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Posted Date: 2 April 2025

doi: 10.20944/preprints202504.0146.v1

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 doi:10.20944/preprints202504.0146.v1

Review

The State of Food Safety Knowledge, Attitudes, and Practice in the Food Establishments in the Arab Countries

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Abstract: A scoping review was conducted to study the current state of food safety knowledge, attitudes, practices (KAP) of food handlers in the Arab countries. The literature search identified forty-one studies aligning with the inclusion criteria, and their findings were analyzed and discussed. While studies commonly reported fair to good knowledge of personal hygiene among food handlers, significant gaps remained in proper hand hygiene practices. Additionally, food safety knowledge deficits were particularly pronounced among street vendors and those in low-socioeconomic countries. Despite inconsistencies in results across the studies, widespread misperceptions and deficiencies were evident regarding temperature control of food, sanitation, and cross-contamination prevention. These shortfalls extended to poor practices and sometimes to attitudes that reflected a lack of awareness of their significance, posing a risk of cross-contamination during the preparation, holding, and storage of food, including in healthcare settings. The KAP data indicate a fundamental lack of knowledge in critical food safety areas across the different food sectors, albeit the hospitals and institutional settings performed better. These results underscore the need for ongoing training on hygienic practices and food safety and formalised and targeted educational programs in food safety. A paradigm shift in vocational education and training, reinforced by the right culture and competencies at the level of public authorities and employing practical learning and stringent licensing programs, could help raise the standards of food safety practices..

Keywords: Food safety; KAP; Food handlers; Food safety knowledge; Food safety attitudes; Food safety practices; food service; Arab region

1. Introduction

Food safety has become a significant public health concern globally, and it is no longer a nascent topic in the Arab region. Even though there's been considerable effort on food safety and preventive measures being put in place across food businesses, foodborne illness outbreaks are still a significant problem worldwide. Despite variations in the current politico-economic situations, the Arab region is experiencing transformative changes in the food systems and regulatory landscapes due to general shifts in dietary habits and lifestyles, specifically in the middle and high-income countries.

 doi:10.20944/preprints202504.0146.v1

Additionally, the expansion of food trade has enabled some countries to prioritise health and consumer protection on their political agendas, often driven by trade obligations. This trend is evident from the regulatory developments and institutional restructuring in the Kingdom of Saudi Arabia, Jordan, Egypt, the United Arab Emirates (UAE), Tunisia, Morocco, and others [1].

Several Arab countries leverage their geographic proximity to the EU and Africa and their agricultural product competitiveness to enhance their agricultural exports. For instance, Morocco, Tunisia, and Egypt are geographically well-positioned to serve European and African markets. Between January and March 2024, Morocco exported nearly 35,000 tons of fresh and frozen produce to Germany, a 40% increase from last year [2]. Also, Egypt's processed food and beverage exports reached US$32.1 billion in 2021 (about 26%) compared to US$25 billion in 2020. In 2022, Saudi Arabia exported nearly US$10.6 million of food products to the U.S., including processed dates [3].

Meanwhile, in addition to the prevalence of street vendors in low- and middle-income countries, the food service industry is also thriving, with many businesses operating either international fast-food franchises or offering local traditional cuisine. It is a standard requirement of international food safety requirements and local regulations that food businesses take all appropriate measures to ensure food handlers are not a source of microbiological, chemical or physical contamination that could lead to foodborne illnesses. Unsafe food can result from undercooked foods of animal origin, improper holding and storage conditions, poor sanitation, cross-contamination during preparation and storage, and contaminated raw ingredients and raw materials. Consequently, it may lead to adverse health consequences and possibly death.

One of the standard requirements to ensure food safety is that food handlers must be trained on the principles of food safety and hygiene, as well as the health policy. The role of food workers in foodborne diseases is well documented, with research linking them to 816 foodborne outbreaks. All the outbreaks involved workers of some kind, and most food workers were infected. According to the CDC, hundreds of the foodborne illness outbreaks reported in the U.S. each year can be traced to one cause: food workers who come to work sick [4]. Food handlers have been implicated in outbreaks, while they were not always aware of their infections [5], either because they were in the phase before symptoms began or because they were asymptomatic carriers. Lengthy post-symptomatic shedding periods and excretion by asymptomatic individuals of many enteric pathogens is an essential issue for the hygienic management of food workers. Sick employees have been implicated in foodborne illness outbreaks caused by at least 14 germs [4]. It is reported that 80% of communicable diseases are reported to be transferred by touch [6], highlighting the need for well-informed food handlers, practical training and education on hand hygiene and safe food handling, and for food facilities to take adequate measures to ensure staff conform with the hygiene requirements.

The Eastern Mediterranean Region, which includes countries in the Arab region, has the third highest estimated burden of foodborne diseases per population after the African and South-East Asian regions. Diarrheal diseases (caused by E. coli, Norovirus, Campylobacter, and non-typhoidal Salmonella) account for 70% of the burden of foodborne disease [7].

The Arab region includes a diverse group of countries, e.g., the Gulf Cooperation Council (GCC) countries (Bahrain, Kuwait, Oman, Qatar, KSA, and the UAE), Algeria, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Somalia, Sudan, Syria, Tunisia, and Yemen. These countries exhibit varying levels of progress and advancement in their national food control systems and resources. On the one hand, the high-income countries, namely the GCC countries, have made substantial strides in their food control systems and initiatives to formalize the food safety training requirements of food workers, such as in the UAE, where the Person in Charge (PIC) program, an initiative, led by Dubai Municipality, mandates that food establishments appoint certified individuals responsible for ensuring food safety compliance, setting a benchmark for food safety standards in the region. On the other hand, enforcement of regulations is inadequate in many countries, particularly the low- and medium-income countries [1]. In 2013, a food outbreak affected more than 100 people who attended a restaurant in Tikrit City [8]. The investigations showed that only one worker of the thirteen interviewed had a valid health card, and

 doi:10.20944/preprints202504.0146.v1

three had a history of diarrhea 2-3 days before the outbreak. They were handling food, and none had attended food safety education and training sessions held by the Health Inspection Section. Similarly, Lebanon has witnessed numerous cases of food poisoning and food fraud that prompted the Lebanese government to initiate an unprecedented food safety campaign [9], which showed non-conformity with the local standards attributed to Salmonella and E. coli contamination due to a lack of knowledge on proper food handling resulting in lack of hygiene and contaminated storage areas.

These cases and others reported globally show that well-informed and compliant food handlers constitute a vital defense for food safety, which starts with acquiring and applying the necessary knowledge in food safety. Food safety knowledge can be defined as the understanding and information that a food handler acquires on foodborne disease transmission and risk factors, and the appropriate handling, manufacturing, holding, and storing of food to prevent and control hazards that could lead to foodborne diseases. Proper knowledge and a positive attitude towards food safety have been linked to strengthening food handling practices, which are instrumental in preventing foodborne diseases [10].

