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A Review of the Implication and Importance of Training-Based Approaches in Food Safety Management Systems

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Abbreviations
BBFST= Behavior-Based Food Safety Training
BRCGS= British Retail Consortium Global Standard
OB= Optimistic bias
BCTs= Behavior-Change Theories
FH= Food Handlers
FS= Food Safety
FSK= Food Safety Knowledge
FSP= Food Safety Practice
FSMS= Food Safety Management System
FST= Food Safety Training
HACCP= Hazard Analysis and Critical Control Points
HAM= Health Action Model
HAPA= Health Action Process Approach
HBM= Health Belief Model
ISO= International Organization for Standardization
KAP= Knowledge, Attitude, and Practice
PRISMA= Preferred Reporting Items for Systematic Reviews
SCT= Social Cognitive Theory
THAM= Tones' Health Action Model
TPB= Theory of Planned Behavior
TRA= Theory of Reasoned Action
TTM= Trans-Theoretical Model

ABSTRACT

Background: The aim of the present review was to evaluate the effectiveness of training-based approaches, strategies, and methods in implementing one of the basic regulations of the food safety (FS) industry: Food Safety Management Systems (FSMSs).

Methods: We searched for FS training approaches in food institutions in nine databases, and out of 500 studies, 141 were included.

Results: Some studies discussed different training methods and theories, such as Behavior-Change Theories (BCTs), the Theory of Planned Behavior (TPB), social cognitive models, Tones' Health Action Model (THAM), the Health Belief Model (HBM), the Trans-Theoretical Model (TTM), the Theory of Reasoned Action (TRA), and the Health Action Process Approach (HAPA). Of the other studies that assessed changes in knowledge, attitude, and practice (KAP) and training of food handlers (FH) in the field of FS, most of them agreed that training can enhance the KAP of FH, whereas some pointed to the ineffectiveness of training methods on KAP of FH due to training methods and materials.

Conclusion: Therefore, as a primary consequence, it can be concluded that FS training in any method and any aspect can be helpful in enhancing FS in food establishments.

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Introduction

The globalization of food production and culinary practices has resulted in increasingly elongated and intricate food supply chains, thereby amplifying the potential for food safety (FS) incidents (Gil et al., 2017; Kussaga et al., 2014). Concerns regarding FS permeate all sectors of the industry, encompassing both large-scale industrial operations and small-scale traditional production systems. In response to these challenges, food safety training (FST) programs have been widely implemented to educate stakeholders across the entire continuum of the food chain from initial producers to consumers (Gilman, 2018).

Despite the proliferation of training initiatives, rigorous inspection protocols, and a substantial body of empirical research conducted globally, FS is still a formidable public health problem. This enduring challenge underscores the necessity of more integrative and culturally responsive approaches to FS governance and education (Yiannas, 2009). The prevalence of foodborne illnesses remains a pressing issue, often exacerbated by inadequate FS education, as well as cultural and linguistic barriers within the food service workforce (Richard et al., 2013).

Emerging pathogens and the growing threat of antimicrobial resistance further emphasize the necessity for food industry professionals to possess comprehensive and current knowledge to effectively implement safety protocols (Kussaga et al., 2014). However, employees in small and medium-sized enterprises mostly lack adequate training due to limited managerial knowledge or time constraints (Ovca et al., 2018). Education in this context not only improves FS but also correlates with economic benefits, improved skill sets, reduced turnover, and adaptability to environmental changes (Ovca et al., 2018).

Training, defined as a planned process to alter knowledge, attitudes, behaviors, or skills through learning experiences (Habiballah et al., 2018), plays an essential role in shaping food safety practices (FSPs). While general training for managers and employees has improved, a significant gap remains in the usability of comprehensive FS system training. This deficiency contributes to limited awareness of hygiene practices and protocols, increasing the risk of unsafe food supply. Moreover, the underutilization of Food Safety Management Systems (FSMSs) has resulted in inadequate oversight and poor managerial competence in hazard control (Kahindi, 2016).

Several structural and contextual factors further undermine the effectiveness of training interventions. These include low literacy levels, socioeconomic constraints, high employee turnover, financial burdens, and dissatisfaction with wages—all of which hinder the consistent application of FS protocols (Stedefeldt et al., 2015). Educational interventions focused on health and hygiene have been recommended to improve food handling practices (Ndu-Agomuo and Akimboye, 2021). To be effective, training must be continuous and tailored to enhance recipients' knowledge, attitudes, and performance. Structured inspection outcomes, mandatory training programs, and proper documentation can collectively reduce the risk of foodborne illnesses (Stedefeldt et al., 2015).

Eslami et al. (2022) investigated the health care staff's knowledge and attitudes regarding FS and hygiene and found that knowledge of the staff was relatively low, but the attitude was better. They concluded that the staff must be educated regarding FS issues (Eslami et al., 2022). Providing appropriate training and knowledge enables organizations to prepare safe, high-quality food for consumers (Kussaga et al., 2014). In light of these considerations, this review explores the concept, strategies, and methods of training-based approaches and their influence on the implementation and effectiveness of FSMS.

Materials and methods

To investigate the effect of training approaches on the implementation of FSMSs, a review of existing relevant articles has been conducted. Figure 1 shows the steps involved in the selection procedure based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021).

Search strategy

An extensive search was performed using the following databases: PubMed, ScienceDirect, Scopus, Web of Science, Medline, and two Persian databases, namely MAGIRAN and SID (Scientific Information Database). Google Scholar and Semantic Scholar were also searched. English and Persian articles published from 2006 to 2025 were reviewed. The keywords used for the search were as follows: ("food safety" OR "foodborne diseases") AND ("training" OR "intervention" OR "practice" OR "attitude" OR "behavior" OR "culture" OR "approaches" OR "food handler" OR "KAP" OR "education" OR "knowledge" OR "management" OR "effectiveness" OR "e-learning"). Possibly related articles were also assessed by manual search (Figure 1).

- *Inclusion and exclusion criteria*

All cross-sectional studies that used self-observations/reported questionnaires, face-to-face interviews, and observational checklists were included in the current review in English and Persian languages with the aim of enhancing Knowledge, Attitude, and Practice

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(KAP) in FS or implementation of FSMS. Moreover, interventional studies that discussed different training methods and theories in FS, including Behavior-Change Theories (BCTs), Theory of Planned Behavior (TPB), Social Cognitive Models, Tones' Health Action Model (THAM), Health Belief Model (HBM), Trans-Theoretical Model (TTM), Theory of Reasoned Action (TRA), and health action process approach (HAPA) were also included. Studies whose design was centered on the national and international rules and regulations related to FST and FSMSs, such as the United Nations' Codex Alimentarius and Hazard Analysis and Critical Control Points (HACCP), were also included in the current review. We explored randomized clinical trials, quasi- randomized clinical trials and experimental designs, controlled before-after, and cross-sectional studies. All investigated articles were performed on FH, managers, and producers from various stages of the food chain, including facilities of food services, universities, schools, and hospitals' cafeterias and canteens, food kiosks, street food vendors, household kitchens, catering services, restaurants, and hotels (i.e., from farm to fork) were included. Investigated outcomes were knowledge, attitudes, and behavior of participants regarding FS issues and practice. All papers were screened by two independent reviewers (B.B. and T.Z.). In case of any disagreement, the opinion of third reviewer (N.Sh.) was obtained. Training articles that were not about FS and review articles were removed from the study.

- *Quality assessment*

The quality of studies was investigated by use of the checklist of the Joanna Briggs Institute (Moola et al., 2020).

Results and discussion

In the initial search, we found 500 articles. After eliminating duplicates, 320 articles remained. After screening the titles and abstracts and applying the inclusion-exclusion criteria, we excluded another 179 studies. Finally, 141 studies were found to be qualified for the literature review and underwent a full-text review (Figure 1). We categorized these articles based on their primary outcomes, such as the impacts of training on knowledge, attitude, behavior, and practices regarding food hygiene and safety following training interventions and the effects of training protocols and approaches on FSMS implementation. Table 1 shows the studies that investigated the factors influencing Knowledge, Attitude, and Practices KAPs of FH. In most of the studies, knowledge and attitude grades increased following education, but practice did not improve, suggesting that training must be performed, educational content must be updated, and more emphasis should be given to HACCP principles and hygiene practices.

