



## Evidence-based health interventions for the educational sector: Application and lessons learned from developing European food hygiene and safety teaching resources

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### ABSTRACT

**Background:** Foodborne illnesses have a significant global burden and can be life-threatening, but good food hygiene practice can prevent most. SafeConsume is an EU-funded, transdisciplinary project aiming to improve consumers' food safety behaviour and reduce the burden of foodborne illness. Young people are at risk of foodborne illness and research indicates a lack of knowledge or concern about food hygiene. Educational settings provide an opportunity to influence behaviour; but for resources to be effective and implementable, they should be evidence-based and thoughtfully designed.

**Aim:** To develop educational resources to teach food hygiene and food safety to school children aged 11–18 years old, through a user-based approach, specific to the educational setting.

**Methods:** Development used a two-step process referred to as: the insight phase; and prototyping and refinement phase. This included using the findings of a needs assessment with students and educators based on the Theoretical Domains Framework (TDF) presented in earlier publications (Eley et al., 2021; Syeda et al., 2021). A user-centred approach to development was then taken, employing an iterative process of idea generation, consultation with a multidisciplinary steering group, and user testing.

**Results:** The insight phase identified students' and educators' deficiencies in knowledge and skills, and cultural and social influences on food safety behaviours. This phase, including Curriculum analysis informed student learning objectives and educator training topics. Following a round of development and consultation, a total of seven teaching resources were developed, with four educator training modules to improve knowledge and confidence of educators.

**Conclusions:** Behavioural theory is a useful foundation for the development of school-based health interventions, which aim to positively influence students' knowledge, behaviour, and attitudes. To support educators' uptake, materials should be aligned to the national curriculum and should consider practical factors like time and

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environmental factors. By working closely with stakeholders at all stages of development, barriers to use, implementation and efficacy can be identified and mitigated.

### Abbreviations

|       |                               |
|-------|-------------------------------|
| TDF   | Theoretical Domains Framework |
| UKHSA | UK Health Security Agency     |
| EU    | European Union                |

## 1. Introduction

Schools are an important setting for health education and can influence young people's behaviour into adulthood (Batista et al., 2021). Regardless of design, many school-based health interventions fail to have the desired impact (Day et al., 2019; Wolfenden et al., 2017). These failures may be explained by a perceived disconnect between programme design and implementation. The application of a user-centred approach has become popular in the development of health-based interventions (Nsangi et al., 2020). A user-centred approach involves multiple iterative cycles of data collection, seeking users' views and experience, with a view of designing, adapting, and optimising an intervention (Yardley et al., 2015). describe this process for developing digital health education interventions. By employing a user-centred approach during intervention design, researchers can maximise end-user engagement with an intervention and improve sustainable implementation, an approach that is encouraged in the field of implementation science (Damschroder et al., 2009).

### 1.1. User-centred design of school resources

In recent decades the landscape of design practice in many sectors has transformed from a largely top-down model to one which seeks to investigate the needs, understand the challenges, and support participation of product and service users (Antonini, 2021; Moser & Korstjens, 2022; Smith, Williams, & Bone, 2022). The core principles of user-centred design includes seeking to understand users' goals, needs and context early in the design process, includes active user involvement throughout design and evaluation, and evaluation of work in the context of the users' environment (Gulliksen et al., 2003; Moser & Korstjens, 2022; Nielsen, 1993). User-centred design often uses surveys, focus groups, workshops and interviews to learn about user needs (Carroll, 1996) and will seek direct involvement of a range of stakeholders through an iterative process (Moser & Korstjens, 2022).

Literature describing a user-centred approach to the development of school-based educational resources is limited, however examples that do exist are unified in desire to develop materials that aim to overcome an implementation barrier. A user-centred approach can provide a solution for developing resources that are culturally sensitive, relevant and age appropriate while making use of research in the field from other contexts (Brooks et al., 2019, 2021; Crosby et al., 2020; Nsangi et al., 2020). The available literature does not contain reference to any standardised framework; one systematic review of participatory research with children and adolescents identified an imbalance of participation towards the earlier stages in which information gathering is the focus, opposed to during later stages of development (Freire et al., 2022).

Brooks et al. (2019) describe the methodology for development of a culturally appropriate toolkit promoting mental health literacy in Indonesia. The research proposes four phases:

- phase 1: review and critical analysis of existing interventions

- phase 2: explore stakeholders views and identify priorities
- phase 3: iterative focus groups with stakeholders to co-produce toolkit
- phase 4: conduct feasibility evaluation within the context

Preliminary results from the early phases indicate a preference for user-based design amongst participants and uniformity amongst desires for design, format and delivery of the toolkit (Brooks et al., 2021).

