Assessing the Impact of Digital Deep Learning Tools on Knowledge, Attitude, Practice, and Behavioural Change in Food Safety Among Food Handler Workers in Al Qassim Hospitals

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Abstract

Food safety in hospital settings is critical due to the vulnerability of patients to foodborne illnesses. This study aimed to evaluate the effectiveness of a digital learning intervention in improving food safety knowledge, attitudes, practices (KAP), and behavioral change among hospital food handlers in public hospitals in Al Qassim, Saudi Arabia. A quasi-experimental pre–post design was employed involving 211 participants. Data were collected using structured questionnaires, behavioral assessments, and qualitative methods. The Wilcoxon signed-rank test revealed statistically significant improvements across all KAP dimensions and behavioral outcomes ($p < .001$), with large effect sizes ($r = 0.87$). Regression analysis indicated that practice improvement was the strongest predictor of behavioral change, followed by knowledge, perceived training effectiveness, and attitude. Qualitative findings highlighted the role of engagement, relevance, and organizational support in enhancing training outcomes. Despite these improvements, barriers such as workload and digital literacy challenges were identified. The study concludes that digital learning is an effective and scalable approach for improving food safety practices in hospital settings, particularly when supported by institutional reinforcement mechanisms.

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Introduction

Food safety within hospital environments represents a critical component of patient care, particularly due to the heightened vulnerability of patients to foodborne infections. Inadequate food handling practices in healthcare settings can lead to severe health consequences, including increased morbidity, extended hospital stays, and additional healthcare costs (Al Banna et al., 2022; Faour-Klingbeil, 2022). Despite the importance of food safety, many healthcare institutions face challenges in maintaining consistent compliance with hygiene standards. One major contributing factor is the lack of structured and continuous training among food handlers. Traditional training methods are often limited by time constraints, low engagement, and insufficient reinforcement, leading to gaps between knowledge and actual practice (Bettridge et al., 2022; Fekadu et al., 2024). Digital learning has emerged as a promising alternative to conventional training approaches. By offering flexible, interactive, and scalable learning environments, digital platforms can enhance engagement, improve knowledge retention, and facilitate behavioral change (Cai et al., 2023; Zaujan et al., 2021). Features such as visual demonstrations, quizzes, and scenario-based learning allow participants to better understand food safety risks and apply knowledge in real-world contexts. However, empirical evidence on the effectiveness of digital learning in hospital food service settings, particularly in Saudi Arabia, remains limited. Most existing studies focus on restaurants, educational institutions, or community settings, with relatively few addressing healthcare environments. This study aims to address this gap by evaluating the impact of a digital learning intervention on food safety knowledge, attitudes, practices, and behavioral change among hospital food handlers in public hospitals in Al Qassim. Specifically, the study seeks to: This study aims to assess baseline food safety KAP levels, evaluate the effect of digital learning on KAP improvement, examine behavioral change following the intervention, identify predictors of behavioral improvement, and explore contextual factors influencing implementation.

Significance of the Study

This study is significant because it addresses an important patient safety issue in hospital food service settings. Food handlers play a direct role in preventing foodborne contamination, particularly in hospitals where patients may be more vulnerable to infection due to illness, weakened immunity, or medical treatment. Improving food safety practices in such settings is therefore essential for protecting patient health and strengthening healthcare quality. The study also contributes to practice by evaluating digital learning as a flexible and scalable training approach for hospital food handlers. Traditional food safety training is often limited by staff schedules, workload pressures, and inconsistent delivery. Digital learning offers an alternative that can provide structured content, repeated access, interactive materials, and practical demonstrations. This makes it especially useful in public hospitals where continuous face-to-face training may be difficult to maintain. Academically, the study adds evidence to the literature on food safety training by focusing on the relationship between digital learning, KAP improvement, and behavioral change. It also contributes to understanding how knowledge, attitudes, and practices interact with perceived training effectiveness to influence actual food handling behavior. From a policy perspective, the findings can support hospital administrators and health authorities in developing more consistent digital food safety training frameworks. The results may help guide the integration of digital learning into routine staff development, compliance monitoring, and hospital food safety quality assurance systems.

