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Review

Scoping Review of Research on the Effectiveness of Food-Safety Education Interventions Directed at Consumers

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Abstract

Improper food handling by consumers at home is a major cause of foodborne illness. Therefore, effective education strategies are essential to change consumers' food safety attitudes and behaviors. The purpose of this scoping review was to identify and characterize primary literature examining the effectiveness of consumer food-safety education interventions. Ten bibliographic databases were searched using a comprehensive search strategy. Citations were identified; two reviewers screened them for relevance and characterized relevant articles. To ensure results would be applicable to end users, stakeholders were engaged to provide input on the review scope, methods, and results. We identified 246 relevant articles, of which 150 were quantitative, 66 qualitative, and 30 mixed-method research studies. Most studies (64.2%) were published in the United States, using an uncontrolled before-and-after study design (31.3%), and investigated the effectiveness of community-based training sessions and workshops (52.0%). Research gaps were found in the number of randomized controlled studies conducted, academic- and school-based courses and curricula investigated, and interventions targeting high-risk populations (e.g., pregnant women, those who are immunocompromised) and using new media channels (e.g., social media). Key opportunities to enhance the utility of future primary research investigating consumer food-safety interventions include the following: using studies based on behavior-change theories and formative research; engaging the target population in the research; using validated instruments to measures outcomes; and reporting intervention characteristics and outcomes completely. Results of this review can be used to prioritize future primary research and decision-making in this area.

Introduction

Foodborne illness has a substantial public health and economic burden worldwide. Globally, approximately 2.2 million deaths occur due to diarrheal diseases, most acquired through food (WHO, 2008). In the United States and Canada, more than 9 and 4 million cases of domestically acquired foodborne illness occur each year, respectively (Scallan *et al*., 2011; Painter *et al*., 2013; Thomas *et al*., 2013). The estimated annual cost of foodborne illness in the United States is US$77.7 billion (Scharff, 2012).

Research shows that foodborne illness can be significantly attributed to unsafe consumer-level food handling (Worsfold and Griffith, 1997; Redmond and Griffith, 2003, 2004; Lee and Greig, 2010; Smadi and Sargeant, 2013). Consumers' food safety practices can have major implications in preventing foodborne illness, regardless of how well the food production industry performs (Haines, 2004; Munro *et al*., 2012).

Theories of behavior change, such as the *Theory of Planned Behavior* and *Health Belief Model,* indicate that as a precursor to implementing food-safety practices at home, consumers must first believe that they are susceptible to foodborne illness and that they are able to take measures to prevent it (Schafer *et al*., 1993; Takeuchi *et al*., 2005; Mullan, 2011). However, previous surveys found only 8–23% of consumers in the United States, Britain, and Canada believe they can contract foodborne illness through their practices at home (Redmond and Griffith, 2003; Nesbitt *et al*., 2009, 2014). Most consumers believe that food-processing plants and restaurants are responsible for the majority of foodborne illness (Redmond and Griffith, 2003; Nesbitt *et al*., 2009, 2014). The underestimation of risk associated with home preparation results in consumers often neglecting safe food-handling techniques.

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Table 1. Search Algorithm as Implemented in Scopus

Category[a]	*Key terms*
Food safety	''food safety'' OR ''food-borne'' OR foodborne OR foodbourne OR ''food-bourne'' OR ''food handling'' OR ''food preparation'' OR ''food poisoning'' OR ''food hygiene'' OR ''safe food''
Population	consumer* OR client* OR population OR public OR people OR person OR persons OR individual OR individuals OR student OR students OR children OR youth* OR adolescent* OR teen* OR parent OR parents OR mother* OR father* OR adult OR adults OR women OR female* OR communit* OR families OR family OR household* OR domestic OR volunteer OR volunteers OR home OR homes OR school* OR campus OR university OR universities OR college*
Intervention	campaign* OR strateg* OR program* OR messag* OR intervention* OR technology OR teach* OR curriculum OR workshop* OR initiative* OR educat* OR communicat* OR information OR media OR brochure OR pamphlet OR learn* OR instruction* OR train* OR label* OR internet
Outcome	awareness OR knowledge OR practice* OR behaviour* OR behavior* OR attitude* OR perception* OR preference* OR learn* OR belief* OR acceptance

[a]Categories of terms combined with the AND operator. Search was conducted in the title, abstract, and keywords of citations.