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Table 1: Studies on KAPs of FH (FH)

Aim	Country	study design	sample size	KAP measurement tool	type of educational intervention	effects on Knowledge	effects on Attitude	effects on Practice	Conclusion	References
To assess the impact of education on KAP food vendors	Nigeria	Quasi-experimental (pre-training and post-training)	52	a pretested semi-structured interviewer administered questionnaire and an observational checklist	Training and lecture	Increase the knowledge after intervention in experimental group.	Increase attitude after intervention in experimental group.	Increase practice after intervention in experimental group	Educational and training programs should be used to affect the KAP positively.	(Akinboye and Lois, 2021)
FSK and practice (FSP).	Saudi Arabia	Cross sectional	163	semi-structured questionnaire (SSQ)	None	Had good FSK	-	Had good FSP	FSP had a strong association with the level of education and previous training.	(Alqurashi et al., 2019)
Assessment the KAP of FH	Pakistan	cross sectional analytical (pre-training and post-training)	72	face to face interviews - structured questionnaire (SQ)	Formal lectures, practical skills by regular visits	FSK increased after lectures.	attitude enhanced knowledge	FSK increased the, FSP	All FH, managers and supervisors of food businesses should have periodic awareness lectures/ trainings in FS and HACCP.	(Aslam et al., 2022)
effect of Food Safety Community Based Education Programme (FSCBEP) on the FSK	South Africa	Cross sectional (pre-training and post-training)	40	A self-administered, semi-structured FSK questionnaire	a peer interactive approach and PowerPoint presentation	Increase of FSK level after FSCBEP in the community members	-	-	FSCBEP should also include the application of HACCP principles at the household level.	(Berejena and Malongane, 2025)
Evaluation of risk for Shiga toxin-producing *Escherichia coli* (STEC) and *Salmonella* contamination	Honduras	Cross sectional (pre-training and post-training)	49	None (pre-training and post-training tests)	Multiple intervention approach	Training increased FSK	-	Training improved practice	Multiple-intervention approach is crucial to improve FS.	(Casas et al., 2020)
effect of education of traffic light on food labeling on the KAP of students.	Iran	Cross sectional (pre-training and post-training)	379	SSQ	pamphlet	Education increased knowledge	Education improved attitude	Practice enhanced	Students selected healthier food.	(Akbari, 2019)

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Aim	Country	study design	sample size	KAP measurement tool	type of educational intervention	effects on Knowledge	effects on Attitude	effects on Practice	Conclusion	References
Compare the effects of two educational methods on the knowledge	Iran	Cross sectional (pre-training and post-training)	420	Semi-structured FSK questionnaire	Book let and trade school (face to face)	educational intervention increased FSK	-	-	No difference was seen between the two educated groups. Training needs to change knowledge as well as behavior.	(Farzianpour et al., 2012)
KAP of FH	Ethiopia	Cross sectional analytical	400	SSQ and an observational checklist.	None	Good FSK	Good FSA	50% had good FSP	Formal education and proper training is necessary.	(Fekadu et al., 2024)
Evaluate FSK among food service personnel on board merchant ships	Italy	Cross sectional analytical	220	SSQ	None	Good FSK- Trained ones had higher FSK	-	-	Training is necessary for understanding basic and fundamental aspects of food hygiene	(Grappasonni et al., 2018)
the role of FS training in improving practices of FH through the application of (KAP) model	Jordan	Cross sectional analytical	110	SSQ	None	FST increased knowledge	-	Increased FSK leads to good FSP	management motivation, availability of necessary resources and facilities and reinforcement programs is important	(Habiballah et al., 2018)
Evaluate the impact of FST by TPB on FSK and FSP	Malaysia	A randomized controlled trial (Intervention and control groups)	79	SSQ and On-site observations	TPB- training by health talks, demonstrations , self-practice and posters	FSK improved after the educational intervention.	-	The self-reported FSP improved after educational intervention	FST of FH by TPB results in sustained improvement in certain areas of FSK, FSP.	(Husain et al., 2016)
Assessment of knowledge, attitude of Consumers of ready-to-eat street-vended food	South Africa	Cross sectional	402	SSQ filled by face-to-face interview	None	Limited FSK,	Limited FSA	Limited FSP	Mostly worried about foodborne diseases when purchase food from street vendors than restaurants and supermarkets.	(Asiegbu et al., 2015)

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to develop learning tools for FS based on HACCP for students, unemployed people and young workers	Romania	Cross sectional	137	SSQ	vocational e-learning training program	Improve their knowledge after training	-	-	eLearning based on HACCP is a successful training	(Iancu et al., 2015)
Comparison of KAP in trained and untrained FH	Brazil	Cross-sectional analytical	183	SQ and checklist	None	Trained FH had more knowledge	no differences in FSA of trained and untrained	no differences in self-reported and observed FSP of trained and untrained	Theoretical training did not increase FSA and FSP of FH but Improved their FSK.	(da Cunha et al., 2014)
Explore age-specific reasons for FS education in high school students	Canada	Qualitative (a phenomenological approach within a constructivist paradigm)	-	SSQ	-	FS education for high school students is important.	-	-	Public health professionals should seek other means for education and advocating for mandatory FS education in high schools.	(Diplock et al., 2017)
KAP of FH working in eating establishments of a hospital regarding FS	India	A before-after intervention study.	280	SSQ	Self-Instructional Manual, short film for sensitization	Training increased FSK	FSA toward changed in a positive direction.	Increase of FSP after the intervention.	The intervention package (training; booklet, short films, lectures, posters display) was useful in improving KAP.	(Dudeja et al., 2017)
KAP of FH	Indonesia	cross-sectional analytical	72	SSQ and checklist	None	FSK and FSA was related. FSK was not related with FSP.	FSA was higher among trained persons	Poor practice.	FSA and FSP was related. Training activities for FH must be held regularly. No relationship was between FSK and FSP.	(Putri and Susanna, 2021)
KAP of FH	Philippines	cross-sectional analytical	50	SQ	None	Fair FSK	Good attitude	good FSP	FSA was related with FSP. FS enhancement must be performed by a holistic approach considers KAP	(Flores and Angbengco, 2024)

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FSK and FSP among meat handlers (MH) in meat processing units	Romania	Cross sectional analytical	168	SSQ	None	good level of knowledge	-	excellent practices	Professional training of MH shows increased quality of their practices.	(Jianu and Goleț, 2014)
Assessment of FSKAP of trained and new untrained workers from two baking industries	Bangladesh	Cross sectional analytical	215	SQ	None	FSK of trained were higher than the untrained workers.	FSA was higher in trained persons	Self-reported practices of trained were higher.	Training is important for untrained workers and BBFST for all employees.	(Jubayer et al., 2020)
The effects of FS education on adolescents' hand hygiene behavior by stages of change	Korea	Cross sectional analytical	400-education for 26	SSQ	lectures, lab experiment. Question and answer	FSK was enhanced after educational intervention	-	Proper hand washing also enhanced after educational intervention	Proper hand washing was mostly influenced by self-efficacy, positive belief and stages of change.	(Kim et al., 2012)
the effects of leadership on food safety and hygiene (FSH) behaviors of FH in the institutional food service of schools	Taiwan	Cross sectional analytical	324	SSQ	-	-	-	Positive impact of leadership style on employees' compliance with FSH behaviors.	Leadership style and organizational climate influence the employees' behaviors with respect to FS and hygiene.	(Ko and Kang, 2019)
FSK and FSP among FH in food establishments	India	Cross sectional analytical	86	SSQ	None	Aware that food can be a source of infection by mishandling.	Good FSA	All FSPs were followed very well.	Most FH were not certified in food training.	(Kubde et al., 2016)
HBM used in explaining practices of FH working in five stars hotels	Jordan	Cross sectional analytical	130	SSQ	None	proper FSK as a modifying factor on the HBM constructs.	-	all of the HBM variables contributed in the explanation of FSP	HBM was able to predict significantly FH' practices	(Habiballah et al., 2020)

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Impact of FST on FSK and FSP of FH in orange-fleshed sweet potato purée processing	Kenya	Cross sectional analytical (Pre-test and post-test)	14	SSQ	Lectures and Videos	FSK improved after training.	-	FSP enhanced after training.	FST as an appropriate tool for improving FH's knowledge and hygiene practices.	(Malavi et al., 2021)
The effect of education on KAP of catering staffs about FSH	Iran	Cross sectional quasi-experimental study	55	SSQ	Lectures (Pre and post-test)	FSK improved after the educational course.	FSA improved after educational course.	FSP improved after the educational course.	The educational content should be revised. Education must be continuous and meticulously planned.	(Marzban et al., 2020)
FS perceptions, beliefs, and FSP of FH in families with children 10 years of age and younger based on HBM	USA	A convergent mixed methods design	72	SSQ and focus group	-	44% received an acceptable score of FSK	-	Many unsafe practices reported and	FSK deficits indicate a false sense of confidence. Education programs that focus on changing main food preparers' behavior and improving FSK may use the HBM	(Meysenburg et al., 2014)
FSK, FSA, self-reported (SRFHP) and observed practices of FH (OFHP) in urban restaurants	Zimbabwe	Cross sectional analytical	101	SQ and checklist		FSK scores increased in who received basic FST.	FSA was correlated with FSK and FSP.	FSK and FSA are the predictors of SRFHPs, and OFHPs.	Mandatory basic and advanced training to improve the FSK, FSA and FSP.	(Ncube et al., 2020)
Explore conformance of institutions to the catering and FSP at the National Youth Service Catering	Kenya	Mixed research	121	SQ interview	-	Basic information for handling FS is not readily available to the staff.	-	Management did not provide adequate training to improve employees' FSP.	Professional training and education courses on HACCP and food hygiene for FH are necessary. .	(Ndaramu et al., 2019)