Nsangi et al. (2020) describe the protocol for developing the 'informed health choices' resource as an iterative process, progressing from idea generation, prototyping, pilot testing and user testing and analysis and revision, describing steps in a continuous cycle until finalised versions could be agreed upon. A randomised control trial with 120 schools identified large improvements associated with the resource (Nsangi et al., 2017).

Both frameworks link with the key principals of user-based design, however, do not include behavioural or cognitive theories. The UK's Medical Research Council recommends that health-related behaviour change interventions start with a robust evidence base (Skivington et al., 2021). Behaviour, including food handling behaviour, is known to be affected by a range of determinants, such as knowledge, attitude, beliefs, and context (Cunha et al., 2013; Faccio et al., 2013). Therefore, for an intervention to successfully foster a change in behaviour, a strong foundation in behavioural theory is required (Glanz & Bishop, 2010). The Theoretical Domains Framework (TDF) is the combination of 33 models of behaviour and consists of 14 behavioural domains that can be used to help structure research methods (Cane et al., 2012); in this way the TDF can be an effective theoretical basis for the development of educational resources.

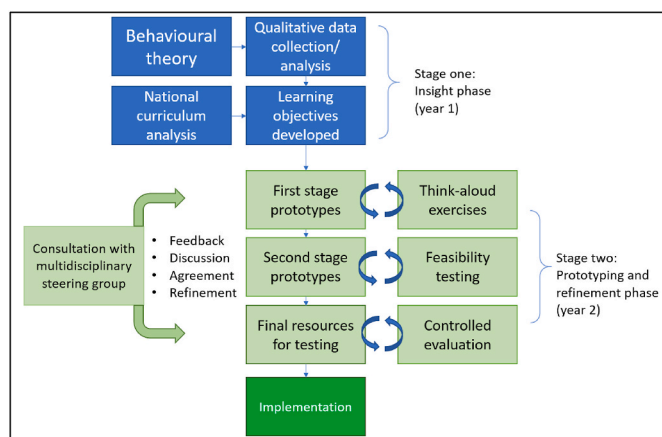
SafeConsume ([www.safeconsume.eu](http://www.safeconsume.eu)) is an EU Horizon 2020-funded transdisciplinary research project that includes eight work packages which drive research and development in consumer directed food-safety interventions. This includes development of educational resources for schools, led by the UK Health Security Agency (UKHSA) based research team behind 'e-Bug' ([www.e-bug.eu](http://www.e-bug.eu)), a health and hygiene education resource, that has been developed and maintained for over 10 years.

This paper outlines the process of resource development to develop educational resources to teach food hygiene and food safety to children aged 11–18 years old, through a user-based approach specific to the educational setting.

## 2. Materials and methods

### 2.1. Framework development protocol

This development was coordinated by a multi-centred European research team (including researchers based in health and academic institutions in England, France, Hungary, Portugal, Greece and Denmark), from herein referred to as the multi-centre team (MCT). The MCT brought together professionals with experience in educational resource design, social and behavioural science, food microbiology, educational sector and public health. Researchers collaborated over two years with the aim of developing food hygiene and safety educational resources, for children aged 11–18 years that could be adapted for use in other countries. The fulfilment of this consisted of two distinct outputs: 1) food hygiene teaching resources for educational settings, and 2) educator training modules. This multi-method framework was used to inform and co-produce the content, structure, and resources in broadly two phases: 1) Insight phase; 2) Prototype and refinement phase (Fig. 1).



**Fig. 1.** Framework for a user-centred approach to school-based intervention development.

## 2.2. Stage one: insight phase

### 2.2.1. Needs assessment

The MCT researchers based in England, France, Hungary and Portugal conducted two needs assessments underpinned by the TDF. The first explored school educators' attitudes, behaviours and knowledge towards food hygiene, safety and education and needs for training and resources (Eley et al., 2021); the second explored young people's needs in relation to learning about and implementing food hygiene and food safety behaviours (Syeda et al., 2021).

### 2.2.2. Curriculum analysis

The MCT conducted analyses of the National Curriculum implemented in their countries. Data relating to the teaching of food hygiene and safety were collected from government websites, Ministries of Education, educators and other education professionals (Syeda et al., 2021).

