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Development of a theory-informed multicomponent food safety intervention to enhance food safety knowledge and behaviours of meat handlers and reduce microbial contamination in butcher shops in Addis Ababa, Ethiopia

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Abstract

Research suggests that behaviour change interventions (BCIs) design should be grounded in behaviour change theories to enhance effectiveness and facilitate replication, however, food safety interventions seldom guided by theoretical frameworks. The objectives of this work were to describe the development of a theory-informed randomized controlled trial (RCT) food safety intervention design and to describe its implementation (mode of delivery). We identified components of our intervention package and selected the behaviour change techniques (BCTs) to be incorporated. These components were mapped onto the intervention options indicated in the behaviour change wheel (BCW) model. We also mapped the BCTs onto the capability, opportunity and motivation (COM-B) model of the BCW and further mapped onto the theoretical domains framework (TDF) determinants. We described implementation of our intervention (mode of delivery) using Implementation Research Logic Model (IRLM) and template for intervention description and replication (TIDieR). A theory-informed multifaceted food safety intervention design was developed. We identified education, training, nudges, hygiene material provision and inspection with 'scores on doors' as elements of our intervention package. These were mapped onto education, training, persuasion, enablement, environmental restructuring and incentivisation of the BCW intervention options. We incorporated 30 BCTs to our intervention which were mapped onto psychological capability, physical opportunity, social opportunity, reflective motivation and automatic motivation of the COM-B model. The BCTs were also related to nine TDF domains including knowledge, skills, professional role and identity, beliefs about capabilities, beliefs about consequences, reinforcement, intentions, environmental context and resources and social influences. The development process of the current RCT food safety intervention design can serve as a practical model for developing food safety interventions in low- and middle-income countries (LMICs) and similar settings. Regulators, policymakers, researchers and other food safety stakeholders can use the elements of our intervention package and the BCTs to design food safety intervention. Future research is needed to develop a more generic food safety intervention design.

Introduction

Foodborne diseases cause substantial public health and socioeconomic burdens worldwide [1]. Food businesses are expected to comply with the Codex Alimentarius Commission (CAC) General Principles of Food Hygiene [2] to ensure the safety of the food they produce. However, their adherence to good hygiene practices (GHPs) largely depends on their food safety culture such as food handlers' behaviour towards food safety, which is influenced by multiple environmental [3–7] and individual [3,4,6,7] factors. Thus, BCIs that target multiple food safety determinants are key to enhancing food businesses' adherence to proper food safety practices. While an intervention is a planned process that has the aim of influencing an outcome, BCI is an intervention that has the aim of influencing human behaviour[8]. Although BCIs are recommended to be grounded in behaviour change theories [9,10], food safety BCIs are rarely guided by theoretical frameworks [11,12]. When theory is used, it is often limited to a single theory [11–13], which captures only a subset of the determinants influencing food safety behaviour, excluding potentially important food safety determinants from considering in interventions. In addition, use of single theories often focuses on identifying determinants of food safety practices [11,12,14] and overlook use of theories to guide intervention design such as selecting target behaviours and intervention options.

To address challenges related to using theories in BCIs designing, researchers working in BCIs have developed comprehensive theoretical frameworks [9,10,15] which allow systematic integration of multiple behavioural determinants into BCI processes. The BCW, for example, allows intervention designers integrating food safety determinants associated with capability, opportunity, and motivation (the COM-B model) and selecting potential intervention options and policy categories [9] while designing BCIs and the TDF enables incorporating 14 domains and 84 behavioural change constructs to the design process (Cane, O'Connor and Michie, 2012). Besides, the behaviour change taxonomy [15] provides 93 distinct BCTs which can be used in BCIs across various disciplines. BCT is a planned process that is the smallest part of BCI content that is observable, replicable and on its own has the potential to bring about behaviour change [8]. Providing detailed descriptions of BCTs used in BCIs allows research replication, evidence synthesis, effective BCIs development and understanding of mechanisms of actions of BCIs [15,16]. Furthermore, linking components of the BCW, COM-B, TDF, and BCT frameworks facilitates a more explicit understanding of the mechanisms of action of BCIs. Although these frameworks and BCTs are widely applied in public health–related BCIs [17–19], their use is rare in food safety BCIs [14,14].

In addition to being grounded in theory during their designing, various aspects of BCIs such as their mode of delivery, materials used, deliverers and so on should be described adequately using appropriate guidelines and models. However, various studies have shown deficiencies in the description of BCIs while reporting [20–25]. For example, Hoffmann *et al*[21] found in their review of 137 interventions that only 39% were adequately described. Inadequate descriptions of BCIs hinders critical appraisal, reduces replicability, limits evidence synthesis, and impedes the translation of findings into practice [26–28].Various guidelines have been developed to facilitate description of behaviour change interventions [27–29].

Given these gaps, this study aims to describe the development of a theory-based multicomponent RCT food safety intervention design in butcher shops in Addis Ababa, Ethiopia. The specific objectives of this work were: (1) to describe the development of a theory-informed RCT food safety intervention design and (2) to describe its implementation (mode of delivery). We posited that outlining the development process of our food safety intervention design could enhance understanding of researchers, policymakers and food safety regulators in designing effective food safety interventions. Furthermore, providing a clear description of the implementation of our food safety intervention may facilitate intervention replication as the description would enhance other researchers understanding of the intervention process enabling them to adapt and apply the approach in their own contexts.

Methods

Study design and setting

We conducted an RCT food safety intervention in butcher shops in Addis Ababa, Ethiopia. In Ethiopia, butcher shops are food retail establishments that specifically sell meat and meat products. According to the Ethiopian Food and Drug Authority (EFDA), a butcher shop must have a minimum floor area of 12 m² to be licensed for operation. About 34% of butcher shops in Addis Ababa are attached to restaurants [30] and sell meat for both on-premises consumption and home use, while remaining butcher shops operate independently and sell raw meat only for off-premises consumption (home use). There is a culture in Ethiopia of eating raw meat, and the meat served in butchers' shops is typically served in thin slices or minced with the addition of condiments and spices such as awaze (locally made from pepper, onion, ginger, salt and other spices). The selection of butcher shops for our current intervention was informed by a consultative workshop involving experts from local and international organisations [31].

A total of 302 butcher shops were signed up to the study. One meat handler was selected from each shop to participate in the study. Eligible participants were adults 18 years of age or older and had primary responsibilities for regular meat handling (e.g., receiving, sorting, cleaning, hanging/storing, cutting [preparing for sale], and selling meat). The 302 butcher shops were randomly assigned to one of two intervention groups (Intervention 1 and Intervention 2) (101 shops each) or a control group (100 shops). Intervention 1 shops (hereinafter called TNM) received training, nudges and hygiene materials while shops in Intervention 2 (hereinafter called TNMI), in addition to the interventions received by TNM shops, were inspected and rated, and the ratings publicly posted ('scores on doors'). Controls received nothing during intervention but received training, nudges and hygiene materials after endline data collection. The objectives of the RCT were to evaluate whether food handlers' knowledge and behaviours and microbial safety of beef (measured by *Escherichia coli* contamination) improved after the intervention. In addition to the RCT, we also conducted other food safety investigations to support the RCT including a) consumers' and butchers' sensory evaluation of raw beef (purchased from butcher shops) attributes treated with slightly acidic electrolysed water (hypochlorous acid) and citric acid against untreated beef and b) assessing raw beef consumers' perceptions and practices on the use of natural food sanitisers (such as lemon, vinegar) on raw beef.