As the food safety landscape and regulatory systems have continued to evolve in the region for the past two decades, ensuring that food safety standards are consistently applied is essential to protect public health and support the food industry's sustainability. This review synthesizes and evaluates data from existing studies on the Knowledge, Attitudes, and Practices (KAP) of food handlers operating within the food service sector in the Arab region. With the increasing availability of KAP research in recent years, this review aims to assess the KAP levels of food handlers across different Arab countries. It seeks to highlight common gaps or misconceptions among food handlers providing evidence-based findings that can inform the development of educational campaigns targeting specific deficiencies in knowledge, attitudes, and practices.

2. Materials and Methods

A scoping review methodology was adopted based on Arksey and O'Malley's framework [11] to systematically explore and synthesize existing literature on the KAP of food handlers within the food service sector in the Arab region. The methodology comprised the following five sequential steps:

Formulation of Research Inquiry:

The primary objective was to explore the KAP levels of food handlers operating within the food service sector in the Arab region.

A food handler, food worker, or food employee is defined as an individual, i.e. receiving, unpacking, storing, preparing, cooking, and serving food. They can prepare raw and prepared food, ready-to-eat (RTE) food, using or in direct contact with food contact and non-food contact equipment and utensils. They may also touch or handle non-food items such as money, vendors, and customers. Such individuals include chefs, assistant chefs (cooks and cook helpers), and managers employed in food service operations such as fine-dining and fast-food restaurants, hospital operations, university cafeterias, schools, and street vending carts.

Identification of Relevant Studies:

A comprehensive search was implemented to identify relevant studies from PubMed, ScienceDirect, and Google Scholar as well as regular Google search and the Egyptian Knowledge Bank.

 doi:10.20944/preprints202504.0146.v1

Keywords related to food safety, food handlers, knowledge, attitudes, practices, and the Arab region were utilized to ensure the inclusion of pertinent literature. In addition, the same terms were combined with each country's name in the region to provide comprehensive coverage of relevant literature. For instance, a literature search was conducted using terms such as “food handlers” OR “food handling” AND “Practices” OR “food safety practices” AND “Attitude” AND “knowledge.” Key terms such as “challenges to food safety practices” AND “Arab region,” “food safety knowledge” OR “food safety” AND “food service establishments” were also included. All keywords were combined with “Arab region” OR “Arab countries,” including the “GCC countries” in every search. We have also included “hand hygiene" terms and “barriers to safe food handling” to account for studies that may have focused on specific areas and factors affecting the KAPs.

Selection of Studies:

Criteria for inclusion and exclusion were established to screen and select studies that aligned with the research focus. Studies examining the KAP of food handlers in the food service sector within Arab countries were included, while those outside the region that did not focus on the KAP were excluded.

The considerations of inclusion criteria included:

(1) Geographical consideration: our search was limited to studies conducted in the Arab region, which include the GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE)), Algeria, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Somalia, Sudan, Syria, Tunisia, and Yemen.

(2) Language: We included publications in English or Arabic to ensure accessibility and comprehensiveness.

(3) Scope: Studies published from 2000 to 2024 on food handlers employed in various food services settings, such as restaurants, cafes, catering establishments, and street food vendors, were included in the search. It was assumed that most KAP studies in the region were conducted within the past two decades and that expanding the scope to a period that witnessed advancements in food safety standards and regulations would also provide comprehensive coverage of existing research.

The search covered research articles and reviews published in peer-reviewed journals and conference proceedings (if available). We included only studies examining food safety knowledge, attitudes, and practices among food handlers or factors affecting these three aspects, as assessed through surveys, interviews, focus groups, or observational methods.

As for the exclusion criteria, studies focusing on farmers’ and butchers’ KAP, home-based online food businesses, and consumers’ food safety behaviours or perceptions were excluded. Scoping and systematic reviews were excluded. Studies and literature reviews lacking validated tools and surveys or published with weak English writing, inadequate methodological quality, or insufficient reporting of results were also excluded.

The article selection process adhered to the principles outlined in the modified PRISMA statement for scoping reviews. This simplified approach was adopted to accommodate a range of studies that vary in design and methodologies, given the goal was to map out existing research on KAPs. Following eliminating duplicate entries, a preliminary selection was conducted based on a

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review of titles and abstracts. Subsequently, full-text analyses of the remaining publications were undertaken to assess their eligibility against predefined inclusion criteria. All co-authors performed the literature search and revised the final list of selected articles to ensure no references were overlooked.

Data Compilation and Analysis:

Data extraction was performed from the selected studies to capture relevant information regarding food safety KAP. Key findings and trends were synthesized, allowing for a comprehensive analysis of the existing literature.

Summary and Reporting of Results:

The extracted data were categorized into three sections: knowledge, attitude, and practices. The findings of each were systematically analyzed, summarized, and discussed to highlight key insights into food handlers' understanding as well as the gaps within practices in the food service sector.

3. Results and Discussion

Overall, the literature search generated 120 articles, of which forty-four met the search criteria. All authors reviewed the studies and assessed the data for extraction, leading to further exclusions due to poor English writing, which rendered the content and interpretation of results unclear, as well as methodological deficiencies. All authors conducted the selection process for these studies. Table 1 presents an overview of the studies (N = 40) included in this review.

Multiple studies assessed the KAP in various settings, with some employing different analytical approaches and interpretations. While some focused on the three KAP components, others specifically researched knowledge, reported practices, or both practices and attitudes. Most studies relied on self-reported practices, except for two conducted in Lebanon and Egypt, where authors used observational assessment to explore food safety practices (Table 1). Also, the analysis methods, determination of the cut-off point for knowledge adequacy, and the scope of the studies varied. For instance, Idris et al. [12] measured food handlers' knowledge on a Likert Scale of agreement, a typical method used to assess attitudes. Such differences limit the scientific accuracy of conducting a comparative analysis across specific variables. Furthermore, the limited number of studies available per country hiders the ability to assess and explore the impact of external factors, such as regional variations in regulatory frameworks, resources, and environments, on food safety compliance and knowledge.

As shown in Table 1, the retrieved studies primarily originated from a few countries in the Arab region, mainly middle-income and GCC countries, indicating a lack of comprehensive information for the region, e.g., Syria, Tunisia and Comoros. Also as expected, the search did not yield any results for low-income countries, and those under prolonged conflicts, such as Yemen, Iraq, Libya, with the exception of a few studies from Sudan and Somalia. The overall KAP scores for food handlers in restaurants, universities, and hospitals ranged from as low as 48.73% to 84.82%. Higher KAP scores (above 70%, a common benchmark in KAP studies) were predominantly reported in hospital settings, except in Lebanon. In the restaurants, KAP scores were relatively similar across Jordan and Lebanon, ranging from 56.6% in Lebanon to 69.4% in Jordan. At the same time, higher scores were reported in the UAE and Kuwait, where mean knowledge scores reached 70% (Table 1).

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Table 1. Studies on the food safety knowledge or KAP of food handlers in the Arab countries.