## 2.3. Stage two: prototype and refinement phase

### 2.3.1. Consultation between multi-centre team

Monthly teleconferences and several face-to-face meetings between the MCT took place to facilitate the iterative cycles of consultation and collaboration required. Resources were shared with the MCT at each stage of development, reviewed independently; feedback was detailed in meeting minutes and recorded in a secure database.

### 2.3.2. Consultation between wider SafeConsume research work packages

Work package leads of the wider SafeConsume research and development project met in person six monthly to discuss project progress, results and future workplans. Evidence and expert input given from the other SafeConsume work packages covering a) public's food hygiene behaviour in the home setting and b) the microbiological evidence on preventing foodborne illness, was particularly important to inform the school food hygiene resource development. Members of other SafeConsume work packages had input into the learning objectives and reviewed the materials at two face-to-face workshops with the UKHSA team and by email.

Final approval of learning objectives and completed resources was given by the MCT and the SafeConsume steering board.

### 2.3.3. Learning objectives and early resource ideas

The MCT agreed key findings from the needs assessment for improving students' and educators' knowledge, motivation and behaviours. These findings were used, together with the national curriculum analysis (for students) and TDF, to develop a set of learning objectives

that the educational resources and educator training would cover. Initial discussions led to a set of early resource ideas, which were informed by educator and students' preferences for educational resources and training, and a literature review of existing resources.

### 2.3.4. Resource piloting

To gain the necessary insight, resource ideas were tested with students and educators in England and discussed within the UKHSA team and the MCT at each stage. Early prototypes and activity ideas were shared with two English schools: a total of 15 students and two educators. 'Think-aloud' exercises were used to gather immediate thoughts, potential barriers, best practice and identify activities that met initial standards and could be developed further. These early tested prototypes were discussed at a wider SafeConsume workshop for scientific rigor, and usability in other countries. Using this information, prototypes were either discontinued or developed into second stage prototypes.

To ensure feasibility and appropriateness, second-stage prototype resources were piloted at three English schools, with four classes of students aged 13–14 years. Researchers observed the educators' delivery of lesson plans and recorded field notes on how the lesson content was adapted, its timing, delivery style, clarity of learning objectives, use of resources and engagement of students (Supplement. 4). Questionnaires (Supplement. 5–6) were used to assess educators and students' experience: Likert scale questions assessed student perceptions and general enjoyment; open-ended or tick box questions assessed key information learnt, suitability for the teaching age, and requested student feedback.

## 3. Results

### 3.1. Learning objectives

#### 3.1.1. Food hygiene resources

Fourteen prototype food hygiene resources were developed to address the agreed learning objectives (Table 1). Implementation factors relevant to the countries involved were considered, resulting in a set of classroom-based resources. To allow further flexibility within resources and encourage use in varied contexts, the resources were developed to contain several 'core' lessons in which the main learning objectives were met, with additional or supplementary resources.

#### 3.1.2. Educator training resources

Educator learning outcomes were based on those developed for students to ensure they provided the knowledge and confidence to educate students on these topics. To meet these needs, five training sessions were proposed (Table 1).

### 3.2. Multi-disciplinary consultation

Discussions between the MCT and at SafeConsume workshops were considered essential for resource development, as they led to agreement about the learning objectives which were critical to develop the resources. These meetings allowed discussions about other factors within the TDF that would need to be addressed as hygiene resources were developed. Comments, modifications, and cultural adaptations were sought for each proposed activity, which helped guide development. For example, due to the highly variable differences in food storing practices across partner countries, development of a single lesson based on food storage was not thought to be useful and relevant to all, and instead food storage information was included within the central lesson, and subject to cultural adaptation. All resources were also reviewed by microbiologists for accuracy of information. During workshops, prototypes of the educator training resources were reviewed, and suggestions from stakeholders were considered in the final development of these resources (Supplementary material Appendix 1, Table 1).

