Consumer food-safety education for the domestic environment:

A systematic review

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Abstract

Purpose

Despite the recognised importance of food-safety, a large number of consumers do not practice adequate food-safety in the home. Many studies have recommended that education is a key step in preventing food borne illness in the domestic environment. However, few educational or psychosocial interventions have been designed and implemented to improve food-safety knowledge, attitudes and behaviours. Even fewer of these studies have been subject to rigorous appraisal. A systematic review of studies that described and evaluated a food-safety intervention in a non-clinical adult sample was conducted.

Design/methodology/approach

A total of ten studies met the criteria for inclusion in the systematic review. Outcomes of interest included food-safety *behaviour, behavioural intention, attitudes, knowledge, microbial transfer* and the use of *Social Cognition Models.*

Findings

The evidence regarding the effectiveness of the reviewed interventions on these food-safety outcomes was somewhat positive, however, many gaps remained. For example, of the 5 self-report behaviour change studies all reported some significant improvement post intervention. However, the percentage of specific behaviours that significantly changed within each study varied between 0.04 to 100%. There were methodological flaws in many of the studies which complicated the interpretation of these results and indicate a need for more research.

Research limitations/implications

Future research should include better defined outcomes, longer follow-up, more rigorous reporting of results and intervention design, the use of randomised controlled trial protocols, and utilising health models to have a greater theoretical underpinning to the studies.

Originality/value

This is the first systematic review examining the effect of psychosocial food-safety interventions on behaviour, attitudes and knowledge.

Key Words: Food-safety, Consumers, domestic, intervention, Social Cognition Models systematic review

1. Introduction

Despite significant theoretical and practical developments in food-safety management (Fischer, A. R. H. *et al.*, 2006) food-borne illness continues to be an increasing global public health concern (World Health Organization, 2002). This preventable yet pervasive health issue generates both clinical problems for the individual (Helms *et al.*, 2003) and an economic burden for society (Altekruse *et al.*, 1997; Mead *et al.*, 1999; NSW Food Authority, 2009).

Data reports from the United Kingdom reveals that food related disease annually affects 5.5 million consumers (Food Standards Agency, 2002), causes 687 deaths (Adak *et al.*, 2005) and cost approximately £1.5 billion (Redmond & Griffith, 2006a). To add further weight to this issue, the actual number of food-borne illness cases may be even more prevalent than these statistics suggest as many incidents are not reported to relevant health authorities (Day, 2001; Mead *et al.*, 1999).

Research suggests that many consumers hold the belief that food-borne illness primarily arises from the practices of food manufacturers and vendors, whilst remaining unaware that the home is a likely place for food-safety problems (Redmond & Griffith, 2004a; Redmond & Griffith, 2004b; Williamson *et al.*, 1992). Despite this assumption held by many consumers, studies from the United Kingdom have estimated that between 50 % and 87 % of reported food-borne disease arise in the home (Redmond & Griffith, 2003; Scott, 2000); with 16 % of cases being direct result of consumer behaviour in the UK (Ryan *et al.*, 1996). This considerable amount of food-borne illnesses commencing in the home at the hand of the consumer highlights the need for consumer protection in the domestic environment being addressed and managed effectively.

Food-safety literature is now placing emphasis on the role of the consumer in engaging in self-protective behaviour. As a consequence, food-safety objectives are now being set at the moment of consumption rather than at the moment of purchase (WHO/FAO, 2004) with consumers being heralded as the essential final link in the food chain to ensure safe food consumption and avoid food-borne disease (The Pennington Group, 1997, as cited in Redmond *et al.,* 2004). This shift in focus has allowed researchers to comprehensively examine domestic food preparation practices using telephone surveys (Cody & Hogue, 2003; Redmond & Griffith, 2004a; Woodburn & Raab, 1997), postal surveys (Angell, 2008; Dharod *et al.*, 2004; Redmond & Griffith, 2005a; Redmond & Griffith, 2005b; Redmond & Griffith, 2006a; Takeuchi *et al.*, 2005a; Takeuchi *et al.*, 2005b; Williamson *et al.*, 1992), online surveys (Byrd-Bredbenner *et al.*, 2007; Nauta *et al.*, 2008; Unusan, 2007), home visits (Worsfold & Griffith, 1996), observations (Anderson *et al.*, 2004; Clayton *et al.*, 2003; Fischer, A. *et al.*, 2007; Jay *et al.*, 1999; Redmond & Griffith, 2006b; Redmond *et al.*, 2004), laboratory simulations (Meredith *et al.*, 2001) and reviews (Redmond & Griffith, 2003; Sattar *et al.*, 1999; Wilcock *et al.*, 2004).

This extensive research of domestic food preparation practices has highlighted the present inadequacy of consumer hygiene in the home. For example, it has been found that inadequate cooking and storage of food is considered to be the main cause of food poisoning in the domestic environment (Cogan *et al.*, 2002). Furthermore, poor hand and surface hygiene is also a significant contributing factor (Cogan *et al.*, 2002) in up to 39 % of domestic food poisoning outbreaks (Ryan *et al.*, 1996). Overall, research has found that the most common behaviours impacting the control of numerous pathogens include proper hand washing and personal hygiene, safe and adequate cooking of food, storing foods at safe temperatures, and effectively washing surfaces and equipment to prevent cross-contamination (Medeiros *et al.*, 2004; Medeiros *et al.*, 2001a; Medeiros *et al.*, 2001b).