Educational interventions to improve consumers' food-safety knowledge, attitudes, and behaviors are critical to mitigate the burden of foodborne illness from food prepared and consumed at home. Previous systematic reviews that summarized research in this area are outdated (Campbell *et al*., 1998; Mann *et al*., 2001) or had narrow inclusion criteria that limited the number of studies reviewed (Milton and Mullan, 2010). Therefore, we conducted a scoping review to identify and characterize global research investigating the effectiveness of consumer food-safety education

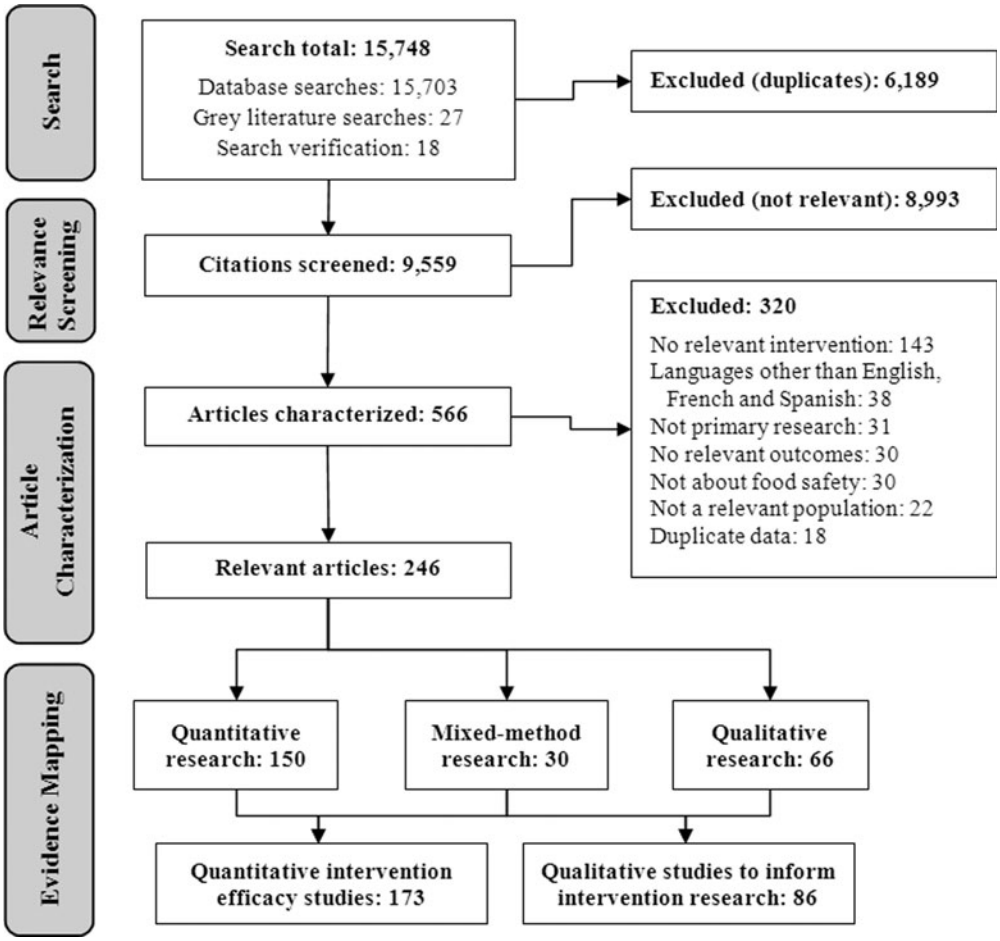

FIG. 1. Scoping review flow-chart. Articles in other languages excluded from this review were published in Chinese ($n=11$), Korean ($n=8$), Portuguese ($n=5$), Japanese ($n=5$), Italian ($n=2$), German ($n=2$), Turkish ($n=2$), Polish ($n=1$), Lithuanian ($n=1$), and Hebrew ($n=1$). The numbers for ''quantitative intervention efficacy studies'' and ''qualitative studies to inform intervention research'' exceeds total number of included studies ($n=246$), as mixed-method research studies with both quantitative and qualitative components were included in both category counts.

interventions, inclusive of all possible education interventions and study designs. Scoping reviews use structured and transparent knowledge synthesis methodologies to ''map out'' the quantity, distribution, and characteristics of a broad research area (Arksey and O'Malley, 2005; Pham *et al*., 2014).

Methods

Review team, protocol, question, and scope

The review team consisted of all seven co-authors with multidisciplinary expertise in the topic area (i.e., consumer food safety) and methodology (i.e., knowledge synthesis). In addition, an expert advisory group was formed consisting of six individuals from various knowledge-user groups (Arksey and O'Malley, 2005). The group was consulted via email prior to conducting the review to provide input on the review protocol, scope, and search strategy.

A review protocol, developed *a priori*, outlined the methods and tools used in this review. The review question was, ''What are the key characteristics of research investigating the effectiveness of consumer food-safety education interventions?'' The review scope included all primary research (quantitative, qualitative, or mixed-method) published in English, French, or Spanish in any of the following formats: peer-reviewed journal articles, research reports, dissertations, and conference abstracts or papers. We defined consumers as home cooks and food handlers not employed in the food industry, including the following: the general public, targeted consumer groups (e.g., high-risk populations, students, ethnic groups), and volunteer food handlers for special food events. We also included any studies on educators of consumers (e.g., train-the-trainer). Relevant interventions included the following: community-based training sessions and workshops; academic institution- and school-based courses and curricula; social-marketing campaigns; and other educational materials and messaging (e.g., brochures, videos). Studies were excluded if the intervention was not directly related to food safety (e.g., generic hand-washing).