**Table 1**  
Student needs assessment findings matched with proposed learning outcomes and teaching resources.

| Student Learning outcomes (Theoretical Domains Framework domains addressed)   | Proposed food hygiene resource(s)  | Proposed educator training resource   | Expected change in behaviour and outcome   |
|---|--|---|--|
| <p>To understand that there are both useful microbes in food and harmful microbes in food that can cause food poisoning, where they can be found, and risks and consequences of food poisoning.</p> <p>TDF domains:</p> <ul style="list-style-type: none"> <li>• Knowledge</li> <li>• Social influences</li> <li>• Social and professional role</li> <li>• Beliefs about consequences</li> <li>• Memory attention and decision processes</li> </ul> | <ul style="list-style-type: none"> <li>• Useful and harmful microbes activity</li> <li>• Outbreak investigation activity</li> <li>• Food Safety debate kit - Structured debate on a food hygiene topic.</li> <li>• Myth busting activity - interactive online slideshow with myths and misconceptions around food safety. (later changed to Food Safety Facts)</li> <li>• The User Journey – risks and solutions are identified from shop to plate.</li> </ul>   | <ul style="list-style-type: none"> <li>• Session 1: Teaching food hygiene: an introduction</li> <li>• Session 2: Microbiological aspects</li> </ul>           | <ul style="list-style-type: none"> <li>• Understanding of the prevalence and impact of foodborne microbes and illness to provide a perception of risk.</li> <li>• Understanding of sources of foodborne microbes in order to provide a perception of risk associated with certain foods.</li> </ul>                |
| <p>To understand food labels and packaging - specifically, to understand differences between use by and best before dates</p> <p>TDF domains:</p> <ul style="list-style-type: none"> <li>• Skills</li> </ul>  | <ul style="list-style-type: none"> <li>• Food labelling and packaging activity - students match up food labels to their correct explanation.</li> </ul>  | <ul style="list-style-type: none"> <li>• Session 3: Food labels</li> </ul>  | <ul style="list-style-type: none"> <li>• Shopping and planning meals with consideration for use by dates.</li> <li>• Consuming food before use by dates.</li> <li>• Organising fridge with reference to use by dates, placing longer lasting food nearer the back.</li> </ul>                                      |
| <p>To understand the chain of infection and critical points for food hygiene.</p> <p>TDF domains:</p> <ul style="list-style-type: none"> <li>• Beliefs about consequences</li> </ul>  | <ul style="list-style-type: none"> <li>• Chain of infection activity: this activity seeks to make students aware of the chain of infection and key hygiene steps.</li> <li>• The User Journey.</li> </ul>  | <ul style="list-style-type: none"> <li>• Session 4: Infection transmission</li> </ul>   | <ul style="list-style-type: none"> <li>• To avoid preparing food for others while ill, with additional care for vulnerable groups.</li> <li>• Practise appropriate hand hygiene.</li> <li>• Consideration for food hygiene at all points in the process of buying, preparing, cooking and storing food.</li> </ul> |
| <p>To develop the skills to identify reliable information sites on how to cook safely and practise food hygiene.</p> <p>TDF domains:</p> <ul style="list-style-type: none"> <li>• Skills</li> </ul>   | <ul style="list-style-type: none"> <li>• Outbreak investigation activity</li> <li>• Reinforcement activity - students research, design and develop a poster, fridge magnet, coaster.</li> </ul>  | <ul style="list-style-type: none"> <li>• Useful links added in the different sessions</li> </ul>  | <ul style="list-style-type: none"> <li>• Skills to seek out reputable sources of information to support better food hygiene behaviours.</li> </ul>   |
| <p>To understand cross-contamination, how it occurs, and develop and normalise skills for good hand and food hygiene and preparation in everyday life to remain in good health.</p> <p>TDF domains:</p> <ul style="list-style-type: none"> <li>• Knowledge</li> <li>• Skills</li> <li>• Goals</li> <li>• Reinforcement</li> <li>• Environmental context and resources</li> </ul>  | <ul style="list-style-type: none"> <li>• Preparing and cooking small meals - adapted for both a cooking and non-cooking environment.</li> <li>• Foodborne microbes card game</li> <li>• Foodo game – Cluedo-style game in which students must guess the place, food item, microbe and food hygiene behaviour which led to a food poisoning occurrence.</li> <li>• Foodopoly game – Monopoly-style game in which beneficial and harmful food microbes are explored</li> <li>• Reinforcement activity – as above</li> <li>• Myth busting activity – as above</li> <li>• The User Journey – as above</li> </ul> | <ul style="list-style-type: none"> <li>• Session 4: Infection transmission</li> </ul>   | <ul style="list-style-type: none"> <li>• To avoid cross contamination by adopting the following behaviours: hand hygiene, surface hygiene, tool hygiene, washing fruits and vegetables, not washing raw meat etc.</li> </ul>   |
| <p>To understand healthy eating and identify the different aspects of food nutrition, ecology, microbiology and allergy</p> <p>TDF domains:</p> <ul style="list-style-type: none"> <li>• Beliefs about consequences</li> <li>• Belief about capabilities</li> </ul>   | <ul style="list-style-type: none"> <li>• Pledge: “I am a Safe Consumer” - students select a food hygiene behaviour they will pledge to uphold.</li> <li>• Recipe e-book – electronic book containing recipes from European countries with additional food handling tips and microbial risks associated with each recipe.</li> </ul>  | <ul style="list-style-type: none"> <li>• Session 1: Introduction</li> <li>• Session 5: e-Bug/ SafeConsume resources and how to use and access them</li> </ul> | <ul style="list-style-type: none"> <li>• To relate aspects of nutrition, food ecology, microbiology and allergy to their own life and performed behaviours learned using the SafeConsume resources while active in the kitchen.</li> </ul>   |