Inadequacy of consumer hygiene in the home highlights the need for the implementation of effective psychosocial interventions which aim to change food-safety behaviours, attitudes or knowledge either via educational materials or training. Several studies have concluded that education regarding the prevention of food-borne disease is required if food hygiene standards are to improve (Barrett *et al.*, 1996; Gorman *et al.*, 2002; Li-Cohen & Bruhn, 2002; Medeiros *et al.*, 2001b; Ropkins & Beck, 2000). Appeals have also been made for the use of Social Cognitions Models such as the Theory of Planned Behaviour (Ajzen, 1991) to be used to assist to provide a framework for both communicating food-safety messages and evaluating the success of interventions (Griffith *et al.*, 1995). Particularly as they have been proven to obtain reasonable levels of predictive validity for both explaining behaviour and providing knowledge to inform the development of theoretically-based health interventions (Jenner *et al.*, 2002).

In spite of calls for domestic food-safety education, very few studies actually focus on implementing food-safety interventions, with even fewer being subjected to rigorous appraisal. Therefore the purpose of this paper is conduct a rigorous and systematic review of psychosocial interventions designed to increase consumers' hygienic behaviour in the domestic environment.

2. Methods

2.1. Literature search strategy

All studies published in English up to April 2009 relating to domestic food-safety interventions were examined. PsycInfo, Web of Science, ProQuest, Science Direct, Google Scholar and the Cochrane Library were systematically searched using appropriate text words and thesaurus terms for papers relating to food-safety, food hygiene, food poisoning, consumer and domestic. Searches were also undertaken by hand with reference lists.

2.2. Study Selection Criteria

Only peer reviewed studies describing and evaluating a psychosocial intervention were eligible for inclusion. Due to limited numbers of food-safety studies that applied psychosocial intervention, all comparative designs with concurrent controls, whether or not allocation was random, were considered. There was no restriction on placed on whether a follow-up measure was implemented. Geographic location was limited to developed countries to ensure uniform comparison across studies.

2.3. Participants

The participants fell into the category of adult men and women. Restrictions were placed on special groups such as pregnant women, children and people with impaired immune function. This was due to the key differences for these groups in implementing domestic food-safety measures compared to the general population. There were no restrictions according to number of participants in the study.

2.4. Types of interventions

Studies eligible for inclusion in the review evaluated psychosocial interventions to improve consumer food-safety. There were no restrictions according to the frequency, intensity, or duration of interventions. Some of the present systematically reviewed studies examined numerous experiments that were not always related to the topic at hand. Only the relevant parts of studies relating to food-safety psychosocial interventions were reported in the current review.

2.5. Types of outcome measures

As appeals have been made for the use of Social Cognitions Models (SCM) as a framework for food safety interventions (Griffith *et al.*, 1995) this was investigated as an outcome measure of particular interest. Furthermore, constructs generally found within these SCM, such as the Health Action Process Approach (HAPA) and the Theory of Planned Behaviour (TPB), were examined as areas of interest. These included either self-reported or

observed changes in *behaviour*, *behavioural intention*, *attitude* or *knowledge* of the consumers' food-safety practices. To add to the strength of the review, more quantifiable outcome measures were also examined, including the *frequency of food related illness* occurring for the consumer and the *microbial transfer* observed in the food preparation area.

2.6. Methods of the review

The abstracts of the identified articles were screened for relevance. Articles were rejected if the abstract determined ineligibility. When an abstract could not be rejected with certainty, the full text of the article was obtained for further evaluation. Ambiguous papers were resolved through consultation among the authors. The reviewer rated the level of evidence provided by each included study. This was performed according to the National Health and Medical Research Council (NHMRC) evidence rating system (See Table 1).

A review template was developed specifying the key information about each study (see Tables 2 and 3). This template was made up of two tables, the first of which included information about the sample included in the study, randomisation procedure, and level of evidence as rated by the reviewer. The second table included information about the design and implementation of the intervention under review and the findings of each study.

3. Results

3.1. Literature search results

Including duplicates, electronic database searching yielded 1548 bibliographic records. In total, 10 of these studies were included in the present review (see Table 2). All the studies identified through electronic database searching were reported in published journal articles. Partial results from two studies (Takeuchi *et al.*, 2005a; Takeuchi *et al.*, 2005b) were also reported in a section of another somewhat larger paper examining food thermometer usage (McCurdy *et al.*, 2006). For the purposes of this paper the studies were

only discussed as a part of the original papers as they contained greater detail. No other studies were reported in multiple papers.

3.2. Study characteristics

Information of the characteristics for each study is presented in Table 2 and 3.

3.3. Study Quality

Overall, the studies had varying quality. The issues arising from this systematic review included many studies solely relying on consumers' self-report, the need for better defined outcome measures, better designed selection and follow-up procedures, more rigorous reporting of results and intervention design, the use of randomised controlled trial protocols, and utilising health models to have a greater theoretical underpinning to the studies. These issues surrounding the quality of the interventions are discussed.

Firstly, the majority of studies utilised self-report questionnaires and surveys as their main outcome measures. Previous food safety literature has documented that solely gathering self-reported food safety information can be an issue; particularly as social desirability bias has been found to be prevalent in many consumer food safety surveys (Redmond & Griffith, 2003). One study, however, did observe food-safety behaviour malpractices (Redmond & Griffith, 2006b) and another utilized both observation and survey (Nauta et al., 2008).

In terms of the design of the studies, there were also some issues due to lack of reporting. For example, blinding of participants to either the conditions or the research question was generally not reported. However, one study reported blinding participants to the research question of the study (Nauta et al., 2008). Two studies included outcome assessment via observations; however, neither study included information about blinding of assessors to conditions (Nauta et al., 2008; Redmond & Griffith, 2006b). Another potential issue in terms of design for the Medeiros, et al. (2004) study was a lack of reporting of the timing differences for the implementation of interventions compared with the control. That is, this study advised that the control group was retested after a two week period; however, there was

no indication of how much time elapsed between baseline and post intervention testing for the intervention groups. This is particularly suspect as the control group had a 100 % response rate, whereas the intervention groups were 33 and 37 %. Overall, these timing issues could potentially confound the results of the study, as other external variables may influence or bias outcomes.