Search strategy

A comprehensive search strategy was developed by reviewing key terms in the titles and abstracts of 15 preselected relevant articles. A preliminary search algorithm was pretested in Scopus to ensure that all preselected articles were captured. The final search algorithm (Table 1 and Supplementary Data; Supplementary Data are available online at www.liebertpub.com/fpd) comprised a combination of terms related to food safety, population, intervention, and outcome. The search was implemented on May 20, 2014, in 10 bibliographic databases: Scopus, PubMed, Agricola, CAB Abstracts, Food Safety and Technology Abstracts, PsycINFO, Educational Resources Information Center (ERIC), Cumulative Index to Nursing and Allied Health Literature (CINAHL), ProQuest Public Health, and ProQuest Dissertations and Theses.

The *Environmental Health Review* and the *Journal of Nutrition Education and Behavior* GEMs (Great Educational Materials) Collection were hand-searched to identify any references not captured by the electronic search. The expert advisory group provided potentially relevant unpublished studies or websites containing reports of relevant studies. Websites of 24 organizations and agencies were searched to identify relevant gray literature (e.g., research reports). The search strategy was verified by hand-searching the reference list of 15 relevant review articles and 15 purposively selected relevant primary research articles (lists available in Supplementary Data).

Table 2. Descriptive Characteristics of 246 Studies That Investigated the Effectiveness of Food-Safety Education Interventions for Consumers

Characteristics	*No.*	*%*
Document type		
Journal article	173	70.3
Thesis	26	10.6
Government or research report	25	10.2
Conference proceedings/abstract	21	8.5
Study location[a]		
North America	174	70.7
Europe	29	11.8
Asia	22	8.9
Australia/New Zealand	11	4.5
Central and South America/Caribbean	6	2.4
Study design[b]		
Experimental and quasi-experimental studies:	127	52.0
Uncontrolled before-and-after (UBA) study	77	31.3
Randomized controlled trial (RCT)	24	9.8
Controlled before-and-after study (CBA)	18	7.3
Nonrandomized controlled trial	8	3.3
Qualitative study	86	35.0
Cross-sectional study	25	10.2
Process evaluation	21	8.5
Control group reported[b,c]		
Internal control group (pre- vs. post-test)	80	46.2
Independent control group	49	28.3
No control group	45	26.0
Timeframe of study conduct reported (yes vs. no)	132	53.7
Data collection methods[b]		
Questionnaire:	161	65.4
In-person	98	39.8
Web-based	23	9.3
Postal	23	9.3
Phone	10	4.1
Not reported	24	9.8
Qualitative interviews:	33	13.4
In-person	24	9.8
Phone	6	2.4
Not reported	24	9.8
Focus groups	66	26.8
Participant observation	20	8.1
Analysis of documents	8	3.3
Other[d]	11	4.5

[a]North America included United States (158) and Canada (16); Europe included the United Kingdom (12), Italy (6), Germany (4), Belgium (2), Netherlands (2), Turkey (2), Norway (1), Switzerland (1), Ireland (1), Greece (1), Denmark (1), Sweden (1), Malta (1), and Finland (1); Asia included India (9), Bangladesh (5), Vietnam (2), South Korea (2), China (2), United Arab Emirates (1), and Iran (1); Central and South America/Caribbean included El Salvador (2), Cuba (2), Jamaica (1), Brazil (1), and Guatemala (1).

[b]Multiple selections were allowed for these questions; thus, column percentages do not add up to 100%.

[c]This question was only tabulated for quantitative articles ($n = 173$).

[d]Other included microbiological and food testing (5), self-reflection (2), workshops (1), website analytics (1), scenario realism checks (1), and questionnaire via kiosk (1).

Relevance screening

Unique citations identified through the search strategy were screened for relevance at the title and abstract level using a relevance screening form (Supplementary Data) that contained one key question to assess the citation's relevance to the review question. When the relevance of a citation could not be determined with certainty, the full article was evaluated.

Article characterization

Full documents for all citations considered potentially relevant were characterized using a prespecified form containing 29 questions (Supplementary Data). The relevance of each article was confirmed and key characteristics extracted include the following: publication type and year; study design and data collection methods; details of interventions, populations, outcomes investigated; and reporting characteristics.

Review management and analysis

Search results were uploaded to RefWorks (Thomson ResearchSoft, Philadelphia, PA), manually de-duplicated, and imported into DistillerSR (Evidence Partners, Ottawa, ON, Canada) to conduct relevance screening and article characterization. We used 50 and 10 purposively selected abstracts and articles to pretest the screening and characterization forms, respectively. Pretest results were discussed among all reviewers and the forms were revised to clarify areas of uncertainty. Kappa scores for inclusion/exclusion agreement were assessed and additional citations were assigned as necessary until between-reviewer agreement was >0.8, which indicates almost perfect agreement and that the forms and eligibility criteria are sufficiently clear (Higgins and Green, 2011). Relevance screening and article characterization were conducted by two independent reviewers for each citation. Disagreements between reviewers were resolved by consensus and, when necessary, by judgment of a third reviewer.