### 3.3. Idea generation

During the classroom ‘think-aloud’ exercises, it was quickly identified that activities such as the hygiene-based board games, while liked by students, could be impractical for the classroom due to time constraints and sourcing equipment (Supplementary material Appendix 2, Table 2).

Feedback from focus groups were discussed by the MCT and used to define a list of hygiene resources to take forward for development. Further hygiene resources identified for development included the food safety animation, scenario-based activity, and food safety versus quality activity. These were intended to provide additional content on certain topics, support diverse learning styles, and target specific opportunities for behaviour change, allowing educators to tailor teaching to their group.

### 3.4. Second-stage piloting

#### 3.4.1. Food hygiene teaching resources

Student feedback questionnaires identified that they enjoyed aspects such as interactive quizzes, the use of videos, learning about food labels, and the visual appeal of the slide sets. Some students identified a lack of interaction and wanted less focus on writing in activities. During piloting of the proposed main lesson ‘The User Journey’, when asked about the suitability of the lesson for their level, 81% (18/22) of students believed the lesson to be ‘just right’, while 13% (3/22) suggested it may be ‘too easy’; none classed it to be too difficult.

Educators reported that the lessons were aimed at the appropriate level and filled a 50-min teaching slot. Suggested improvements included more detailed educator-facing background information.

#### 3.5. Educator training resources

The educator training resources were designed considering the main findings mentioned during the need assessment (Eley et al., 2021) and

considering the comments made during the partner workshop (Supplementary material Appendix 1, Table 1). There was no pilot phase for the educator training resources.

To improve relevance and support of information to all educators (in some countries food hygiene is taught by science educators and in others it is more practical teaching including cooking classes), the sessions were designed to be flexible. In this way, educators could guide their own learning and follow additional links to further information if they wished. Once the resources were developed, they were reviewed by the project microbiologists and by the MCT.

The main changes proposed were title changes, simplification (e.g. simpler presentation of statistics of the main pathogens through visual graphs) and myths redeveloped. Other work package researchers had suggested the need to avoid incorrect ‘myth’ statements as some less qualified educators may incorrectly remember these as true, and facts would be better for learning.

Resource 4 (practical session summarising all the key messages on food hygiene) was presented by researchers in France, during two interactive workshops about food safety at a university symposium,

made up of a diverse audience of health care professionals and educators. Participants appreciated the practical advice and gained perspective on the importance of educating about the risk of cross-contamination. Stakeholders, including the French Agency for Food, Environmental and Occupational Health & Safety (ANSES) and French Ministry of Agriculture and Food (DGAL) reviewed and added to the scientific accuracy of the food hygiene messages.

### 3.6. Finalising resources

#### 3.6.1. Food hygiene resources

When developing the final hygiene resources, barriers highlighted by educators, such as time allocated to the topic, access to equipment or printing, educator’s knowledge and confidence were considered. Educators prefer short lessons with minimal requirements for set-up and a clear link to the national curriculum. Teacher sheets on how to run the lesson and background information on the topic, summaries and additional resources were developed to make lessons more accessible to educators with varying abilities and confidence levels. To support