Selection issues were also potential source of bias for a number of studies. Only four studies reported response rates post-intervention. Overall, response rates of completion were very low and ranged from 32 to 37% for all studies except one control group which had a response rate of 100%. Low response rates may increase the incidence of bias, as there may be confounding differences in the candidates who responded compared those that chose not to partake in the studies. No studies reported sufficient data that would allow for the evaluation of differential dropout that could be responsible for post test group differences. No studies reported consent rate meaning that the issue of selection bias cannot be fully evaluated. However, several potentially confounding selection issues are still apparent. For example, the Unusan (2007) study applied a self selected voluntary procedure to divide participants into one of two conditions. Overall, this process is methodologically weaker due to the lack of control group for comparison and the self selection procedure not attempting to reduce bias. A further selection issue found was that three of the ten studies used participants who were enrolled in nutrition and food-safety program (Angell, 2008; Medeiros *et al.*, 2004; Nies & Van Laanen, 1995). This may bias results as participants may have a pre-existing interest in this area and therefore the results may not generalise to the mainstream consumer community.

An additional cause for concern was the improper implementation of methods to review the interventions in many of the studies included in this review. In two of the studies, a questionnaire was distributed to participants who had attended one of the food education programs over the past two (Nies & Van Laanen, 1995) to three years (Angell, 2008). These

studies subsequently asked participants to complete a retrospective survey inquiring about their pre and post intervention food-safety knowledge (Angell, 2008) and behaviours (Angell, 2008; Nies & Van Laanen, 1995). Two methodological issues arise from this procedure; firstly, a large amount of time may have elapsed between the intervention and the questionnaire which may hinder accurate responses from participants due to recall issues. Furthermore, retrospective questioning without baseline measure may also result in recall issues coupled with the potential for social desirability biases to arise. That is, participants may underestimate their food-safety knowledge and behaviour pre intervention whilst over estimating changes post intervention.

Only three studies were designed as controlled trials (Medeiros *et al.*, 2004; Nauta *et al.*, 2008; Redmond & Griffith, 2006b). Two of these, however, reported unequal sample sizes between the intervention and the control condition without rationale (Medeiros *et al.*, 2004; Redmond & Griffith, 2006b). Furthermore, due to the small nature of the Redmond & Griffith (2006b) pilot study, effect size analysis rather than statistical significance tests were conducted. As such this study may not be able to effectively draw conclusions about differences between the efficacy of the control and intervention procedures.

An additional issue was that some studies grouped outcomes together that should instead be mutually exclusive. Unusan (2007), for example, grouped both concerns and practices as the one outcome variable; Dharod et al.'s (2004) study also grouped food-safety attitudes with the knowledge and behavioural outcomes rather than place it as a separate construct.

A final point for discussion in terms of quality was the application of Social Cognition Models (SCM). Of the ten studies, four did not refer to any SCM (Dharod *et al.*, 2004; Nauta *et al.*, 2008; Nies & Van Laanen, 1995; Unusan, 2007). Two of studies referred to SCM in their introductions, but failed to apply any of this theory to their study design (Angell, 2008; Medeiros *et al.*, 2004). For example, Angell (2008) discussed the Theory of Planned

Behaviour (TPB) yet only examined knowledge and behaviour in depth and touched on motivation which is not a construct on the TPB. Furthermore, areas such as Subjective Norms, Attitude, Perceived Behavioural Control and Behavioural Intentions were ignored for both the intervention and the assessment components.

The Cody & Hogue (2003) study questionnaire does appear to apply the Health Belief Model (HBM) constructs (*perceived susceptibility, perceived seriousness, demographic variables, perceived threat of disease, cues to action* and *likelihood of change*) to its survey questions. However, there are some issues in terms of application. For example, the paper does not examine the HBM construct *perceived benefits vs. costs of preventative action*. Furthermore, the study only refers to the HBM in the discussion section of the paper. Thus, it is not made clear in the introduction or methods sections that the HBM is the main model utilised in the study.

The Redmond study (Redmond & Griffith, 2006b) refers to the Health Action Process Approach (HAPA) in the methods section, in which the researchers utilise the HAPA for participant recruitment. However, as the Redmond study is observational it only focuses on the HAPA *Action* stage. Therefore, no data is gathered in relation to *Self Efficacy, Outcome Expectancies, Risk Perception, Intention* and *Planning.*

Finally, both the Takeuchi studies (Takeuchi *et al.*, 2005a; Takeuchi *et al.*, 2005b) utilise the Transtheoretical Model of Behaviour change (TTM). These are the only studies which clearly include their Social Cognition Model in their intervention, their outcome measures and discussion.

4. Outcomes

4.1. Social Cognition Models

The Takeuchi studies (Takeuchi *et al.*, 2005a; Takeuchi *et al.*, 2005b) were the only studies that reported results in terms of Social Cognition Models. In both studies, results

generally found that interventions were successful in moving some participants through to the next stages of the TTM (See Table 2 for full results). For example, in one study (Takeuchi *et al.*, 2005a) participants in the contemplation stage increased from 8% pre-intervention to 12% post intervention and there was a noted increase number of participants into the action stage (1% pre intervention to 18% post intervention). Results were presented as percentages and significance levels were not reported.