Literature Review

Food safety in healthcare settings has received increasing attention due to its direct impact on patient safety and public health outcomes. Hospital food handlers play a critical role in preventing foodborne illnesses; however, studies consistently report gaps in food safety knowledge, attitudes, and practices, particularly in resource-constrained environments (Al Banna et al., 2022; Fekadu et al., 2024). The Knowledge–Attitude–Practice (KAP) framework has been widely used to assess food safety behavior. The model suggests that knowledge acquisition influences attitudes, which in turn shape practices and behavior (Kwol et al., 2020; Soon et al., 2020). However, evidence indicates that this relationship is not always linear, as knowledge does not automatically translate into safe practices due to contextual and organizational constraints (Nawawi et al., 2022; Taha et al., 2024). In recent years, digital learning has emerged as a promising approach to food safety training. Digital platforms provide flexible, interactive, and scalable learning environments that can enhance engagement and knowledge retention (Cai et al., 2023; Zaujan et al., 2021). Studies have shown that digital interventions can improve food safety outcomes through multimedia content, quizzes, and scenario-based learning (Cai et al., 2023; Bettridge et al., 2022). Behaviour changes theories further explain how

training interventions influence food safety practices. The Health Belief Model emphasizes the role of perceived risk in motivating preventive behaviour, while the Theory of Planned Behavior highlights the importance of attitudes, subjective norms, and perceived behavioral control in shaping behavior (Olaimat et al., 2022; Soon et al., 2020). Despite growing evidence on digital learning, limited research has examined its application in hospital food service settings, particularly within Saudi Arabia. This study addresses this gap by evaluating the effectiveness of digital learning tools in improving food safety KAP and behavioral change among hospital food handlers in public hospitals in Al Qassim.

Study Design

This study employed a quasi-experimental mixed-methods design to evaluate the effectiveness of digital learning tools in improving food safety knowledge, attitudes, practices (KAP), and behavioral change among hospital food handlers. The quantitative component followed a one-group pre-test/post-test design, while the qualitative component explored participants' experiences, perceptions, barriers, and facilitators related to the digital learning intervention.

Study Setting and Participants

The study was conducted in public hospitals in Al Qassim, Saudi Arabia. A total of 211 hospital food handlers participated in the study. Eligible participants were food handlers directly involved in food preparation, storage, distribution, or serving within hospital food service departments. The sample included participants with varying educational backgrounds, work experience, and prior exposure to food safety training. More than half of the participants had not received formal food safety training before the intervention, indicating a clear need for structured training.

Data Collection Instruments

Data were collected using a structured questionnaire, behavioral assessment tools, and qualitative methods. The questionnaire assessed food safety knowledge, attitudes, practices, perceived digital learning effectiveness, and behavioral change before and after the intervention. An observational checklist was used to assess actual food handling behaviors, including hand hygiene, use of protective equipment, prevention of cross-contamination, and temperature control. Qualitative data were collected through key informant interviews and focus group discussions to explore perceptions of the intervention and contextual factors affecting implementation. The instruments were adapted from validated food safety studies and aligned with the KAP framework (Kwol et al., 2020; Taha et al., 2024).

Digital Learning Intervention

The intervention consisted of a structured digital food safety training programmed designed for hospital food handlers. The training included interactive modules, visual demonstrations, scenario-based learning, and quizzes for reinforcement. Core topics included hand hygiene, cross-contamination prevention, temperature control, safe food storage, and use of personal protective equipment. The digital format allowed participants to access training materials flexibly and revisit key content, supporting engagement and knowledge retention (Cai et al., 2023; Zaujan et al., 2021).

Data Analysis

Quantitative data were analyses using SPSS. Descriptive statistics were used to summaries participant characteristics and baseline responses. Since normality assumptions were not fully met, the Wilcoxon signed-rank test was used to compare pre- and post-intervention scores. Effect size was calculated using:$\boldsymbol{r} = \frac{|\boldsymbol{Z}|}{\sqrt{\boldsymbol{N}}}$ Multiple regression analysis was conducted to identify predictors of behavioral change. Qualitative data were analyses thematically to identify recurring patterns related to engagement, perceptions, barriers, facilitators, and sustainability of digital learning implementation]

Results

Descriptive Statistics

The baseline analysis showed that participants had low to moderate levels of food safety knowledge, attitudes, and practices before the intervention. The lowest baseline areas were related to protective equipment use, hand hygiene consistency, food separation, and temperature control. In addition, 53.1% of participants had not received previous formal food safety training, indicating a clear training gap among hospital food handlers.

Pre–Post Comparison of KAP Scores

Pre- and post-intervention scores were compared using the Wilcoxon signed-rank test because the data did not fully meet normality assumptions. The results showed statistically significant improvements across all KAP domains after the digital learning intervention

Construct	Z-value	p-value	Effect Size (r)	Interpretation
Knowledge (K)	−12.626	< .001	0.87	Large
Attitude (DL)	−12.626	< .001	0.87	Large
Practice (FSP)	−12.635	< .001	0.87	Large

All participants recorded higher post-intervention scores, with no negative ranks, indicating a consistent positive shift after the intervention.