Selection of theoretical frameworks

We selected relevant theoretical frameworks for development of our food safety intervention design based on iterative discussions and literature. We employed the BCT taxonomy [15] to select BCTs for our food safety intervention. We used BCW [9] to map the BCTs selected for our intervention with behaviour change determinants in capability, opportunity and motivation (COM-B) model of BCW and to map components of our intervention with its intervention options. The selected BCTs were further mapped to relevant behaviour change determinants of the TDF [10] constructs. Prior BCI designers have also used BCT taxonomy [17–19,32], BCW [19,32], and TDF [17–19] to develop their intervention design. Moreover, we used constructs linked to theories of learning such as theory of andragogy [33], cognitive load theory [34] and spaced effect principles [35,36]. Implementation of our intervention (mode of delivery) was described using Implementation Research Logic Model (IRLM) [29] and template for intervention description and replication (TIDieR) [28]. We will describe the effectiveness of our intervention (data analysis and interpretation of our intervention) using the Consolidated Standards of Reporting Trials (CONSORT) guideline [37].

Steps of development of the intervention design

Step 1: Identification of target groups and behaviours

Meat handlers were selected as the study participants (target groups) because they play a central role in implementing food safety practices in butcher shops. Our RCT food safety intervention was designed to enhance GHPs in butcher shop operations. We determined the contents of our intervention package based on existing literature related to general principles of food hygiene (WHO, 2006; FAO and WHO, 2023; Food and Drug Administration, 2023). For example, the CAC [2], in their General Principles of Food Hygiene guideline, recommends that food hygiene training programmes should consider general principles of food hygiene, foodborne hazards, and the handling, processing, storage, and packaging of food, while considering the knowledge and skill levels of food handlers. The CAC General Principles of Food Hygiene [2] further recommends food businesses to implement the GHPs including keeping personal hygiene (cleanliness of hands and wearing appropriate protective clothing), using clean water, maintaining cleaning and disinfection of work surfaces and equipment, implementing pest control, waste management and food safety culture to control foodborne illnesses.

These CAC hygiene principles informed the content of our intervention (such as contents of the training modules) and are consistent with food hygiene requirements for butcher shops in Ethiopia, as outlined in the inspection checklist of the Ethiopian Food and Drug Authority. Although the intervention aimed to influence food safety knowledge and practices of meat handlers in various food safety aspects, we mainly focused to improve their food safety practices related to hand hygiene, appropriate use of clean protective clothing, use of safe water, cleaning of work surfaces and tools, safe meat storage, prevention of cross-contamination (separate principles), environmental sanitation, worker health and food safety training (Table 1).

Table 1
Target food safety behaviours for our RCT food safety intervention in butcher shops

No	Good hygiene practices (GHPs) domains	Description
1	Keeping hand hygiene (clean hands)	• Keep hands clean • Keep fingers short • Wash hands at appropriate times following proper procedures • Sanitise hands • Cover wounds or cuts on hands • Not wearing jewellery, watches, bracelets etc on hands when at work
2	Using proper and clean worksite clothing (clean clothes)	• Wear white gowns without outside pockets • Wear hairnets • Provide adequate supply of white gowns and hairnets • Keep gowns and hairnets clean
3	Keeping water clean (clean water)	• Treat water using recommended chemicals such as chlorine tablets • Store water in a container with tight lid • Use water from safe sources such as municipal piped water sources
4	Cleaning and disinfection of work surfaces (clean work surfaces and tools)	• Clean, sanitise utensils and equipment • Clean and disinfect work surfaces following appropriate steps (remove dirt, wash, disinfect, dry) • Keep cleanliness of equipment and tools used in the shops including meat cutting boards, meat hanging boards, meat chopping logs, knives, knife files, meat grinders, hooks, etc. • Keep cleanliness of shops floor, walls, doors, windows, etc. • Conduct deep cleaning of shops (comprehensive cleaning where every part of the shop including hidden areas/pockets which could not be reached in routine cleaning is cleaned thoroughly. Deep cleaning involves all parts of the shop such as floors, walls, doors, windows, ceilings, tools and equipment [cutting board, hanging board, chopping logs, hooks, knives, grinders, tables, etc] and even the environment surrounding the shop. This is often done once a week). • Use different colour wiping towels and cleaning buckets to adopt cleaning procedures based on status of work surface dirtiness.
5	Preventing cross-contamination (separate principle)	• Workers handling money and cutting meat are different (shops should have cashier who handles money) • Separate red meat from offal while storing • Use different knives for red meat and offal • Use different cutting boards for red meat and offal • Use different grinder for red meat and offal • Separate old meat and newly received meat • Use different wiping towels and cleaning buckets for different levels of work surface dirtiness
6	Using proper food contact surfaces	• Use cutting boards, handing boards, chopping logs with smooth surfaces • Use cleanable equipment such as plastic cutting boards
7	Keeping environmental sanitation	• Establish proper handwash facility (handwashing station with water, soap, drying towels) • Proper solid and waste management • Control of pests such as flies using appropriate techniques • Sufficient lighting in the shops
8	Keeping meat safe	• Keep meat at appropriate temperature • Use food sanitisers on meat • Receive meat from approved sources
9	Keeping worker health	• Workers inform their managers if they feel ill or have signs of illness • Managers provide sick leave for sick workers • Managers pay workers when on sick leave
10	Food safety training	• Managers provide regular food safety training for meat handlers

No	Good hygiene practices (GHPs) domains	Description
		• Managers keep records for meat handlers' food safety training•

Step 2: Identification of intervention package

We chose potentially effective components of our intervention package based on existing literature and tailored to the butcher shop context. Through iterative discussions within the research team, education and training, nudges, material provision, and inspection with public posting of ratings ('scores on doors') were identified as components of our intervention package. Various studies have indicated effectiveness of education and training [12,38,39], nudges [11,40–43], and material support [11,39] in enhancing food handlers food safety behaviours. Public disclosure of food inspection ratings empowers consumers to make informed purchasing decisions, which in turn, incentivizes food business operators to comply with hygiene standards [44,45] while food inspection can also serve as a potential source of food safety education for food businesses [46]. Furthermore, past studies indicated lack of education and training [3,6,7], absence of nudges (such as reminders/environmental cues) [4,6], insufficient material supplies [3,4,6,7] and influence of consumers and regulators [3,5,7] as important factors impacting food safety behaviours of food handlers.

We mapped components of our intervention package onto the intervention options specified in the BCW. The BCW has capability, opportunity, and motivation (the COM-B model) behaviour determinants at its centre surrounded by nine intervention options designed to address deficits in one or more of the behaviour determinants in the COM-B components and further encircled by seven policy categories that enable implementation of the intervention options (Michie, Van Stralen and West, 2011). Components of our intervention package were mapped to education, training, incentivisation, persuasion, enablement and environmental restructuring intervention options of the BCW (Table 2). We used iterative discussions to decide the mapping outcomes based on the planned activities of our food safety intervention in butcher shops.