4.2. Constructs of Social Cognition Models

4.2.1. Behaviour

Of the 10 studies included in this review, seven considered some form of consumer food-safety behaviour as an outcome. Six studies considered self-reported behaviour change based on the intervention via pre/post intervention survey designs (Angell, 2008; Cody & Hogue, 2003; Dharod *et al.*, 2004; Nies & Van Laanen, 1995; Takeuchi *et al.*, 2005b; Unusan, 2007), one study looked at behavioural intention using a questionnaire design (Nauta *et al.*, 2008) and one study examined behaviour via observation (Redmond & Griffith, 2006b). All studies found some significant evidence of a positive increase in food-safety behaviours post intervention.

4.2.1.1. Self Reported Behaviour

The Angell (2008) study revealed that there was a significant positive increase in self-reported behaviour change on all food-safety with six of the seven questions showing significance at the 99% confidence level ($p<.01$) and the remaining question showing significance at the 95% confidence level ($p<.05$). The Cody and Hogue (2003) showed that from 1999 to 2002 there was an increase in food safety behaviours in three areas including hand-washing, cross contamination and thermometer usage ($P=.03$, .04 and .01 respectively). Dharod et al. (2004) found two significant improvements in food-safety behaviour out of a potential nine for defrosting meats \ ($P = .01$) and proper hand-washing ($p<.01$). Takeuchi,

Hillers, McCurdy, and others (2005b) found there was a significant change thermometer usage post intervention ($p<0.01$). The Nies and Van Laanen study (1995) found that all behaviours improved after the intervention, but only seven of them were significant (6 of 11 behaviours $p<.01$; 1 of 11 behaviours $p<.05$). Despite differing terminology of the outcomes, Unusan (2007) found self-reported behaviour improved significantly for the e-mail group improved significantly for 11 of the 25 concerns and practices; however, the handout intervention group only improved significantly in one area. Overall, of the 5 self-report behaviour change studies all reported some significant improvement post intervention. However, the percentage of specific behaviours that significantly changed within each study this varied between 22.2 to 100 %.

4.2.1.2. Observed Behaviour

Despite not examining significance, Redmond and Griffith's (2006b) observational pilot study, also showed improved food-safety behaviours immediately after the intervention (Effect Size = 0.65) which was reduced to a much smaller effect size at follow-up 4 to 6 weeks later (Effect Size = 0.32).

4.2.2. Behavioural Intentions

Behavioural intentions to conduct safe food handling practices when preparing food was examined in one study (Nauta *et al.*, 2008). The survey study outlined in the Nauta et al. (2008) paper investigated the effect of an intervention that included education with persuasive messages aimed at eliciting emotions such as disgust or aggression. An ANOVA revealed that both versions of the risk information intervention and the control significantly affected participant food-safety behavioural intentions ($p < 0.001$). Although the aggression condition appeared slightly less effective when compared to both disgust ($p = 0.11$) and no emotion conditions ($p=0.22$), this difference was not significant.

4.2.3. Food-safety Knowledge

Apart from one study, evidence regarding the effect of reviewed interventions on food-safety knowledge was mixed. Four survey studies aimed to consider the effects of a food-safety intervention of consumers' food-safety knowledge (Angell, 2008; Cody & Hogue, 2003; Dharod *et al.*, 2004; Medeiros *et al.*, 2004).

The Angell (2008) study revealed that food-safety knowledge increased significantly between pre and post test ($p<.0001$). The Dharod et al. (2004) study also revealed positive results as individuals exposed to the campaign were more likely to have a higher food-safety knowledge score than unexposed counterparts ($p<.001$). Medeiros and her colleagues (2004) also found that the mean "knowledge gain" scores for the intervention groups were significantly higher than for the control ($p<.01$). However, the Cody and Hogue study (2003) revealed that knowledge gaps remained in all areas covered in national food-safety awareness programs, including "cook," "chill," "clean," and "separate".

4.2.4. Attitudes

The outcome measure of attitudes was more difficult to define as some studies stated vastly different purposes for measuring attitudes is their study or applied differing methods of obtaining and reporting the attitudinal data.

Overall, there were mixed results in terms of consumer attitudes towards food-safety. For example, the Cody and Hogue (2003) study found widening gaps in consumer food-safety beliefs and knowledge over time ($p<.01$). However, their study did reveal some positive attitudes towards the importance of food-safety in the home (97%) and receiving food-safety education (82%). Positive attitudes towards food-safety was also found in the Takeuchi (2005b) study, which increased as participants progressed along the stages of change continuum (e.g. from contemplation to action).

Two studies attitudinal outcome measures lacked clarity as discrete measures as they combined food-safety knowledge with attitudinal data for some (Cody & Hogue, 2003) or all (Dharod *et al.*, 2004) of their attitudinally based questions. This process is not recommended in terms of methodological best practice. Unfortunately, despite developing an attitudinal measure with discrete attitudinal constructs, the Medeiros (2004) study did not test this measure in any psychosocial interventions.

4.3. Other Constructs

4.3.1. Microbial transfer

Only one observational study examined microbial transfer as an outcome measure (Nauta *et al.*, 2008). The study found that behavioural cues aimed at eliciting disgust did appear to have some positive impact in changing pathogen levels in the kitchen.