	Research setting	Sample size	Survey approach	Overall food safety knowledge†	Country	References
	Hospitals					
1	Hospital and fast food restaurants	N= 140	KAP towards food poisoning	76.63±19.6	Egypt	[13]
2	Ministry of Health and Population hospitals of Gharbia Governorate (N=17)	N= 161	Observational assessment of food safety practices before and after educational intervention	N/A	Egypt	[14]
3	Hospitals (N= 4)	N= 132	Effect of educational program on KAP	9.2 ± 5.3 (before) 18.5±3.9 (after)*	Egypt	[15]
4	Egyptian government hospitals (N=27)	N= 542	KAP	81.67%	Egypt	[16]
5	Hospitals (N=3)	N= 50	KAP	No overall score on knowledge	Iraq	[17]
6	Hospitals (N= 37)	N= 532	Food safety knowledge	62.5%	Jordan	[18]
7	Public and private hospitals (N=6)	N= 245	Food safety knowledge	71.2%	Jordan	[19]
8	Hospitals (N= 7)	N= 200	KAP	84.82%	Jordan	[20]
9	Hospitals (N= 10)	N= 163	Food safety knowledge and practices	77.9%	KSA	[21]
10	Hospitals (N=5)	N= 315	Food safety awareness and practices	No overall score	KSA	[22]
11	Hospitals (N= 13)	N= 254	KAP	59.2%	Lebanon	[23]

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12	University hospital	N= 72	Food safety knowledge and practice	0.54 ±0.15, corresponding to 54% of the questions answered correctly.	Morocco	[24]
113	Hospital (N= 1)	N= 43	KAP‡	91.9 %	Qatar	[25]
14	Hospital (N=3)	N=86	KAP	62.27%	Sudan	[26]
15	Hospital (N = 7)	N = 32	Knowledge and practices	No data	Sudan	[27]
	Food businesses					
16	Cafeterias, restaurants, food establishments and roadside food seller	N=994	KAP	39.2%	Egypt	[28]
17	FSEs (N= 79) on 34 university campuses	N= 520	Food safety knowledge	67.1%	Jordan	[29]
18	Fast food restaurants (N= 297)	N= 1084	Food safety knowledge	69.4%	Jordan	[30]
19	Restaurants (N= 2), university canteens (N= 5)	N= 87	KAP	No data	KSA	[31]
20	Restaurants (e.g., banquet kitchens, fast food, fine dining, and traditional food restaurants)	N= 389	KAP	9.3 ± 1.8	KSA	[32]
21	Restaurants	N= 402	KAP	70%	Kuwait	[33]
22	Catering establishments in community and healthcare settings	N= 405	Food handling and proper hygiene practices	N/A	Kuwait	[34]
23	Restaurants (N=50)	N= 80	KAP	56.6±21.0 on a 100 points scale	Lebanon	[35]
24	Restaurants (N= 50)	N= 80	Observational assessment of	N/A	Lebanon	[36]

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			food safety practices			
25	Catering establishments (N=22)	N= 282	KAP	65.31%	Morocco	[37]
26	Restaurants (N=21)	N=21	Food safety Knowledge	No overall mean score	Oman	[38]
27	Restaurants (N=18)	N=54	Food safety Knowledge and hygienic practices	No overall mean score on knowledge	Oman	[39]
28	Restaurants (N= 202)	N= 308	Food sanitation practices	N/A	Palestine	[40]
29	FSEs (N= 53)	N= 53	Food safety practices**	N/A	Qatar	[41]
30	Fast-food restaurants in Qatar university	N= 102	KAP	No data	Qatar	[42]
31	FSEs (N= 88) restaurants, cafeterias, coffee shops	N= 646	Food safety knowledge	70%	United Arab Emirates	[43]
32	Restaurants (N=30)	N=30	Food hygiene practices	N/A	Somalia	[44]
33	Restaurants (N= 34)	N=40	Food safety practice	81.74% ± 5.29	Sudan	[45]
34	Food premises (N= 24) in nine university campuses	N=105	Knowledge and practices	No overall mean score – authors referred to proportions.	Sudan	[12]
	Street food					
35	Street vendors, cafeterias, and popular restaurants,	N=130	KAP	No overall mean score	Iraq	[46]
36	Mawakibs‡ (N=100)	N= 504	KAP	No overall score	Iraq	[47]
37	Street food vendors	N= 405	KAP	32% (<50% poor)	Jordan	[48]

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38	Street vendors	food	N= 120	Food safety knowledge and attitudes	54% (with 60% cut off point)	Jordan	[49]
39	Street vendors	food	N= 50	Food safety knowledge and practices/ Microbial quality assessment	No overall score	KSA	[50]
40	Street vendors	food	N= 30	Food safety practices and microbiological quality of food	N/A	Lebanon	[51]

The total score of KAP is not reported in all studies. N/A: not applicable; KAP: Knowledge Attitudes and practices. ‡ Temporary rest areas (locally called Mawakib) serving food to Arbaeenia mass gathering† Mean percentage score: Overall score of food safety knowledge calculated by summating correct answers and later converted into a percentage. * There is no information on the basis used to calculate the overall knowledge score in this study. **The authors referred to the education and training levels of surveyed subjects as "food safety knowledge.".

3.1. Food Safety Knowledge

In general, studies addressing food safety knowledge have analysed scores differently. Some authors calculated the scores thematically, assigning a score for each food safety knowledge theme (e.g., cross-contamination, personal hygiene, etc.) and presenting the results as frequency distributions. Others have established scoring methods with a cut-off point to evaluate knowledge adequacy, e.g., poor, fair, good.

For instance, El Sherbiny et al. [15], Al-Shabib et al.[31], Al-Ghazali et al.[39], and Mohieldin et al. [27] classified knowledge scores into broad categories such as "personal hygiene" and "cleaning and sanitation." However, the authors did not provide details on the variables measured under each theme.

Hence, the findings of all studies are presented and discussed thematically, with the key insights summarised in Table 2. For studies that used nearly identical questions and scoring methods, their data are presented in Tables 3, 4, and 5, While for other studies, the data are presented and discussed in the corresponding section.

Table 2. Summary of key findings.

Theme	Key Findings
Personal Hygiene	Knowledge of handwashing necessity was high but poor to fair for specific occasions when handwashing is important before food handling (e.g., after handling money). Awareness of correct handwashing techniques was not strong overall. There was a high awareness of the contamination risk from touching ready-to-eat food with bare hands. However, gaps in knowledge and self-reported practices in relation to correct glove use and PPE were notable.