Step 3: Identification of BCTs and behaviour change determinants

We selected BCTs based on their relevance and feasibility within the butcher shop intervention context and mapped with behaviour change determinants or constructs of theoretical frameworks or classical theories. We used the acceptability, practicability, effectiveness, affordability, side-effects and equity criteria (APEASE criteria) to select the BCTs (Supplementary Table S1). We assigned low (L), medium (M), high (H), unsure (U) and not applicable (NA) to each criterion to rate the BCTs as per the methods set by West *et al* [47]. We excluded BCTs if they rated low, or unsure for acceptability, practicability, effectiveness and affordability or rated medium, high, or unsure for side effects (unintended outcomes) or equity (increase or decrease differences among shops than usual) (Supplementary Table S2).

BCTs or behavioural constructs were selected from BCT taxonomy [15], theory of andragogy [33], cognitive load theory [34] and spaced effect [35,36]. Additionally, we considered constructs linked to methodological processes/ecosystem of our food safety intervention to be treated as BCTs. The BCT taxonomy has 93 BCTs clustered into 16 groups [15] which can be used in BCIs across disciplines. Andragogy theorises that adult learning should be relevant, context-specific, problem-oriented, participatory, and respectful of learners to optimize learning motivation [33,48,49], while the cognitive load theory posits that learning is constrained by the limited capacity of auditory/verbal and visual/pictorial processing channels, and that effective instruction should minimize extraneous cognitive load while optimizing essential processing in working memory [34,50,51].

We mapped the selected BCTs onto the behaviour change determinants of COM-B model of the BCW. We further mapped onto the behaviour change determinants of the TDF as recommended by Cane *et al* [10]. The TDF [10] contains 14 domains and 84 behaviour change constructs derived from 33 theories and 128 theoretical constructs related to behaviour change interventions.

Step 4: Implementation of intervention (mode of delivery)

We described the implementation of our food safety intervention using the TIDieR checklist and guide (Supplementary TIDieR checklist S3). The guide recommends to provide detailed description of BCIs regarding their title, rationale, methods, procedures, deliverers, mode of delivery, location of delivery, time and intensity, tailoring, modifications and participants adherence [28].

Step 5: Developing logic model of the intervention

We developed the intervention logic model of our food safety intervention using Implementation Research Logic Model (IRLM). The model enables describing BCIs by showing relationships among their intervention determinants, intervention strategies, intervention mechanisms of action and intervention outcomes [29].

Results

Identifying BCTs (constructs)

Overall, we identified 30 BCTs to be incorporated into our RCT food safety intervention: 20 from BCT taxonomy while ‘optimizing motivation to learn’ linked to theory of andragogy, ‘optimizing cognitive efficiency’ linked to cognitive load theory, ‘multiple sessions’ linked to spaced effect principles and the rest seven BCTs derived from our food safety intervention methodological processes. The BCTs were mapped onto psychological capability, physical opportunity, social opportunity, reflective motivation and automatic motivation of COM-B model and onto knowledge, skills, professional role and identity, beliefs about capabilities, beliefs about consequences, reinforcement, environmental context and resources, intentions and social influences of TDF domains (Table 2).

Table 2
BCTs/constructs applied in the current RCT food safety intervention and their mapping onto our RCT intervention packages, TDF intervention functions, COM domains.

No.	TDF domains	COM-B components	Intervention functions (from TDF)	Our RCT Intervention packages	Behavioural change techniques (constructs)	BCT family/groupings	Related theory / references	Description
Psychological capability								
1	Knowledge	Psychological capability	Education	Education	Optimizing motivation to learn	---	Andragogy [33]	Use techniques that motivate learning
2	Knowledge	Psychological capability	Education	Education	Optimizing cognitive efficiency	---	Cognitive Load Theory [34,50]	Reduce cognitive overload
3	Knowledge	Psychological capability	Education	Education	Multiple training sessions	---	[35,36]	Deliver training in multiple sessions
4	Skills	Psychological capability	Training	Training	Instruction on how to perform behaviour	Shaping knowledge	BCTv1 [15]	Provide practical guidance
5	Skills	Psychological capability	Training	Training	Demonstration of the behaviour	Comparison of behaviour	BCTv1 [15]	Demonstrate target behaviours
6	Skills	Psychological capability	Training	Training	Behavioural practice	Repetition and substitution	BCTv1 [15]	Prompt practice of the behaviour
7	Skills	Psychological capability	Education, persuasion	Education	Generalisation of target behaviour	Repetition/substitution	BCTv1 [15]	Apply learned skills in new contexts
Social opportunity								
8	Social Influences	Social opportunity	Education	Education	Information about others' approval	Comparison of behaviour	BCTv1[15], TPB[52]	State others' expectations
9	Social Influences	Social opportunity	Enablement	Enabling food safety ecosystem	Creating enabling food safety ecosystem	---	ME	Engage multiple stakeholders
Physical opportunity								

Note: TPB: theory of planned behaviour; BCTv1: Behaviour Change Technique Taxonomy (v1) of 93 hierarchically clustered techniques; ME: indicates that th our intervention methodological ecosystem; ---: represents that the BCT does not belong to BCTv1 grouping; *: represents that the BCT is mapped to both sk capabilities of TDF domains

No.	TDF domains	COM-B components	Intervention functions (from TDF)	Our RCT Intervention packages	Behavioural change techniques (constructs)	BCT family/groupings	Related theory / references	Description
10	Environmental Context and Resources, beliefs about capabilities	Physical opportunity	Enablement, Incentivisation	Material provision	Adding objects to the environment	Antecedents	BCTv1 [15]	Supply enabling tools
11	Environmental Context and Resources	Physical opportunity	Enablement	Education, training, nudges, material provision, inspection	Robust study design	---	ME	Strong study design/evaluation methods
12	Environmental Context and Resources	Physical opportunity	Enablement	Education, training	Restructuring the physical environment	Antecedents	BCTv1 [15]	Modify context to support behaviour
13	Environmental Context and Resources	Physical opportunity	Enablement	Nudges	Prompts/cues	Associations	BCTv1 [15]	Reminders in conte
14	Environmental Context and Resources	Physical opportunity	Enablement	Material provision	Use of novel technologies	---	ME	Apply innovative tools
Reflective motivation								
4*	Beliefs about capabilities	Reflective motivation	Training	Training	Instruction on how to perform behaviour	Shaping knowledge	BCTv1 [15]	Provide practical guidance
5*	Beliefs about capabilities	Reflective motivation	Training	Training	Demonstration of the behaviour	Comparison of behaviour	BCTv1 [15]	Demonstrate target behaviours

Note: TPB: theory of planned behaviour; BCTv1: Behaviour Change Technique Taxonomy (v1) of 93 hierarchically clustered techniques; ME: indicates that th our intervention methodological ecosystem; ---: represents that the BCT does not belong to BCTv1 grouping; *: represents that the BCT is mapped to both sk capabilities of TDF domains