5. Discussion

The evidence regarding the effectiveness of the reviewed interventions on food-safety behaviour was generally positive. Results from food-safety interventions showed evidence that psychosocial and educational courses and interventions lead to an increase in self-reported food-safety behaviours. However, it is advised that some caution is taken when interpreting the data. Firstly, the percentage of total self-reported behaviour change that did show a significant improvement ranged between 0.04 and 100% (Angell, 2008; Cody & Hogue, 2003; Dharod et al., 2004; Nies & Van Laanen, 1995; Unusan, 2007); with three of the five studies reporting significant changes for less than 50% of the behaviours in question (Cody & Hogue, 2003; Dharod et al., 2004; Unusan, 2007). This reveals that not all food safety behaviours within each study had significant positive changes. Furthermore, Angell's (2008) study which gained 100% significant self-reported behaviour change had numerous dubious features. These included utilising a retrospective questionnaire, sending the

questionnaire to participants up to 3 years after completing the study and only gaining a 36% response rate. For obvious reasons this may bias the study's results. Secondly, all surveys have limitations in assessing behaviours as it relies on self-report. The surveys are not validated by checking actual consumer behaviours such as whether recommended hand-washing techniques were followed or whether thermometers were used correctly. The use of these self-report measures have repeatedly been described as unreliable indicators of behaviour (Griffith et al., 1995; McKenzie-Mohr & Smith, 1999) particularly as social desirability bias has been found to be prevalent in many consumer food safety surveys (Redmond & Griffith, 2003). That is, for knowledgeable consumers, giving the "correct" answer might reflect their reaction to social norms, rather than a genuine response of following the specific behaviour appropriately.

Only one observational study was conducted that examined the effect of an intervention on food-safety behaviours (Redmond & Griffith, 2006b). Despite some promising immediate results post intervention, this was a small pilot study targeting a specific cohort of the population (older females of low SES) which did not examine significance. This makes it difficult to generalise to the wider community and only really provides weight to the argument that further research is needed in this area. Furthermore, as 4 to 6 week follow-up data revealed that the food-safety intervention effect size was not sustained adequately, more research is required with a larger population.

In terms of food-safety knowledge, the evidence was mixed. The Angell (2008) study revealed that food-safety knowledge increased significantly, however, the study retrospective design allowed for bias to occur. Two studies (Dharod *et al.*, 2004; Medeiros *et al.*, 2004) studies also revealed positive significant results for knowledge gain scores for the intervention groups compared with those unexposed to the intervention. However, the Cody and Hogue study (2003) revealed that knowledge gaps remained in all most food-safety areas.

The outcome measure of attitudes was more difficult to define as some studies used differing methods of obtaining and reporting the attitudinal data, as discussed previously. Despite these construct difficulties some interesting results were found. Overall, results indicated that consumers acknowledge the importance of food-safety behaviours, however, still hold the belief that food related illnesses are not commonly a domestic issue.

The impact of food-safety information combined with a behavioural cue to elicit disgust as an emotional response showed a positive impact in changing microbial levels in the kitchen. Overall, using both disgust and microbial presence was a novel way of conducting an intervention. Although well designed, microbial transfer was a major outcome measure in just one study (Nauta *et al.*, 2008). As such, it is difficult to draw conclusive results without a larger body of literature to support this style of psychosocial food-safety intervention and thus more research is recommended.

The final outcome measure examined in the current review was the use of Social Cognition Models. Overall, it was found that there was relatively inconsistent application of these in most studies. The two studies that did actually apply their SCM consistently was the Takeuchi studies (Takeuchi *et al.*, 2005a; Takeuchi *et al.*, 2005b) which utilised the Transtheoretical Model of Behaviour Change. The TTM, however, has had some criticism with a 2005 systematic review of 37 randomized controlled trials stating that "there was limited evidence for the effectiveness of stage-based interventions as a basis for behaviour change" (Bridle *et al.*, 2005).

5.1. Implications for future research

Despite some positive results in terms of food-safety, numerous methodological concerns coupled with the inconsistency in findings even when comparing similar surveys and studies created difficulties in drawing robust conclusions based on the available evidence. Easily addressed issues such as increasing sample sizes, improving selection and

randomisation procedures, applying longer post intervention follow-up measures, reporting blinding procedures, consent rates and differential drop-out as well as basing the experimental design on Social Cognition Models are highly recommended for future research.

Eight of the ten studies relied on self-report. As discussed previously, this method of data collection can be subject to social desirability bias. It is therefore recommended that future studies using self-report data ensure some social desirability controls are implemented. A further recommendation is that as most studies utilised a pretest/posttest survey design, other types of measures such as those used in observational studies are implemented to add to the body of knowledge in food-safety behaviours.

The mixed results for many of the behavioural and attitudinal constructs highlight the need for further research in consumer food-safety education. Particular focus might be targeted at consumer beliefs surrounding the likelihood and severity of food poisoning arising from domestic food preparation. Due to the success of the disgust behavioural cues in the Nauta (2008) study, future psychosocial food-safety research may wish to incorporate disgust cues into their interventions to assist in highlighting the probability and severity of food poisoning arising in the home.

The lack of discrete attitudinal questions that have been applied in current psychosocial interventions is concerning. This blur of constructs, such as those evident in Unusan's (2007) and Angell's (2008) studies, makes it difficult to assess what outcomes are being influenced by the psychosocial intervention or campaign. Overall, this makes future psychosocial interventions difficult to base on past research. It is therefore strongly recommended that better defined attitudinal constructs, such as those developed in the Medeiros (2004) study, are applied in future research to reduce the need to continually reinvent the wheel.

Many of the studies discussed theoretical underpinnings of health models in their introductions; however, failed to apple these models' constructs as outcome variables. This showed that despite some awareness, many of the studies generally did not adhere to pre-existing health models and therefore may inadvertently lose methodological strength and reduces transferability across differing intervention areas. Furthermore, inconsistencies across studies in terms of defining outcome variables, merging of outcome variables and variance in the reporting of findings results in difficulties in terms of interpreting and comparing studies. Other issues found, such as failing to measure and report on an outcome despite discussing it in the aims of the study should also be avoided. If future research applies these pre-existing models of health, such as the Theory of Planned Behaviour or the Health Action Process Approach, a clearer picture of food-safety in the domestic environment may indeed be drawn. Furthermore, it may assist in lay the foundations for further research and development of psychosocial food-safety interventions in a more systematic and rigorous fashion.