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Cross-Contamination	There is a general good knowledge of the importance of handwashing after handling raw meat, but significant gaps in understanding of the rationale behind it such as pathogen transfer from raw to cooked food was observed in the majority of studies, with the exception of moderate to high knowledge levels reported in hospitals. Knowledge deficits were commonly reported in areas related to sanitation and the concept of separation (separating raw from cooked food, as well as utensils used for raw and cooked food).
Temperature Control & Food Storage	Knowledge of correct refrigeration/freezer temperatures was inconsistent, and awareness of proper thawing and refreezing methods was low. Few studies examined practical temperature control measures.
Food Temperatures	Awareness of cold and hot holding temperatures was generally low.
Handling & Storing Leftovers	Food handlers had poor knowledge of the safe handling and storage of leftovers to protect from temperature abuse and cross-contamination risk.
Foodborne Illnesses Knowledge	Recognizing foodborne illness symptoms varied, with higher awareness in Jordan but significant knowledge deficits in UAE, Saudi Arabia, and Lebanon, particularly in understanding that contamination isn't always visible or distinguishable from spoilage.
Foodborne Pathogen Knowledge	Generally low knowledge, with significant gaps in awareness of specific pathogens like *Listeria*, E. *coli*, and Hepatitis A, particularly in Jordan, Kuwait, and Lebanon.
Temperature Control & Storage	Knowledge of temperature control and the bacterial danger zone was generally poor, with significant gaps across Lebanon, Qatar, Saudi Arabia, and Kuwait, despite food safety training in some cases.

3.1.1. Personal hygiene

The majority of the studies indicated that while food handlers generally know the role of hygiene in preventing contamination, knowledge gaps remain in specific handwashing scenarios (Table 3). In Egypt, only 37.1% of participants recognized that non-compliant food handlers could be a source of food pathogens (Hamad and Mahmoud, 2020). Over 80% of food handlers were aware of the need to wash their hands after obvious contamination events, such as using the toilet, handling wastes, or sneezing. However, awareness was notably lower for handwashing after handling money [18,29,43,50] or before and after wearing gloves [43]. In Iraq, 99% of the food handlers agreed that washing hands should be a frequent practice [47]. Food handlers in hospitals and restaurants exhibited different levels of knowledge. In Lebanon, 62% of food handlers in studied hospitals believed that washing with water alone was sufficient [23]. In contrast, 63% of food handlers in Jordanian hospitals recognized the importance of handwashing after handling money, compared to 72% of university food service workers [18,29].

Food handlers' knowledge of handwashing after handling raw meat varied between and within countries. For instance, a high proportion of food handlers demonstrated a strong knowledge in studies conducted in Jordan and Kuwait (over 90%)[18,19,29,30,52]; similarly, in Lebanon, Faour-Klingbeil et al. (2015) found that most interviewed food handlers (90%) knew the importance of handwashing after touching raw meat and raw eggs and before handling unwrapped RTE foods. Whereas less than half (50%) of food handlers in Egyptian restaurants, Saudi Arabian catering services, Jordanian street vendors, and Moroccan food establishments were aware of its importance in preventing cross-contamination [15,21,24,28,48]. Furthermore, food handlers across various work environments were insufficiently knowledgeable about proper handwashing duration. Up to 75% of food handlers in Jordanian hospitals, Moroccan restaurants, the UAE, and Kuwaiti food service facilities were unaware of the recommended 20-second standard [18,29,30,37,43,52]. Food handlers in university cafeterias in Jordan displayed better awareness of maintaining clean and sanitised hands [49].

 doi:10.20944/preprints202504.0146.v1

Studies assessing mask use, uniforms, and hair covering among food handlers revealed notable gaps in knowledge and self-reported practice (Table 3). Studies conducted in Jordan[18,19,29], Oman [38], the UAE [43], and Kuwait [52] showed significant gaps in understanding work attire and hairnet usage. As for mask usage during food distribution, studies in Jordan [18,29] and Oman [38] found that fewer than 60% of respondents recognized its importance.

Differences in knowledge were also observed based on the work environment. Food handlers in hospitals and university cafeterias demonstrated greater awareness than their counterparts in restaurants. In Jordan, hospital food handlers exhibited higher recognition of mask usage and work attire importance than restaurant workers, possibly due to stricter hygiene policies in healthcare settings [18,29]. Similarly, awareness of personnel illness as a source of food contamination was higher among hospital workers than in restaurants, where less than 60% of respondents acknowledged the risks associated with handling food while experiencing symptoms of nausea, vomiting, or diarrhoea [15,50]. Several studies assessed personal hygiene as part of a knowledge questionnaire or through food handlers' perceptions. These variations in methods, along with inconsistencies in question formulation and response options made a direct comparison challenging.

Table 3. Food handlers' knowledge on personal hygiene.

Questions on the importance of performing each of the following:	**N (%)[a]**	**N (%)[b]**	**N(%)[c]**	**N (%)[d]**	**N (%)[e]**
	Hospitals (Jordan)	Universities (Jordan)	Food business (UAE)	Food business (Kuwait)	Food business (Jordan)
Washing hands after touching money	337 (63.3)	378 (72.7)	351 (54.3)	No data	90.5
Washing hands after eating meals	518 (97.4)	500 (96.2)	490 (75.9)	No data	98.1
Washing hands before preparing meals /food preparation	441 (82.9)	502 (96.5)	560 (86.7)	400 (99.5)	95.8
Washing hands after using toilets	528 (99.2)	504 (96.9)	591 (91.5)	400 (99.5)	98.6
Washing hands after handling raw meats or poultry	521 (97.9)	485 (93.3)	459 (71.1)	390 (97.0)	97.6
Washing hands after touching the body	410 (77.1)	472 (90.8)	455 (70.4)	386 (96.0)	92.7
Washing hands during continuous food handling /making salad	471 (88.5)	442 (85.0)	318 (49.2)	No data	94.1
Washing hands after touching the sanitized countertop	311 (58.5)	384 (73.8)	256 (39.6)	No data	82.2
Washing hands after sneezing and coughing	485 (91.2)	485 (93.3)	521 (80.7)	No data	96.9
Washing hands after cleaning tables	474 (89.1)	472 (90.8)	504 (78.0)	392 (97.5)	97.0
Washing hands after handling the garbage	522 (98.1)	496 (95.4)	559 (86.5)	395 (98.3)	98.0
Washing hands after touching work clothes	405 (76.1)	389 (74.8)	349 (54.0)	No data	89.7

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Washing hands after using mobile phone	224 (42.1)	No data	No data	No data	
Washing hands before wearing gloves	392 (73.7)	291 (56.0)	390 (60.4)	No data	
Washing hands after removing gloves	453 (85.2)	375 (72.1)	411 (63.6)	No data	
The duration of hand washing is 20 seconds or more	157 (29.5)	166 (31.9)	395 (61.1)	264 (65.7)	31.9
Wearing gloves before touching RTE food products	503 (94.5)	479 (92.1)	493 (76.3)	373 (92.8)	91.9
Wearing gloves when touching or distributing unwrapped food to patients† / unpackaged food‡/uncovered food	489 (91.9)	388 (74.6)	473 (73.2)		
Wearing a uniform during touching or distributing unwrapped food to patients† / unpackaged food	488 (91.7)	413 (79.4)	435 (67.3)		
Wearing a mask during touching or distributing unwrapped food to patients / uncovered food	310 (58.3)	112 (21.5)	330 (51.1)		
Wearing hair net during touching or distributing unwrapped food to patients	468 (88.0)	339 (65.2)	493 (76.3)		

Source: Faour-Klingbeil [1].[a] Osaili et al. [18]; [b] Osaili et al.[29]; [c] Taha et al.[43]; [d] Al-Kandari et al.[33] ; [e] Osaili et al.[30]. The percentage figures represent the % answers as "yes" to questions.