No.	TDF domains	COM-B components	Intervention functions (from TDF)	Our RCT Intervention packages	Behavioural change techniques (constructs)	BCT family/groupings	Related theory / references	Description
6*	Beliefs about capabilities	Reflective motivation	Training	Training	Behavioural practice	Repetition and substitution	BCTv1 [15]	Prompt practice of the behaviour
15	Beliefs about Consequences	Reflective motivation	Education, persuasion	Education	Information about health consequences	Natural consequences	BCTv1 [15], TPB [52]	Explain health outcomes of behaviour
16	Beliefs about Consequences	Reflective motivation	Education, persuasion	Education	Information about social and environmental consequences	Natural consequences	BCTv1 [15], TPB[52]	Explain social/environment outcomes
17	Beliefs about Consequences	Reflective motivation	Education	Education	Pros and cons	Comparison of outcomes	BCTv1 [15], TPB [52]	Compare reasons for/against change
18	Beliefs about Consequences	Reflective motivation	Education	Education	Comparative imagining of future outcomes	Comparison of outcomes	BCTv1 [15]	Visualise improved vs. unchanged futu
19	Intentions	Reflective motivation	Education, Incentivisation, persuasion	Nudges, persuasion, education	Commitment	Goals/planning	BCTv1 [15]	Affirm intention to change
20	Beliefs about Consequences	Reflective motivation	Education	Education	Imaginary punishment	Covert learning	BCTv1 [15]	Imagine performing unwanted behaviou and its unpleasant consequences
21	Beliefs about Consequences	Reflective motivation	Education	Education	Imaginary reward		BCTv1 [15]	Imagine performing wanted behaviour and its pleasant consequences
22	Professional role and identity	Reflective motivation	Persuasion, education	Education	Credible source	Comparison of outcomes	BCTv1 [15]	Speech provided by professionals

Note: TPB: theory of planned behaviour; BCTv1: Behaviour Change Technique Taxonomy (v1) of 93 hierarchically clustered techniques; ME: indicates that th our intervention methodological ecosystem; ---: represents that the BCT does not belong to BCTv1 grouping; *: represents that the BCT is mapped to both sk capabilities of TDF domains

No.	TDF domains	COM-B components	Intervention functions (from TDF)	Our RCT Intervention packages	Behavioural change techniques (constructs)	BCT family/groupings	Related theory / references	Description
Automatic motivation								
23	Reinforcement	Automatic motivation	Incentivisation	Inspection	Feedback on behaviour	Feedback/monitoring	BCTv1 [15]	Inform on performance
24	Reinforcement	Automatic motivation	Incentivisation	Inspection	Feedback on outcome	Feedback/monitoring	BCTv1 [15]	Provide results of behaviour
25	Reinforcement	Automatic motivation	Incentivisation, education, training	Nudges, education, training	Habit formation	Repetition and substitution	BCTv1 [15]	Prompt behaviour repetition
26	Reinforcement	Automatic motivation	Incentivisation	Inspection	Incentives (outcome)	Reward/threat	BCTv1 [15]	Link rewards to performance
27	Reinforcement	Automatic motivation	Enablement	Education, training, nudges, material provision, inspection	Using multiple components	---	ME	Combine several intervention types
28	Reinforcement	Automatic motivation	Enablement	Education, training, nudges, material provision, inspection	Using multiple theories	---	ME	Ground intervention in multiple theories
29	Reinforcement	Automatic motivation	Enablement	Education, training, nudges, material provision, inspection	Aligning intervention components	---	ME	Ensure coherence o elements
30	Reinforcement	Automatic motivation	Incentivisation	Education, training, nudges, material provision, inspection	Use of follow-up prompts	---	ME	Maintain focus post training

Note: TPB: theory of planned behaviour; BCTv1: Behaviour Change Technique Taxonomy (v1) of 93 hierarchically clustered techniques; ME: indicates that th our intervention methodological ecosystem; ---: represents that the BCT does not belong to BCTv1 grouping; *: represents that the BCT is mapped to both sk capabilities of TDF domains

Implementation of the intervention

Training

The training material has four modules, each targeting specific learning objectives and arranged progressively from fundamental to relatively more difficult concepts. Training contents were tailored to address GHPs in butcher shops. Module one was an introduction to food safety training. Module two focused on food safety concepts, foodborne hazards and their control measures, impacts of unsafe food, how to keep food safe and benefits of maintaining workplace hygiene. Module three covered basic GHPs [2] that food businesses are expected to follow including hands hygiene, wearing appropriate and clean protective clothing, worker health, cleaning and disinfection of worksite surfaces and tools, use of safe water, safe meat storage, pest control, waste management and ensuring proper internal structures and facilities of butcher shops. Module four was on creating and maintaining a positive food safety culture in food businesses. The modules were prepared in English and translated into Amharic (the local language) and delivered in Amharic.

The training was delivered in multiple sessions (three sessions): First, butcher shop workers attended a four-hour training (in two sessions, with 20 minutes rest between the sessions) at a hotel near their workplaces (offsite training) conducted by ILRI research team. Data collectors invited the shops to the training during baseline data collection by delivering a letter of invitation stating the date of training and that the meat handler should attend. We organized eight training sessions to educate 202 meat handlers (required four days to complete the training aiming to train 50 workers per day, 25 workers by each trainer) who participated from intervention shops. This offsite training was provided by two research team members from ILRI who involved in the design of the overall project and the training materials. The training at the hotels was delivered as multimedia instruction (presenting words and pictures using PowerPoint presentation), practical demonstration (trainers showed the learners how to perform a skill or task through a step-by-step live demonstration followed by hands-on practice by learners) and active discussion. Participants received pre-and post-test during offsite training. Participants also received certificates that show successful completion of the training. Of the invited meat handlers to the offsite training from intervention shops (excluding control shops), 91% (183/202) of them attended the training: 94% (94/101) for TNM and 88% (89/101) for TNMI shops.

Next, one week later, they received on-the-job training at their shops (2-hour training at each shop) to reach meat handlers who did not attend the training at the hotels and reinforce knowledge for those who did, 95% (192/202) of the shops trained: 96% (97/101) for TNM and 94% (95/101) for TNMI shops. This was because shops often have two or more workers, but it would be difficult to send all workers to offsite training on the same day, so some missed the hotel training. The contents of on-the-job training were the same as offsite training but shortened to fit the limited time available to butcher shop workers, given the busy nature of their work. The training modules were summarized in a booklet [53] to be used by the trainers at this on-the-job training and this booklet was also provided to the butcher shops to refer to it while at their work. In addition, two months after the on-the-job training, refresher training (2-hour training at each shop) was conducted by on-the-job training at the butcher shops. Food business inspectors from AA-FDA who were trained on the training materials (by the two research team members who provided the offsite training) provided both on-the-job training and the refresher training. Eleven food inspectors (one from each sub-city of Addis Ababa) provided the training in their own sub-city (where they routinely work).

