

ORIGINAL ARTICLE

Impact of a nationwide web-based training program on food allergy knowledge and perceived competences management in schools

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Summary

Background. Food allergy (FA) is a growing public health concern among school-aged children. Schools are high-risk settings for accidental exposures and anaphylaxis, yet staff frequently report insufficient preparedness to manage such emergencies. Educational programs are essential to improve knowledge, confidence, and preventive practices. This study aimed to develop and evaluate a nationwide web-based FA training program for school professionals, aimed at improving knowledge and perceived competence in FA management. **Methods.** A quasi-experimental interventional study was conducted among 639 Portuguese school professionals, of whom 477 completed FA questionnaires. Participants were in pre-test (n = 172), post-test (n=100), and pre-post groups (n = 205). The intervention was an online program based on guidelines from the European Academy of Allergy and Clinical Immunology, Portuguese education and health authorities, and a national FA manual. FA knowledge was assessed with a 26-item validated questionnaire covering general concepts, allergen avoidance, and school practices. Perceptions of competence were gauged using Likert scales. Statistical analysis used General Linear Model repeated measures. **Results.** Knowledge scores increased significantly from baseline (62.1%) to post-intervention (79.6%) ($p < 0.001$). The most significant gains were observed in anaphylaxis management (+35.6%), bullying awareness (+42.4%), and prevention of accidental exposures. Perceived competence in allergen identification, label reading, and exposure prevention also

improved significantly ($p < 0.001$). **Conclusions.** This nationwide web-based program substantially enhanced school staff's FA knowledge and perceived competence, addressing critical gaps in emergency preparedness. Its scalability supports integration into national and international school health policies to improve safety and inclusion for children with FA.

Key words

Food allergy; anaphylaxis; school health; education program; teachers.

IMPACT STATEMENT

Nationwide web-based training improved school professionals' food allergy knowledge and preparedness, offering a scalable approach to enhance anaphylaxis management, prevent exposures, and support safer, more inclusive school environments.

Introduction

Food allergy (FA) is a public health concern, with increasing prevalence and persistence (1).

The primary strategy for managing FA is strict avoidance of known allergens, and in case of anaphylaxis, the first-line treatment is the prompt administration of intramuscular epinephrine (2-5).

In Portugal, food is the leading cause of anaphylaxis in children, and one of the major practice problems confronted by nurses and teachers when managing FA in school settings (6). Schools often lack sufficient preparedness, leaving professionals unsure of how to respond to allergic emergencies (4,7). This gap in promptness is particularly concerning given that 87.2% of allergen exposures result in clinical reactions, frequently occurring in everyday environments such as homes and schools (8,9). While canteens are recognised as high-risk zones, reactions also happen in classrooms, playgrounds, and buses, often due to non-ingestion exposures like craft materials (10,11).

Portuguese children spend more time in school than their European counterparts, increasing their risk of exposure (12,13). Before the COVID-19 pandemic, 20% anaphylactic episodes occurred in schools, highlighting the urgent need for improved training and protocols (14,15).

Beyond physical risks, FA also has a relevant psychosocial impact. Affected children often experience anxiety, depression, and social isolation due to dietary restrictions. Bullying and teasing further exacerbate emotional distress, making school environments particularly challenging for these students (16). In response, Portuguese regulations require schools to follow the School Food Allergy Regulations issued by the Directorate-General for Health (DGH) (17). This regulation addresses the availability of epinephrine auto-injectors (EAI), the need for

Individual Health Plan (IHP), and food allergy-specific training for school personnel (17). Despite these protocols, the absence of dedicated school health teams and inconsistent training leads to gaps in emergency preparedness (18).

In this context, school health teams, which include nurses, psychologists, nutritionists, and other health professionals, provide training to kitchen staff when needed, especially on precautions to prevent cross-contamination with allergens, based on the 2012 Food Allergy Reference (EduQA-DGH) (17,19). These teams are made up of specialised professionals who work in the educational environment to promote the health and well-being of students. These technicians are prepared to support the development of health promotion actions in schools, working in collaboration with teachers, educators, parents, and other health professionals (20).

Previous educational interventions have shown promising results in raising awareness (21), and enhancing teachers' ability to deal with food allergy requirements and emergencies (22,23). Similarly, the implementation of training programmes and the availability of stock epinephrine align with international guidelines and have the potential to enhance school staff awareness (24).

This study aims to develop and evaluate the effectiveness of a comprehensive web-based food allergy education training programme designed to enhance school staff's knowledge and perceptions regarding food allergy management. The project involves creating an educational programme on food allergy, developing a webinar based on the Food Allergy for Schools Educational Manual, implementing the web-based training in alignment with international guidelines, and assessing its impact on school staff's knowledge and perceived competences.

Materials and Methods

This study was designed as a quasi-experimental interventional study evaluating the impact of a structured web-based training programme on food allergy knowledge and perceived competence among school staff. Participants were prospectively assigned to receive a structured intervention. The training program launched in September 2024, and data collection occurred between May and July 2025. Informed consent was obtained from all participants before data collection.

The target audience consisted of teachers, educational assistants, health professionals, school directors, and other staff from public and private schools throughout Portugal. Recruitment was conducted by the Portuguese Institute for Education, Quality and Evaluation, IP (EduQA), and participation was voluntary. Interested staff registered for the Food Allergy for Schools webinar and were asked to complete a short questionnaire on demographic characteristics and preferred session date (two options were available). Written informed consent was obtained electronically before participation.

The study was conducted following the Declaration of Helsinki and received approval from the Ethics Committee of the University of Porto (24/CEUP/2016), the Faculty of Nutrition and Food Sciences' Ethics

Committee, the University of Porto Data Protection Office (735/2017), and the Portuguese Directorate-General for Education. All participants provided their informed consent before their inclusion in the study.