Article characterization results were exported into Microsoft® Excel 2010 (Microsoft Corporation, Redmond, WA) and descriptively analyzed. Evidence maps were created to graphically represent cross-tabulations between publication year and region, study design, and intervention type. Publication year categories were selected so that each category would have a roughly similar number of articles.

Results

A total of 9559 unique citations were screened for relevance, of which 566 were characterized and 246 were confirmed as relevant (Fig. 1). The 246 relevant articles included 150 quantitative, 66 qualitative, and 30 mixed-method research studies that reported on 173 quantitative intervention efficacy studies and 86 qualitative studies with relevance to intervention research. A citation list of relevant articles is available in the Supplementary Data.

The median publication year of relevant articles was 2006 (range: 1980–2014). All relevant articles were published in English, except for one published in Spanish. Table 2 shows the descriptive characteristics of all 246 articles. Most studies were conducted in North America (70.7%), mainly the United States (64.2%) (Table 2). Of the 173 quantitative studies, the majority ($n=77$) were uncontrolled before-and-after (UBA) studies (44.5%). Randomized controlled trials (RCTs) represented only a small proportion of all quantitative studies (13.9%). Figure 2 shows that the number of published UBA studies and RCTs has been increasing over the last 34 years.

Table 3 shows the key sociodemographic characteristics of participants investigated in the studies. Most studies focused on consumers (93.1%) as the target population compared to educators of consumers (16.7%). The studies examined a

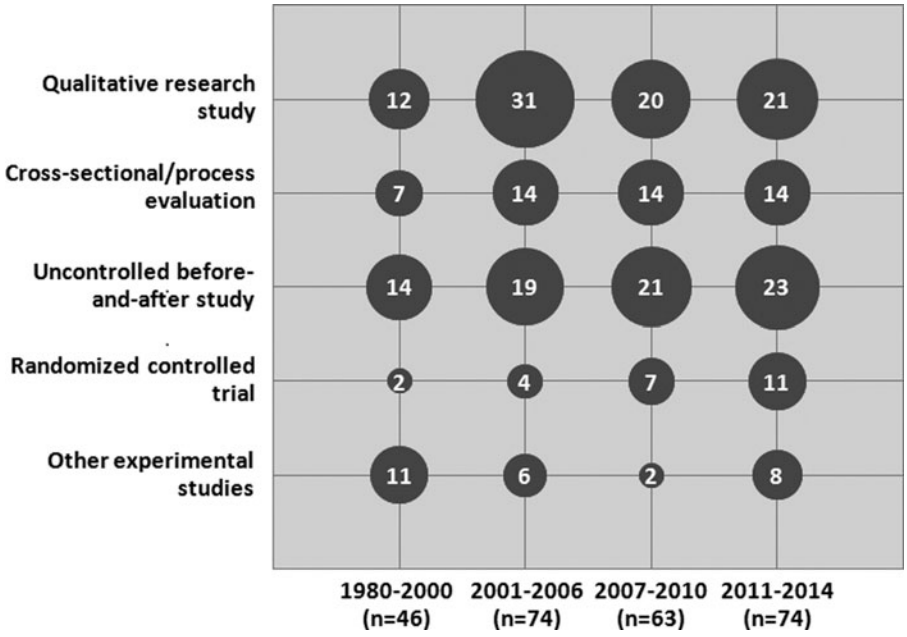

FIG. 2. Evidence map of study design by publication year for 246 studies that investigated the effectiveness of food-safety education interventions for consumers. ''Other experimental studies'' includes controlled before-and-after studies, nonrandomized controlled trials, and a combination of both designs. Some articles reported more than one study design.

Table 3. Socio-demographic Characteristics of the Study Population in 246 Quantitative and Qualitative Studies That Investigated the Effectiveness of Food-Safety Education Interventions for Consumers

Characteristics	*No.*	*%*
Target population of study[a]		
Consumers	229	93.1
Educators of consumers	41	16.7
Key socio-demographic characteristics[a]		
Female[b]	37	15.0
Age groups:		
Elderly (>60 years)	29	11.8
Adults (20–60 years)	35	14.2
Youth (15–19 years)	16	6.5
Children (14 years and under)	17	6.9
Specific race/ethnicity targeted	30	12.2
Geographic locations:		
Urban	15	6.1
Rural	11	4.5
Urban and rural	7	2.8
Socio-economic status[c]:		
Low	46	18.7
Middle/high	8	3.3
Students:		
Preschool/elementary students	15	6.1
Middle/high-school students	22	8.9
College/university students	26	10.6
Specific occupations:	36	14.6
Teachers/professors/school administrators	12	4.9
Healthcare professionals	11	4.5
Other[d]	14	5.7
Education levels[c]:	11	4.5
Low	10	4.1
High	7	2.8
Immigrant/migrant communities	5	2.0
Targeted high-risk populations:	97	39.4
Caregivers[e]	66	26.8
Pregnant/postpartum women	17	6.9
Immunocompromised	14	5.7
Other[f]	8	3.3
None reported	28	11.4