Environmental Nudges (nudge kit)

Food inspectors also posted the nudges at both TNM and TNMI shops during the on-the-job training. The nudge kit included posters, practical instructions for implementing food safety practices, and a booklet summarizing the training modules, all provided in the local language (Amharic). The posters were displayed in shops to act as guides and reminders and to promote hygienic behaviors.

- First poster “clean shop, clean butcher, happy customer” advised butcher shops to adhere to the ‘5 cleans’ (clean hands, clean clothes and cloths, clean water, clean surfaces, clean tools) and ‘3 S’ (separate, sanitize, safe storage) proper food safety behaviours to protect themselves and their customers from harmful bacteria that can cause foodborne illness (Fig. 1). This was posted where meat handlers can always see while at their work.
- Second poster “clean hands, happy customer” illustrated steps of proper handwashing (Fig. 1). This was posted at handwashing basin of the shops to remind meat handlers the proper handwashing steps.
- The third poster attempted to harness consumer demand for clean safe food. It gave tips to customers how to evaluate butcher shops hygiene status including: cleanliness of meat handler hands, work surfaces and tools, worksite clothes such as gowns and hairnets and inspection rating of shops (Fig. 2). This was posted at places where customers can easily see while purchasing meat from shops.
- The fourth poster was a commitment device, a type of nudge and also a moral incentive, which showed food safety behaviours that meat handlers pledged to adhere to by signing on the poster (Fig. 2).
- The fifth poster was an inspection scorecard which displayed shops inspection ratings (Fig. 3). Posted hygiene ratings, based on inspection are used in many high-income countries (HICs) to inform consumers and give incentives to business operators to improve hygiene [45]. These scorecards communicate shop hygiene level to the customers quickly and intuitively.

We also provided the butcher shops instruction (as a brochure) on how to conduct different food safety practices, for example, how to treat water with chlorine tablets and to decontaminate meat and disinfect work surfaces using slightly acidic electrolysed water (hypochlorous acid). Coloured-coded hygiene materials such as different coloured cleaning buckets and cloths also served as nudges to motivate differential cleaning.

Hygiene material provision (hygiene kit)

During on-the-job training, food inspectors also provided both TNM and TNMI shops the same list of hygiene materials (hygiene kits). These materials aimed to facilitate the targeted food safety behaviours of meat handlers, and the lists were aligned with contents of training modules (especially the GHPs). For example, we provided hand sanitisers, chlorine tablets, laundry soaps, etc (Supplementary Table S4). Some materials, such as chlorine tablets, dust bins, and cleaning buckets, were supplied in sufficient quantities to last throughout the intervention. However, the primary focus of the intervention was to motivate butcher shops to adopt, sustain, and self-supply hygiene materials beyond the intervention period.

Butcher shops food safety inspection with ‘scores on doors’

We used butcher shops inspection with disclosure of their inspection ratings (inspection with ‘scores on doors’) as one of the elements of our intervention package. The inspection was done using inspection checklist which was prepared based on AA-FDA butcher shops inspection checklist and existing literature on the general principles of food hygiene requirements in food businesses [2,54,55]. Items in inspection checklist also aligned with contents of training modules. The inspection checklist covered hands hygiene, wearing appropriate and clean protective clothing, worker health, cleaning and disinfection of worksite surfaces and tools, use of safe water,, safe meat storage, pest control, waste management and ensuring proper internal structures and facilities of butcher shops. This inspection checklist has 28 items (Supplementary inspection checklist S5), with each item having detailed weighted conditions to rate

hygiene compliance of the shops. Food inspectors, from Addis Ababa Food and Drug Authority, who trained on the inspection checklist inspected the butcher shops.

During on-the-job training, the TNMI butcher shops received self-inspection checklists to help them prepare, though the timing of the inspection was not disclosed. Two rounds of inspections were carried out: one week and two months after on-the-job training with each inspection lasting approximately one hour per shop. The checklist was digitized using the SurveyCTO App, which automatically calculated scores based on inspectors' selections of item conditions. Ratings were assigned as follows:

- No star (score < 50): warning of closure.
- One red star (50 ≤ score < 65): urgent hygiene improvement is required.
- Two yellow stars (65 ≤ score < 75): hygiene standards are good.
- Three green stars (≥ 75): hygiene standards are very good.

Butcher shops inspection scorecards (in Amharic) were posted at their shops where consumers can easily see.

Innovative technologies

We also used innovative technologies to enhance our intervention effectiveness. A key intervention was slightly acidic electrolysed water (hypochlorous acid) as meat decontaminant and disinfectant of work surfaces. Other innovations included nudges: for example, color-coded cleaning buckets with red for initial cleaning, pink for intermediate, and green for final cleaning to promote step-by-step cleaning based on the dirtiness of the work surfaces, which followed the widely recognised "traffic lights" sequence where red is danger and green is safe. We also trained meat handlers how to conduct deep cleaning. This is a periodic thorough cleaning process that goes beyond routine or surface-level cleaning as it involved removing dirt, grease, and residues from hard-to-reach areas in routine cleaning such as from ceilings, grooves, etc. Deep cleaning was not a concept or practice previously used in Ethiopia.

Logic model of the intervention

Our food safety intervention package including training, nudges, material provision and inspection with 'scores on doors' along with the overall intervention activities were designed to enhance meat handlers' food safety knowledge and beliefs which could enhance their adherence to proper food safety practices. These intervention strategies also expected to create enabling food safety ecosystem of butcher shops by influencing key stakeholders including butcher shop operators, regulators and consumers. We used strategies including iterative discussions and strong coordination among the research team, training of intervention deliverers, adequate logistic support and use of RCT design to enhance the quality of data generated from the research project. Furthermore, a pilot study was conducted to evaluate the relevance and acceptance of the intervention materials and approaches prior to the actual intervention, and to refine data collection instruments, butcher shops inspection scorecards, and the posters. This food safety intervention enabled us to develop effective and tested food safety intervention package which can be applied in similar contexts by other researchers (Fig. 4).

Discussion

The purposes of this work were to describe the development of a theory-informed multicomponent food safety intervention design in butcher shops and to describe its implementation (mode of delivery). To the best of our knowledge, this work is the first attempt to guide food safety intervention design at food retail establishments (specifically butcher shops) by behaviour change theories. We also believe that this is the first food safety intervention to identify and incorporate potentially effective behavioural change techniques (BCTs) into its intervention process. Moreover, this is the first time that food business inspection with 'scores on doors' has been used as component of an intervention package of a food safety intervention. We incorporated 30 BCTs into our intervention which were mapped onto psychological capability, social and physical opportunity and, reflective and automatic motivation of the COM-B model. Our findings suggest that a theory informed food safety intervention integrating effective BCTs can improve food safety outcomes. Preliminary analysis of our RCT shows significant improvements in food safety knowledge and practices among meat handlers as well as microbial safety in butcher shops [56].

Seven of the BCTs used in our intervention were mapped onto psychological capability of the COM-B model, reflecting their potential to impact knowledge and skills of meat handlers' food safety practices. Psychological capability is an individual's capacity to engage in the necessary thought processes, comprehension and reasoning to enact the target behaviour [9], linked to individual's knowledge and skills of the target behaviour [10]. The COM-B model posits that individuals capability influences their behaviour directly and indirectly by its mediating effect on their motivation [9].