Design and Development of a Nationwide Web-Based Training Programme on Food Allergy Knowledge and Perceived Competences Management in Schools

The study was designed as a structured, multi-phase educational intervention targeting school staff across Portugal. Participants were recruited through institutional channels of the Directorate-General for Education. The intervention comprised two components: a live webinar and practical educational toolkits. A total of 639 school professionals registered on the programme, but only 515 attended the webinars. Among these, 477 participants completed at least one knowledge questionnaire and were included in the analyses. According to the timing of questionnaire completion, participants were allocated into three groups: a pre-test group ($n = 172$), who completed only the pre-webinar questionnaire; a pre- and post-test group ($n = 205$), who completed both questionnaires; and a post-test group ($n = 100$), who completed only the post-webinar questionnaire. All groups participated in one of two identical live webinars delivered on May 28th and June 5th. The webinar training programme was developed and aligned with the European Academy of Allergy and Clinical Immunology (EAACI) guidelines and the forthcoming 2025 edition of the Food Allergy in Schools Educational Manual. The training focused on equipping school professionals with the knowledge and perceived competences necessary to manage FA effectively, ensuring student safety and promoting well-being (3,25).

The live webinar covered key topics, including FA concepts, food labelling, recognition and management of FA in students, and appropriate responses to emergency situations. Its objectives included raising awareness of the needs of food-allergic students, strengthening knowledge of fundamental FA concepts, preventing accidental exposures, understanding food labelling and nutritional recommendations, and addressing the psychosocial impact of the condition. By the end of the training, participants were expected to be able to recognise major allergens, clinical manifestations, and emergency procedures, while also implementing integration strategies and best practices within the school environment (Figure 1).

Implementation of a Nationwide Web-Based Training Programme on Food Allergy Knowledge and Perceived Competences Management in Schools

The intervention consisted of an exclusively online webinar, conducted through the EduQA Zoom Platform. It was announced through EduQA's official communication channels and primarily via mailing lists sent to school clusters across Portugal. Each session lasted three hours, and access was restricted to registered participants, who received individualised links from the research team. Two identical training sessions were organised in May and June 2025 to maximise participation and ensure broad national coverage.

Both the webinar and toolkits were developed following EAACI guidelines. They were also aligned with the upcoming Portuguese Food Allergy in Schools Educational Manual, which the DGH and the EduQA will jointly publish in 2026 (26). A review of the 2012 guidelines published by EduQA-DGH now incorporates a more practical and inclusive approach to allergy education, broadening the scope to include teachers, operational assistants, and school directors, beyond just catering staff (17,19). The webinars were based on the latest edition of the Food Allergy for Schools Educational Manual, which covered the following topics (26):

1. General Concepts on FA: concept of food allergy; main allergens; food intolerances and autoimmune diseases; signs and symptoms; treatment; anaphylaxis (26).
2. Allergen avoidance: legislation; food labelling; cross-contamination; management of food meals; management of anaphylaxis situations and eviction diets (26).
3. Practical Procedures in Schools: school procedures; Individual Health Plan; emergency protocols; school practices and safety measures (26).

The training emphasised the importance of emergency protocols and individualised health plans for food-allergic students. To enhance engagement and assess learning outcomes, the webinar incorporated interactive elements using gamification tools, such as Mentimeter®, as well as the demonstration of intramuscular adrenaline administration, supported by an instructional video produced by the Faculty of Medicine of the University of Porto and the Immunoallergology Department of São João Hospital.

The toolkits were developed to reflect EAACI best practice on the management of children with FA and to support the Food Allergy for Schools Educational Manual (4,25). The following tools were developed: Food Allergy Management Practices in Classrooms (27); Food Allergy Management Practices in Canteens (28); Anaphylaxis protocol toolkit (28).

Food Allergy Knowledge Assessment

Following the recruitment of participants, an assessment of their knowledge was conducted using the Food Allergy Community (FAC) Programme questionnaires (29). The responses demonstrate the effectiveness of the food education strategies implemented, as well as the areas of intervention that need to be addressed in future projects (3).

Participants completed a short questionnaire on Google Forms about their demographic details, such as age, sex, location, educational background, job, and workplace information (including school grade level and type of establishment).

The FAC questionnaire comprised 26 multiple-choice items, scored as percentage points (0 to 100%, for correct items). Items were divided into three domains: theoretical knowledge of FA General Concepts (epidemiology, diagnostic methods, recognition of major allergens, signs, symptoms, treatment and differences in FA and intolerances). The second domain focused on Allergen Avoidance and immediate emergency procedures, covering allergen consumption, cross-contact, allergen ubiquity, food labelling, legal frameworks, and the appropriate sequence of actions in the event of an anaphylactic reaction. The third domain assessed Good Practices in Schools through school-based and case-based scenarios, including recognition and practical management of allergic reactions, school procedures, prevention of accidental exposures, workplace practices, bullying, social isolation, and the role of the Individual Health Plan. Overall, the questionnaire was designed to assess knowledge acquisition and practical competencies in relation to the programme's learning objectives.

Participants were allocated to one of three evaluation groups according to the timing of questionnaire completion: a pre-test group, a post-test group, or a pre- and post-test group. This design enabled evaluation of the immediate effects of the intervention while allowing comparison between participants assessed before, after, or both before and after the training.

The initial questionnaire was used to establish the baseline level of knowledge of the target population. This was essential to generate statistically valid information to assess the intervention's impact. Participants in the pre-test and pre- and post-test groups did not have access to the correct answers or their scores until the end of the intervention.

Participants in the pre- and post-test group completed the baseline questionnaire up to two hours before the webinar and the post-intervention questionnaire within 24 hours of its conclusion, after the training session, enabling assessment of the immediate effect of the intervention.

Food Allergy Perceived Competences Assessment

The second section of the questionnaire was created to explore the perceptions of responsibilities, capabilities, and self-perceptions in allergen identification, food labelling, and recognition of accidental exposures (29).

These perceptions were measured using a 10-item Likert scale (0-10), where 0 = not capable, 1 to 2 = slightly capable, 3 to 5 = moderately capable, 6 to 8 = very capable, and 9 to 10 = fully capable.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 29.0 (IBM Corp., Armonk, NY, USA).