3.1.2. Sanitation and cross-contamination prevention

The majority of the studies showed gaps in food handlers' understanding of proper cleaning and sanitation of food contact surfaces, such as knives and cutting boards (Table 4). Less than 65% of food handlers in Kuwait, Lebanon, Egypt, the UAE, and Jordan recognized the necessity of both, washing and sanitising utensils [15,18,19,29,30,33,35,43,48,49]. This limited knowledge is particularly concerning given that improper cleaning and sanitation in food premises may contribute to cross-contamination risks. In Iraq, nearly all food handlers (96%) incorrectly believed that using detergent alone was sufficient for decontamination [17], indicating a fundamental misunderstanding of proper hygiene practices.

Regarding cross-contamination prevention, only 10–60% of food handlers in restaurants and hospitals in Jordan were aware that separate cutting boards and knives should be used for vegetables and raw meat. Similar proportions were reported in Morocco (40–60%), the UAE (40–50%), and Saudi Arabia (30%) [18,24,29,30,37,49,53]. In contrast, a higher proportion of food handlers in Iraq (90%) correctly knew the need for utensil separation [46]. Cross-contamination emerged as a potential concern in the studied Lebanese hospital, where only 78% of employees used separate kitchen utensils to prepare raw and cooked food despite their attitudes being considerably much more positive toward this task (94%)[23].

In a question about knowing the need for raw and processed food to be handled separately, only 54.6% of workers in collective catering facilities in central Morocco agreed with this [37], and it was even much less (8%) during serving food at a Mawakib mass gathering in Iraq [47], but the latter may not be typical of most food service operations because Mawakib food handlers are volunteers and

 doi:10.20944/preprints202504.0146.v1

not all the handlers reported prior experience in food handling, which may explain a lack of knowledge in food safety and personal hygiene.

Proper food refrigeration, such as placing raw meat or poultry on lower shelves to prevent contamination from dripping, was inconsistently understood across studies. Food handlers in Lebanese restaurants [35] and Jordanian hospital kitchens [20] demonstrated a relatively high awareness of proper food storage in refrigerators to avoid cross-contamination. In contrast, in Egypt, a mere 34% know about storing vegetables on a rack above meat to prevent cross-contamination [28]. Similar knowledge deficiencies with regard to handling and storage of leftovers safely were observed among food handlers in several studies in Jordan [18,19,29,30] (Table 5). However, a high proportion of correct answers does not necessarily reflect a true understanding of the concept of cross-contamination or the reasoning behind safe practices, as responses may also be influenced by the interpretation of questions or the way questions are formulated. For instance, in the Lebanese study, the majority (95%) correctly stated that raw and cooked food handling and preparation should be separate; however, when asked for the reason for this separation, only two-thirds (62%) answered correctly. Moreover, less than half (49%) recognized the most common cause of food contamination [35].

Faour-Klingbeil et al. [35] also found that when food handlers were asked why frozen meat should be thawed on the lowest rack of a refrigerator containing salad, 34% incorrectly believed that the lowest shelf has the least cold atmosphere, making it suitable for the thawing process. Notably, nearly half of them (47%) had received training in food safety. Poor knowledge in this area was reported in Iraq (33.8%) [46], Egypt [13,15] (10 – 35%), the UAE [43] (60%), Morocco [24] (38%), and Saudi Arabia [21] (30%).

Additionally, fewer than 30% of food handlers in a Jordanian study were familiar with the use of disposable tissues and color-coded utensils [49]. However, a study in Saudi Arabia reported that 94.3% of food handlers were aware of the benefits of color-coded utensils [22].

Table 4. Food handlers' knowledge of cross-contamination prevention and sanitation.

Questions on the appropriateness of each of the following:	**N (%)[a]**	**N (%)[b]**	**N(%)[c]**	**N (%)[d]**	**N (%)e**
	Hospitals (Jordan)	Universities (Jordan)	Food business (UAE)	Food business (Kuwait)	Food business (Jordan)
Using the same knife to cut raw meat or poultry and to chop vegetables	17 (3.2)	8 (1.5)	18 (2.8)		
Washing knife used to cut raw meat or poultry with cold water before using it to chop vegetables	24 (4.5)	35 (6.7)	32 (5)		21.0
Washing knife used to cut raw meat or poultry with hot water before using it to chop vegetables	44 (8.3)	77 (14.8)	139 (21.5)	274 (68.2)	55.4
Washing knife used to cut raw vegetables before using it to	125 (23.5)	138 (26.5)	155 (24.0)	298 (74.1)	48.4

 doi:10.20944/preprints202504.0146.v1

chop meat or poultry with water and soap					
Washing knife used to cut raw meat or poultry with water and soap then applying sanitizer before using it to chop vegetables	227 (42.7)	176 (33.8)	394 (62.0)	276 (68.7)	50.6
Wiping knife used to cut raw meat or poultry with a piece of cloth before using it to chop vegetables	25 (4.7)	30 (5.8)	47 (7.3)		10.9
Changing knife to cut raw meat or poultry and to chop vegetables	232 (43.6)	272 (52.3)	336 (52)		73.6
Using the same cutting board to cut raw meat or poultry and to chop vegetables	13 (2.4)	10 (1.9)	8 (1.2)		3.3
Washing cutting board used to cut raw meat or poultry with cold water before using it to chop vegetables	20 (3.8)	17 (3.3)	26 (4)		16.9
Washing cutting board used to cut raw meat or poultry with hot water before using it to chop vegetables	44 (8.3)	63 (12.1)	141 (21.8)	282 (70.1)	54.0
Washing cutting board used to cut raw meat or poultry with water and soap before using it to chop vegetables	99 (18.6)	120 (23.1)	161 (24.9)		45.0
Washing cutting board used to cut raw meat or poultry with water and soap then applying sanitizer before using it to chop vegetables	215 (40.4)	154 (29.6)	401 (62.1)		51.6
Wiping cutting board used to cut raw meat or poultry with a piece of cloth before using it to chop vegetables	24 (4.5)	27 (5.2)	37 (5.7)		8.0
Changing cutting board to cut raw meat or poultry and to chop vegetables	252 (47.4)	299 (57.5)	391 (60.5)		75.5
Storing vegetable salad on the upper shelf in the refrigerator	214 (40.2)	165 (31.7)	390 (60.4)		69.0

 doi:10.20944/preprints202504.0146.v1

if raw meat or chicken in the middle shelf					
Storing vegetable salad in the middle shelf in the refrigerator if raw meat or chicken in the middle shelf	13 (2.4)	15 (2.9)	24 (3.7)		9.8
Storing vegetables salad in the lower shelf in the refrigerator if raw meat or chicken in the middle shelf	50 (9.4)	39 (7.5)	53 (8.2)		12.2
Storing vegetables salad in vegetable refrigerator	299 (56.2)	313 (60.2)	359 (55.6)		
Washing surface with water and soap then apply a sanitizer is the most effective method in cleaning and sanitizing food contact surfaces	393 (73.9)	278 (53.5)	339 (52.5)	265 (65.9)	77.1

Source: Faour-Klingbeil [1].[a] Osaili et al. [18]; [b] Osaili et al.[29]; [c] Taha et al.[43]; [d] Al-Kandari et al.[33] ; [e] Osaili et al.[30] Percentage figures represent the % answers as "yes" to questions.