We applied different BCTs into our intervention to enhance meat handlers' knowledge and skills. We used various strategies related to andragogy theory ('optimizing motivation to learn') to motivate meat handlers to learn [33,49,50]. First, training content was tailored to butcher shop contexts to help meat handlers address real workplace challenges. According to the theory of andragogy, adults are more motivated to learn when learning is context-specific and aligned with immediate workplace needs [33,49]. Second, we used theoretical instruction, plenary discussions, demonstration of the behaviour (hands-on practice), and scenario-based learning (scenario-based demonstration) to enhance engagement of meat handlers in the learning process. Andragogy also recommends that adult education programs should enhance engagement as this would help adult learners connect new information to prior experiences [33,49]. Third, we trained meat handlers at offsite (at hotels near their workplace) and onsite (at butcher shops). Andragogy further recommends providing adult training in settings which is not similar to the traditional school-like situations (such as conducting in commercial centres rather than in school settings) to promote respectful and relevant engagement of adult learners [33].

We also employed different approaches linked to cognitive load theory ('optimizing cognitive efficiency') [34] to enhance cognitive efficiency and long-term knowledge retention. Training content was divided into modules, each targeting specific learning objectives and arranged progressively from basic to more

advanced concepts. The instructional material was presented in words (on-screen text) and pictures (photos, graphics) to benefit from the assumptions that humans possess separate systems for processing words and pictures. We also avoided using non-essential features (extraneous materials) such as background sounds and animations in the instructional material to reduce cognitive overload [50]. Moreover, we optimized the learning environment by ensuring appropriate lighting, audiovisual systems and minimizing distractions [51]. Such strategies reduce extraneous information, optimize processing of essential information and facilitate transfer of newly acquired knowledge to long-term memory through enhanced germane cognitive load [50,51]. Furthermore, training was delivered in multiple sessions to enhance knowledge acquisition and retention. Learning is more effective when training sessions are spaced over time (delivered in multiple sessions) rather than delivered in a single session [35,36]. However, while the training was provided at multiple sessions in our training, all topics were covered in each session rather than being distributed sequentially. This format may not fully leverage the benefits of spaced learning, which promotes better retention and mastery through progressive reinforcement.

Seven BCTs used in our intervention were mapped onto opportunity component of the COM-B model, showing influence of our intervention in creating enabling food safety ecosystem at the butcher shops. The opportunity components of the COM-B model represent environmental factors which involves all factors that lie outside the individual that make the behaviour possible or prompt it and is classified as physical and social opportunity [9]. Physical opportunity involves time and parts of the environmental system (such as financial, material resources) that do not involve people or organisations, whereas social opportunity involves people and organisation (such as culture, social norms, organisational factors, consumer influences, regulatory systems) [8]. Although our study participants (target groups) were meat handlers, we also attempted to influence other key actors of food safety at butcher shops including butcher shops, consumers, and food regulatory authorities. Studies also indicated that factors associated with food business such as lack of material supplies [3,4,6,7] and lack of managerial support [3,4,6] as well as food businesses effort to meet consumers expectation [3,7] and regulatory requirements [5,7] impacted food safety practices of food handlers.

Food businesses management awareness to food safety is an important factor to implement effective food safety intervention in food industries [2]. We conducted various activities to enhance food safety culture of butcher shops. First, we provided hygiene materials (adding objects to the environment) and on-the-job training to enhance food safety awareness at shop level, including shop managers. Second, shops were inspected and publicly displayed their ratings to enhance reputational or consumers pressure on shops incentivising to maintain or improve hygiene standards. Third, we posted nudges at the shops to reinforce food safety behaviors. Fourth, we provided colour-coded hygiene materials such as coloured wiping towels (grey, yellow, blue) to the shops to nudge sequential (step-by-step) cleaning of work surfaces depending on the status of dirtiness. Multi-colour tools also enable preventing cross-contamination during food preparation [57].Words, images, or events can influence our emotions and feelings, ultimately having a significant impact on our behaviour [41] and use of such environmental cues (nudges) are proven to be effective in improving food safety behaviours such as handwashing [11,40,58]; handling food contact surfaces [11], preventing cross-contamination [40] and thermometer usage [11]. Furthermore, butchers participated in sensory evaluations of meat treated with slightly acidic electrolysed water (hypochlorous acid), comparing it with untreated meat and meat treated with citric acid. This intervention could potentially enhance food safety culture of shops including of meat handlers (workers) and managers as the purpose of the project was explained to the butchers to improve their understanding of using food sanitisers on raw meat.

A range of interventions were implemented to influence food safety awareness of consumers. Posters (nudges) and inspection scorecards were displayed in butcher shops to raise consumer awareness about food safety. Research indicates that consumers often make informed purchase decisions using food inspection ratings which can motivate food retail establishments to adhere to hygiene standards as consumers avoid poor rated premises [44]. During our intervention, consumers also participated in sensory evaluations comparing meat treated with slightly acidic electrolysed water (hypochlorous acid) to control samples and those treated with citric acid (unpublished). We believe that their participation in this evaluation could further enhance their understanding about food safety as the purpose of the sensory evaluation was clearly explained to them, using hypochlorous acid as decontaminant on raw meat to combat foodborne illness. Regarding regulators, we engaged local food regulators by training food inspectors in food safety and collaborating with them throughout the intervention. Regulators education and training, and collaboration with stakeholders are key factors that impacted effectiveness of national food control systems [59,60].

We also used innovative technologies such as slightly acidic electrolysed water (hypochlorous acid) as meat decontaminant and work surface disinfectant in our intervention to enhance intervention effectiveness. Innovation is any idea, practice, or object that is perceived as new [61]. Microbial contamination of meat and work surfaces is common in Ethiopian slaughterhouses and butcher shops [62,63], with higher contamination documented in butcher shops [62]. Previous food safety interventions failed to improve microbial quality if contaminated food is received by retail food establishments [64]. If food is highly contaminated when it arrives at food retail establishments no amount of good practice or hygienic technologies can make it safe. Either interventions are needed downstream (which have proved difficult and expensive) or a decontamination step must be added. In HICs (especially EU and less so USA) there is a widespread disapproval of tolerating heavily contaminated food in the value chain and remediating with chemicals. In LMICs this may be the only feasible option but requires a paradigm shift by authorities who are strongly influenced by HICs norms. During our intervention, we trained shops to use slightly acidic electrolysed water (hypochlorous acid) as meat decontaminant and work surface disinfectant. Hypochlorous acid has been known for its wide safety margin, approved by several regulators across the world [65] including EFDA for use as food sanitizers and worksurfaces disinfectant.

