-face interviews included in the street or sampling points, such as at specified supermarkets.[55] Of the interviews studied, 43% were telephone surveys, for example, an Australian survey conducted by Jay *et al.*[56] and an American survey conducted by Altekruse *et al.*[57] As with postal surveys, telephone interviewing is a convenient and relatively cheap method of data collection, and there is the additional advantage of speed.[44] Although response rates may be high (69–71%),[53,58] this method is more suitable for brief questionnaires. Large-scale telephone surveys have been used in the USA as a means of assessing the prevalence of behavioural risk factors in the population.[59]

'Types' of data collected using surveys

Quantitative surveys used for collection of consumer food safety information have aimed to measure general knowledge of food safety and hygiene,[48,55,60,61] understanding and awareness of specific food safety issues,[18,19,49,62–64] general attitudes towards aspects of food safety,[19,65,66] and self-reported practices of consumers.[17,23,60,67–69] Few surveys have used the constructs of psychological theories such as The Theory of Reasoned Action (TRA)[70] and The Theory of Planned Behaviour (TPB)[71] to attempt to understand the relationships between knowledge, attitudes, intention and behaviour of food safety practices.[49,72]

Determination of knowledge is relatively straightforward and information gained is usually an accurate description of what issue is sought. Before the implementation of some food safety education initiatives, it is necessary to determine the level of knowledge consumers possess regarding behaviours targeted by the initiative. Furthermore, determination of consumer knowledge has been used to evaluate effectiveness of health promotion initiatives.[73] Evaluation of consumer attitudes is considered to be central to understanding actual behaviours. Attitude determination has been used within psychological models such as TRA and TPB, which have attempted to predict behaviour. Although some researchers have found that attitudes can influence behaviour directly,[74] other workers have not found positive correlations within the attitude–behaviour relationship.[75] Attitudes are viewed as being central to health promotion[26] as they affect responses and potential effectiveness of initiatives. Intention has been identified as the most immediate determinant of behaviour.[76] Intentions are an integral part of a variety of social cognition models such as TRA and TPB and The Health Action Process Approach (HAPA).[77] Self-reported practices are personal accounts of actions, which may or may not reflect actual behaviours. Social scientists have suggested that a respondent may claim to carry out the perceived 'correct' behaviours opposed to behaviours perceived to be undesirable thereby providing a response to represent a positive image.[30] This concept is known as 'social desirability bias' and is reported to occur more frequently in questionnaires and telephone interviews than face-to-face interviews.[37] An evaluation of such data could result in misleading findings.[42]

Data collection using focus groups

The use of focus groups as a means for obtaining information on consumer food safety information is a relatively under-utilized research method, accounting for only 8% of food safety surveys reviewed (see Table 1). Focus groups are particularly effective for providing information about *why* people think or feel in the way that they do, and group interaction provides a greater insight into why certain opinions are held.[78,79] The qualitative procedures present a more natural environment for obtaining information than during an individual interview because participants influence and are influenced by others just as they are in real life.

Forms of validity and reliability required for implementation of effective focus groups can be seen in Tables 4 and 5. As for survey techniques, validity of the measurement tool (the discussion guide) is required to obtain valid information about the food safety subject under discussion. As focus groups are open, yet guided, group discussions of different groups of consumers, it may not be possible to assess precision validity and responsiveness to change.

A series of focus groups have been carried out in USA[80] to determine what limits consumer usage of thermometers when cooking meat and poultry products. Information gained from the discussion groups has been used to aid development of an effective consumer education campaign aimed at increasing consumer thermometer usage. In England, focus groups have been used to explore public attitudes towards food safety.[65,66] Results from such groups have been used to identify consumer expectations of the new Food Standards Agency and to help development of communications strategies in relation to current food safety concerns. Formative research undertaken in South Wales utilized focus group findings to determine perceptions of behavioural determinants, intervention types and general attitudes to food safety issues. Findings were used to develop two food safety social marketing initiatives, targeting specific food safety behaviours of older women aged 60–65 years[19,20] and mothers with young children.[81]