3.1.3. Temperature control

Several studies examining food handlers' knowledge of temperature control (Table 5) showed that knowledge of proper thawing methods was suboptimal, rarely exceeding 80% [18,19,29,33,37]. There was a wide variation in food handlers' familiarity with the safe internal temperature of food as shown in studies from Jordan (30%- 84%) [18,19,29] and Egypt (35%) [15]. Whereas food handlers in hospitals demonstrated slightly higher awareness compared to those in restaurants [18,19,29].

Similarly, knowledge of the correct refrigerator and freezer temperatures varied widely. In Jordan, fewer than 50% of respondents were aware of correct refrigeration temperatures[18,29,30], in contrast to a higher proportion (88%) reported by Abdel Hakeem et al. [19]. A similar discrepancy was observed in Morocco where 40% were aware of the correct temperature [37] compared to 80% reported by Guennouni et al. [24]. On the other hand, in Lebanon, Faour-Klingbeil et al. [35] found that 77.5% and 55% of food handlers knew the correct operation temperature of the refrigerator and freezer, respectively. None of the studies in Saudi Arabia, Oman, or Iraq reported knowledge levels exceeding 80% [21,22,43].

Food handlers knowledge of cold storage temperature of food was notably low in Sudan (14%) [26], the UAE (62.5%) [54], and Iraq (33.5%)[47]. At the same time, less than 70% in Jordan, Sudan, Lebanon, and Iraq knew the correct hot holding temperatures compared to 90% in one study from Saudi Arabia [22]. However, the findings from Faour-Klingbeil et al. [35] were concerning, as only 11% of respondents identified the correct answer on the hot holding temperature. The authors noted that half of them were trained (44%), which represents a major knowledge deficiency in food safety (Faour-Klingbeil et al., 2015). In general, food handlers were not well-informed about the safe reheating temperature across multiple countries, highlighting a critical gap in food safety educational campaigns and training. Along these lines, the authors found that 57.5% did not know the temperature danger zone. Of those who correctly answered, 69% were unable to give the correct temperature range. Additionally, only less than half (48%) were aware of the safe temperature for reheating food. Similarly, only 40% of the respondents in an Egyptian study were aware of the risks

 doi:10.20944/preprints202504.0146.v1

of leaving covered food at room temperature for extended periods [28]. In comparison, in Iraq, 78.7% were aware that eating perishable food left out for more than 2 hours at room temperature can lead to food poisoning[47].

Table 5. Food handlers' knowledge of the temperature control.

Questions on the appropriateness and importance of the following:	**N (%)[a]**	**N (%)[b]**	**N(%)[c]**	**N (%)[d]**	**N (%)[e]**
	Hospitals (Jordan)	**Universities (Jordan)**	**Food business (UAE)**	**Food business (Kuwait)**	**Food business (Jordan)**
Thawing frozen raw meat or poultry on the kitchen counter in an open container	18 (3.4)	16 (31)	21 (3.3)	197 (49.0)	(15.9)
Thawing frozen raw meat or poultry on the kitchen counter in a covered container	65 (12.2)	102 (19.7)	129 (20.0)		(32.5)
Thawing frozen raw meat or poultry in the refrigerator	270 (50.8)	256 (49.2)	351 (54.3)	264 (65.7)	(66.7)
Thawing frozen raw meat or poultry under running tap water		41 (7.9)	323 (50.0)	135 (33.6)	(23.8)
Thawing frozen raw meat or poultry in the microwave	6 (1.1)	42 (8.1)	342 (52.9)		(4.1)
Thawing frozen raw meat or poultry in still water	178 (33.5)	147(28.3)			
Refrigerator operating temperature is 1-4°C		169 (32.5)	339 (52.5)	323 (80.3)	(47.5)
Freezer operating temperature is -18°C	240 (45.1)	175 (33.7)	405 (62.7)	331 (82.3)	(46.4)
Hot ready to eat holding temperature is > 60°C	165 (31.0)	78 (15.0)	348 (53.9)		
Temperature of internal chicken tissues should reach 74°C during cooking	189 (35.5)	153 (29.4)	373 (57.7)		

 doi:10.20944/preprints202504.0146.v1

Food should reach 73°C during reheating	106 19.9	43 (8.3)	365 (56.5)		(19.6)
Checking poultry is sufficiently cooked when it expels its water	27 (5.1)	47 (9.0)	87 (13.5)		
Checking poultry is sufficiently cooked by appearance	130 (24.4)	140 (26.9)	215 (33.3)		
Checking poultry is sufficiently cooked by thermometer / from its temperature	104 (19.5)	66 (12.7)	370 (57.3)		(31.2)
Checking poultry is sufficiently cooked by experience	201 (37.8)	318 (61.2)	272 (42.1)		
Checking poultry is sufficiently cooked by touching	160 (30.1)	189 (36.3)	176 (27.2)		
Store leftover on steam table	75 (14.1)	79 (15.2)	358 (55.4)		(40.0)
Store leftover in the refrigerator	303 (57.0)	162 (31.2)		196 (48.8)	(53.1)
Store leftover on the countertop or table in the kitchen	12 (2.3)	14 (2.7)	70 (10.8)		(3.8)
Store leftover on the shelf in the kitchen	11 (2.1)	8 (1.5)	34 (5.3)	83 (20.6)	(2.2)
Store leftover in the oven to keep warm	31 (5.8)	63 (12.1)	118 (18.3)		(20.6)
Discard leftover	125 (23.5)	266(51.2)	348 (53.9)		

Source: Faour-Klingbeil [1].[a] Osaili et al. [18]; [b] Osaili et al.[29]; [c] Taha et al.[43]; [d] Al-Kandari et al.[33] ; [e] Osaili et al.[30] Percentage figures represent the % answers as "yes" to questions *Number of responses not recorded.

3.1.4. Symptoms of food poisoning and food pathogens

A majority of food handlers were familiar with the food poisoning symptoms (>80%) in Iraq [17], Jordan [18,19,29,30], Sudan [55], and the UAE [43]. However, notably lower proportions were reported in Saudi Arabia (<65%) and Jordan (<30%) [48,50].