Demographic data and results are presented as means and standard deviations (SD), medians, ranges, maximums, and minimums. Categorical data are shown as counts and proportions (n; %). Descriptive analyses were performed to characterise the participants' sociodemographic profile and summarise their responses to the FA survey tools using proportions and frequencies.

For the baseline and final assessments of the participants in the three groups, Mixed Models were chosen to include both quantitative variables (knowledge scores) and qualitative variables (perceptions assessed through categorical scales), allowing for the simultaneous evaluation of different data types while accounting for intra-individual variability.

To evaluate the impact of the training webinars and their progression, paired samples proportion tests were conducted in the intervention group. Statistical analysis was performed on the proportion of correct answers obtained in the three main topics before and after the training using a test for paired proportions.

To measure improvement in participants' knowledge, General Linear Model for Repeated Measures tests (ANOVA) were conducted on the mean scores before and after the intervention. The association models are presented with an unadjusted model only by time, and an adjusted model including age, sex, occupation, educational qualifications, and previous training in FA, considered as covariates in the repeated-measures ANOVA model.

Post hoc pairwise comparisons following repeated-measures ANOVA were adjusted using Bonferroni correction.

Paired-samples t-tests were conducted to compare the initial and final evaluation knowledge score means, assessing participants' improvements. Alternatively, t-tests for independent samples were performed to compare scores between groups.

Results

Of 639 individuals enrolled in the Food Allergy webinar programme, 515 attended the sessions, and 477 completed the associated questionnaires. Participants were categorised into three groups: the pre-test group (n=172), the post-test group (n=100), and the pre-and post-test group (n=205) (Figure 1).

The average participant age was 52 years (SD = 8.18), with a range from 22 to 71. The sample was predominantly female, comprising 89.9% (n=429) of respondents. Most held a bachelor's degree (66.2%), followed by a master's (19.9%). Participants primarily worked in upper secondary education (27.2%), primary education (23.3%), and secondary education (22.4%).

A significant majority (89.1%) were employed in school clusters, meaning schools have their own administration and management figures. They are usually made up of preschool establishments, plus one or more teaching levels and cycles that share a common pedagogical project (30-33).

Most participants were teachers (n=370; 77.6%) or operational assistants (n=78; 16.3%). 62.7% reported having some form of FA. The most common allergens were fish and shellfish (3%); nuts (0.8%); and wheat, peaches, and kiwis (0.6% each).

Regarding prior training in FA, 61.2% had none. Among those with training, the most common formats were webinars (20.3%), face-to-face sessions through School Health Teams (11.5%), online modules (3.6%), academic classes (1.7%), and medical instruction (2.3%) (Table I).

A total of 477 valid responses were analysed, showing a significant increase in knowledge scores from a mean of 59.33% (SD: 17.04) at baseline to 77.74% (SD: 12.97) post-intervention (Figure 2).

Food Allergy Knowledge Impact before and after the intervention

There were significant improvements in three topics ($p < 0.001$). The most important enhancements were observed in the identification of major allergens (+39.5 percentage points (pp)), the differentiation between FA and intolerances (+30.8 pp), diagnostic methods (+27.7 pp), and the management of emergency procedures (+38.3 pp). In the school practices domain, the most significant increase was observed in awareness of food allergy-related bullying (+40.3 pp), highlighting improvement in recognition of the psychosocial dimensions of FA management, accompanied by substantial progress in preventing accidental exposures and canteen procedures (Table II).

Finally, differences in post-intervention outcomes were observed between the two webinar sessions. Participants attending the June 5th webinar achieved higher post-test scores ($M = 81.47$, $SD = 8.92$) than those attending the May 28th session ($M = 77.14$, $SD = 13.29$). There were also significant differences between the pre- and post-test group and the pre-test group in the initial evaluation, and between the pre- and post-test group and the post-test group, in the final assessment.

Food Allergy Perceived Competences Impact before and after the intervention

There was a significant improvement in the perceived competence of the participants, reporting higher levels of perceived competences in identifying allergens, labelling, and preventing accidental exposures ($p < 0.001$) (Table II).

Food Allergy Knowledge Impact for the intervention group

Focusing only on the pre- and post-test group ($n = 205$), a significant rise in mean knowledge score was observed, from 62.10% ($SD = 14.84$) at baseline to 79.56% ($SD = 11.23$) after the webinar. This indicates a mean increase of 17.46 percentage points ($p < 0.001$) (Table III). The lower standard deviation observed after the intervention indicates less variability in post-test scores compared with baseline. Knowledge improvements were also consistent across age, sex, occupation, and educational qualifications. The impact of prior training in FA on outcomes was examined, with participants who had undergone prior training demonstrating a more pronounced progression ($p = 0.003$). Furthermore, it was observed that participants holding a bachelor's degree ($p = 0.049$) performed significantly better compared to those who had completed only secondary education.

Concerning the pre- and post-test group and the baseline questionnaire, participants were less knowledgeable when asked to identify food allergens (14.6%); FA diagnosing methods (21.5%); accidental exposure prevention situations (31.2%); the impact of bullying (16.1%), and FA on adolescents (26.3%).

After the intervention, regarding allergen avoidance, the most notable change was observed when participants were asked how to respond in the event of an anaphylactic reaction ($p < 0.001$). There was also a significant improvement in recognising allergen ubiquity (difference = -0.171; $p < 0.001$) and food allergen labelling (difference = -0.146; $p < 0.001$). For clinical manifestations and associated symptoms, there was no statistically significant change ($p = 0.162$; $p = 0.105$, respectively), most likely due to higher baseline scores. Concerning the role of the IHP, there was also a statistical improvement ($p = 0.006$), reinforcing the understanding of preventive strategies.