Data collection using observation

The observation technique is a method of data collection used for understanding complex behavioural situations more accurately.[30] Observation does not depend on second-hand reported accounts of behaviour from respondents who may have put their own interpretation on events[82] and, therefore, the direct observation of human and animal behaviour may be considered by social scientists to be superior to other methods of data collection. This belief stems from the assumption that data gathered through the direct observation of actions reflect those behaviours directly rather than through an intermediary means such as a questionnaire.[83] The majority of international consumer studies that have evaluated the safety of food preparation practices have, to date, largely been based on determination of consumer knowledge and self-reported practice rather than actually measuring observed performance of actual food-handling behaviour.

Use of the observational technique as a means for data collection includes the application of a variety of different approaches. Assessment of behaviour can be made by the 'participant' or 'non-participant' observer. A participant observer is to some extent part of the group of individuals under observation, whereas a non-participant observer observes from a distance and should have no effect on the actions being observed.[34] All of the observational studies under discussion, which have evaluated food safety behaviour, have been 'non-participant' studies.

Recording of food safety behaviours

Observation methodologies may be structured or unstructured, direct or indirect. Direct, structured observation has been utilized for all of the consumer food safety observational under discussion. Structured observation is systematic, quantitative and is limited to defined, measurable and observable behavioural variables, which are determined before the actual observation is carried out.[83] Data denoting observed actions from structured observations are usually collected and recorded using a predetermined, standardized and validated 'coding schedule' or 'observational checklist'. Development of a unique observational checklist with clearly defined categories[84] has to meet a variety of criteria to ensure that an accurate measurement of behaviour is obtained.

A variety of methods for recording and analysing observed food safety practices has been used for the evaluation of consumer food safety behaviour. In the UK, a risk-based checklist and scoring system has been developed to enable quantitative assessment of food safety in the domestic kitchen.[19] Risk scores based on recent epidemiological data have been allocated to specific food-handling malpractices, using a logarithmic scale. A higher risk score represents implementation of more cumulative food safety errors and fewer control measures implemented.[85] Use of this technique has enabled comparisons to be made between different meal preparations, between specific behaviours, and between and within meals.[86] In addition to this, comparisons between participant risk scores have enabled eval-

uation of a hierarchy of food safety education interventions. In addition, it has been considered that use of a predetermined checklist should yield highly reliable results by virtue of its replicability.[82] Use of notational analysis is another technique that has been used for the evaluation of observed consumer food safety behaviour.[87] The technique is used for objectively and systematically monitoring, recording and studying actions and events. Notation of actions has been frequently used for sports analysis, however, its approach has been applied to consumer food safety using a specially designed computer program, thereby providing detailed data denoting food-handling malpractices.

Reliability and validity of observation studies

Observational data collected needs to be reliable. To test for reliability of recorded observations, an assessment of intra- and inter-observer reliability needs to be determined. To assess inter-observer reliability of recorded observations, the records in a checklist from one observer can be correlated with those of another observer.[34] Intra-observer reliability is a measure of the extent to which a single observer obtains consistent results when measuring the same behaviour on different occasions.[19] Inter-observer and intra-observer reliability has been determined during consumer food safety observation studies conducted in UK.[19,20] Owing to provision of detailed descriptions of a food safety checklist and training in the observational technique, results showed that differences between recording of observed food safety malpractices using a predetermined checklist were minimal.[86]

To establish reliability and validity of direct structured observational methods, the various potential for biases needs to be addressed. Observer bias is considered to be the greatest threat of reliability when using the observational technique.[82] This type of bias is a systematic difference between a true situation and that observed owing to observer variation in perceptions.[30] Another potential for bias in observational studies is owing to the reactive effect of research arrangements, known as the 'Hawthorne Effect', where behaviours may be distorted in some way simply as a result of being studied.[30,34] For example, if consumers are specifically informed that their food safety behaviours were subject of detailed observation they may consciously improve such behaviours so to convey a more positive image of themselves, and thus distort results. A study conducted in USA informed recruits for a food safety observational study that data was required 'for market research of food preparation practices and the development of a food kit' in an effort to eliminate such bias for food safety research.[88]