In Egypt, only 36.2% knew that food poisoning is caused by pathogenic microbes, and just 44.5% were aware that it could lead to hospitalization or death [28].Among foodborne pathogens, *Salmonella spp.* was the most commonly recognized among food handlers studied in Iraq, Jordan, Kuwait, Morocco, Oman, and Qatar, whereas recognition of *Shigella*, Hepatitis A virus, *Listeria monocytogenes*, *Staphylococcus aureus*, and *E. coli* O157:H7 was comparatively lower [17,24,25,33,38,48].

 doi:10.20944/preprints202504.0146.v1

In this context, Faour-Klingbeil et al. [35] reported that 77% of food handlers in studied Lebanese restaurants could not differentiate between food spoilage and food contamination, believing that changes in taste, smell, and appearance would indicate contamination risk. However, over two-thirds (70%) identified the common symptoms of foodborne diseases. Similarly, Al Quraishi et al. [21] and Guennouni et al. [24] found less than 30% correctly knew that changes in taste, smell, or appearance indicate spoilage rather than pathogenic contamination. Only Abdelhakeem et al. [19] and Omar et al. [49] examined food handlers' understanding of how washing, freezing, or refrigeration reduces microbial contamination and reported low knowledge levels (<35%).

3.1.5. Factors affecting Food Safety Knowledge

The relationship between socio-demographic factors and food safety knowledge varies widely. Some studies report higher knowledge levels among females [16] or a significant association with the male gender [19,28,29,38]. Conversely, several studies found no significant impact of gender differences on food safety knowledge [22,24,43].

The findings regarding the influence of age and work experience on food safety knowledge also varied across studies. While more substantial knowledge was observed among older food handlers [43,56] and those with over 10 or 12 years of experience [16,29,35], others reported no significant associations [22,23] or lower knowledge levels among older food handlers [48]. Education level was found to have a positive impact on food safety knowledge [38,43,48,56], but some studies did not establish this link [23,24], suggesting that the effectiveness of education depends on its quality [57].

As for the occupational roles and urban-rural differences, cooks and dietitians demonstrated higher awareness about food safety [37,38]. Furthermore, the total score of food safety knowledge was significantly higher among those who occupied higher positions than cook or section chef [35], whereas urban food handlers consistently outperformed their rural counterparts [38].

This discrepancy in findings shows that improving knowledge is a function of a complex interaction of several factors, i.e., experience, education, work environment, and culture, and that a multi-dimensional approach to food safety is vital to improving knowledge in the long run. Training was a factor that improved food handlers' knowledge over time. In Egypt, Hassan et al. [58] found an increase in the mean knowledge scores immediately after training and further after three and six months through multiple training methods such as lectures, demonstrations, videos, and discussions. Significant improvements were also observed in a previous study from Egypt, where knowledge scores increased by 58–123%, depending on hospital location after training [59]. Similarly, in Iraq, Al-Obaidi and Dawood [60] found knowledge improved following a week-long training program, and Faour-Klingbeil et al. [35] reported a significantly higher overall score on food safety knowledge of trained food handlers than their untrained counterpart.

While these studies highlight the empowering impact of training on food handlers' knowledge, their findings may only reflect a snapshot of the knowledge status, as acquired knowledge may not be retained over time. Faour-Klingbeil et al. [35] reported that trained food handlers' knowledge of temperature control and cross-contamination was insufficient, with food handlers unable to recall answers to questions learned in previous training, suggesting that without ongoing reinforcement and periodic retraining, the knowledge gained from initial training may diminish over time.

3.2. Attitudes

Attitude is one of the personal factors influencing behaviour. It reflects the degree to which an individual evaluates the behaviour in question favorably or unfavorably [61]. With ample evidence supporting this theory, it can be inferred that food handlers' positive attitudes can translate their

 doi:10.20944/preprints202504.0146.v1

knowledge into appropriate food safety practices. Hence, food handlers with adequate food safety knowledge are expected to implement this knowledge if their attitudes are favorable.

A positive attitude towards food safety means food handlers are more likely to be aware of potential risks, follow best practices, and prioritise preventing foodborne illness. They view the world (their kitchen or food-handling environment) through a lens of caution and care. Conversely, a negative attitude might lead to complacency or disregarding food safety guidelines. Food handlers might not see the potential dangers lurking in their "window" (kitchen). For instance, individuals with a positive attitude will consistently wash their hands frequently throughout food preparation. Such an attitude promotes regularly checking food temperatures to ensure they remain out of the danger zone, whereas a negative attitude might neglect this crucial step. Someone with a positive attitude would prioritise cleaning and sanitising surfaces and equipment consistently, while someone with a negative attitude might do it less frequently or inadequately.

With a positive attitude, food handlers are more likely to collaborate with others on food premises. Chefs and staff can openly discuss food safety concerns and work together to maintain a safe environment. Therefore, it is important to consider both knowledge and attitude to fully understand how they influence food safety behaviour.

Studies examining food handlers' attitudes are limited (Table 1) and adopted varying approaches. Few studies measured attitudes using a Likert scale [20,33,35,42], while others represent them as total points on "correct answers" to a series of statements. The statement formulation also differed, which might lead to different interpretations by respondents. As such, our discussion focuses on specific aspects explored across the studies.

Overall, the majority of studies revealed a generally positive attitude towards food safety, albeit with varying levels of agreement. There were regional differences in attitudes, as evidenced by food handlers in Kuwait, who exhibited a mean attitude score of 69.12 ± 9.97[33], with only 65% strongly agreeing on the importance of food safety knowledge, a stark contrast to the 98.9% agreement in Saudi Arabia[31]. Similarly, in Egypt, Hamed and Mohammed [28] reported that less than half (43.8%) of the surveyed food handlers considered safe food handling as an essential part of their job tasks, and another 42.9% thought that food safety training courses were necessary; in Lebanon, the attitude score was higher at 86.3/100, indicating stronger agreement on the necessity of food safety and hygiene training [35]. Meanwhile, in Jordanian hospitals, a great majority (95.5%) of food handlers favored regular training [18]. Similarly, most food handlers working in surveyed hospitals in Egypt showed that similar positive attitude, affirming that safe food handling was an important part of their job responsibility [13]. Surprisingly, 83.2% of street food vendors in Jordan showed overall negative attitudes [48]. This stark contrast underscores the critical need for targeted interventions and education to improve food safety practices among street vendors and also highlights how attitudes towards food safety can significantly differ across various food establishment types.

The work environment was shown to influence food handlers' attitudes significantly. Those in corporate-managed restaurants agreed (89.7%) more on monitoring food temperatures than their counterparts in sole-proprietor businesses (50%), who often relied on their own experience [35]. Additionally, long-term experience in the food sector was reportedly linked to better attitudes towards food safety [20,23].