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Assess KAP of the food consumers and street food vendors	Vietnam	Cross sectional analytical	838 consumers , 598 vendors-FSP (677)	SSQ and checklist	-	Average FSK	Average FSA	majority of the vendors had unhygienic practice	Trained consumers and vendors had better FSK and FSA compared to untrained consumers and vendors.	(Ngoc et al., 2020)
KAP of the hospice FH	South Africa	Cross sectional analytical	100	SQ	-	The trained and untrained FH had very different FSK.	positive attitudes	Attendance of FS course had better FSP.	Need for FS education for all hospice FH.	(Nkhebenyane and Lues, 2020)
Assessment of knowledge separately for HACCP team members and FH	Bosnia and Herzegovina	Cross sectional analytical	FH:740, HACCP team:80	SSQ	-	FSK of HACCP team members are low	-	-	Recommended to develop specific FST on higher level for HACCP team members	(Novaković et al., 2019)
Sanitary conditions of vending sites as well as FSP of street food vendors	Nigeria	cross-sectional analytical study	286	SSQ and checklist	-	-	-	Food vendors had good food handling practices.	Most sites appeared clean and should continue to maintain standard environmental and personal hygiene	(Okojie and Isah, 2014)
Examine the relationship between training and employee FSP in public hospitals FH	Malaysia	Cross sectional analytic	220	SQ	-	-	-	Motivation significantly affects FSP.	A significant relationship between training attributes and FSP, and motivation.	(Omar and Mohd Shahril, 2019)
Explores the impact of basic or foundation level FST on the attitudes, and intentions of FH to conduct FSP	UK	quantitative and qualitative approaches.	249- 60 interviews	SSQ and semi-structured interviews	-	-	All untrained FH were inclined to attend FST.	other's opinions were the most significant affecting intention of FSP.	Despite encouragement of food hygiene training, it does not translate into improved food handling behavior.	(Phillip and Anita, 2010)
Assess the KAP of canteen FH	Thailand	Cross sectional analytical	90	SSQ and checklist	-	Average FSK.	69% had good FSA.	59% had good FSP.	Effective ongoing training programs must be provided to improve FSK and FSP.	(Phyu et al., 2019)

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Assess FSK and important behavioral antecedents (FSA, intentions) of FS.	USA	Cross sectional analytical	242	SSQ and observation	-	Average FSK.	-	Low FSP.	mandatory training for all FH is not consistently associated with improved FSK, FSP.	(Pilling et al., 2008)
Assess the KAP of FH, and FSK and FSP of head chefs and managers in hotels' restaurants.	Brazil	Cross sectional analytical	265 FH-32 chefs and managers	SQ and Interview-observation	-	FSK was good in FH and low in head chefs and managers	FSA was good in FH	Self-reported FSP good in FH but inadequate FSP.	No significant association between the FSK, FSA and self-reported FSP by FH. The need for a better qualification of the FH, chefs and managers.	(Rebouças et al., 2017)
Assess the effect of training on FSK and FSP.	USA	Cross sectional analytical	402 (242 pre- and 160 post-training)	SSQ and observation	Class and document	FSK improved after training	-	FSP was good before training	hand washing improved After training but not on other fields. Method of training is very important, as FSK alone does not always improve FSP.	(Roberts et al., 2008)
Effect of providing managers with FST on their employees' FSK and FSP in hot/cold self-serve food bars.	USA	Cross sectional analytical	Managers: 99; Employees:201	audit and observation and SSQ	Lectures	FSK of managers increased post-training.	-	FSP was low after training.	After the training, FSK wasn't transferred from the managers to the employees. Current training materials/methods do not equip managers with the tools they need to train their employees.	(Rowell et al., 2013)
The role of educational intervention in changing FSK and FSA of rural homemakers	Iran	Cross sectional analytical	100	SSQ - pre- and post-test	Lectures	The educational intervention increased FSK.	FSA was elevated.	-	A need to use periodical educations (every 6 months) to teach important subjects food hygiene.	(Safari et al., 2017)

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The role of education in changing the FSK and FSA of urbane mothers.	Iran	Cross sectional analytical	200	SSQ - pre- and post-test	Lectures	FSK elevated after education.	FSA elevated after education.	-	Education did not promote the knowledge of married subjects.	(Safari et al., 2018)
The impacts of mothers training in nutrition, hygiene and FS on child undernutrition.	Malawi	Randomized controlled trial	179	A Semi-structured questionnaire	Lectures	-	-	FSP improved	Comprehensive training immediately guides mothers into improved dietary and hygiene practices.	(Seetha et al., 2018)
Determine the differences in organizational knowledge and skills, managerial attitudes, and performances of FSMS.	Thailand	Cross sectional analytical	326	SSQ	-	FSK was high.	good managerial attitudes towards FSMS	Performance was good.	The high level of organizational knowledge, skills and positive managerial attitudes regarding FSMS were crucial for maintaining a high level of FS system performance.	(Siripanwattana et al., 2018)
the long-term impact of community-based information, education and communication (IEC) activities on food hygiene and FS behaviors.	Vietnam	longitudinal	125-185	SSQ	workshops, newsletters, bulletin boards, and flip chart communication	-	-		Flip chart communication administered by community groups is effective for improving multiple food hygiene and FS behaviors.	(Takanashi et al., 2013)
Examine the FSK of FH in hotels' kitchen to determine existing knowledge gaps in FS	Turkey	Cross sectional analytical	378	SSQ	-	FSK was average.	-	-	FST is not sufficient alone to have knowledge. Content and adequacy of FST must be improved.	(Tuncer and Akoğlu, 2020)

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Evaluation of FSK of university foodservice workers.	Trinidad and Tobago	Cross sectional analytical	57	SSQ	-	No difference of FSK between trained and untrained persons.	-	moderate level of FSP among the foodservice employees	Neither education level, nor the length of employment had an impact on FSK. Urgent need to remodel the FST to include regular workshop sand training sessions	(Webb and Morancie, 2015)
Determine the hygiene knowledge of the staff employed in kitchen and service departments of catering firms.	Turkey	Cross sectional analytical	317	SSQ	-	FSK was higher in trained staff. The production staff had higher FSK.	-	-	FSK were quite lower than what must be taken. Periodical training programs should be organized to increase the awareness of the staff about hygiene.	(Yardımcı et al., 2015)
Evaluate FSK and FSA and the presence of indicator bacteria on the hands of FH in the pastrami retail	Turkey	Cross sectional analytical	150	SSQ and checklist	-	high scores on FSK	good	Hand hygiene was poor.	In addition to FSTs, the sources of problems, such as lack of hygiene infrastructure, in the practice should be identified and resolved.	(Yildirim et al., 2020)
The effectiveness of traditional ServSafe FST and a TPB intervention program targeting employees' perceived barriers and attitudes	USA	longitudinal	33	SSQ and Observations	ServSafe and TPB	Training and intervention improved handwashing knowledge	-	intervention was necessary to improve overall behavioral compliance	Traditional training approaches (such as ServSafe) may not be particularly effective, and new behavior-based approaches need to be developed.	(York et al., 2009)

FSH= Food Safety and Hygiene
FSCBEP= Food Safety Community Based Education Programme
SSQ= semi-structured questionnaire
SQ= structured questionnaire

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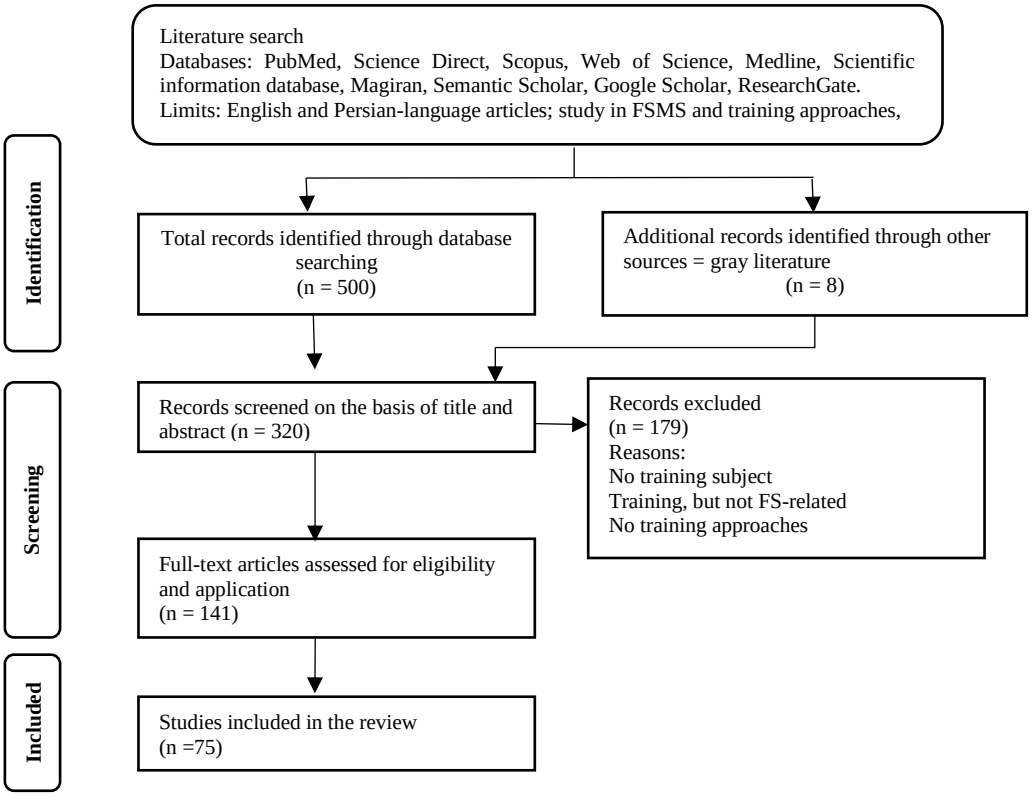


Figure 1: The PRISMA flow chart

To investigate FST methods and interventions within the scope of FSMS, we focused on empirical studies that reported the effects of training approaches on FSMS principles and related subjects. Most of these experimental studies included data on educational approaches and interventions for FS and hygiene. Of all the studies we have included in this review, one discussed competency-based training, seven TPB, three behavior based theory/BCT, six Social Cognitive Theory (SCT), three HBM, two TRA, three TTM, one THAM/HAM, and one HAPA. Table 2 shows the characteristics of the studies that focused on training approaches.