5.3. Future research designs

To summarise these recommendations, a future study would base its intervention design and questionnaires on Social Cognition Models. Furthermore, it would utilise a randomised controlled study design using observational data gathering techniques similar to Redmond's pilot study (2006b) with sufficient sample size. Pre/post testing and a 6 month follow-up would take place to evaluate the interventions short term and long term impact. The study would also gather self reported data on Knowledge, Self Reported Behaviours and TPB constructs including *Attitudes, Subjective Norms, Perceived Behavioural Control* and *Behavioural Intentions* at each experimental stage. This would allow for a full exploration of how food safety interventions can assist in changing consumer food safety behaviours. However, as previously discussed in the Redmond paper (Redmond & Griffith, 2006b), it is

noted that such a study would have much greater time and monetary costs that the traditional survey approach.

5.2. Potential biases in the review process

Potential bias at the data extraction stage was minimised by developing a study review template, which was subsequently used by the reviewer to extract key data from each study. However, this review only examined published studies and did not assess research from grey literature sources and government documents. This examination method may allow the review to be subject to some publication bias. In addition, there may be relevant studies published in languages other than English that have not been indexed by the bibliographic databases used in the present review. Furthermore, many food-safety interventions are completed in the developing world or focus on industry workers; however, due to the present reviews inclusion criteria these studies were not examined even though they may have been a rich source of information.

On a final note, some of the included studies also focused on other areas of food safety as well as providing a psychosocial food-safety intervention. For example, the Medeiros study's (Medeiros *et al.*, 2004) main aim was to develop a food safety knowledge and attitude questionnaire, but still provided a psychosocial intervention. This factor has the potential for a methodologically weaker design in terms of the psychosocial intervention sections of their studies, despite having strong designs for areas outside the scope of this review.

6. Conclusions

To support consumers to adhere to better food-safety practices more research is required to ensure that the most effective types of education and interventions can occur. The current review of the evidence suggests that food-safety interventions are somewhat effective at eliciting food-safety changes in terms of behaviour, knowledge and attitudes; however,

many studies report improvements in only partial improvement post interventions. Furthermore, there is a general lack of research in this area, and a related lack of well designed studies. Although randomised controlled trials are best practice for evaluating these types of interventions, few well designed studies have been conducted in this area of the literature. A greater amount of these types of studies is required to more wholly examine the effects of the wide variety of interventions conducted in this field.

There is also a need for improvements in the reporting of intervention studies in this area. For example, response rates of participants for all stages of data collection allows for the evaluation of differential drop-out. This allows for the identification of bias in the results, and provides a guide to how representative the sample may be to the wider population. As such, consent rates, loss to follow-up and characteristics of individuals who did not participate in all stages of the trial should be routinely reported wherever possible. Accurate evaluation of interventions is assisted by the provision of complete details of analysis and results this is recommended for future studies. Reporting of such features would also allow serious methodological flaws, such as those evident in some papers reviewed here, to be more easily identified and more easily overcome.

As a final point, is suggested that future research builds on features of interventions that have been found to be successful in the past so that the mechanisms through which they operate can be more fully appreciated. This would assist in minimising the many large differences between interventions investigated in the literature particularly in relation to the outcomes measured. An overarching recommendation is that already well defined and established health models should be incorporated into research to allow for better definition of prospective studies designs and to lay more solid foundations for research in this area.

Table 1. NHMRC Evidence Rating System (1999)

Level of Evidence	Description
I	evidence obtained from a systematic review of all relevant randomised controlled trials (RCTs)
II	evidence obtained from at least one properly designed RTC
III-1	evidence obtained from well-designed pseudo-RCTs
III-2	evidence obtained from comparative studies with concurrent controls and allocation not randomised, case–control studies, or interrupted time series with a control group
III-3	evidence obtained from comparative studies with historical control, two or more single-arm studies, or interrupted time series without a parallel control group
IV	Evidence obtained from case series, either post-test or pre-test/post-test

Table 2. Design of included studies.

Author	Level of evidence	Entry criteria	Randomisation procedure	Gender	Sample size
Angell (2008)	III – 3	Cohort of all participants who had previously attended the "Good Food Good Health (GFGH) Programme" over the past 3 years.	No randomisation reported	Gender: not reported	N=31
Cody & Hogue (2003)	III-3	General Public who were heads of the household and prepared a main meal at least 3 times per week.	Random digit dialling technique implemented to ensure that both listed and unlisted participants included in the study.	Gender: Presurvey (1999): 30% Female and 70% Males; Postsurvey (2000): 35% Female and 65% Males	N=1000 (1999) N=1006 (2002)
Dharod, Perez-Escamilla, Bermudez-Millan, Segura-Perez, & Damio,(2004)	III-3	Cohort of respondents from Latino households, with at least one child 12 years old or under, located in 5 predominantly Latino neighborhoods in inner-city Hartford, Connecticut.	Purposive sampling used to target Latino population, no random allocation reported.	Gender: Presurvey (1999): Males = 8%; Females= 92% Postsurvey (2000): Males =3%; Females= 97%	N=250 (1999) N=250 (2000)
Medeiros, Hillers, Chen, Bergmann, Kendall, & Schroeder (2004)	III-2	Cohort of an extension consumer audiences in Washington State who had partaken in a educational program, an extension consumer audiences in Washington State who had not partaken in a educational program (control group) and college students in nutrition classes for non-nutrition majors at Washington State University.	No randomisation reported	Gender: not reported	N= 158 (Group 1: extension consumer audiences) N=103 (Group 2: college students in either nutrition classes or non-nutrition majors) N= 19 (Control: extension consumer audience)
Nauta, Fischer, van Asselt, de Jong, Frewer, & de Jonge (2008)	**Online Study:** II **Observational Study:** III-2	Voluntary sample of the general public	**Online Study:** Random allocation to one of the four different risk information conditions. **Observational food preparation Study:** Allocation to the one of three conditions based on exposure to intervention in online study outlined above.	Gender: not reported	N= 3422 (Online Study) N= 86 (Observational food preparation Study)
Nies & Van Laanen (1995)	III-3	Cohort of people who participated in the Texas Agricultural Extension Service (TAEX) education program.	From an available pool of 463 TAEX program participants 100 people were randomly selected for a phone interview.	Gender: Females = 92%, Males = 8%	N = 100