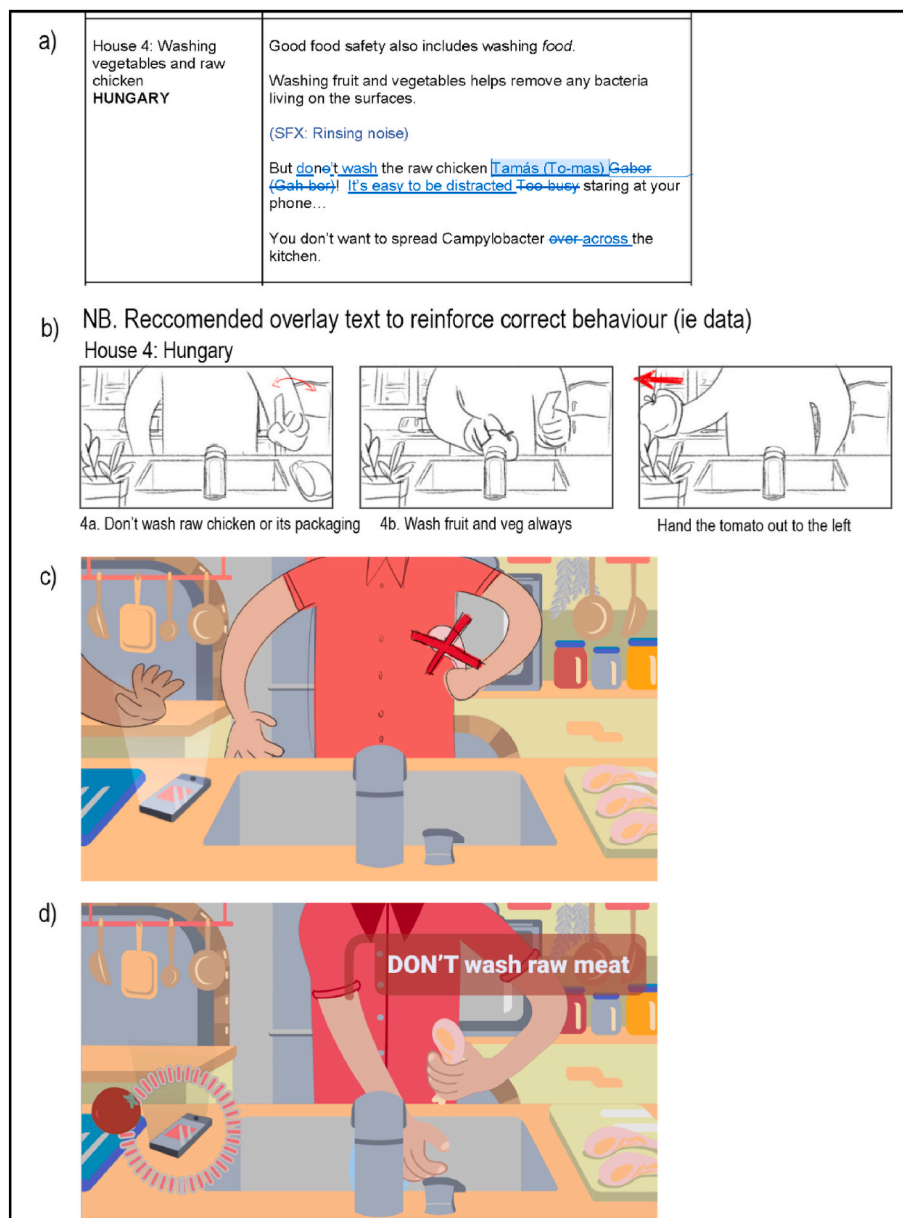


Fig. 2. Drafting User Journey animation. a) script edit stage b) draft storyboarding c) rough animation d) final animation.

engagement of students, a variety of activity types were developed that were suitable for different abilities, contexts and learning styles.

Following two rounds of student and educator feedback, the final suite of resources was agreed: five lesson plans including presentation slides, educator instructional sheets and student worksheets with three supplementary materials: an animation (Fig. 2), student debate kit, and recipe e-book.

### 3.6.2. Educator training resources

Creating structured educator training resources that allow educators to guide their own learning, enables resources to be adapted to their needs and time constraints. Adapting resources beyond simple translation was essential to provide country-specific content (Fig. 3, Supplementary material Appendix 3, Fig. 1).

Slide 7: Opbevaring / udpakning

**SAFE CONSUME**  
Infection transmission

**Storing / unpacking** More information on the cold chain

- Curriculum links
- Test your knowledge
- See teaching resources
- How to use teaching resources

- ✓ Control temperature of fridge ( $\leq 4^{\circ}\text{C}$ ) and identify low and high temperature zones  
Some harmful microbes can multiply at relatively cold temperature. To avoid their multiplication, it is important to keep the fridge temperature less than or equal to  $4^{\circ}\text{C}$ .
- ✓ Defrost in fridge  
As freezing does not kill bacteria, pathogenic bacteria (*Salmonella enterica*, *Listeria monocytogenes*) potentially present can multiply in the thawed food as soon as temperature gets high enough. This may happen if foods are thawed at room temperature. Frozen foods must be thawed in fridge and eaten or prepared rapidly. If you are in a hurry, defrost can also be done in the microwave or in hot water.