The current review summarizes the effect of educational approaches on implementing FSMSs in food establishments. According to our findings, FST approaches play a prominent role in implementing FSMS principles. One of the most important results obtained is that training based on knowledge transfer did not affect the performance of FH' safety practices, but the behavior-based education approach seems to be effective (Clayton et al., 2002; Yu, 2015; Yu et al., 2018). FS experts have realized that more stringent regulations cannot alone influence FS and that approaches should be able to change the mindset and behavior towards FS (Yiannas, 2009). The result of another study also highlighted the need for a risk-based training intervention and demonstrated that practice changes would not happen only as the result of training (Clayton et al., 2002). Thus, education content must be reviewed, and closing the gap between knowledge acquisition and its practical application is necessary to bring actual food handling behaviors in line with established safety standards (Marzban et al., 2020). In this regard, the design and assessment of an FST program will enhance FS performance among employees (Omar and Mohd Shahril, 2019). However, according to Liang et al. in the new era, there are some modern technologies that can identify and track FS hazards even without the need for trained personnel like giant magnetoresistance for detecting foodborne pathogens and toxins (Liang et al., 2022). As the new page of the FSMS moves from hard science to soft science, a helpful program based on FST approaches will be presented as a guide to implementing integrated FSMS in food service establishments.

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Table 2: Summary of training approaches

Training Approach	Interventions/ Methods	Data collection	Participants (n)	Country	Conclusions (Knowledge, Attitude, Behavior, or Practice)	Reference
Competency-Based Training	Documents (hard and electronic copies), e-learning courses and materials, Manuals, and reference guides	Interviews	**37**	India	Developing a uniform, structured course with competency-based learning is critical.	(Thippaiah et al., 2014)
BCTs	Targeted training interventions	Questionnaire Chi-square test	40	Malawi	Significant increase in the proportion of participants who followed recommended hygiene practices after training. Targeted training on practical hands-on activities increases the adoption of recommended hygiene and sanitation practices.	(Geresomo et al., 2018)
BCTs	Online knowledge-based training (SERV Safe) Motivational intervention	SSQ and observation	88	USA	Knowledge-based training alone failed to improve employees' FSP. behavior-based training approach by identifying critical behaviors, educating and motivating employees to achieve and sustain safe level is necessary. A behavior-based training approach effectively improved employees' FSP. The proper rates of all the behaviors that could prevent and control FS hazards significantly increased during the motivational phase of BCT.	(Yu, 2015)
SCT	A Pilot study of the educational materials	-	63	Korea	A helpful program model based on SCT that could serve as a guide to developing an educational model regarding FS and nutrition was developed.	(Lee et al., 2016)
SCT	Post-literature review, examination of laws and regulations, focus group data, and interview contributions	-	271	USA	A significant lack of knowledge about FS was discovered. The use of SCT to predict positive FS scores is supported. Managers and owners have an overall positive attitude towards FS training.	(Ghezzi et al., 2020)
SCT	-	Questionnaires	137	Wales	The need for risk-based training is highlighted. Behavioral change will not occur merely as a result of training. FSPs will only be implemented given adequate resources and an appropriate management culture.	(Clayton et al., 2002)
SCT	Literature review Group interviews	SSQ	201	USA	Behavioral intentions are a significant mediator of the relationships between self-efficacy and self-reported FS behaviors, self-regulation and self-reported FS behaviors, outcome expectations and self-reported FS behaviors, and environmental determinants and self-reported FS behaviors.	(Boutros and Roberts, 2020)
SCT-Longitudinal multilevel modeling approach	-	-	-	USA	The managerial differences between organizations influence training outcomes more significantly than individual differences in the FS training context. Trainees' FS behavior change is generated by the interactions between personal factors, instructional factors, and organizational factors, which support the SCT.	(Yu, 2018)
SCT	Printed fact sheets, bulletins/brochures, and demonstrations/displays	Online survey	510	USA	Determining FS behaviors and assessing the critical thinking styles of FH by using the SCT. Efforts should focus on assessing the contributions the SCT can make.	(Leal et al., 2017)
HBM	-	Transcribed interviews	72	USA	The low knowledge scores and reported practices based on HBM revealed a false sense of confidence.	(Meysenburg et al., 2014)
HBM	-	Self-administrated questionnaires	130	Jordan	Significant impact of different HBM constructs (beliefs of proper food handling benefits, beliefs of expected barriers against proper food handling, and perceived risks of food handling malpractices) on practices of FH. Significant correlation between proper food handling knowledge and practices as modifying factors based on the HBM constructs.	(Habiballah et al., 2020)

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HBM	-	Survey	230	Iran	Support for the HBM as a powerful framework for scrutinizing the intention to engage in FS behaviors; Offering a reasonable explanation for the participants' engagement intentions in on-farm FSPs based on HBM; Providing practical information that can be incorporated into the development of more effective on-farm FS interventions in Iran.	(Rezaei and Mianaji, 2019)
TRA	-	Questionnaires	500	Pakistan	All factors in TRA variables positively influence participants' attitudes, intentions, and subsequently behavior.	(Hussain et al., 2016)
TRA	-	Survey	-	USA	Workers' reports of their FS intentions and behaviors were best predicted by the TRA.	(Betts and Hinsz, 2015)
TTM	Educational intervention strategies	-	263	Brazil	Changes for the best in the conception of good manufacturing practices after the education intervention. Adoption of active methodologies associated with diagnosing propensity to change based on the TTM.	(Garcia et al., 2015)
TTM	Cross-sectional study	Questionnaire	181	Iran	The overall stage of change based on TTM was not significantly associated with age, educational status, or household income.	(Ebadi Vanestanagh et al., 2019)
TTM	-	Questionnaire expert review, cognitive interviews with non-experts, and pilot-testing	1231	USA	TTM-related constructs, including self-efficacy, decisional balance, and processes of change, were useful for examining differences among people at different stages.	(Takeuchi et al., 2005)
TPB	Slides and group discussions, videos, pictures, story analysis, and practical demonstrations	Pre-training and post-training tests	107	Netherland	The knowledge level of most participants improved.	(Ledo et al., 2021)
TPB	Pilot FS intervention	-	45	Australia	Changes in TPB cognitions appeared to be best translated to behavior via behavioral intentions and perceived behavioral control. The TPB FS intervention was shown to be effective in terms of significantly increasing the perceived behavioral control and observed FS behaviors of young adult participants. Significant correlation between self-reported and observed behavior, which gives weight to the construct validity of self-report when measuring behavior.	(Milton and Mullan, 2012)
TPB	-	Self-reported questionnaire	249	UK	The impact of basic or foundation-level food hygiene training on attitudes, and intentions of FH to conduct safe food handling practices on every occasion.	(Phillip and Anita, 2010)
TPB	Cross-sectional study	Researcher-made questionnaire	220	Iran	A significant, positive correlation between FS behaviors and all the TPB constructs ($r = 0.15$-0.38; $P < 0.05$). Intention was significantly correlated with FS behaviors ($r = 0.35$; $p < 0.001$), and 27% of the behavior variance was explained by the TPB constructs. Perceived behavioral control was the strongest predictor ($\beta = 0.3$; $P < 0.001$), and 31% of the intention variance was explained by the TPB constructs. Subjective norm was the strongest predictor ($\beta = 0.41$; $P < 0.001$). The TPB could be used as a framework for educational interventions aimed at health observance in food preparation.	(Momayyezi et al., 2020)
TPB	-	Questionnaire	300	UK - Brazil	TPB was a useful model for understanding the factors influencing FH' intention to	(Rodrigues et

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					carry out safe food handling practices, and OB could be a significant predictor of intention. Positive effect of training on reducing OB and improving FSP.	al., 2020)
TPB	-	Questionnaire	184	Australia	The TPB predicted a high proportion of variance in both intention and behavior, but neither intervention improved participants' food hygiene behavior.	(Mullan and Wong, 2010)
TPB	-	Questionnaire	901	China	The explanatory power of the two extended TPB models was strong, and almost the same, and the eight variables of attitude, habit, past behavior, subjective norm, face consciousness, conformity consciousness, perceived behavior control, and perceived ease were found to be significant predictors of hygienic food handling intention. Intention was found to be particularly dependent on perceived behavior control and perceived ease, explaining the phenomenon that consumers have positive attitudes but are less likely to generate intentions. Interventions aimed at improving safe food handling intentions should focus on the impacts of attitude, perceived behavior control, perception of ease, normative influences, and habits.	(Bai et al., 2014)
HAM	-	-	-	USA	The HAM model can be used as a guide to develop customized FS educational materials in various settings and target audiences in food production facilities.	(Nieto-Montenegro et al., 2006)
HAPA	-	Self-report questionnaires	109	UK	Aspects of the HAPA may be useful in determining hygienic food handling behavior.	(Mullan et al., 2010)
Behavior-Based Training Approach	-	Four-phase within-group experimental study with a behavioral motivation intervention	-	USA	Knowledge-based training alone failed to improve employees' hygienic practices, especially when employees had multiple work tasks simultaneously during the busy meal service time. In comparison, the behavior-based training approach effectively improved employees' FSPS and frequency. Proper rates of all the critical behaviors measured were significantly increased during the motivational phase.	(Yu et al., 2018)
Knowledge-Sharing Model	-	-	-	USA	Describing a six-step knowledge-sharing model: generation, adaptation, dissemination, reception, adoption, and implementation. Organizing the knowledge-sharing model into two dyads: (i) transfer between the researcher (i.e., knowledge generators) and educator; and (ii) transfer between educator and food handler (i.e., knowledge implementers).	(Yeargin et al., 2021)

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FSMSs

An FSMS is an interconnected network of elements associated with ensuring that food does not adversely affect humans. These include plans, programs, policies, processes, practices, procedures, goals, aims, methods, controls, roles, documents, records, responsibilities, relationships, and resources (Singh, 2015). Mandating the implementation of integrated FSMSs is considered by many to be one of the surest routes to ensuring FS due to the essence of foodstuffs, the problem of evaluation of their safety prior eating, and the potential adverse effects of a failure of FS on human life (Mensah and Julien, 2011). In this context, the International Organization for Standardization (ISO) developed standards at the level of risk-based FSMSs (ISO 22000:2005; ISO/TS 22003:2013; ISO 22000:2018) that have been designed for organizations of all types to assist them in identifying, controlling, and preventing FS hazards and ensuring safer products (Gil et al., 2017; ISO, 2018; Kussaga et al., 2014; Shehzadi et al., 2019). Implementing ISO 22000 in food establishments can ensure safer food, enhance the quality of these products in the global market, and ultimately increase international trade competitiveness (Fernández-Segovia et al., 2014). Additional notable advantages include the development of employee competencies, the strengthening of corporate reputation, the improvement of product sales performance, the expansion of market share, and increased access to both emerging and established markets (Gil et al., 2017).