Control can be exercised not only of the structure of recorded data, but also over the environment in which the observations take place.[34] Observational study settings may occur in natural (uncontrolled) or laboratory (controlled) environments. There are advantages and disadvantages when carrying out observational research in both environments. Half of the reviewed observation studies obtaining information on consumer food preparation practices occurred in participant home kitchens, which can be described as the uncontrolled 'naturalistic' environment. It has been reported that observations carried out in the natural environment are more realistic than in a laboratory, which may provide a highly artificial, possibly inhibiting atmosphere. In a natural environment, *if* there is no reactivity bias, observed behaviours have been considered to be entirely genuine.[34] However, extraneous variables may be poorly controlled in the natural environment, such as consumer domestic kitchens, and may pose a greater threat to validity than in the laboratory. This may result in a greater ambiguity of observable actions and, therefore, an increased potential for observer and reactivity bias. In addition to this, replication of collected data is more difficult.[34] Direct comparisons of recorded behaviours between subjects in different environments may not necessarily be viable or possible. Research conducted in the UK has determined the consistency of observations of consumer food safety behaviours in a model domestic kitchen and in consumer home kitchens. Using data based on a risk-based observational checklist and scoring system, analysis of results have shown that there was no significant increase or decrease in overall mean risk scores between food preparations in the two locations, suggesting that key food safety behaviours were consistent.[19]

Consumer food safety observation studies

Various methods of observation that have been applied to non-participant observations include personal direct

observation or observation using video recordings. Both methods have the potential for reactivity bias, however, video recording has the advantage that behaviour can be analysed after the event at any required pace.[34] This can be of great benefit because sometimes real-time recording of data is extremely difficult, especially when there are many different behaviours, such as complex food-handling actions to be recorded. Videoed observations are also advantageous when behaviours are initiated and terminated very rapidly and frequently.[83] In total, 15 observation studies of consumer food safety practices have been reviewed. Data collected for many of the studies (47%) was collected using direct observation. Observers openly watched the participants' meal preparations in home kitchens and concurrently recorded preparation. In total, 43% of direct observation studies were from the UK[19,51,72] a further 43% of the studies were from USA[89–91] and one study (14%) was conducted in England.[20] Observations using video-camera recording of consumer food-handling practice have been carried out South Wales, Australia and the USA. The majority (67%) of observation studies using video recordings have taken place in South Wales, UK. Observations of consumers' food preparation practices have occurred using CCTV in a model domestic kitchen. A variety of studies have been completed, determining the repeatability and reproducibility of consumers' food safety behaviours[19,86,92] and quantifying food safety behaviours of a cross-section of the population.[86] Additional studies have been completed determining food safety behaviours of different targeted groups of individuals and assessing the relationship between actual observed behaviour and psychological variables, such as knowledge, attitudes/beliefs and intentions,[49] and comparing observed malpractices with pathogenic isolations campylobacter and salmonella.[28] Research undertaken in Australia[43] used time-lapse video monitoring from a single mounted camera in home kitchens for periods of time lasting 1 or 2 weeks. The American study[88] used portable video cameras to record the food preparation practices of one meal preparation in participant home kitchens.

Repeatability of observed hygiene behaviours

To date, most information detailing actual consumer food safety behaviours has been based on single meal preparations. However, research carried out in the UK has determined the consistency of consumer food safety practices.[19,86,93] Repeatability refers to the consistency of food safety actions when the same meal is prepared over and over again on separate occasions. Reproducibility refers to the consistency of food safety actions when different meals are prepared repeatedly.[85] Information detailing the consistency of implementation of specific food safety errors is useful for the development of consumer food safety education initiatives. In addition to this, when assessing consumer food safety behaviour before and after interventions it is important to know how transferable the implementation of food safety behaviours are during different situations. Results have provided a more accurate picture of consumer food safety behaviours as well as validating the observation technique of food-handling practices in the model domestic environment.[19,85]