Behavioral Change Results

Behavioral change scores also improved significantly following the intervention, $Z = -12.630$, $p < .001$, with a large effect size ($r = 0.87$). All 211 participants showed positive ranks, with no negative ranks or ties. Improvements were particularly evident in hand hygiene, use of personal protective equipment, food separation, and temperature monitoring

The effect size was calculated

$$\text{as: } r = \frac{|Z|}{\sqrt{N}}$$

$$r = \frac{12.630}{\sqrt{211}} \approx 0.87$$

The intervention produced a very large effect on behavioral change (r=0.87). However, given the one-group pre–post design, this magnitude should be interpreted cautiously, as testing effects, response shift bias, or reduced post-test variability may have contributed to the strength of the observed effect. Improvements were mainly reflected in hand hygiene, use of personal protective equipment, food separation practices, and temperature monitoring.

Effect Size Calculation

Multiple regression analysis was conducted to identify predictors of behavioral improvement. The model was statistically significant, $F(4,206) = 33.20$, $p < .001$, and explained 32.5% of the variance in behavioural change ($R^2 = 0.325$).

Predictor	B	Beta (β)	t-value	p-value
Knowledge Improvement	0.285	0.32	4.75	< .001
Attitude Improvement	0.195	0.22	3	0.003
Practice Improvement	0.31	0.35	4.43	< .001
Digital Learning Effectiveness	0.24	0.25	3.1	0.002

Practice improvement was the strongest predictor of behavioral change, followed by knowledge improvement, perceived digital learning effectiveness, and attitude improvement. These findings suggest that behavioral improvement was driven by a combination of practical skill development, increased knowledge, positive attitudes, and perceived usefulness of the digital learning intervention

Discussion

This study examined the effectiveness of digital learning tools in improving food safety knowledge, attitudes, practices, and behavioral change among hospital food handlers in public hospitals in Al Qassim. Overall, the findings demonstrate that the digital learning intervention produced substantial improvements across all measured domains, indicating that technology-supported training can be an effective approach for strengthening food safety performance in hospital food service settings. The significant improvement in knowledge scores suggests that digital learning provided participants with clearer understanding of key food safety principles, including hand hygiene, cross-contamination prevention, temperature control, and appropriate use of protective equipment. This finding is consistent with previous studies showing that digital and interactive training methods can enhance knowledge retention by combining visual content, quizzes, and scenario-based learning (Cai et al., 2023; Zaujan et al., 2021). In the present study, the use of structured digital modules likely helped simplify complex food safety concepts and made them more relevant to daily hospital kitchen tasks. The improvement in attitudes indicates that the intervention did more than transmit information; it also influenced how food handlers perceived the importance of food safety. This is important because positive attitudes are essential for translating knowledge into practice. The qualitative findings supported this interpretation, as participants reported that visual demonstrations made contamination risks feel more real and increased their sense of responsibility. This aligns with the Health Belief Model, which suggests that individuals are more likely to adopt preventive behaviors when they perceive risks as serious and relevant. Food safety practices and behavioral change also improved significantly after the intervention. These results suggest that digital learning helped reduce the gap between knowing and doing, a common challenge in food safety research. Improvements in hand hygiene, glove use, food separation, and temperature monitoring indicate that participants were able to apply training content in practical workplace situations. Regression results further showed that practice improvement was the strongest predictor of behavioral change, followed by knowledge, perceived digital learning effectiveness, and attitude. This confirms that behavioral improvement depends on the combined effect of cognitive understanding, motivation, and practical application. The qualitative findings add important explanatory depth to the quantitative results. Participants described digital learning as accessible, engaging, and practically useful. Interactive quizzes, videos, and scenario-based examples encouraged active participation and helped staff reflect on their daily routines. However, the findings also showed that digital learning effectiveness depends on organizational conditions. Workload pressure, limited time during peak meal preparation, and initial digital literacy gaps were identified as barriers. In contrast, leadership support, monitoring, peer encouragement, and supervisory reinforcement facilitated adoption and sustained engagement. These findings suggest that digital learning should not be treated as a standalone solution. Its success depends on being embedded within a supportive hospital training system. Digital modules should be combined with protected training time, practical demonstrations, refresher sessions, and routine monitoring. Without these supports, staff may complete modules superficially or struggle to apply learned behaviors consistently under work pressure. The study contributes to the KAP framework by showing that digital learning can strengthen the pathway from knowledge to attitude, practice, and behavioral change. However, the findings also suggest that this pathway is not purely linear. Behavioral change was shaped not only by knowledge and attitudes but also by engagement, perceived usefulness, leadership support, and workplace constraints. Therefore, digital food safety training should be understood as both an educational and organizational intervention. Overall, the findings provide strong evidence that digital learning tools can improve food safety KAP and behavioral compliance among hospital food handlers. In the context of public hospitals in Al Qassim, digital learning represents a scalable and practical strategy for improving food safety training, particularly where traditional training is limited by staffing, scheduling, or resource constraints. Nevertheless, long-term sustainability will require continuous reinforcement, institutional commitment, and integration into routine food safety compliance systems.