In parallel with the development of FS regulations by ISO (Fernández-Segovia et al., 2014), other standards, such as British Retail Consortium Global Standard (BRCGS), HACCP, ISO 22000, SQF (Safety Quality Food), and IFS (International Food Standard) were developed by various organizations (Abu Al-Rub et al., 2020; Fernández-Segovia et al., 2014; Shehzadi et al., 2019). The use and maintenance of these FS systems depend on four factors, including: (1) education and training; (2) obligation; (3) pressure from external sources; and (4) availability of resources. As mentioned, training is one of the methods and requirements of FSMSs. However, the implementation of FSMSs is impeded by a range of factors (Shehzadi et al., 2019). These challenges can be broadly categorized into three domains: financial constraints, infrastructural limitations, and human resource-related issues. Specifically, such barriers have the potential to undermine the design, effective implementation, and continuous enhancement of an integrated FS control system. Moreover, they hinder efforts to adequately equip personnel with the necessary competencies in FS (Mensah and Julien, 2011). These barriers include lack of training and commitment in management (Kahindi, 2016; Mensah and Julien, 2011), (Shehzadi et al., 2019)], lack of technical knowledge and skill in employees (Kahindi, 2016; Mensah and Julien, 2011), and resistance to change (Mensah and Julien, 2011), inadequate infrastructure capabilities for FSMS validation and verification (Mensah and Julien, 2011), untrained staff (one of the key factors), large numbers of products, size of company, low resources and supplies, lack of knowledge of the critical nature of safe behaviors (Boutros et al., 2021; Clayton et al., 2002; Kahindi, 2016) and requirements (Mensah and Julien, 2011), lack of technical experts (Kahindi, 2016), and limited personnel (Clayton et al., 2002; Kahindi, 2016). Additionally, the limited availability of personnel to dedicate time and effort to the adaptation of FS control systems—beyond routine operational responsibilities—serves as a significant barrier to effective system adoption (Clayton et al., 2002; Novaković et al., 2019; Rowell et al., 2013). Moreover, lack of attitude (Clayton et al., 2002; Kahindi, 2016; Stedefeldt et al., 2015), high costs [related to expansion and implementation of FSMS (Mensah and Julien, 2011) and training and re-training of staff (Clayton et al., 2002; Novaković et al., 2019; Rowell et al., 2013), and time pressure (Boutros et al., 2021; Clayton et al., 2002) were also mentioned in the literature. Key obstacles to effective FSP include limited awareness of risks associated with food handling activities, a false sense of control over safety measures, the dissemination of theoretical knowledge with minimal practical application, a lack of motivation or intention to adopt behavioral changes, and various psychological and behavioral factors that influence decision-making and compliance (Stedefeldt et al., 2015). In fact, despite the substantial effect of training on staff KAP, this level of KAP was insignificant due to budget and time spent (Marzban et al., 2020).

Challenges regarding FST in FSMS

Extensive training initiatives contribute significantly to enhancing Food Safety Knowledge (FSK) among managers and employees. However, non-large enterprises mostly lack access to such training opportunities due to limited awareness and time constraints faced by food industry personnel (Ovca et al., 2018). Most food companies do not train their personnel and managers on FS systems. This issue contributes to a deficiency in FSK among employees and managers (Kahindi, 2016), the prevalence of unsanitary working environments, and a general lack of awareness regarding FS regulations. It also results in poor hygiene practices and inadequate food handling procedures (Okojie and Isah, 2014; Yeargin et al., 2021). Furthermore, refusal of established FS guidelines and protocols by food service personnel has been documented (Pilling et al., 2008). These shortcomings can lead to reduced employee satisfaction, increased staff turnover, exposure to legal penalties and financial costs,

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diminished operational efficiency and effectiveness, and an elevated risk of foodborne illnesses (Habiballah et al., 2018). Lack of management training results in a lack of alertness regarding the use of FSMS (Kahindi, 2016; Okojie and Isah, 2014) and prevents managers from transferring knowledge to their employees (Rowell et al., 2013).

As previously noted, insufficient training and education among FH constitutes a fundamental contributor to the occurrence of foodborne diseases. Conversely, the provision of comprehensive training in food hygiene and safety yields numerous advantages for food service organizations. These benefits include the enhancement of workplace conditions, improved organizational reputation and sales performance, increased satisfaction among both customers and staff, the establishment of constructive relationships with regulatory authorities, and adherence to legal and regulatory requirements (Habiballah et al., 2018).

To address the challenges that impede compliance with FS regulations and the use of integrated FSMSs, several strategic interventions may be employed. These include increasing budgetary allocations for workforce training, conducting in-house training initiatives, promoting knowledge-sharing practices, and establishing dedicated educational departments. Such measures are essential for enhancing the knowledge base and competencies of personnel involved in FS operations (Mensah and Julien, 2011).

Organizational competencies, managerial knowledge, and attitudes toward FSMSs are strongly correlated with overall FS performance. Consequently, the provision of regular and continuous professional training and educational programs—particularly those focused on HACCP, as well as food hygiene and safety— are essential for enhancing FS outcomes in establishments. Such training initiatives play a critical role in equipping personnel with the requisite knowledge and practical skills essential to uphold and improve FS standards (da Vitória et al., 2021; Ndaramu et al., 2019; Siripanwattana et al., 2018).

The contextual disparity between training and implementation often poses challenges for FH in applying acquired knowledge to practical settings. Effective knowledge transfer requires a comprehensive understanding of the dynamic relationship among the knowledge itself, the organizational structure, and the surrounding operational environment. This alignment is essential for successful FSP (Yeargin et al., 2021). The training program offers basic knowledge but must to be improved to meet the real needs of the market (Topliceanu et al., 2015). The adherence of food employees to good manufacturing practices is largely influenced by their level of motivation. To effectively foster such motivation within the workplace, several strategic measures may be employed. These include recognizing and valuing personnel, identifying and reinforcing positive behavioral changes, initiating encouragement programs, delegating authority appropriately, and conducting regular evaluations of employee conduct. Consequently, FS education, targeted training, and sustained motivational efforts are critical determinants of safe food handling practices among both operational staff and managerial personnel (Stedefeldt et al., 2015).

Implementing interventions that alter the existing culture within enterprises is another way to perform integrated FSMSs (Mensah and Julien, 2011). Four main components strongly influencing FS culture are commitment, control (leadership), connections, and merit (Reynolds and Rajagopal, 2017). Establishing a robust safe food culture within a company necessitates systems approach, exemplified by the implementation of a behavior-based FSMS. This framework emphasizes the integration of behavioral principles into FS protocols to promote sustained compliance and proactive engagement. Key components essential for the continuous improvement of such systems—and for the cultivation or reinforcement of an FS culture—include clearly defined expectations, comprehensive education and training programs, effective communication strategies, accountability mechanisms aligned with organizational goals, systematic performance measurement, and consistent reinforcement of desired behaviors (Yiannas, 2009). A behavior-based FSMS is process- and people-centered (Yiannas, 2009). Evaluating the cultural determinants of FS —such as managerial and peer support, communication efficacy, individual commitment, environmental conditions, occupational stress, and risk perception—can provide valuable insights into the organizational norms that shape FSP. Such assessments are instrumental in identifying evidence-based strategies and best practices for shaping a positive and sustainable FS culture within the organization (Abidin, 2013; Reynolds and Rajagopal, 2017). As previously noted, fostering a culture of FS necessitates a system-based approach that is grounded in scientific understanding of human behavior, company culture, and FS principles (Yiannas, 2009). According to Nakat et al. (2023), several factors were correlated with the enhancement of FS culture within organizations. Specifically, individuals with a scientific background, those who participated in FST programs and employees working in managerial or quality assurance roles demonstrated higher levels of FS culture. Additionally, companies engaged in export activities exhibited stronger FS culture compared to those operating solely in domestic markets. Conversely, the study found no significant association between FS culture and factors such as company size, company type, or the implementation of

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formal FSMS (Nakat et al., 2023), as observed in another study (Tomašević et al., 2020). Although companies with substantial resources and well-established FSMS tend to exhibit more robust FS environments, this does not necessarily translate into a strong FS culture or heightened risk awareness. This distinction underscores the importance of addressing behavioral and cultural dimensions alongside structural and procedural elements in FS management (Focker and Van der Fels-Klerx, 2020). Furthermore, it has been suggested that incorporating economic considerations and stakeholder preferences into FS planning enhances transparency and supports the development of more effective control measures, monitoring systems, and policy frameworks (Focker and Van der Fels-Klerx, 2020). Therefore, continuous training of employees regarding FS promotes a culture of FS and increases employees' compliance with the organization (Zabukošek et al., 2017). In this context, managers should prioritize the FS culture and classify occupations to enhance the implementation of FS behavior (Clark et al., 2019).