Furthermore, some of our BCTs were mapped onto motivation component of the COM-B model, representing the effect of our intervention in incentivising meat handlers towards food safety. Motivation is a mental process that energises and directs a behaviour [8] and is classified as reflective motivation which involves judgements, intentions or plans and automatic motivation which involves habitual, instinctive, drive-related and affective processes [9,66]. Several studies have identified lack of food handlers' motivation as the most common barriers to engage in food safety bahaviours [3,6,7], reflecting the importance of incorporating potentially effective BCTs in enhancing motivation into intervention design. Some of the BCTs under motivation (Table 2) in our intervention were mapped onto beliefs about consequences domains of TDF [10]. Meat handlers were trained on health, social, and environmental consequences of food

safety issues such as importance of food safety training, maintaining hygiene standards, and the dangers of foodborne illness to improve their attitudes toward food safety (beliefs about consequences). Individuals are more likely to engage in a behaviour when they recognize its value and the probability of potential consequences linked to the behaviour [52,67]. Besides, three BCTs were mapped onto beliefs about capabilities. These would important in influencing meat handlers behaviours because individuals are more likely to perform a behaviour when they believe they possess the necessary skills, resources, and opportunities required to perform the behaviour [52]. The rest of the BCTs under motivation in our intervention were mapped onto reinforcement domains of TDF [10]. We reinforced meat handlers learning through various ways such as providing feedback on their hygiene performance strengths and weaknesses, providing hygiene rating based on their hygiene level and repeated exposure to the contents of the intervention such as aligning contents across intervention packages. Studies show reinforcement systems such as rewards and feedback can motivate organizational workers to engage in the desired behaviours [4,68,69]. For example, Pragle *et al* [4] identified rewards as motivators to food safety practices for food handlers.

Reflection on the theories

The BCW [9] provides a set of intervention options that can be used in BCIs but these options lack operational detail. For example, incentivisation could include financial, material, social incentives and so on but the framework does not explicitly specify these options. Additionally, the BCW offers the policy categories (legislation, regulation, guideline, fiscal, environmental/social planning, service provision) which aim to create enabling environment for the intervention options to occur. These policy factors list seem inadequate as food safety interventions effectiveness should consider additional other factors related to policy (regulatory environment) such as inputs and resources (policy and legal frameworks, infrastructure, finance, human resources), monitoring and response functions, regulators interaction with stakeholders, and access of regulators to scientific evidence [60]. This suggests the need to develop theoretical frameworks specific to food safety interventions.

The COM-B model of the BCW also specifies six food safety behavioural determinants (physical and psychological capabilities, physical and social opportunities and, reflective and automatic motivation) but these determinants may not be detailed enough to specifically influence in BCIs. However, mapping these determinants with TDF domains and constructs [10] enables identifying more detailed behaviour determinants. For example, reflective motivation of COM-B is mapped to social/professional role & identity, beliefs about capabilities, optimism, beliefs about consequences, intentions and goals. Further mapping of these determinants with BCTs allows linking the determinants with the smallest active elements of the intervention. These mapping processes among theoretical frameworks show benefits of applying multiple theoretical frameworks in BCIs designing in identifying more detailed behaviour determinants and linking to BCTs (the smallest element of BCIs), improving our understanding of mechanisms of actions of BCIs. However, this mapping process is not straightforward and requires iterative discussion and consensus among research team, as determinants from theoretical frameworks may not be mapped automatically. Previous studies [19] also indicated that mapping of behaviour determinants between theoretical frameworks requires iterative discussion among research teams and that BCW intervention options lack sufficient operational detail. These findings suggest the need to develop guidelines to support systematic mapping of behaviour determinants across theoretical frameworks and to develop detailed intervention options for BCIs. Past BCIs designers also used TDF, COM-B and BCT taxonomy to design their BCIs (Foy et al. 2007; French et al. 2012; Wang et al. 2025).

Effectiveness of food safety interventions also relies on the development of theory-informed instructional materials, appropriate modes of delivery, rigorous study designs (e.g., RCTs), and context-specific innovative approaches. However, major behaviour change theoretical frameworks (such as TDF, BCW, and COM-B model) lack constructs that inform these design and implementation elements of interventions. To overcome these limitations, we used constructs related to andragogy (Knowles 1980) and cognitive load theory (Sweller 1988) to design instructional materials such as contents of training modules and its PowerPoint for presentation while learning. Andragogy (Knowles 1980) supports developing context-specific and adult-oriented training content that enhances learner motivation while cognitive load theory (Sweller 1988; Mayer and Moreno 2016) informs designing instructional materials that optimise information processing (such as avoiding extraneous material. We further incorporated constructs related to our intervention design logic including use of multiple intervention components, aligning contents of intervention components, robust study design, innovative technologies and multiple theoretical frameworks to enhance effectiveness of our intervention. These suggest that behaviour change theoretical frameworks should also include constructs that guide other aspects of BCIs such as instructional material development, mode of delivery and innovative approaches to enhance effectiveness.

Although the TIDieR checklist allows detailed description of our intervention, it failed to support the description through linking the interaction among intervention determinants, intervention strategies and intervention mechanisms of action. We used IRLM to fill this gap.

Implications and future research directions

The development process of the current RCT food safety intervention design can serve as a practical model for developing food safety interventions in LMICs and similar settings. Regulators, policymakers, researchers and other food safety stakeholders can use the components of our intervention package and the BCTs to design food safety intervention. Designers of BCIs should consider using constructs from classical theories and methodological processes specific to their intervention as the theoretical frameworks (such as TDF, COM-B) may lack constructs that address some aspects of the intervention such as instructional material designing and mode of delivery. While the identified BCTs have broad applicability in food safety interventions, they may not be exhaustive as they were selected for our specific intervention. In addition, the designing process is not generic to food safety intervention. For example, we did not consider policy categories in our current work as it is specific to the intended food safety intervention in butcher shops rather than being a generic proposal for food safety. Consistent with our approach, Truelove and colleagues [32] did not incorporate policy categories into their design as it was intended to be implemented under a specific project but Wang and colleagues [19] incorporated policy categories in their intervention design as it was a generic proposal for the target behaviour intervention. Future research is needed to generate a more generic designing process (intervention proposal that could be applied by many stakeholders) for food safety intervention in food industries.

We also suggest identifying constructs for food safety interventions that specifically target consumers and regulators. Tailoring the current food safety intervention strategies to other food value chains (such as vegetable and dairy sectors) as well as in other settings, including regional (local cities as the current intervention was done in the capital city of Ethiopia, Addis Ababa) and peri-urban cities, would improve our understanding of its effectiveness under different food safety contexts.

Abbreviations

APEASE	Acceptability, Practicality, Effectiveness, Affordability, Side-effects, Equity
BCI	Behaviour change intervention
BCT	Behaviour change technique
BCW	Behaviour change wheel
CAC	Codex Alimentarius Commission
COM-B	Capability, Opportunity, Motivation behaviour
EFDA	Ethiopia Food and Drug Authority
FAO	Food and Agriculture Organizations of the United Nations
GHP	Good hygiene practices
HICs	High-income countries
IRLM	Implementation Research Logic Model
LMICs	Low-and middle-income countries
ME	Methodological Ecosystem
RCT	Randomized controlled trial
TDF	Theoretical domains framework
TDieR	Template for intervention description and replication
TNM	Training, nudges, material provision
TNMI	Training, nudges, material provision, inspection
TPB	Theory of planned behaviour
WHO	World Health Organization

Declarations

Ethics approval and consent to participate

This study was reviewed and approved by the International Livestock Research Institute (ILRI) Institutional Research Ethics Committee (ILRI-IREC2023-04) in accordance with ILRI institutional Research Ethics Committee (IREC) Operating guidelines [70]. The study was also reviewed and approved by Faculty of Engineering and Science Research Ethics Committee (FES-FREC -23.06.56) of the University of Greenwich, UK and City Government of Addis Ababa Health Bureau (ref: A/A/H/9/08/227). Only study subjects who provided informed consent participated in the intervention.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Clinical trial number

This study is registered on 04 September 2023 with AsPredicted.org (https://aspredicted.org/T5G_CRT), number 142627.