Comparisons between consumer food safety information obtained using surveys, focus groups and observation

As described previously, different research methodologies have been used internationally for the collection of information about consumer food safety. Data in Table 6 illustrate results obtained from surveys, focus groups and observational studies for generic food safety behaviours. Generally, information obtained from surveys (questionnaires and interviews) provides a positive picture of consumer food safety, whereas information obtained from focus groups appears to provide a less optimistic view of how food is prepared in the domestic environment. The gradation of concern continues when analysing actual food safety behaviours from observations of consumer meal preparations. Results indicate that many consumers frequently implement unsafe food-handling actions. Overall, it can be seen that implementation of different research methodologies to determine consumer food safety have produced inconsistent findings. Discrepancies between consumer food safety knowledge, attitudes, intention, self-reported practice and actual behaviour have been identified and previously discussed.[32]

Quantitative questionnaire and interview data indicate that large proportions of consumers have responded positively to the importance, necessity and

Table 6 Comparison of consumer food safety information obtained using surveys, focus groups and observation

	Surveys			
	Questionnaires	Interviews	Focus groups	Observational technique
Hand-washing/ hand-drying	100% consumers recognised when and how it was necessary to wash hands.[49] 95% consumers thought hand-washing is important after handling raw chicken.[19]	82% recognized that washing hands before handling or preparing food was vitally important food hygiene activity.[56] 87–92% respondents always/ usually wash hands with soap and water before handling food.[94–96]	*'I just rinse them under hot water'*.[81] *'I might wipe my hands on a towel'*.[81] *'I normally put mine under the cold tap, leave it running and . . . splash about'*.[20] '*I put washing-up liquid, Fairy, I give it a good old scrub and then run the tap'*.[20]	~75–100% failed to wash and dry hands immediately and adequately after handling raw chicken.[20,43,49,86,87,97]
Cross contamination	100% consumers answered questions correctly about use of different utensils between use of raw and RTE foods.[49]	64% thought that it was very important to use separate chopping boards for raw meat and other foods.[22] 59–76% always/usually use separate utensils, e.g. chopping board for preparation of raw meat and cooked food.[94–96]	*'I always wipe over the board . . . between preparing things'*.[81] '*I just swill everything'*.[81] '*I've got a meat knife and a vegetable knife'*.[81]	52–75% failed to wash/dry c/board and/or knife for preparation of RC then salad ingredients.[20,49,86]
Heating efficacy	96% knew that it is important to check the inside of the chicken to ensure that it is fully cooked.[98] 88% assessed end of cooking subjectively.[64]	74–92% responded that eating unddercooked meat/chicken could cause food poisoning.[99,100] 12% always use a meat thermometer to check doneness of meats.[100]	'*When its cooked all the way, its done'*.[80] *'the smell tells you it's close to being done'*.[80] '*. . . wiggling the leg, if its loose, its done'*.[80]	46–83% undercooked home-made burgers/ meatloaf and chicken.[19,86,88] 0% consumers used a meat thermometer to determine heating adequacy of roast chickens or beef burgers.[19]
Cooling	49% agreed that cooked food should be cooled at room temperature before refrigeration or freezing.[69] 84% agreed that it is acceptable to cool foods at room temperature.[19]	69% respondents knew that keeping food at room temperature/contamination of food after cooking causes food poisoning.[101]	'*I leave it in the saucepan, put the lid on, and then leave it to cool'*.[19] '*It takes forever to cool doesn't it*'.[19]	100% failed to implement all actions required for adequate cooling.[20]
Storage practices	75% knew that bacteria responsible for causing foodborne illness grow at room temperature.[60] 73% consumers answered all knowledge questions regarding storage correctly.[49]	75% consumers think that food should be refrigerated within one hour of cooking completion.[102]	Re a cooked turkey '*I left it overnight (*at room temperatures) *but covered it with a tea towel'*.[19]	57% left chicken salad at room temperature for storage.[20]