[a]Multiple selections were allowed for these questions; thus, column percentages do not add up to 100%.
[b]No interventions were identified that specifically targeted males.
[c]Classified as high or low if stated in the original article.
[d]Others included volunteers/staff at local community centers/food banks ($n=6$), food safety advisors/experts (3), farmers (2), extension agents (2), media personnel (1), sanitarians (1), fish suppliers (1), and government employees (1).
[e]Caregivers include parents/caregivers of children, elderly, and ill individuals.
[f]Other includes people who consume certain foods (e.g., fish, deli meat) ($n=3$), developmentally disabled (2), children living in single-parent households or two-working-parent households (1), home food preservers (1), and people involved in consumer organizations (1).

wide range of target population groups. Interventions targeting caregivers (26.8%) and those with low-income/socioeconomic status (18.7%) were most common.

Quantitative research studies were further described by intervention type, content, delivery methods, and outcomes (Tables 4 and 5). Most quantitative studies examined the effectiveness of community-based training sessions and workshops (52.0%), compared to other intervention types. However, the number of studies evaluating published media campaigns and other messaging interventions has increased in recent years (Fig. 3). Included studies examined a wide range of intervention delivery methods, the most common being in-person training (62.4%), and content areas (Table 4). Approximately 26.6% and 40.5% of studies informed their interventions with a theory of behavior change or formative research, respectively. In addition, 45.7% of studies examining a theory-based intervention reported their outcomes in the context of theory. Most studies included a facilitator or instructor in the intervention delivery (65.9%), and 45.1% engaged participants in the development, delivery, and/or evaluation of the intervention. Intervention settings varied widely, most commonly being school or academic locations (32.4%).

Many different outcomes were used to measure the effectiveness of interventions, and many studies employed more than one (Table 5). Food-safety behaviors (67.1%) and knowledge (64.2%) were most commonly investigated. Most studies that measured behavior outcomes used self-reported measures (57.8%) compared to observing actual behaviors of participants (13.9%). Outcome measurement frequently occurred only once or twice (83.2%). Approximately 52% of quantitative studies did not specify whether measurement instruments were assessed for psychometric properties; 35.3% did not report the length of participant follow-up, while >40% reported some outcomes in an insufficient format to allow for potential meta-analysis.

Discussion

This review identified a variety of studies investigating the effectiveness of consumer food-safety education interventions. The majority of the studies were conducted in the United States, using a quasi-experimental UBA study design, and investigated the effectiveness of community-based training sessions and workshops. The data for many of these studies came from U.S. extension programs such as the Expanded Food and Nutrition Education Program, Supplemental Nutrition Assistance Program—Education, and the Special Supplemental Nutrition Program for Women, Infants, and Children. These programs generally target families and individuals with financial need (Trepka *et al*., 2006; National Institute of Food and Agriculture, 2013; USDA Food Nutrition Service, 2004). Although minor differences exist in specific topics covered by individual programs, they often include a range of related health topics (i.e., nutrition, physical activity, and food safety), which may help improve implementation cost-effectiveness (Trepka *et al*., 2006; USDA Food Nutrition Service, 2004).

High-risk populations are under-represented in the literature as targets of food-safety education strategies; these populations are more susceptible to foodborne illness and have unique needs requiring tailored interventions. A recent Canadian survey reported that consumers from high-risk groups such as immunocompromised (28%), pregnant women (27%), and elderly persons (11%) do not identify themselves as high risk (EKOS Research Associates Inc., 2010). Thirty-seven studies specifically targeted females, and no studies targeted males. Men are increasingly involved in household food handling, and greater numbers of single men

Table 4. Intervention Characteristics of 173 Quantitative Studies Investigating the Effectiveness of Food Safety Education Interventions for Consumers