**More information :**  
[Multi-country outbreak of \*Listeria monocytogenes\* serogroup IVb, multi-locus sequence type 6, infections linked to frozen corn and possibly to other frozen vegetables](#)  
**NHS** [How to store food and leftovers](#)  
**Food Standards Agency** [How to chill, freeze and defrost food safely](#)

**SAFE CONSUME** X Back to main page Previous <

Keep/remove slide:

|              |  |            |   |
|--------------|--|------------|---|
| Remove slide |  | Keep slide | x |
|--------------|--|------------|---|

Translation (if the slide is retained):

| Original text   | Translation   |
|---|---|
| Control <b>temperature of fridge</b> ( $<4^{\circ}\text{C}$ ) and identify low and high temperature zones   | Hold styr på <b>køleskabets temperatur</b> ( $<5^{\circ}\text{C}$ ) og koldere / varmere zoner  |
| Some harmful microbes can multiply at relatively cold temperatures. To avoid their multiplication, it is important to keep the fridge temperature less than or equal to $4^{\circ}\text{C}$ . | Nogle bakterier kan formere sig ved relativt lav temperaturer. For at indgå bakterievækst er det vigtigt at holde køleskabets temperatur på $5^{\circ}\text{C}$ eller mindre. |

Fig. 3. Extract from the word file used to adapt and translate the teacher training sessions.

#### 4. Discussion

This project used an adapted version of a user-centred approach, underpinned by behavioural science, to develop a suite of educational materials on food hygiene for school students aged 11–18 years old, and accompanying training resources for educators. Key information gathered during the insight phase aligned to the TDF (Syeda et al., 2021) was used to suggest learning objectives listed in national curricula and then used to inform activities and lesson plans. Activities were designed to account for differences across the collaborating countries, making them suitable for settings with varying access to kitchens or hygiene facilities and range of abilities and teaching styles.

Think-aloud exercises using first-stage prototypes highlighted the need for activities to be easily implementable in schools and sustainable, indicating that traditional lesson structure using presentation slides was the preferred intervention design, ensuring activities fitted into the time available.

During piloting of second-stage prototypes, it became apparent that educators who would deliver food hygiene and safety education had varied backgrounds and training, and required different levels of support to teach certain topics (Hayes et al., 2021). This resulted in the development of background information and instructional sheets, and educator training resources.

Creating self-guided educator training resources allowed dynamic navigation without an imposed order which could be adapted to different contexts (Eley et al., 2021). In addition, the adaptation phase allowed the different countries to ensure that the proposed resources were in line with their epidemiological and cultural context.

As a result of the SafeConsume project, five lesson plans, three additional supporting activities, and four teacher training sessions were developed, to support teaching food hygiene and safety to secondary school children, and are freely available on [www.e-Bug.eu](http://www.e-Bug.eu) in French, Hungarian, Portuguese, Danish and Greek.

##### 4.1. Comparison to other school-based health interventions

The ASSIT + Frank (A Stop Smoking In Schools Trial and Talk to Frank) provides an example of co-design (Hawkins et al., 2017), whereby the end-users (Public Health Wales delivery team, secondary school students, and health professionals) worked alongside researchers to develop a peer-led drug prevention intervention. Researchers reported that co-design enabled them to observe and address potential delivery barriers early but was time-consuming because of ongoing iterative cycles of development work and a high level of involvement with end-users. The process outlined in our paper increases researcher autonomy, providing a streamlined approach for educator-led resources, whilst still integrating key student and educator feedback at regular intervals of development.

The user-centred development process of the Informed Health Choices (IHC) intervention (Nsangi et al., 2020) is comparable in several ways to our resource development, utilising multiple, iterative cycles of development and bringing student and educators' input into every stage of development. The authors describe using brainstorming techniques with educators to develop early prototypes in a similar fashion to our use of 'think-aloud' exercises, developing and refining products iteratively after every round of feedback (Nsangi et al., 2020). However, the authors outlined no systematic process of information gathering, did not consider the potential behavioural determinants relevant to the intervention and did not link to the national curriculum, stating only that they consulted with educators to define a list of 'key concepts'. This omission may have significant implications on the implementation of the resource and behavioural outcomes of the IHC intervention.

##### 4.2. Strengths and limitations

This paper shared an approach and considerations to design

educational health resources that are applicable across multiple contexts through a rigorous multi-centre process, including, iterative cycles of consultation with end-users, behaviouralists, researchers and an MCT to ensure relevant cultural factors were acknowledged at every stage. While the piloting phases of the educational lesson plans gathered feedback from only a small number of students and educators based in the UK, the needs assessment, which informed the lesson plans, assessed the needs, barriers and resource suggestions in a large sample of students and educators from multiple European countries (Eley et al., 2021; Syeda et al., 2021).