Redmond & Griffith (2006b)	III-2	Cohort of females aged 60-75 years from a specified community in Cardiff that fall in the socio economic classification of skilled manual workers, working class or underclass.	Participants in the control and experimental groups were recruited from demographically matched geographical communities (i.e. matched cluster sampling).	Gender: Female	N= 24 (Experimental Condition) N=14 (Control Condition)
Takeuchi, Hillers, Edwards, Edlefsen, & McCurdy (2005a)	III-3	Cohort of consumers in Washington and Idaho who had previously returned a stage classification survey regarding food thermometer use.	Convenience sample with no random allocation reported.	Gender: Female =63%; Male = 37%	N= 793 (initially contacted via mail) N= 275 (responded to questionnaire)
Takeuchi, Hillers, McCurdy, & Edlefsen (2005b)	III-3	Cohort of randomly selected adult consumers in Washington and Idaho.	Randomisation procedure not described in detail.	Gender: not reported	N=2500 (initially contacted via mail) N= 286 (response to both pre and post-survey)
Unusan (2007)	III-3	Cohort of administrative personnel working at the Selcuk University, Turkey.	Multistage, self selected (voluntary) sample rather than random allocation.	Gender: Female= 42.6%; Male= 57.4%	N=68

Table 3. Intervention design and findings.

Author	Consent rate (CR), response rate (RR)	Intervention Design	Study timeline	Relevant outcome measures	Results
Angell (2008)	36% RR	Retrospective food safety survey sent out to participants who had completed or dropped out of program over the past 3 years.	No baseline data collection; Participants participated in GFGH program; all program participants were posted retrospective survey.	Food-Safety Knowledge; Self-reported Food-Safety Behaviours	**Food-safety knowledge:** significant positive increase between pre and post test ($p<.0001$). **Self-reported behaviour change:** significant positive increases in all areas (six of seven areas $p<.01$; one of seven $p<.05$)
Cody & Hogue (2003)	Not Reported	Phone based food safety survey completed in 1999 and again in 2002 examining changes due to public food-safety interventions.	1999 baseline data collected. The "Home Food-safety . . . It's in your hands" and the "FightBAC" food hygiene campaigns launched. 2002 follow-up data collected.	Food-Safety Knowledge; Food-Safety Attitudes; Self-reported Food-Safety Behaviours.	**Food-safety Knowledge:** Knowledge gaps remained in all areas including "cook," "chill," "clean," and "separate". **Attitudes towards food-safety:** The belief that it was common for food prepared at home making one sick decreased from 34% to 28% (P=.01). **Self-reported food-safety behaviour:** From 1999 to 2002, respondents indicated that they were cooking foods more thoroughly; fewer respondents reported making changes to their cleaning and food-handling practices in 2002 than in 1999. An increase from 1999 to 2002 in hand washing with soap and water after handling raw meat, raw chicken, or raw fish (P=.03). An increase in safe behaviours that lead to cross contamination from cutting boards was present (P=.04). More consumers also reported using thermometers (P=.01).
Dharod, Perez-Escamilla, Bermudez-Millan, Segura-Perez, & Damio,(2004)	Not Reported	Cross-sectional 30-item pre and post intervention food safety survey administered to Adult Latino consumers in either English or Spanish.	November 1999 to February 2000: Baseline data gathered. March to August 2000: The Fight BAC! campaign was delivered in English and Spanish. July to October 2000: Follow-up data gathered.	Food-Safety Knowledge; Food-Safety Attitudes; Self-reported Food-Safety Behaviours.	Exposed participants more likely to have a higher food-safety knowledge scores compared with unexposed counterparts (odds ratio = 3.54; 95% CI 1.74- 7.18; $P < .001$). Two significant changes in behaviour were present out of a potential nine; with participants increasing the frequency of defrosting meats in the refrigerator ($P = .01$) and washing hands with soap before cooking ($p<.01$).
Medeiros, Hillers, Chen, Bergmann, Kendall, & Schroeder (2004)	Consumer Group: 37% RR College Student Group: 33% RR Control: 100% RR	43-item pre and post intervention food safety knowledge questionnaire was completed for two different food-safety programs and a control group.	Baseline food-safety questionnaire administered. Participants partook in one of the two food-safety programs. The control group did not undertake any program. 2 weeks post baseline: Control group again completed the food-safety questionnaire.	Food-safety Knowledge; Food-Safety Attitudes	Comparison between baseline and follow-up mean scores for both consumers college students intervention groups increased significantly ($p<.01$). The control group had no significant difference between baseline and follow-up. Mean knowledge gain scores for groups that received instruction were significantly higher than for the control group ($p<.01$).