Implementing FSP requires adequate human resources, money, equipment monitoring, training assistance, and proper management (Abidin, 2013; Kahindi, 2016; Stedefeldt et al., 2015). In other words, an FS culture is "a set of management commitments, employee attitudes, and resources required to produce safe and healthy food products" and can also be said to be "a set of common attitudes, values, and beliefs around FS" (Yiannas, 2009) .

An analysis of multiple regression models conducted by Zabukošek et al. (2017) examined the influence of FS culture dimensions on educational effectiveness and risk perception. The findings indicated that employees' characteristics, including gender, age, educational background, and professional experience did not significantly impact the development of FS culture (Zabukošek et al., 2017). Instead, the most critical determinants were identified as managerial commitment and the FS behaviors exhibited by employees. Consequently, food service operators can mitigate the risk of foodborne illnesses by fostering favorable working conditions that promote and reinforce positive FSP and cultural norms (Neal et al., 2012). An inadequate organizational culture can contribute to the failure of FS initiatives and the ineffectiveness of training programs. This may result from factors such as trainer incompetence, managerial unwillingness to allocate resources for training, entrenched organizational values, employee beliefs and assumptions, and cultural barriers that hinder the adoption of best practices (Saniga et al., 2023). Conversely, cultivating a strong FS culture within an organization is essential for safeguarding public health against foodborne illnesses. This cultural foundation can be reinforced through targeted training initiatives that engage both management and staff across all operational sectors, ensuring comprehensive understanding and consistent implementation of the company's FS protocols (Yiannas, 2009).

Enhancing communication to raise awareness of FS requirements represents a critical strategy for the effective implementation of FSMSs. Clear, consistent, and targeted communication facilitates employee understanding, engagement, and compliance with FS protocols across all organizational levels (Mensah and Julien, 2011; Zhang et al., 2026). Effective communication facilitates the clear comprehension, sustained reinforcement, and uniform adoption of FS messages throughout the organizational hierarchy (Robach and Jespersen, 2018). Training initiatives can foster a shared set of skills and beliefs among employees, which in turn enhance organizational communication and participation. This collaborative environment contributes to increased job satisfaction by promoting engagement, mutual understanding, and a sense of collective purpose (Yu et al., 2019). An effective training program should incorporate periodic evaluations to assess its impact, alongside clearly defined guidelines for managerial oversight, systematic workflow monitoring, and regular procedural reviews to ensure stable compliance with FSP (Stedefeldt et al., 2015). Establishing standard operating procedures and documented FS programs enhances process consistency, which directly impacts overall FS (Mensah and Julien, 2011) and contributes to implementing an integrated FSMS. Successful implementation of HACCP-based strategies requires the collaboration and commitment of FH, which requires professional and continuing training courses (Ndaramu et al., 2019).

FST is a structured process aimed at imparting essential knowledge and practical skills to individuals involved in food handling across all stages of the food system. This process encompasses the provision of adequate resources and facilities, the establishment of effective communication channels, and the motivation of both employees and managerial staff (Gatwiri et al., 2026; Richard et al., 2013). To further safeguard public health, it is imperative that governments integrate food fraud investigations into national development agendas and health policies. Such efforts should be aligned with international public health standards and norms, and supported by comprehensive training programs, as well as robust quality and safety assurance protocols that enhance national self-regulatory capacities (Asiegbu et al., 2015). The available evidence indicates that although consumers residing in urban low- and lower-middle-income country contexts tend to exhibit a reasonable degree of knowledge and favorable attitudes toward FS, notable deficiencies in actual practices persist, with the potential to undermine

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public health outcomes. Consequently, future investigations should direct attention toward underserved geographical areas, adopt more robust methodological frameworks, and integrate both longitudinal and qualitative research designs. Such approaches would yield more nuanced understandings of the underlying factors and facilitate the development of targeted, evidence-informed interventions (Choudhury et al., 2026).

FST approaches, programs, and materials

Some FST materials for FH include PowerPoint™ presentations, training videos, booklets, posters, techniques of discussion (including problem solving and role playing), practice scenarios (Richard et al., 2013), non-verbal displays, pictures, simulations, and interactive activities (e.g., games) (Rowell et al., 2013). In addition to creating effective FST for a diverse workforce and validating comprehension, it is essential to determine the most efficient delivery methods. On-the-job training, classroom instruction, self-directed study, coaching, and mentoring can all be used to optimize learning (Robach and Jespersen, 2018). Among all these methods, it has been shown that FH who received interactive training in addition to lectures or video presentations performed significantly better in post-training tests in comparison with those who just received theoretical content of FS with less emphasis on a “hands-on” approach to FST (Kassa et al., 2010). The provision of both on-the-job and in-classroom training is essential for enhancing the FSK of employees and managerial personnel (Kahindi, 2016). Yeargin et al. conducted a review and described a six-step knowledge-sharing model defined as the procedure of generating and then using knowledge to change a behavior or practice (Yeargin et al., 2021). These six steps include production, adaptation, dissemination, reception, adoption, and implementation. Richard et al. described the “Countertop” Training Program, which links information learning with attitudes and behaviors (Richard et al., 2013). As they pointed out, this model states that individuals first receive information about a behavior. That behavior causes the development of an attitude and then results in a practice that is in accordance with that attitude. Countertop training meaningfully increased participants’ knowledge of FS (Machado and Cutter, 2018).

The effects of three types of FST-individual e-learning modules, group e-learning modules, and group discussion-based virtual tour training—on employees' attitudes, personal agency, perceived norms, intentions, knowledge, and behaviors were assessed. It was found that individual training had the least efficacy. When comparing different training methods, group training using direct instructions and individual training was less effective than social and situational learning theories using planned instructions to increase employees' knowledge of FS (Saniga et al., 2023). In this regard, there are two ways of training: (1) Face-to-face training which includes four scopes in FS: knowledge, attitude, behavior, and skill performance. This type of training program can have a positive effect on improving FSPs (Richard et al., 2013). (2) Online training which is not only inexpensive but also helps to train employees in their workplace continuously. Online training also gives all employees access to the same information (Rowell et al., 2013).

Most managers (82.8%) reported receiving classroom training (Rowell et al., 2013). While this type of training provides managers with consistent information, employees are often not given this opportunity due to high turnover rates. Most of the employees (67.2%) in the mentioned research revealed that they received on-the-job training, commonly shown by a manager or a senior employee. This type of training is usually not continuous and can change over time. A ServSafe® FST course with defined FS document (thermometers use, hand washing, and contact control) showed a dramatic increase in overall FS behaviors from pre- to post-class training (York et al., 2009).

The One Health concept further operates as a global framework for expanding interdisciplinary collaboration and communication across the interrelated domains of human, animal, and environmental health (Stroud et al., 2016). The essence of a good health approach is to use a specialized team to solve complex problems instead of a specialist working in a separate field (Angelos et al., 2016). A health-educational approach to FS can provide helpful information for researchers, students, educators and public policymakers (Angelos et al., 2017). In an example of an educational intervention package, a collection of Hindi-language self-help manuals for caterers, a short film to make FS sensitive to FS entitled "Gravy Extra", a documentary entitled "Farm-to-Fork Food Safety", and an educational guide entitled "High Technology, High Touch", it indicates that all training with emotional content and personal touch were performed among the caterers in the north India Higher Care Hospital (n = 280). Knowledge of FS and the practices of FH increased significantly after the intervention. Therefore, it is concluded that the intervention package was helpful in promoting knowledge, creating a good attitude, and promoting FSPs for FH (Dudeja et al., 2017).

According to theory-based models, educational materials may be more effective in addressing the causes of FS problems (Nieto-Montenegro et al., 2006). In this context, some theories, models, and approaches in the field of diagnostic strategies and training are categorized (Stedefeldt et al., 2015) as follows:

-Competency-based learning approach

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This approach emphasizes using assessments to determine the level of competency against desired outcomes and focuses learning and development efforts on helping the individual determine the direction of learning, identify learning experiences, and achieve desirable competencies (Robach and Jespersen, 2018). The Integrated Food Safety System based on competency-based learning system is used to create and improve many training subsystems, including programs and learning design, expansion of integrated training, assessment of quality and approval of position, presentation mechanisms, systems of instructor quality, self- and supervisor-gap assessment and analysis, competence coaching, programs of learning, record keeping and management of learning, and assessing systems (Kaml et al., 2013).

After a competency-based training, needs assessment through the implementation of a Competency Importance Rating Scale for 37 workforce regulations of food with regional and central government departments of health and family welfare in India, the need to develop a uniform course structured according to competency-based learning aims, methodology, suitable content, and the new roles of food regulatory workforce seemed crucial (Thippaiah et al., 2014).

- BCT (behavior-based training)

Successful and sustainable FS requires a behavior-based FSMS, or FS culture, in place that integrates the food sciences with the behavioral and social sciences (Yiannas, 2009). Thus, behavior-based FSMSs can be developed using the model of continuous improvement. Ensuring that performance expectations for FS are clear, achievable, and understandable to all and is the first phase in establishing a behavior-based FSMS (Yiannas, 2009). Strong evidence from food establishments suggests that using behavior change theories in the design and implementation of educational interventions is effective because they target the basic determinants (such as attitude, subjective norm, and self-efficacy) required for FSP and health measures (Ledo et al., 2021).