Observing the risk of accidental exposure in children compared to adolescents, there was a significant increase in awareness within this group ($p = 0.038$). However, it is a less meaningful value compared to other issues. Regarding locations where accidental exposures might occur, there was no statistical significance ($p = 0.202$).

Food Allergy Perceived Competences for the intervention group

There was a marked increase in perceived competence, with the proportion of participants rating themselves as “very capable” rising from 16.1% to 50.7% for allergen identification, and from 22% to 45.8% for label reading. A significant, albeit smaller, improvement was also observed for accidental exposure prevention, with p -values under < 0.001 , for all items (Table IV).

Perceived competences regarding the capability in the identification of allergens on labels were only statistically influenced by the sex of participants ($p = 0.029$). The other perceptions evaluated were consistent across age, sex, occupation, educational qualifications, and FA prior training.

The training was highly effective, demonstrated by an average score of 8 out of 10.

Discussion and Conclusions

Our study is a large-scale nationwide web-based programme in Portugal for schools and one of the largest reported in this context, addressing a critical gap in school staff readiness. This national intervention and the observed increase of approximately 18 percentage points in knowledge scores in the intervention group suggest that a brief, structured online intervention can substantially improve school staff’s understanding of FA management, particularly considering that participants were recruited nationally and represented diverse school professionals. Gains were consistent across all domains, demographic groups and educational backgrounds, demonstrating that such training is widely accessible and relevant. Notably, participants reported increased preparedness to manage emergencies such as anaphylaxis, a critical outcome given the potentially fatal consequences of delayed or inappropriate action.

These findings are consistent with the FAC Programme, which demonstrated that school-based training initiatives may improve staff knowledge and attitudes in managing food allergy and anaphylaxis (22, 29). Furthermore, sustained implementation of such programs has been demonstrated to be feasible, as evidenced by a collaborative initiative across 421 Utah schools that achieved a year-to-year retention rate exceeding 68% and a 245% increase in unassigned epinephrine availability (34). The outcomes of this study also build on previous research. Although the EuroPrevall survey showed the high prevalence of FA among European children, our data emphasise the ongoing gap between epidemiological risk and the ability of educational settings to manage allergic reactions (35). By showing that structured online training can markedly increase knowledge and confidence in FA management, this study supports scalable educational strategies aligned with EAACI recommendations (4). Remarkable progress was seen in distinguishing FA from intolerance, identifying allergens, and handling anaphylactic emergencies. Although improvements in recognising symptoms were modest, likely due to high initial knowledge, participants showed significant changes in attitudes and practices, especially in allergen avoidance and risk mitigation. In line with previous interventions, even short sessions like a one-hour training have proven effective in boosting staff readiness (21).

Clinically and practically, the programme improved school staff's knowledge and perceived competences in FA management, particularly regarding allergen avoidance, emergency procedures, and practical school-based prevention strategies. Beyond knowledge acquisition, participants demonstrated increased self-reported confidence and competence, which are essential determinants of effective real-world action during emergencies such as anaphylaxis (23).

The substantial improvement observed in emergency procedure knowledge is particularly relevant given the time-sensitive nature of anaphylaxis management in school settings. The training programme incorporated practical components focused on recognising allergic reactions, understanding emergency protocols, and demonstrating the correct use of intramuscular adrenaline devices through an instructional video. These practice-oriented elements may have contributed to increased knowledge and perceived competence regarding the appropriate response to allergic emergencies. Improving school staff preparedness is essential, as early recognition and prompt administration of adrenaline are critical components of recommended anaphylaxis management. Therefore, strengthening emergency management skills among school professionals may help reduce delays in intervention and improve safety for children with food allergy in educational environments.

The programme's practice-oriented pedagogical approach likely played a key role in fostering improvements in knowledge and perceived preparedness and competence, aligning with outcomes reported in other European studies addressing similar domains. This alignment with prior European evidence, such as the FAC Programme and findings by Polloni *et al.* further substantiates the results and underscores their broader international significance (22). Finally, the web-based format ensures the programme's scalability and transferability across

different educational systems. Taken together, these strengths highlight the programme's substantial potential for integration into national and international school health policies, supporting safer and more inclusive environments for children living with food allergy.

Participants demonstrated improved ability to identify hidden allergen risks (e.g., trace contamination, labelling, medications), to recognise the severity of allergic reactions, and to manage emergency scenarios (36). These outcomes are concordant with EAACI recommendations, which emphasise comprehensive staff training, availability of stock epinephrine, simulation-based practice, and the implementation of school-wide policies (8, 36).

The intervention's interactive, practice-oriented nature likely contributed to the observed gains, highlighting the importance of combining cognitive knowledge with behavioural skill development in educational programmes (37).

Beyond clinical safety, this web-based programme raised awareness of the psychosocial dimensions of FA in schools, including bullying, social exclusion, and emotional burden (38). The substantial improvement observed in awareness of food allergy-related bullying (+40.3 percentage points) highlights an important but often overlooked dimension of food allergy management in educational settings. Training programmes have traditionally focused mainly on clinical aspects, such as allergen avoidance and emergency response, while the psychosocial consequences of FA may receive less attention. As school professionals play a key role in shaping the school environment, increasing awareness of these challenges is essential to promote safer and more inclusive settings for children with FA. By incorporating psychosocial aspects alongside medical management, this programme broadened the scope of FA education beyond the prevention of allergic reactions, addressing the wider impact of the condition on students' well-being (39).

Despite this improvement, persistent misconceptions regarding FA-related bullying and the recognition of adolescents as a potentially vulnerable group indicate the need for continued targeted education (39). Earlier research revealed that 21% of FA-related bullying and harassment was perpetrated by school staff, and FA-related bullying has been shown to encompass a range of behaviours, including verbal threats, deliberate allergen exposure, and social exclusion (40,41). Current American Academy of Paediatrics guidelines reinforce these concerns, noting that teachers have been identified as perpetrators, highlighting the ongoing need for professional training and awareness (8). Consistent with these concerns, the FAC Programme demonstrated that many educators did not recognise bullying as a significant issue or identify adolescents as a high-risk group (29). Furthermore, Nocerino *et al.* highlighted that FA-related bullying is not only prevalent but also associated with substantial psychosocial consequences for affected children (42). Together, these findings support the integration of comprehensive FA training approaches that address both medical management and psychosocial well-being.