The process for resource development described in our paper is similar to that used across the e-Bug programme and builds on more than a decade of experience of developing and refining e-Bug teaching resources using comprehensive user-based needs assessments and piloting informed by behavioural theories. Interventions with a strong basis in behavioural science are found to be more effective than those that lack this (Glanz & Bishop, 2010). Our resource development used the TDF to suggest key targets for knowledge and behaviour change, forms a foundation for future developments. The e-Bug resources contain diverse activities that are suitable for a range of abilities, and address many of the factors raised in a review of health resources for those with learning disabilities (Eley et al., 2018; Owens et al., 2020) such as the need to be realistic about the abilities and skills of the students with the aim of supporting diverse needs.

Development also included a controlled evaluation of the materials across four partner countries, France, Portugal, Hungary and the UK (Hann et al., pending) which found the central educational resource, the 'User Journey' to be an effective resource for improving food safety knowledge among school children aged 11–18 years.

##### 4.3. Recommendations for resource developers

When embarking on developing health educational behaviour change interventions or resources for the educational setting, work should be defined in two phases, the 1) insight phase and 2) prototyping and refinement phase.

The insight phase should aim to utilise behavioural science when designing methodology to collect information about the intervention's users: educators and students. Insights should seek to illuminate the many determinants of that behaviour, from cultural, learned skills and knowledge to social, environmental and contextual factors and others. We recommend the TDF, as the framework links directly to intervention development (Atkins et al., 2017).

Our experience demonstrates that for a school-based intervention to be successful in gaining widespread adoption, it must be aligned as closely as possible with the national curriculum of the country in which it is used (Hayes et al., 2020). For this reason, we recommend undertaking an in-depth analysis of the national curriculum, and for this to be used to define the learning objectives central to the resource, and to engage decision makers in Ministries/Departments of Education to support implementation.

The prototyping and refinement phase has benefitted from close consultation with end-users at every stage. It is helpful for this process to start with a strong foundation created during the insight phase; carefully defined learning outcomes can be used as a framework from which to develop the structure of the resource. Iterative cycles of prototyping, consultation, and refinement should continue until development reaches a stage in which feasibility testing is successful, and the development process concludes with a final review by stakeholders (Fig. 1). If the resources are designed for more than one country adaptation must be feasible, as some countries may require more interactive resources, or have less equipment.

Stakeholder engagement should occur concurrently within the development process. External groups such as public health offices, local authorities, or subject matter experts should be recruited to provide additional perspectives at every stage, following the consultation, and

refinement described above. Although not detailed in this paper, the prototyping and refinement phase should include plans for an impact evaluation at an early stage (Hann et al., pending).

For effective implementation educators need confidence and knowledge to deliver the health resources, and therefore development of educators' training resources is needed.

## 5. Conclusions

School-based health interventions benefit from being designed with a solid basis in behavioural theory to influence students' knowledge, behaviour, and attitudes positively. To support uptake by educators, materials must be aligned to educational structures like the national curriculum; and it is helpful to consider practical factors including educators' time, access to equipment or printing, knowledge and confidence. By working closely with stakeholders at all stages of development, barriers to use, implementation and efficacy can be identified and mitigated.

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## CRediT authorship contribution statement

**Magda Hann:** Writing – original draft, Project administration. **Catherine V. Hayes:** Investigation, Writing – review & editing. **Virginie Lacroix-Hugues:** Methodology, Investigation, Resources. **Pia Touboul Lundgren:** Conceptualization, Methodology, Investigation. **Clodna McNulty:** Conceptualization. **Rowshonara Syeda:** Investigation. **Charlotte Eley:** Conceptualization, Methodology. **Paula Teixeira:** Resources. **Dimitra Gennimata:** Resources. **Mónica Truninger:** Conceptualization, Resources, Methodology. **Susanne Knöchel:** Resources. **Lars Münter:** Methodology. **Rosalie Allison:** Writing – review & editing. **Ágnes Fehér:** Development or design of . **Tekla Izsó:** Development or design of . **Atilla Kunszabó:** Development or design of methodology; creation of models, Writing – review & editing. **Gyula Kasza:** Development or design of methodology; creation of models, Writing – review & editing. **Alicia Demirjian:** Supervision.

## Data availability

The authors are unable or have chosen not to specify which data has been used.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.foodcont.2022.109219>.

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