To create an FS culture in a company, a “behavior-based FSMS” is needed (Yiannas, 2009). Behavior-change models should be considered as a way to examine the factors influencing individual intentions and behaviors. Behavioral models initiate new approaches and training methods (Stedefeldt et al., 2015). The components of continuous improvement of behavior-based FSMSs—and of creating or reinforcing an FS culture—include expectations, training and education, communication, accountability and objectives, measurement, and strengthening. (Yiannas, 2009). However, one of the important elements of behavior change that is often not present in theories and models of behavior change is the importance of environmental or physical factors (design of facilities, selection of equipment, and tools) on a person's desire to perform certain behaviors (Yiannas, 2009). Accordingly, FST based on behavior offers a model with five steps, and it is argued that it can lead to implementing FS if practiced. These steps are: 1- human impact on critical control points; 2- principles of safe food handling; 3- recognizing current behaviors and their causes; 4- interventions to make change; and 5- monitoring (Fig. 2). This model as a conceptual framework, asserts that other factors exist besides science, education, and training which affect FS management aspects and must be considered completely (Ndaramu et al., 2020).

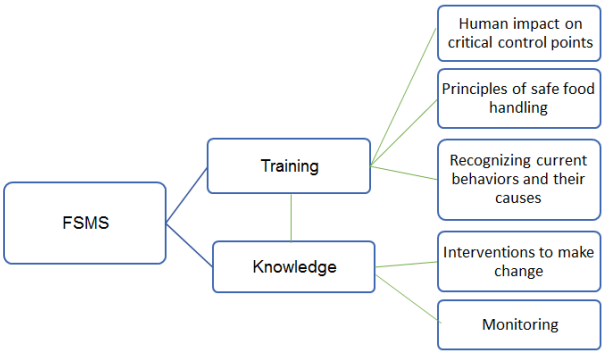


Figure 2: BCT five-phase model

An educational intervention based on TPB was performed by Ledo et al. In that research, the effectiveness of the educational intervention in influencing the behavior of 107 ranchers to perform safety and health control measures was analyzed (Ledo et al., 2021). They found that by measuring the pre- and post-training processes, the knowledge of most ranchers improved. Implementing TPB as the basic theory, they also identified the impact of subjective norms as an important factor in safety performance and on-farm health control measures in communities where collective culture is prevalent. In a similar study, the analysis of data obtained from targeted behavior change training interventions on practical hands-on activities of 40 mothers from 303 households showed a

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significant increase in following the recommended hygiene and sanitation practices after training and a meaningful decrease in foodborne disease (45% to 8.6%) (Geresomo et al., 2018).

Knowledge-based training alone cannot initiate preventive measures, particularly when employees perform multiple tasks simultaneously that nourish the efficiency of Behavior-Based Food Safety Training (BBFST). In contrast, training based on behavior has been very effective in enhancing the hand-washing performance of employees (Yu, 2015). A four-stage study with behavioral-motivational intervention was performed by Yu et al. to evaluate the impact of BBFST in elevating the methods and frequency of hand washing among FH (Yu et al., 2018). They once again showed that knowledge-based training alone could not enhance employee hand-washing performance, while the BBFST approach effectively enhanced employee hand-washing performance and frequency.

- *SCT*

SCT highlights that individual, behavioral, and social-environmental factors determine and influence individual behavior (Lee et al., 2016; Yiannas, 2009). Among all these factors, behavioral intention seems to be the best predictor of FSK scores (Ghezzi et al., 2020). People's behavior will be influenced by their beliefs, attitudes, and perceptions. The main concepts of SCT are skills and self-efficacy. If one understands the motivation for a particular behavior, one must believe that one can do it (self-efficacy). The likelihood of recurring behavior increases due to successful behavior (Yiannas, 2009). After conducting a pilot study on educational materials by targeting 63 participants using factors affecting individual behavior, including individual, behavioral, and environmental factors, based on SCT, Lee et al. provided a model of a helpful program that is usable as a guide to developing an educational approach regarding FS and nutrition (Lee et al., 2016). In a study assessing the current knowledge of FST methods of 271 food truck managers and owners through the SCT concepts, the results partially supported using SCT for predicting positive FS scores. Qualitative outcomes showed managers and owners generally had a good attitude toward FST (Ghezzi et al., 2020).

Using SCT elements to assess food stakeholder beliefs about FS and determine practices reported by food self-reporters, some questionnaires were filled by 137 food vendors from food businesses in Wales. The outcomes exhibited that food professionals were commonly aware of the FS measures that they needed to take but recognized some barriers preventing them from doing so. These barriers are contained within a lack of time, workers, and resources (socio-environmental factors). The participants also considered their work relatively low-risk (personal perceptions), yet they actually produced high-risk food (Clayton et al., 2002).

Using SCT to predict FS behaviors, Boutros and Roberts developed a data collection questionnaire based on a complete review and the outcomes of five focus group interviews, and pilot testing, and used a multi-stage random sampling technique. The questionnaire targeted 150 food vendors in Mexican and Chinese restaurants. Mediation analysis displayed that behavioral intentions are essential mediators for the relationships between self-efficacy and self-reported FS behaviors (b = 0.24, CI [0.161, 0.336], self-regulation and self-reported FS behaviors (b = 0.252, CI [0.155, 0.366]), result expectations and self-reported FS behaviors (b = 0.355, CI [0.247, 0.469]), and environmental determinants and self-reported FS behaviors (b = 0.269, CI [0.172, 0.393]) (Boutros and Roberts, 2020).

The change in trainees' FS behavior is caused by the interaction among personal, educational, and organizational factors, in line with SCT (Fig. 3) (Yu, 2018). In particular, temporal variations in self-efficacy and learning motivation at the interpersonal level, alongside individual differences in learners' motivation to learn and perceived enjoyment, as well as managers' prioritization of safety and their proactive supervisory behaviors across organizational boundaries, collectively exert a positive and statistically significant influence on changes in FSPs (i.e., training outcomes).

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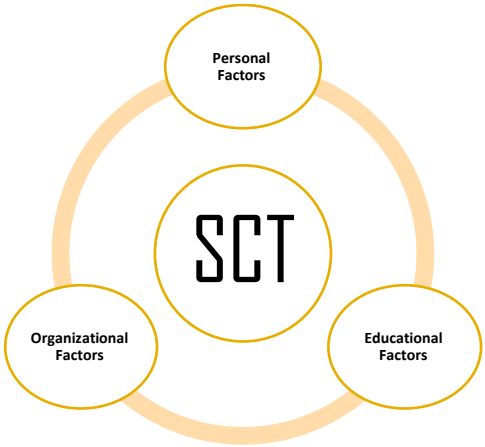


Figure 3: SCT pattern for changing FS behavior

A study was performed by Leal et al. to determine the FS behaviors of 510 Florida residents while assessing their critical thinking styles using the SCT through an online survey. They suggested that efforts should focus on evaluating the contribution of the SCT to critical thinking approaches regarding FS behavior (Leal et al., 2017).

-TRA

This theory includes control perceptions. In this theory, individual intentions are the primary factors in performing certain behaviors. The TRA primarily focuses on attitudes, beliefs, and intentions. Based on this theory, an individual's intention to perform a particular behavior is primarily due to his intention (Yiannas, 2009).

Betts and Hinsz conducted a survey among workers in a poultry factory using the TRA approach, and results indicated that job attitudes and rational (reasoned) action variables predicted FS behaviors. This study examined how reasoned action and job attitude models can estimate the factors contributing to safe food production (Betts and Hinsz, 2015).

-TTM

As mentioned earlier, one of the factors influencing the successful use of an integrated FSMS system is the .

employees' resistance to change. To better understand and analyze this barrier, we can use the TTM, which describes behavior change as a set of steps that a person goes through concerning their readiness for change (Yiannas, 2009). In TTM, behavioral change is conceptualized as a temporal process characterized by progressive advancement through a sequence of six distinct stages (Fig. 4) (Diplock, 2016; Stedefeldt et al., 2015; Yiannas, 2009). The TTM describes the stages of change, along with the processes generally shared across most behavioral transformations, constitute a core component of this theoretical framework. Central to this model is the premise that individuals exhibit varying degrees of readiness and motivation for change (Diplock, 2016). The TTM is designed to explain or predict an individual's success or failure in attaining the intended behavioral change. Furthermore, the model serves to identify a person's emotional and non-emotional needs pertaining to the behavior requiring modification—an assessment that can be inferred from the individual's stated readiness or desire for change (Richard et al., 2013). Adopting active methodologies related to the tendency to change, based on TTM is practically effective for all attitudes. This model, along with motivational stimulation, offers specific and consistent training programs (Garcia et al., 2015).