Some domains showed more modest improvements, including recognition of allergic symptoms and the application of knowledge in daily school practice. These findings align with reports from other European studies, suggesting that staff may grasp the FA conceptually but remain uncertain in real-life scenarios (22). This emphasises the importance of regular, scenario-based reinforcement and institutional support structures to maintain consistency of responses across schools.

The intervention proved broadly effective across age, sex, occupation, and workplace, confirming its inclusivity and relevance (29). However, occupation influenced responses to specific questions, especially in distinguishing between FA and intolerance, indicating that some professional groups may need targeted training. Participants with prior FA training achieved greater progress, consistent with findings from a Turkish study (43). Higher education and health literacy levels were also linked to better performance in more complex concepts. Moreover, those completing both pre- and post-tests outperformed others, highlighting the value of formative evaluation in consolidating learning, as shown in the FAC Programme and Riccio's study (29,44). Consistent with EAACI recommendations, it advocates for the creation of support networks and awareness-driven practices to reduce allergic reactions and ensure safe, protocol-based responses (4).

Differences in post-intervention knowledge scores were also observed between the two webinar sessions. Although both sessions followed the same educational content and structure, subtle variations in communication style or delivery by the trainers may have influenced participants' learning. Additionally, because the sessions were conducted one week apart and involved professionals from the same educational system, informal communication between participants regarding the training content or questionnaire items may also have contributed to the higher scores observed in the second session. As these factors were not formally evaluated, they should be regarded as possible explanations rather than definitive conclusions. Future studies should consider strategies to minimise potential contamination between intervention groups and further explore the influence of trainer-related factors on educational outcomes.

Collectively, these findings underscore the potential of this nationwide programme as a scalable and sustainable model to enhance school preparedness and to improve the protection and inclusion of children with food allergy.

This study has several limitations. First, participation was voluntary, which may have introduced selection bias towards more motivated or engaged school staff. Second, the intervention was evaluated only before and after the training, precluding assessment of long-term knowledge retention, sustained behavioural change, and the durability of the observed improvements. The temporal stability (test-retest reliability) of the FAC questionnaire was not evaluated, limiting conclusions regarding the consistency of the instrument over time. Third, reliance on self-reported competence may overestimate actual preparedness in real-life emergency situations. Finally, the study did not directly assess whether the intervention led to a reduction in anaphylactic events in schools.

Despite these limitations, the findings offer important evidence on the feasibility, effectiveness, and scalability of web-based FA training for school professionals.

Future research should examine the sustainability of knowledge and competence gains, assess behavioural outcomes in real emergencies, and explore national integration of such programmes into mandatory professional training. The integration of this training into compulsory professional development is strongly recommended, alongside the implementation of stock epinephrine and Individual Health Plans, as recommended by EAACI (4). At the European level, harmonisation of FA training standards could help address disparities across countries and ensure consistent protection for allergic children.

This nationwide web-based training programme significantly improved indicators of knowledge and perceived preparedness among school staff to manage food allergy and anaphylaxis. By addressing misconceptions, strengthening perceived competences, and improving emergency readiness, it represents a scalable and cost-effective model for school health interventions. Importantly, its design is transferable across countries and directly aligns with EAACI and National guidelines for accessible, scalable strategies to improve child health and safety in educational settings. Adoption of this model into national and international school health policies has the potential to foster more inclusive school environments, address the psychosocial challenges associated with food allergy, and enhance overall preparedness for managing allergic emergencies.

Fundings

This research did not receive any specific funding.

Contributions

RM: Conceptualisation (lead), Methodology (lead), Investigation (lead), Writing – original draft (lead).

IP: Methodology (equal), Formal analysis (lead), Validation (equal), Supervision (equal), Writing – review & editing (equal).

RL: Project administration (equal), Resources (lead), Software (lead), Writing – review & editing (equal).

PM: Supervision (equal), Validation (equal), Writing – review & editing (equal).

AM: Supervision (equal), Validation (equal), Writing – review & editing (equal).

RB: Project administration (lead), Resources (lead), Validation (lead), Supervision (lead), Writing – review & editing (equal).

All authors reviewed and approved the final manuscript.

Conflict of Interest Statement

The authors declare no conflicts of interest.

Acknowledgements

The authors thank the Directorate-General of Education for supporting participant recruitment and the Food Allergy webinar, and the Directorate-General of Health for aligning it with national guidelines. We also appreciate school professionals' participation and dedication to improving food allergy management.

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Table I: Characteristics of Participants from the Food Allergy Web-based Programme for National School Staff.