			Completion of program (no date specified): The food-safety questionnaire was completed by the Consumer Group and the College Student Group.		
Nauta, Fischer, van Asselt, de Jong, Frewer, & de Jonge (2008)	Not Reported	**Online Study:** Four differing food-safety interventions were compared: 1) provided basic food-safety messages 2) provided the same basic messages with additional "aggressive" messages 3) provided the same basic messages with additional "disgust" message; 4) a control condition that only provided nutritional information. **Observational food preparation study:** Assignment to one of three conditions (*control; information; information + behavioural cue*). Intervention provided, subsequently food preparation observations took place. Microbial transfer and survival was measured post observation.	Pilot Study Completed Online questionnaire placed on the Netherlands Nutrition Centre Webpage in conjunction with a newspaper advertisement of the study. Participants of the online study and people in their social networks were recruited for a subsequent observational food preparation study.	Self-reported Motivation; Behavioural Intentions; Microbial Transfer and Survival	**Online Study:** Overall, significant difference in motivation found pre and post intervention ($p < 0.01$). The disgust condition (versus control $p = 0.001$; versus no emotion $p = 0.056$) was more effective in changing self-reported motivation to prevent microbiological contamination when compared to aggression (versus control $p = 0.004$; versus no emotion $p = 0.10$).All three versions of the intervention (disgust, aggression and control) significantly and positively affected participant Behavioural Intention ($p < 0.001$). **Observational food preparation study:** No significant differences between *control* and *information* with group *information + behavioural cue* ($p = 0.068$) for microbial transfer and survival. However, Post hoc comparisons showed significant differences between the *information* group and the *information + behavioural cue* group ($p = 0.026$), and a marginally significant difference when comparing the *control* group and the *information + behavioural cue* group ($p = 0.093$).
Nies & Van Laanen (1995)	Not Reported	A retrospective 11-item pre-test/post-test questionnaire concerning self-reported food-safety behaviours was administered via phone.	Participants completed the TAEX education program. Of the 463 participants of the TAEX program, 100 were contacted via phone to complete the food-safety questionnaire.	Self-reported Food-Safety Behaviours	Six of the 11 behaviours showed significant improvement between the before and after responses ($p<.01$). One of the 11 behaviours (also showed significant improvement at a 95% level of confidence ($p<.05$). Changes in the remaining four behaviours were in a positive direction but not significant.
Redmond & Griffith (2006b)	Not reported	Assigned to experimental group or control group. Participants food handling behaviours were observed (via CCTV) before, immediately after, and 4-6 weeks after implementation of a small-scale food-safety intervention (no intervention provided to Control).	Time 1: Baseline Observational data of Food safety malpractices gathered for Experimental and Control Groups. Experimental group received food-safety intervention. Time 2: Immediately post intervention Experimental and Control Groups observed completing a second meal preparation task. Time 3: Follow-up observational data gathered 4-6 weeks later.	Observed food-safety behaviour malpractices	**Food-safety Malpractice measure by effect size (ES):** The ES = 0.65 at Time 2 for all observed food-safety behavioural malpractices; which reduced to ES = 0.32 at Time 3. Of the five observed behavioural malpractices, the ES for Time 2 ranged between 0.10 and 0.47. At Time 3, ES ranged between 0 and 0.39 for the five observed behavioural malpractices.

Takeuchi, Hillers, Edwards, Edlefsen, & McCurdy (2005a)	34.7% RR	Participants (previously classified via the stages of change model into pre-contemplation, contemplation, preparation, action, maintenance stages). Participants subsequently sent educational materials on thermometer usage and asked to evaluate via survey.	Consumers classified into 5 different Stages of change model in previous study. Educational materials sent which targeted thermometer usage (brochure, video, recipe cards and a magnet). Six weeks later, an evaluation questionnaire completed by participants.	Motivation towards using a food thermometer; Stage of Change.	Participants reported food thermometer usage motivation brought about by the brochure (63%), recipe cards (45%), and the video (38%). Participants in the pre-contemplation stage reduced from 80% pre-intervention to 46% post intervention. Participants in the contemplation stage increased from 8% pre-intervention to 12% post intervention. There was an increase number of participants into the action stage (1% pre intervention to 18% post intervention).
Takeuchi, Hillers, McCurdy, & Edlefsen (2005b)	Pre-intervention survey 32% (793) RR of the 2500 contacted. Post-intervention survey 36% RR of the 793	Pre-and post intervention survey were mailed to randomly selected adult consumers.	Baseline data collected via Pre-intervention Stages of Change Survey, mailed to randomly selected adult consumers. Food-safety educational materials (brochure, recipe cards and video) surrounding thermometer usage disseminated to responding participants. Post-intervention Stages of Change Survey (plus 5 additional questions) mailed out.	Stages of Change; Usefulness of educational materials; Attitude.	Significant change in thermometer usage ($p<0.01$). At baseline, 4% of respondents regularly used a food thermometer and 85% had never used a food thermometer when cooking meat. The percentage of persons in Action and Maintenance stages increased from 9% (pre-intervention) to 34% (post-intervention).
Unusan (2007)	Not Reported	Participants allocated in two food-safety education groups (hand-out group and an e-mail group). A 34-item pre and post intervention questionnaire was completed.	Baseline measures were taken from the 34-item questionnaire. Both food-safety education groups (hand-out group and an e-mail group) completed the course. The 34-item questionnaire was again completed after the conclusion of the education course.	Food-safety concerns and practices	The e-mail group improved significantly pre to post intervention for 11 of the 25 concerns and practices (5 at $p<0.01$ and 6 at $p<0.05$). Only one significant change was observed for the hand-out group ($p<0.01$).

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