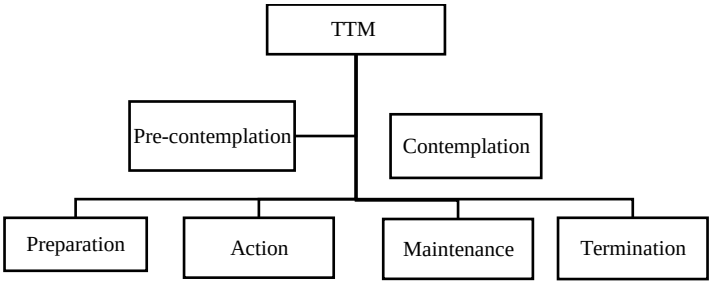


Figure 4: TTM steps

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By analyzing TTM-based educational intervention strategies among 263 FH in 12 restaurants in Brazil, the results showed a change in the concept of good manufacturing practices for the better after the training (Garcia et al., 2015). Ebadi Vanestanagh et al. investigated the application of TTM to assess readiness to enhance FS among 181 housewives and found that the overall stage of change was not significantly associated with age, educational background, or household income (Ebadi Vanestanagh et al., 2019). Using the TTM, Takeuchi et al. developed and validated the questionnaire through expert reviews, cognitive interviews with non-specialists, and a pilot experiment with 1,231 subjects in Washington and Idaho (Takeuchi et al., 2005). They demonstrated that TTM-related constructs, including self-efficacy, decision-making balance, and processes of change were useful for examining individual differences at different stages.

-TPB

According to this theory, the closest behavioral background is intentional behavior, and intentions are predicted and guided by attitudes, subjective norms, and perceived behavioral control (Gilman, 2018; Milton and Mullan, 2012; Pilling et al., 2008). It has been proven that TPB can be a suitable tool for developing interventions that aim to increase self-reported behavior. TPB is a valuable FS framework used in FS applications to predict intentions, attitudes, and actions. If the attitude of FH stays the same, their FSP will not change (Gilman, 2018; Milton and Mullan, 2012). This theory measures and predicts an individual's intentional behavior by looking at attitudes, personal control, and social pressure or peer pressure to adopt a behavior (Gilman, 2018; Ledo et al., 2021; Stedefeldt et al., 2015). As mentioned earlier, knowledge does not usually lead to changes in attitudes and behaviors, so assessing the impact of training by measuring behavior using TPB shows the interaction of fundamental principles and how they interact, leading to an influence on behavior (Gilman, 2018). According to Ledo et al., the TPB intervention subsequently improved knowledge and led to changes in behavior (Ledo et al., 2021).

Learning is an active process, and learners construct their understandings through the accumulation of data, experiences, and practices (Baba and Esfandiari, 2023). As a result, videos, images, and story analysis have improved average knowledge scores (Momayyezi et al., 2020), as well as games, since games are active learning environments due to their characteristics related to the way people learn (Baba and Esfandiari, 2023), while practical representations enrich the acquired knowledge. The TPB model also explains the predictors of the intention to perform on-farm safety and hygiene practices. Therefore, TPB can be implicated as a construct for educational interventions to maintain safety in food preparation (Momayyezi et al., 2020). The TPB is a reliable tool for predicting food hygiene behaviors that further supports TPB application (Milton and Mullan, 2012; Momayyezi et al., 2020; Phillip and Anita, 2010).

According to a study by Gilman, by developing an FST needs assessment based on FS principles, applying the TPB based on identified needs, and evaluating the impact of training on participants' attitudes, behaviors, intentions, social norms, and perceived behavioral control, significant differences can be made in behavior toward the processing environment and perceived behavioral control structures for all FH (Gilman, 2018). A pilot TPB-based FS intervention was conducted among 45 young adult participants, and the results supported the use of TPB as a method to improve FS behavior. Changes in TPB cognitions were best translated into behavior through behavioral intentions and perceived behavioral control. In addition, the TPB FS intervention effectively increased the perceived behavioral control and observed FS behaviors of young adult consumers. The last noteworthy finding was a significant correlation between self-reported and observed behavior, which emphasizes the validity of self-reporting when measuring behavior (Milton and Mullan, 2012). Phillip and Anita used TPB to explore the effect of basic FST on the attitudes and intentions of FH to conduct safe food handling practices and to evaluate the relative impact of different factors on the intentions and self-reported behaviors of 249 FH in hospitality settings (Phillip and Anita, 2010). They revealed that the TPB provides a helpful tool for understanding the factors influencing FH' intentions to perform FSP in any situation. A strong positive correlation was seen between FS behaviors and all TPB constructs ($r = 0.15$-0.38; $P < 0.05$) among 220 women in Yazd, Iran (Momayyezi et al., 2020).

In the study of Rodrigues et al., 300 FH from the United Kingdom (n = 150) and Brazil (n = 150) completed a TPB-based questionnaire containing additional questions about optimistic bias (OB) (Rodrigues et al., 2020). The results presented that TPB could predict the factors influencing FH' intention to perform FSP, and OB can be a strong predictor of intention. The results also pointed to the reduction of OB by training and possible cultural differences in intention determination (which may have a more significant influence than OB). Therefore, training may reduce OB and enhance FSPs. B. Mullan and Wong evaluated the effectiveness of a TPB-based food hygiene intervention among 184 employees by completing a TPB questionnaire about past behavior and FSK (Mullan and Wong, 2010). The TPB predicted a high proportion of the variance in intentions and behavior, but none of these interventions improved participants' food hygiene behaviors.

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-THAM

The application of the HBM in the field of FS is presented in THAM. THAM is a combination of HBM and TRA models and contains several key points about TRA/TPB, such as the impact of norms and the motivation to change behavior (Seaman, 2010; Stedefeldt et al., 2015). The THAM consists of five structures or systems, as follows: (1) knowledge: initial FSK; (2) legal: laws and rules of service; (3) motivational: motivational elements of service; (4) belief: the values and beliefs of the target audience; and (5) environmental conditions of service (Fig. 5). These factors are thought to directly affect behavior of FH, not just knowledge (Stedefeldt et al., 2015). In other words, Health Action Model (HAM) identifies critical psychological, social, and environmental factors that affect the adoption and maintenance of an individual's safe or unsafe related behavior (Mazaheri and Heidarnia, 2015).

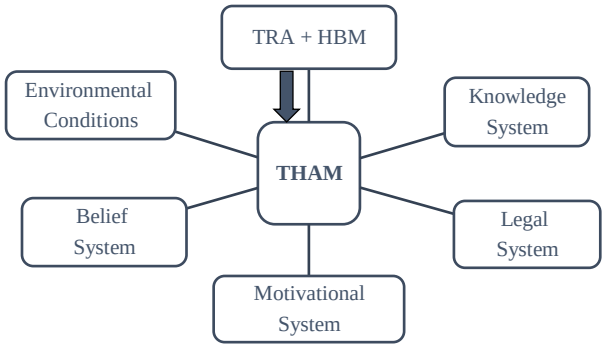


Figure 5: THAM conceptual framework

HAM-based training needs assessment is a good basis for designing an FST program (Nieto-Montenegro et al., 2006). Nieto-Montenegro et al. studied HAM as a basis for developing FS educational documents for Hispanic workers in the mushroom industry (Nieto-Montenegro et al., 2006). The findings presented using this framework was helpful in identifying factors to consider in designing an educational intervention. Therefore, they concluded that the HAM model could be used as a tool for developing custom FS educational documents in various settings and target audiences in food production facilities.

-HAPA

HAPA is a model that incorporates action planning into health behavior change. This approach consists of two phases: the first is motivational, and the second is volitional. In the first phase, risk awareness, result expectancy, and self-efficacy influence intentions toward a health (safety) behavior. The second phase involves action planning and bridging the gap between intention and behavior. Increasing risk awareness and outcome expectancy, increased motivation, and the chance of an individual planning to implement the behavior increased accordingly (Diplock, 2016). A study with 109 participants was conducted using self-report questionnaires to identify determinants of food storage health behavior using HAPA (Mullan et al., 2010). The results confirmed that aspects of HAPA may be helpful in determining hygienic food handling behavior.

According to current study, FST needs especial improvement with regard to recent advancements in the field of digital technology. In a study, the use of FOODAlyzer©, a web-based application designed to increase FSK among university students in Malaysia was investigated. Three principal themes emerged regarding FS education. First, participants advocated for the enhancement of educational content through the establishment of more explicit criteria, intended to inform both consumers and premises operators. Second, the integration of incentive-based motivation—including gamification, quizzes, and promotional rewards—was recommended as a means of fostering sustained engagement. Finally, respondents emphasized the necessity of more refined assessment instruments, calling for simplified question formats, more intuitive rating scales, and abbreviated questionnaires to mitigate respondent fatigue and enhance data accuracy (Seow et al., 2025).

Conclusion

The challenges of food production, processing, and distribution for the world's nine billion people from 2050 onwards can create very complex problems. The capability of modern societies to overcome these and other food problems requires an educated workforce trained in areas such as food security, public health, the production and processing of new foods, and sustainable FSPs. Hence, with targeted training, the behavior and performance of people involved in the field of food can be improved. Therefore, providing appropriate training and knowledge of FS measures in organizations will be useful to ensure the safety and health of customers. In other words, having

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a base of knowledge regarding FS is enough on its own; training has a greater impact on increasing FSP. Of all the studies that assessed changes in KAP and training of food handlers in the field of FS, most agreed on the effectiveness of training methods on KAP of FH. As some studies have pointed out, current training methods in the food establishments do not equip personnel with the necessary skills in the FS scope, and it is better to use educational models such as HAM and TPB for designing educational content and improving behavior, respectively. Training effectiveness may vary depending on the type of intervention, outcome assessed, methodological quality of the studies, and managerial factors. However, more studies should be conducted on the use of educational models in the scope of FS to train and improve the practice of FH.

Conflict of interest

The authors declare that they have no competing interests regarding the results of the present study.

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Data availability

Data will be made available upon reasonable request.

Ethical consideration

This study was performed according to the international code of ethics.

Author contributions

B.B: investigation, methodology, and writing original draft; N.S: conceptualization, supervision, and writing original draft; T.Z: supervision, investigation, methodology, writing original draft, review, and editing.

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