Implications for Theory and Practice

The findings of this study have important implications for both theory and practice. From a theoretical perspective, the results support the Knowledge–Attitude–Practice (KAP) framework by showing that improvements in food safety knowledge and attitudes can contribute to better food handling practices and behavioral change. However, the findings also suggest that this relationship is not purely linear. Behavioral change was influenced not only by knowledge gain, but also by practical application, perceived usefulness of digital learning, and organizational support. The study also extends the application of behavior change theories in digital food safety training. The findings indicate that digital learning can strengthen risk awareness, motivation, and confidence in applying safe food handling behaviors. This supports the relevance of the Health Belief Model and the Theory of Planned Behavior in explaining how food handlers move from awareness to action in hospital food service settings. In practice, the study demonstrates that digital learning can be used as an effective training strategy for hospital food handlers. Interactive modules, visual demonstrations, quizzes, and scenario-based learning can help staff understand food safety risks more clearly and apply correct procedures in daily work. Hospitals can therefore use digital learning to standardize food safety training, reduce reliance on occasional face-to-face sessions, and improve training access for staff working different shifts. The findings also show that digital learning should be integrated with practical supervision and routine monitoring.

Training is more likely to produce sustained behavioral change when supported by leadership, peer encouragement, protected training time, and refresher sessions. Therefore, hospitals should treat digital learning as part of a broader food safety improvement system rather than as a standalone training activity.

Policy Implications

The findings of this study have important policy implications for hospital food safety governance and workforce training. The results suggest that digital learning should be formally recognized as a valid and effective training method for hospital food handlers, particularly in public hospitals where continuous face-to-face training may be difficult to implement. Health authorities and hospital regulators, including the Ministry of Health and relevant food safety agencies, should consider developing standardized digital food safety training frameworks. These frameworks should define minimum training content, required competencies, assessment procedures, and refresher training schedules for hospital food handlers. The findings also support linking digital food safety training to compliance monitoring and hospital accreditation systems. Requiring documented completion of digital training modules could strengthen accountability and ensure that food handlers receive consistent and updated food safety education. In addition, policymakers should support investment in digital infrastructure, including access to devices, internet connectivity, and user-friendly training platforms. This is particularly important for hospitals with limited resources or staff with varying levels of digital literacy. Overall, digital food safety training can serve as a scalable policy tool to improve food safety compliance, reduce contamination risks, and strengthen patient safety within healthcare food service system

Conclusion

This study provides strong evidence that digital learning is an effective approach for improving food safety knowledge, attitudes, practices, and behavioral compliance among hospital food handlers. The findings demonstrate that the intervention not only enhanced cognitive understanding but also translated into consistent improvements in daily food handling behaviors, particularly in critical areas such as hand hygiene, cross-contamination prevention, and temperature control. Importantly, the results confirm that behavioral change is not driven by knowledge alone but emerges from the interaction between knowledge, attitudes, practical skills, and perceived training effectiveness. The significant predictive role of practice improvement further highlights that hands-on applicability and behavioral reinforcement are central to achieving meaningful food safety outcomes. From a practical perspective, digital learning offers a scalable and flexible training solution that can overcome many of the limitations associated with traditional training methods, especially in resource-constrained hospital environments. However, the findings also indicate that the effectiveness of digital learning depends on supportive organizational conditions, including leadership commitment, monitoring systems, and adequate time allocation for training. Overall, this study suggests that digital learning can serve as a valuable component of hospital food safety systems, particularly when integrated within broader institutional frameworks that support continuous learning and behavioral reinforcement.

Limitations

Despite its contributions, this study has several limitations that should be considered when interpreting the findings. First, the study employed a one-group pre–post design without a control group, which limits the ability to establish causal inference. The observed improvements may partly reflect testing effects or response consistency rather than intervention effects alone. Second, the evaluation focused on short-term outcomes, and therefore does not provide evidence on the long-term sustainability of behavioral change. Future studies should incorporate longitudinal follow-up assessments to determine whether improvements are maintained over time. Third, the study relied partially on self-reported measures, which are subject to social desirability bias. Although qualitative and observational data were used to support the findings, some degree of response bias cannot be ruled out. Fourth, the study was conducted in public hospitals within a single region (Al Qassim), which may limit the generalizability of the findings to other healthcare settings with different organizational structures or resource levels. Finally, contextual factors such as workload pressure and operational constraints were not quantitatively measured, although they were identified qualitatively as important influences on behavioral compliance.

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