– Total, pre, post, pre-post groups

Participants characteristics n (%)	Total (n=477)	Pre-and-post- test group (n=205)	Pre-test group (n=172)	Post-test group (n=100)	<i>p-value</i>
Sex[†]					
Female	429; (89.9%)	191; (93.2%)	148; (86%)	90; (90%)	0.047
Male	48; (10.1%)	14; (6.8%)	24; (14%)	10; (10%)	
Education qualifications[†]					
Secondary education	58; (12.2%)	25; (12.2%)	17; (9.9%)	16; (16%)	0.414
Bachelor	316; (66.2%)	140; (68.3%)	113; (65.7%)	63; (63%)	
Master	95; (19.9%)	36; (17.6%)	39; (22.7%)	20; (20%)	
Doctorate	8; (1.7%)	4; (2%)	3; (1.7%)	1; (1%)	
Job/Occupation[†]					
School Teacher	370; (77.6%)	155; (75.6%)	140; (81.4%)	75; (75%)	0.235
Operational Assistant	78; (16.3%)	36; (17.5%)	21; (12.3%)	21; (21%)	
Nutritionist	3; (0.6%)	2; (1%)	1; (0.6%)	-	
Psychologist	2; (0.4%)	2; (1%)	-	-	
School Health Team Nurse	15; (3.1%)	6; (2.9%)	7; (4.1%)	2; (2%)	
Superior Technician	5; (1%)	3; (1.5%)	-	2; (2%)	
School Head	4; (0.8%)	1; (0.5%)	3; (1.7%)	-	
Workplace[†]					
School Cluster	425; (89.1%)	179; (87.3%)	156; (90.7%)	90; (90%)	0.102
Non-cluster school	48; (10.1%)	25; (12.2%)	13; (7.6%)	10; (10%)	
Private Schools	3; (0.6%)	-	3; (1.7%)	-	
City council	1; (0.2%)	1; (0.5%)	-	-	
Teaching year[†]					
Day-care	3; (0.6%)	2; (1%)	1; (0.6%)	-	0.424
Preschool education	65; (13.6%)	32; (15.6%)	22; (12.8%)	11; (11%)	
Primary secondary	111; (23.3%)	48; (23.4%)	47; (27.3%)	16; (16%)	
Lower secondary	61; (12.8%)	28; (13.7%)	19; (11%)	14; (14%)	
Secondary education	107; (22.4%)	41; (20%)	41; (23.8%)	25; (25%)	
Upper secondary	130; (27.2%)	54; (26.3%)	42; (24.4%)	34; (34%)	
Age[‡]					

Mean (SD)	52.6 (8)	52.6 (7)	52.2 (8)	53.1 (9)	0.738
Min - Max	22 - 71	27 - 68	22 - 66	27 - 71	

Legend:

Pre-and post-test group: participants who responded to questionnaires before and after the web-based programme.

Pre-test group: participants who responded to questionnaires before the web-based programme.

Post-test group: participants who responded to questionnaires after the web-based programme.

† Listed p-values for Pearson's Chi-Square test; ‡ Listed p-values for One-way ANOVA test; Bolded p-values are significant at the 0.05 level.

Table II: Food Allergy Knowledge and Perceptions Characteristics of participants from the Food Allergy Web-based Programme for National School Staff.

Food Allergy Knowledge	Baseline Evaluation [§] (n=377)	Final Evaluation [¶] (n=305)	p-value
Total score			
Mean (SD)	59.3% (17)	77.74% (13)	<0.001
Median; Min - Max	62; 3.9 - 92.3	87; 23.1 – 100	
Range	88.4	76.9	
Question domains (% correct answers)			
Food Allergy General Concepts			
Allergy vs. Intolerance (Q17)	47.2%	78%	<0.001
Major Allergens (Q18)	14.3%	53.8%	
Signs (Q19)	82.5%	88.2%	
Symptoms (Q41)	88.1%	88.5%	
Diagnose methods (Q21)	21.2%	48.9%	
Treatment (Q22)	69.2%	88.5%	
Milk Allergy vs. Intolerance (Q39)	69.8%	86.6%	
Wheat Allergy vs. Gluten Intolerance (Q40)	63.7%	82.3%	
Allergen Avoidance			
Allergen consumption (Q20)	78.2%	94.1%	<0.001
Cross-contact concept (e.g. walnut) (Q23)	89.7%	97.7%	
Allergens ubiquity (Q24)	62.6%	78.4%	
Emergency procedures (Q25)	48.3%	86.6%	
Precautionary labelling (Q26)	89.4%	98%	
Food allergens labelling (Q27)	47.7%	62%	
Cross contamination (Q38)	82%	94.8%	
Good Practices in Schools			
Severity of a reaction (Q28)	41.4%	56.7%	<0.001
Food allergy and isolation (Q29)	74.8%	84.9%	
Practical case: school dining (Q30)	63.7%	90.5%	
Accidental exposure prevention (Q31)	24.9%	53.4%	
Food allergic reaction triggers (Q32)	54.6%	85.2%	
Practical case: school trip (Q33)	55.4%	71.1%	
Bullying (Q34)	16.4%	56.7%	

Food allergy and adolescents (Q35)	26.3%	31.8%	
Psychosocial impact (Q36)	56.5%	77.4%	
Accidental exposure spaces (Q37)	89.7%	92.8%	
Individual Health Plan (Q42)	85.1%	94.4%	
Food Allergy Perceptions			
	Baseline Evaluation[§] (n=377)	Final Evaluation[¶] (n=305)	p-value
Capability in the identification of allergens on labels (Q43)			
Not capable	4%	0.4%	
Slightly capable	28.1%	3.7%	
Moderately capable	46.5%	37.9%	<0.001
Very capable	17.9%	49.8%	
Fully capable	3.5%	8.2%	
Capability in reading labels (Q44)			
Not capable	1.6%	0.4%	
Slightly capable	22.3%	3.4%	
Moderately capable	46.1%	38.6%	<0.001
Very capable	24.2%	45.5%	
Fully capable	5.8%	12.1%	
Capability in identifying accidental exposure (Q45)			
Not capable	5.6%	0.3%	
Slightly capable	36.1%	2.6%	
Moderately capable	43.7%	40.4%	<0.001
Very capable	13%	48.2%	
Fully capable	1.6%	8.5%	

[§] Baseline evaluation: pre-test and pre- and post-test groups; [¶] Final evaluation: post-test and pre- and post-test groups; Total scores are presented as means (SD); Percentage of correct answers range from 0 to 100%; All listed p-values for knowledge are Linear Mix Model; All listed p-values for perceptions are independent t-tests; Bolded p-values are significant at the 0.05 level; Scale for statements (from 0 to 10): 0- not capable; 1 to 2- slightly capable; 3 to 5- moderately capable; 6 to 8- very capable; 9 to 10- fully capable.

Table III: Food Allergy Knowledge Impact on the Intervention Group from Food Allergy Web-based Programme for National School Staff.