self-reported practice of hand-washing and hand-drying during food preparation. However, qualitative data from focus groups indicate that consumers do implement hand-washing malpractices. It is suggested that focus group data may represent a more accurate description of self-reported practices than survey data. Focus group results have shown that consumers are more likely to describe specific food preparation procedures, whereas responses to generic questions in surveys may be subject to social desirability bias.[32] Such findings compare favourably with observations of consumers where analysis of hand-washing and hand-drying actions showed that between 75% and 100% consumers failed to wash and dry hands immediately and adequately after handling raw chicken during food preparation. Such differences between quantitative surveys and quantitative observational studies illustrate the discrepancies in data collected about consumer food safety practices using different research methodologies. Although consumers have demonstrated knowledge, positive attitudes and intentions to implement safe practices, substantially larger proportions of consumers have been observed to implement many food-handling malpractices.

As with hand-washing and hand-drying, actions related to cross contamination, heating efficacy, cooling and storage, based on knowledge, attitudes, intentions and self-reported practices (from surveys) do not appear to be consistent with observational data. Such findings illustrate that responses to questionnaire and interviews conducted to identify aspects of domestic food safety are subject to social desirability bias.[42] Indeed, Curtis *et al.*[42] considered that data collected through direct observation of hygiene-related behaviours has greater validity than data obtained through questionnaire interviews.

Out of all of the generic food safety behaviours discussed, fewer respondents demonstrated correct knowledge of cooling practices. In addition to this, observation results indicated that no consumers implemented all of the appropriate actions required for adequate cooling. Furthermore, it appears that qualitative responses from focus groups illustrate specific actions that consumers report to implement during food preparation, by citing examples opposed to agreement or disagreement whether generic practices are implemented. For example, although three-quarters of responses in surveys indicated that consumers possessed knowledge of, and correctly implemented, appropriate storage procedures, focus group comments denoting storage procedures of a cooked turkey appeared to agree with observational data more readily than survey data.

Although questionnaire and interview surveys have been the most commonly used instruments to obtain information about consumer food safety, the validity of the findings is questionable. Other workers have examined the level of agreement between questionnaire responses and direct observation of hygiene behaviours in Bangladesh[44] and Burkina Faso.[42] Both studies determined a low degree of concordance between questionnaire responses and direct observation, findings that also support inferences made from this discussion about consumer food safety data.

Table 7 Summary of findings

- Interest in domestic food-handling has prompted implementation of consumer food safety studies from international origin, the majority of data has been collected in UK and Northern Ireland (48% studies) and USA (42%).
- Use of surveys (questionnaires and interviews) has been the most frequent method of data collection about consumer food safety, accounting for 75% of reviewed studies.
- Quantitative survey methods are important for collection of information about consumer knowledge, attitudes and self-reported practices, yet comparisons of results from such surveys with observational findings have shown that discrepancies between the methods of data collection are present.
- Survey data illustrate a more positive picture of consumer food safety than data obtained from observations of actual food preparations.
- Observation results suggest that substantial numbers of consumers' still implement unsafe food-handling practices. For example, up to 100% consumers have failed to wash/dry their hands adequately after handling raw chicken and more than half consumers fail to use separate or adequately washed and dried utensils between the use of raw meat/poultry and ready-to-eat foods.
- Observation provides the most reliable data denoting consumers actual food safety behaviour, however, the observation technique is typically time consuming and expensive.
- Focus group data can provide detailed qualitative data regarding perceptions of food safety, barriers and benefits to implementing food behaviours and perceptions of food safety education.

Conclusions

A summary of main findings from this discussion can be found in Table 7. It can be concluded that a comparison of different research methodologies used for obtaining information about consumer food safety in the domestic environment provides inconsistent findings about consumer food-handling behaviours. Although many surveys have presented data detailing that large proportions of consumers possess adequate food safety knowledge and also self-report to implement many safe food-handling actions, observation data have identified the contrary. Direct observations of consumer food safety behaviour in a model domestic environment and in consumer homes have indicated that many food safety malpractices occur on frequent occasions during food preparation. Educational efforts are required to reduce the risk of food-borne disease and improve consumers' food-handling behaviours in the domestic environment.

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