Characteristics	*No.*	*%*
Intervention type[a]		
Community-based training session/workshop	90	52.0
Media campaign/social marketing/other messaging	65	37.6
Preschool to high-school course/curriculum	20	11.6
University or college course/curriculum	11	6.4
Method of intervention delivery[a]		
In-person training:	108	62.4
Group	85	49.1
One-to-one	23	13.3
Print media (e.g., brochures)	51	29.5
Online information (e.g., online training modules)	22	12.7
Promotional material distribution	21	12.1
Demonstration/skit/mascots/home visits	14	8.1
Radio/TV	12	6.9
Product labels	7	4.0
Social media	7	4.0
Videos	6	3.5
Other[b]	13	7.5
Not reported	10	5.8
Intervention content[a]		
Personal hygiene	96	55.5
Time–temperature control	93	53.8
General/background food safety	85	49.1
Avoiding cross-contamination	83	48.0
Adequate cooking of foods	76	43.9
Avoiding food from unsafe sources/ high-risk foods	44	25.4
Food spoilage	42	24.3
Washing fruits/vegetables	25	14.5
Other food-safety topics[c]	5	2.9
Nonfood safety topics[d]	56	32.4
Not reported	30	17.3
Intervention targeted a specific hazard or product (yes vs. no)	44	25.4
Intervention informed by a behavior change theory/model[a]		
Yes:	46	26.6
Health Belief Model	10	5.8
Stages or Change Theory/ Transtheoretical Model	10	5.8
PRECEDE-PROCEED model	10	5.8
Theory of Planned Behavior	7	4.0
Social Learning/Cognitive Theory	5	2.9
Other[e]	26	15.0
Not reported	127	73.4
Results reported in the context of the theory or model[f] (yes vs. no)	21	45.7
Intervention informed by formative research[a]		
Yes:	70	40.5
Focus groups	28	16.2
Surveys	24	13.9
Literature review/needs assessment	20	11.6
Interviews	10	5.8
Stakeholder discussions/informal feedback	10	5.8
Other[g]	11	6.4
No/not specified	103	59.5
Intervention included facilitators/instructors		
Yes[a]:	114	65.9
Extension professionals/paraprofessional educators	43	24.9
Community members[h]	28	16.2
School teachers	13	7.5
Professors/lecturers	11	6.4
Healthcare/public health professionals	11	6.4
Dietitians/nutritionists	6	3.5
Other[i]	14	9.2
Not specified	13	7.5
No/not specified	59	34.1
Target population engaged in the intervention		
Yes[a]:	78	45.1
Engaged in intervention development	50	28.9
Engaged in intervention delivery/ implementation	47	27.2
Engaged in intervention evaluation	28	16.2
No/not specified	91	52.6
Intervention setting[a]		
School/university/college	56	32.4
Homes	46	26.6
Internet/web	26	15.0
Community/religious centers/extension offices	25	14.5
Public places/camps	18	10.4
Healthcare facility/medical clinic/senior care/daycare	17	9.8
Media	13	7.5
Grocery stores/markets	8	4.6
Other[j]	7	4.0
Not reported	34	19.7

[a]Multiple selections were allowed for these questions; thus, column percentages do not add up to 100%.
[b]Other includes experiential learning activities ($n=4$), self-audit/ checklist of kitchen (3), mass emails (2), web-based video games (1), medical alerts (1), loudspeaker announcements (1), and online newspapers (1).
[c]Other includes food preservation techniques ($n=3$), food-recall information (1), and Hazard Analysis Critical Control Points (1).
[d]Nonfood safety topics included nutrition ($n=43$), food security (13), general sanitation/environmental hazards (13), physical activity/other life skills (10), other infectious diseases (3), childcare (2), agricultural literacy (1), and cultural diversity (1).
[e]Other includes theories that were investigated in <5 articles.
[f]This question was only tabulated for articles that indicated that the intervention was informed by a theory/model ($n=46$).
[g]Other includes unspecified formative research ($n=6$), participant observations ($n=4$), and scenario realism checks ($n=1$).
[h]Community members include student/adult volunteers from the community who helped out with the intervention.
[i]Other includes researchers ($n=5$), food service personnel/ students ($n=4$), job coaches ($n=1$), professional events management agency ($n=1$), change agents ($n=1$), social workers ($n=1$), and other specialized instructors ($n=1$).
[j]Other includes school-teacher conventions ($n=2$), food-service centers ($n=2$), research centers ($n=1$), food banks ($n=1$), and community events ($n=1$).

are the primary caregivers of children (Cabrera *et al*., 2000; Gauthier *et al*., 2004). Future research should investigate gender-based differences in consumer food-safety education, as previous surveys found more high-risk food-handling practices (e.g., thawing frozen meat at room temperature)

Table 5. Outcome and Reporting Characteristics of 173 Quantitative Studies That Investigated the Effectiveness of Food-Safety Education Interventions for Consumers

Outcome characteristics	*No.*	*%*
Food-safety outcome types[a]		
Behaviors[a]:	116	67.1
Self-reported	100	57.8
Observed	24	13.9
Knowledge/awareness	111	64.2
Attitudes/perceptions/beliefs	89	51.4
Behavioral intentions/motivations	39	22.5
Program participation/coverage rates	16	9.2
Incidence of foodborne illness	8	4.6
Microbial prevalence/counts	6	3.5
Behavioral theory constructs	5	2.9
Other[b]	8	4.6
Frequency of outcome measurements[a]		
Measured once	71	41.0
Measured twice	92	53.2
Measured three or more times	30	17.3
Not reported	6	3.5
Length of participant follow-up reported (yes vs. no)	112	64.7
Outcome measurement instrument assessed for psychometric properties		
Yes[a]:	82	47.4
Validity	59	34.1
Reliability/internal consistency	43	24.9
Other	5	2.9
No/not specified	90	52.0
Intervention efficacy outcomes sufficiently reported to allow for possible meta-analysis[c]		
All outcomes sufficiently reported	99	57.3
All outcomes insufficiently reported	38	22.8
Some outcomes sufficiently reported	30	18.0

[a]Multiple selections were allowed for these questions; thus, column percentages do not add up to 100%.
[b]Other includes health measures ($n=3$), campaign recall frequency ($n=2$), sources of information ($n=1$), emotions after reading messages ($n=1$), and economic measures ($n=1$).
[c]This question was only tabulated for studies where intervention efficacy was measured ($n=167$).

among males than females (Altekruse *et al*., 1999; Byrd-Bredbenner *et al*., 2007b; Nesbitt *et al*., 2009).