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Author contributions

GD: conceptualization, methodology, investigation, resources, validation, formal analysis, visualization, project administration, writing - original draft, writing-reviewing and editing. **SD:** investigation, supervision, project administration, writing- reviewing and editing. **DM:** investigation, supervision, project administration, writing- reviewing and editing; **KA:** conceptualization, methodology, validation, investigation, supervision, project administration, writing-reviewing and editing. **HN:** conceptualization, methodology, validation, supervision, project administration, funding acquisition, writing- reviewing and editing**.** **DG:** conceptualization, methodology, validation, investigation, resources, supervision, project administration, funding acquisition, writing- reviewing and editing.

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Availability of data and materials

The datasets generated during the current study are available from the corresponding author on reasonable request.

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Figures





Figure 1

Posters with '5 Cleans' and '3 Safes' food safety behaviour rules (left) and handwashing steps (right).





Figure 2

Posters that advise consumers regarding assessing butcher shops hygiene status (left) and pledge form meat handlers signed after training (right).

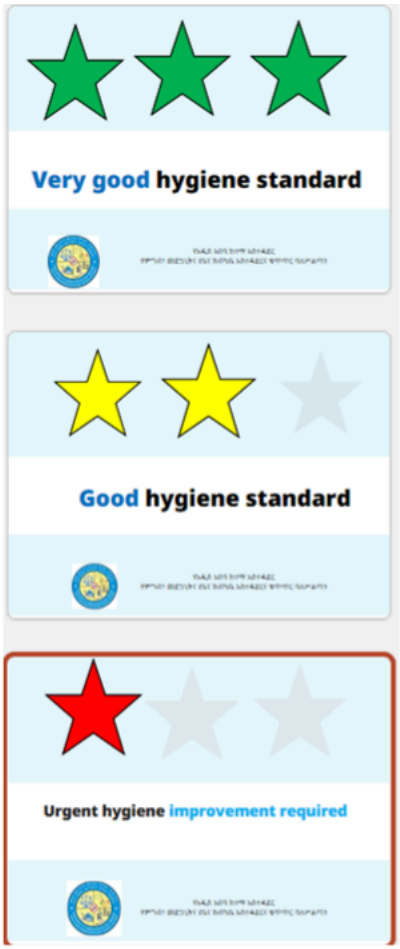


Figure 3

Butcher shops inspection scorecard

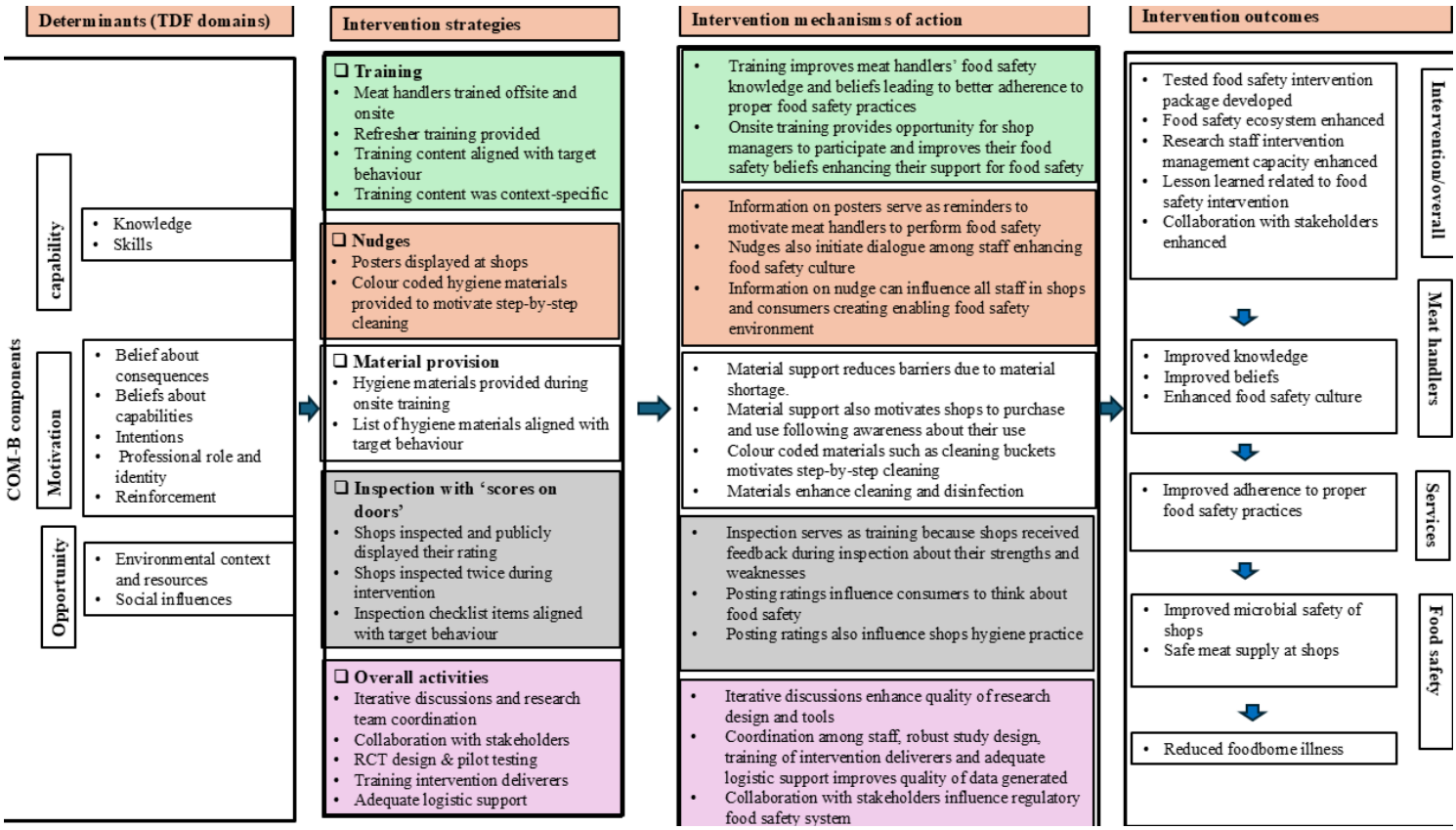


Figure 4

Implementation research logic model of the RCT food safety intervention

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AdditionalInformation.docx
- SupplementaryTableS1.docx
- SupplementaryTableS2.xlsx
- SupplementaryTIDieRchecklistS3.docx
- SupplementaryTableS4.docx
- SupplementaryinspectionchecklistS5.docx