Food Allergy Knowledge	Intervention Group (n=205)					
	Pre-webinar	Post-webinar	Unilatera l <i>p-value*</i>	Mean (SD) for each domain		<i>p-value**</i>
				Pre-webinar	Post-webinar	
Total score						
Mean (SD)	-	-	-	62.1% (14.8)	79.6% (11.2)	<0.001
Median; Min - Max	-	-	-	62%; 3.8 – 92.3	81%; 23.1 - 100	
Knowledge Domains (% of correct answers)						
Food Allergy General Concepts						
Allergy vs. Intolerance (Q17)	49.3%	80.5%	<0.001			
Major Allergens (Q18)	14.6%	55.6%	<0.001			
Signs (Q19)	86.3%	89.8%	0.162			
Symptoms (Q41)	88.8%	92.2%	0.105			
Diagnose methods (Q21)	21.5%	51.7%	<0.001	60.1% (20.6)	79.5% (19.5)	<0.001
Treatment (Q22)	73.7%	91.7%	<0.001			
Milk Allergy vs. Intolerance (Q39)	77.6%	90.7%	<0.001			
Wheat Allergy vs. Gluten Intolerance (Q40)	68.8%	83.4%	<0.001			
Allergen Avoidance						
Allergen consumption (Q20)	82%	96.6%	<0.001			
Cross-contact concept (e.g. walnut) (Q23)	91.7%	98%	0.001			
Allergens ubiquity (Q24)	61.5%	78.5%	<0.001	74.2% (19,5)	88,4% (12,5)	<0.001
Emergency procedures (Q25)	53.7%	89.3%	<0.001			
Precautionary labelling (Q26)	94.1%	98.5%	0.006			
Food allergens labelling (Q27)	47.8%	62.4%	<0.001			
Cross contamination (Q38)	88.3%	95.6%	<0.001			
Good Practices in Schools						
Severity of a reaction (Q28)	45.4%	58.5%	<0.001			
Food allergy and isolation (Q29)	75.6%	85.9%	0.004	55.9% (18)	74.0% (14.9)	<0.001
Practical case: school dining (Q30)	67.3%	92.2%	<0.001			

Accidental exposure prevention (Q31)	31.2%	58%	< 0.001
Food allergic reaction triggers (Q32)	56.1%	85.9%	< 0.001
Practical case: school trip (Q33)	58.5%	74.1%	< 0.001
Bullying (Q34)	16.1%	58.5%	< 0.001
Food allergy and adolescents (Q35)	26.3%	33.7%	0.038
Psychosocial impact (Q36)	59%	78.5%	< 0.001
Accidental exposure spaces (Q37)	91.7%	94.1%	0.202
Individual Health Plan (Q42)	87.8%	94.6%	0.006

Legend: Intervention group: pre- and post-test group; GLM (General Linear Model); *Listed p-values for the paired samples proportions; **Listed p-values for the paired samples t-Student test; SD: Standard deviation; Bolded p-values are significant at the 0.05 level.

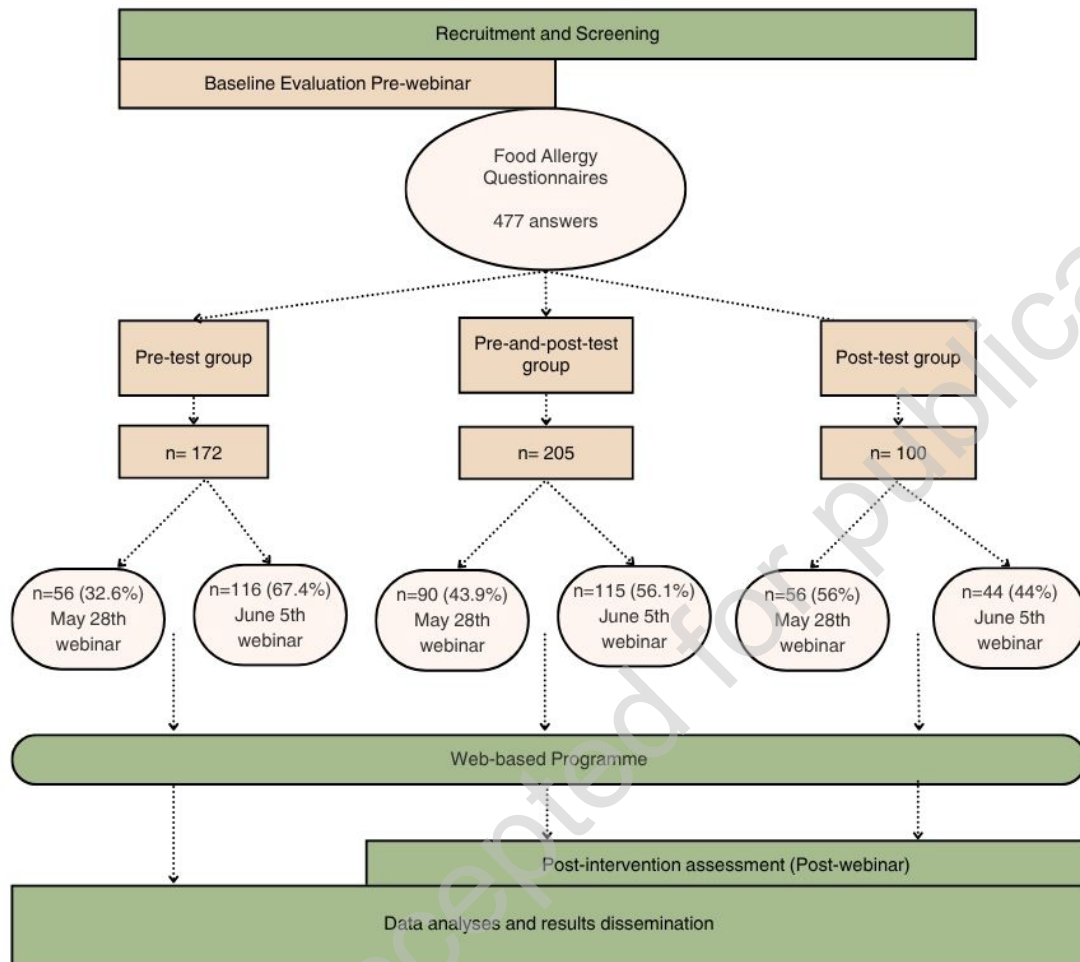
Table IV: Food Allergy Perceived Competences Impact on the Intervention Group from Food Allergy Web-based Programme for National School Staff.