The majority of studies used an UBA design, which measured changes in outcomes using a pre- versus post-test without a control group. They are simpler and logistically easier than controlled trials; however, their utility to inform decision-making is limited due to the Hawthorne effect and other potential biases (Grimshaw *et al*., 2000; Eccles *et al*., 2003; Coalition for Evidence-Based Policy, 2007; Bhattacharyya *et al*., 2011). The Hawthorne effect is the overestimation of intervention effects because participants alter their behaviors due to the knowledge of being observed (Grimshaw *et al*., 2000). In addition, the possibility of secular trends and other external changes between pre- and post-tests limits our ability to attribute outcome changes to the intervention (Eccles *et al*., 2003; Coalition for Evidence-Based Policy, 2007; Bhattacharyya *et al*., 2011). The primary utility of UBA studies is to show ''proof of concept'' for the efficacy of interventions to inform more robust experimental designs (Coalition for Evidence-Based Policy, 2007). RCTs are the ''gold standard'' for determining intervention efficacy because the random allocation of participants to control and intervention groups controls for unmeasured confounding variables that could otherwise influence the results (Coalition for Evidence-Based Policy, 2007; Higgins and Green, 2011). Future RCTs should be prioritized for food-safety education interventions shown to be effective in UBA studies.

Effective community-based training sessions and workshops (52%) made up the majority of interventions. This is not surprising, since this category encompasses the U.S. Department of Agriculture–funded food-safety programs already described. Less research investigated the effectiveness of school-based courses despite arguments supporting the likelihood of health behaviors continuing into adulthood when introduced at a young age (Bandura, 2004; Viner and Macfarlane, 2005). Undergraduate college and university courses are other key points for food-safety education, as undergraduates typically begin to prepare their own food during this time (Morrone and Rathbun, 2003; Booth *et al*., 2013).

Studies on the use of media campaigns and other education tools (e.g., brochures, videos, web content) have increased in recent years (Fig. 3). We identified 7 articles published since 2010 that explored the effectiveness of social media-based interventions and 22 studies published since 2001 that investigated the effectiveness of online information/training interventions. This largely aligns with increasing accessibility to the Internet and preferences of young adults for social media and web-based food safety information (Jacob *et al*., 2010; Mayer and Harrison, 2012; Nesbitt *et al*., 2014). Alternatively, previous focus groups of elderly populations indicate a preference for traditional media (e.g., television, print media) (Cates *et al*., 2004; Powell, 2007; Kosa *et al*., 2011). This evidence highlights the need for researchers to carry out formative research to understand preferences, behaviors, and motivations of their target populations prior to designing interventions (Wright *et al*., 1998; Jacobs *et al*., 2012). Less than half of the studies in this review reported formative research in their studies. Only 41.5% of studies reported engagement of the target population in the development, delivery, and evaluation of interventions; this important step enhances research quality and credibility, health and community capacity outcomes, and research uptake (Viswanathan *et al*., 2004).

The 86 qualitative research studies were conducted for 2 main purposes: (1) to understand the needs of the target population prior to development of an intervention; and (2) to evaluate why an existing intervention was effective or not. Qualitative studies complement quantitative research by providing a better understanding of the underlying mechanisms and barriers to intervention effectiveness (Dixon-Woods *et al*., 2005). They should be considered for future primary research on food-safety education interventions in the context of formative research or to aid in process and outcome evaluation.

We found that only 26.6% of studies based their intervention on a theory of behavior change. Theories are important to consider when designing interventions, as they provide a framework to understand the process of behavior change, identify constructs influencing behavior, and measure intervention effectiveness using important outcomes (Prochaska