Food Allergy Perceptions (%)	Pre-webinar	Post-webinar	<i>p-value*</i>
Capability in the identification of allergens on labels (Q43)			
Not capable	2.9%	0.5%	<0.001
Slightly capable	25.9%	3.9%	
Moderately capable	52.2%	37.6%	
Very capable	16.1%	50.7%	
Fully capable	2.9%	7.3%	
Capability in reading labels (Q44)			
Not capable	1%	0.5%	<0.001
Slightly capable	21%	3.5%	
Moderately capable	49.7%	38%	
Very capable	22%	45.8%	
Fully capable	6.3%	12.2%	
Capability in identifying accidental exposure (Q45)			
Not capable	0.5%	0.5%	<0.001
Slightly capable	3.9%	3%	
Moderately capable	37.6%	38.5%	
Very capable	50.7%	50.2%	
Fully capable	7.3%	7.8%	

Legend: Intervention group: pre- and post-test group; GLM (General Linear Model); *Listed p-values for the paired samples t-Student test; SD: Standard deviation; Bolded p-values are significant at the 0.05 level.

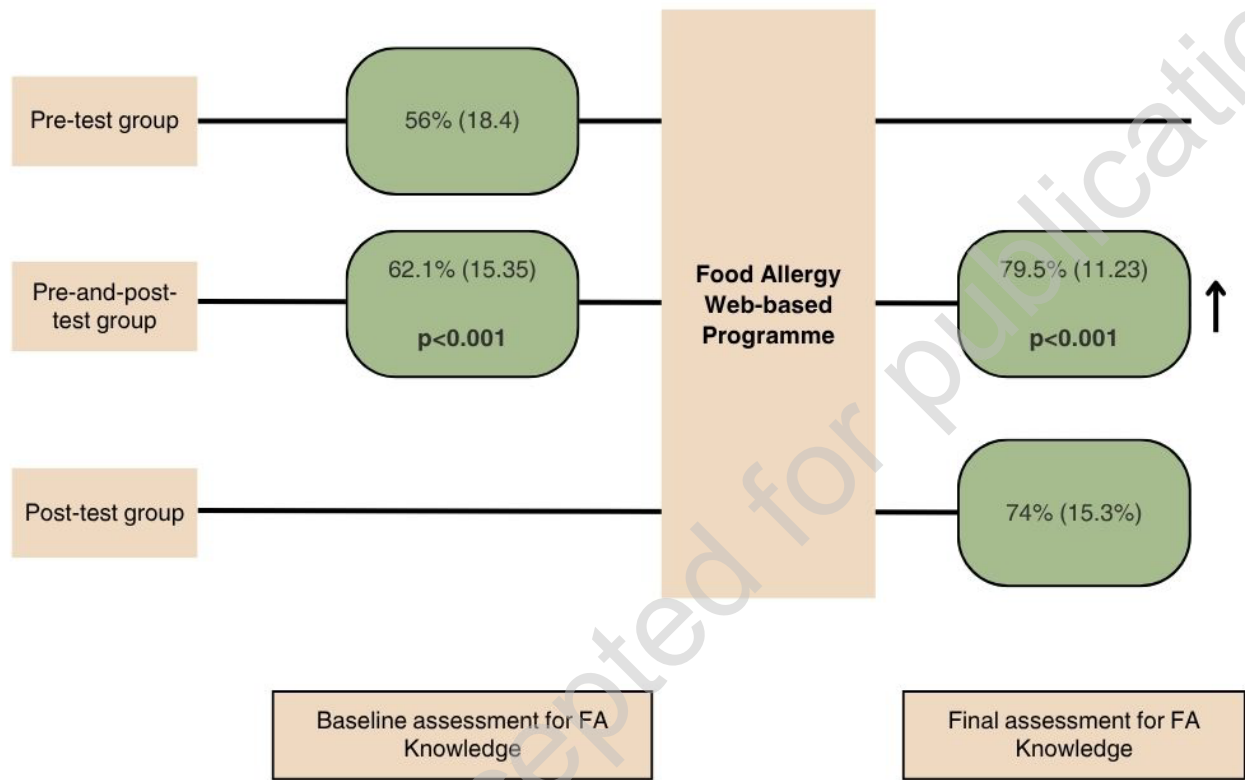
Scale for statements (from 0 to 10): 0- not capable; 1 to 2- slightly capable; 3 to 5- moderately capable; 6 to 8- very capable; 9 to 10- fully capable.

Figure 1. Food Allergy Web-based Programme for National Schools' Staff: flow-chart design and intervention.



Legend: Participants' description as n (%); Pre-test group: participants who complete the knowledge and management perceptions assessments before the web-based programme; pre-and post-test group: participants complete the knowledge and management perceptions assessments before and after the web-based programme; Post-test group: participants complete the knowledge and management perceptions assessments after the web-based programme.

Figure 2. Knowledge Score for the 3 Groups from the Food Allergy Web-based Programme for National School Staff.



Legend: Participants were assigned to 3 groups. Pre-test group (n= 172); post-test group (n=100); pre-test and post-test group (n=205); Mean differences were assessed before and after the webinar, in percentage of correct answers, from 0 to 100%.

Pre-test group: participants who complete the knowledge and management perceptions assessments before the web-based programme; pre-and post-test group: participants complete the knowledge and management perceptions assessments before and after the web-based programme; Post-test group: participants complete the knowledge and management perceptions assessments after the web-based programme; FA: Food Allergy.