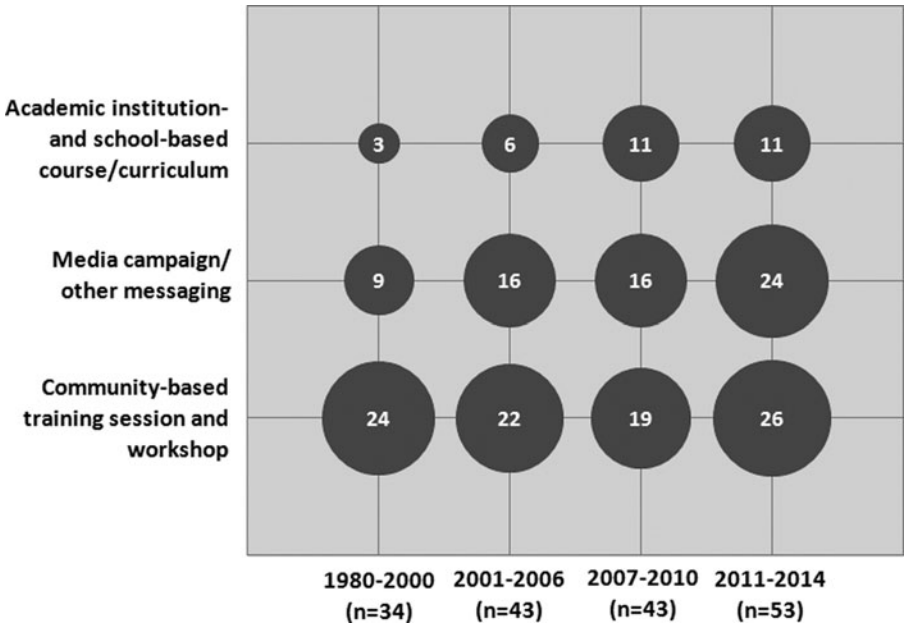

FIG. 3. Evidence map of intervention type by publication year for 173 quantitative studies that investigated the effectiveness of food-safety education interventions for consumers. Some articles reported more than one intervention type.

and DiClemente, 1983; Rosenstock *et al*., 1988; Ajzen, 1991). In this review, the most commonly examined theories of behavior change were the *Health Belief Model*, *Stages of Change Theory/Transtheoretical Model*, and the *Theory of Planned Behavior*. The *PRECEDE-PROCEED model* frequently provided a framework to build health-promotion campaigns (Richard *et al*., 1996). When designing future food-safety education interventions, an appropriate theory should be selected based on target population needs, the situation at hand, and goals of the intervention (Angus *et al.*, 2013).

A significant proportion of quantitative studies used self-reported behaviors, and only 13.9% observed participant behaviors. Self-reported behaviors are easier to collect, but can be subject to social desirability bias, which results in over-reporting of healthy behaviors by participants to be viewed more favorably by researchers (Redmond and Griffith, 2003; Dharod *et al*., 2007; Milton and Mullan, 2010). For example, washing hands and using thermometers are commonly over-reported food safety behaviors (Anderson *et al*., 2004; Dharod *et al*., 2007). However, it is difficult to develop an objective measure of behavioral assessment, as observations are also subject to biases such as the Hawthorne effect. Knowledge and awareness were the second most frequently investigated outcomes and tend to be assessed more objectively (e.g., using a scored test) than other measures (e.g., attitudes) if measurement instruments are valid and reliable. Knowledge is an important precursor of behavior change (Prochaska and DiClemente, 1983; Rosenstock *et al*., 1988; Ajzen, 1991), but it should be used together with other constructs of behavior as it may not always predict food-safety behavior outcomes on its own (Redmond and Griffith, 2003; Milton and Mullan, 2010; Mullan, 2011; Nesbitt *et al*., 2014). No matter what outcomes are measured, it is critical to ensure that outcome measurement tools be assessed for their psychometric properties. Validation prior to implementation ensures that instruments measure what they are intended to measure and that responses will be reproducible and consistent (Medeiros *et al*., 2001; Byrd-Bredbenner *et al*., 2007a).

Many studies did not report key intervention characteristics (e.g., setting and length of follow-up). These characteristics are important for proper assessment of study methodology and risk of bias. Additionally, most studies reported outcomes in an insufficient format for potential use in follow-up systematic reviews and meta-analysis. This is concerning, as previous research has shown that fully reported outcomes are more likely to be statistically significant than insufficiently reported outcomes (Dwan *et al*., 2013), which might provide a misleading summary of the evidence when synthesized in systematic reviews and meta-analysis. We encourage primary researchers in this field to follow internationally recommended reporting guidelines such as CONSORT for RCTs and TREND for nonrandomized controlled trials (Des Jarlais *et al*., 2004; Schulz *et al*., 2010).

A limitation of this review is the exclusion of 38 articles published in languages other than English, French, and Spanish, with the consequent exclusion of research conducted in some geographic regions (e.g., Asia). Additionally, some potentially relevant articles could have been missed by the search; however, we attempted to minimize this potential bias by conducting a comprehensive search verification.

Conclusions

We used a structured and transparent scoping review approach to summarize the distribution and characteristics of research on the effectiveness of consumer food-safety education interventions. Engagement of knowledge-users in an expert advisory group was useful to ensure the scope of this review, and its results were relevant and applicable to key stakeholders. Most relevant studies were conducted in the United States, using a UBA study design. There is a need for more RCTs on this subject, particularly on interventions

shown to be effective in uncontrolled designs. Additional research is warranted to investigate interventions incorporating new technologies (e.g., social media), interventions in academic institutions and school settings, and those targeting high-risk populations. Key opportunities to enhance the utility of future primary research include designing and implementing interventions based on theories of behavior change and formative research, engaging the target population in the research, ensuring measurement instruments are valid and reliable, and appropriately reporting key study characteristics and outcomes.

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