Food handlers' attitudes towards wearing personal protective clothing and handling food when injured vary significantly. In Kuwait, 72.9% exhibited strong positive attitudes towards protective clothing, scoring on average 4.6 out of 5 [33]. In contrast, 96.2% in Lebanon and 94.4% in Qatar strongly agreed on the use of appropriate clothing [35,42]. In Iraq, 98% of participants expressed a positive attitude toward personal hygiene questions, such as wearing masks and gloves, viewing these as important measures to reduce the risk of food contamination [62]. In Jordan, approximately 63% of street food vendors acknowledged the importance of using face masks and gloves, whereas a significantly smaller percentage, around 37%, felt the same about hairnet [48]. When asked about handling food with injuries, 70% of handlers in Kuwait and 82.8% in Saudi Arabia agreed to exclude

 doi:10.20944/preprints202504.0146.v1

injured food handlers [31]. In contrast, only 57% of Lebanese restaurants concurred, citing staff shortages as a concern [35]. In a study conducted in Egypt, merely 10.2% stated they would refrain from handling food if they had diarrhea [28]. Moreover, food handlers who reported abstaining from work due to hand lesions or common colds constituted 12.1% and 14.6%, respectively. In comparison, in Lebanon, Bou-Mitri et al. [23] reported positive attitudes towards food handlers working in hospitals, scoring an average of 86.3 out of 100, with a majority (94%) believing that excluding food handlers with skin injuries is an important food safety measure. Similarly, in a recent study in Morocco, food handlers demonstrated generally positive attitudes towards food safety, with an overall score of 75.6%. The majority (88.7%) agreed that safe food handling is crucial to their profession, and 78.4% agreed on the importance of avoiding work when ill. Similarly, 88.3% acknowledged the role of personal protective equipment in reducing contamination risks. Additionally, 71.3% believed in the principle of separating raw and cooked foods during storage and 75.2% agreed on the necessity of monitoring refrigerator and freezer temperatures [37].

These results highlight strong safety attitudes overall, although some knowledge gaps persist. Almost all food handlers agreed on separating cooked food from raw ingredients to prevent cross-contamination, a practice universally endorsed except by 44% of handlers in Egypt [28] and 59.3% of street food vendors in Jordan [48]. In KSA, 64.4% agreed on proper thawing practices, and 60.9% on storing leftovers correctly [31]. Comparatively, only 22.8% and 16.7% of Lebanese food handlers adhered to these practices [35]. In Kuwait, 71.6% acknowledged the importance of the temperature danger zone, but only 59.2% believed cooling appliances should be regularly monitored, compared to 97.6% in Lebanese hospitals [23,33]. In Iraq, Kannan et al. [46] found that 54.6% of respondents disagreed that keeping cooked food at room temperature (25°C) for two hours is harmful. While this was interpreted in the study as a misperception, obviously, it reflects limited knowledge of temperature control and its effects on food safety. According to the authors, most participants demonstrated poor knowledge, with 57% not following appropriate procedures to protect food from cross-contamination and temperature abuse.

Along these same lines, Alzhrani and Shatwan [32] found that higher KAP scores are associated with better food safety attitudes and practices, indicating the need for targeted interventions to improve the knowledge, attitudes, and practices of food handlers in the poor group. The authors categorized food handlers into "poor" (KAP score < 70%) and "good" (KAP score ≥ 70%) groups based on their cumulative KAP scores. Significant disparities in food safety attitudes were noted between these groups. A considerable proportion of the poor group (31.9%) disagreed with frequent handwashing during food preparation compared to 14.4% in the good group. Although most respondents endorsed the use of meat thermometers, disagreement was more pronounced in the poor group (11.6%) than in the good group (4.4%). Similarly, disagreement with thawing food in a cool place was more prevalent in the poor group compared to the good group. Awareness of the hazards of leaving cooked food unrefrigerated was greater in the good group (83.1%) compared to the poor group (68.1%).

3.2.1. Factors affecting food handlers' attitudes towards food safety

Several factors, including experience, age, education, gender, workplace environment, training, and management support, influence the attitudes of food handlers towards food safety. These factors can either positively or negatively impact their perception of food safety and their willingness to adhere to proper practices. Experience plays a significant role in shaping food handlers' attitudes. Those who have worked for more than 21 years were more likely to demonstrate positive attitudes (90.0%) and better practices (88.5%) compared to those with 11 to 20 years of experience (79.4% and 79.0%, respectively) [23]. In Jordan, analysing the factors influencing the food safety attitudes of street food vendors revealed that years of experience and gender were the strongest positive predictors. Specifically, female food vendors with over five years of experience demonstrated significantly more

 doi:10.20944/preprints202504.0146.v1

positive food safety attitudes [48]. This comes in line with Sharif et al. [20] who revealed that in Jordanian military hospitals, female food handlers had slightly higher mean scores for knowledge, attitudes, and practices (KAP) compared to male food handlers.

Age plays a significant role in shaping food handlers' attitudes. Younger food handlers (aged 20–24) in Egypt scored less on attitudes towards temperature control compared to older food handlers (aged 40+) [56]. Similarly, in Iraq, older food handlers tended to have more positive attitudes than younger ones [47].

Education can play a significant role in shaping food safety attitudes and behaviours. Food handlers with a college or university education had significantly higher mean scores for knowledge, attitudes, and practices than those with only a primary school education [20]. Similarly, food handlers in Egypt with higher education levels showed more positive attitudes towards food safety and temperature control than those with basic education [56]. However, contradictory results were reported by Lami et al. [47] in Iraq, showing that food handlers with the lowest education level (illiterate) had a higher percentage of positive attitudes towards food safety and personal hygiene compared to those with higher education levels. Similarly, Ali et al., [17] highlighted that even with limited education, individuals can still develop positive attitudes towards food safety, emphasising the importance of continuous training programs for food handlers in the region.

While education is important, it must be complemented with hands-on training programs to effectively change attitudes and practices. Training should focus on specific areas like handwashing, personal hygiene, cross-contamination prevention, and sanitation methods [17,31]. In Egypt, Abdelwahed et al. [56] stated that previous food safety and temperature control training can have a positive impact on food handlers' attitudes towards these topics, with 28.8 ± 1.937 in those who had training and 28.5 ± 2.251 in those who did not have training. However, the difference in mean scores was relatively small, indicating that while training may be beneficial, other factors also likely influence attitudes.

Additionally, the overall food safety climate and corporate environment within food businesses are increasingly recognized as critical drivers for improving food safety behaviours. These elements significantly influence the well-being and attitudes of food handlers, affecting their motivation and adherence to safety protocols and procedures. To create an environment where resources and abilities are supported and encouraged, leadership must set the tone and clear expectations.

Leadership styles in Arab cultures can be effective, yet there can be challenges in implementing them for improved food safety. Strict hierarchies, flexible rules based on personal connections, and a focus on relationships over efficiency can hinder consistent enforcement of food safety protocols. Leaders who build trust, focus on shared goals, and empower employees with clear communication and recognition can navigate these cultural dynamics and create a more open, collaborative environment for improved food safety practices [63].However, Sharif et al. (2013) assumed that the positive attitudes of food handlers in military hospitals might be partially attributed to their tendency to follow orders, which could influence their adherence to food safety practices. This means that a disciplined environment and culture in military hospitals might contribute to better adherence to food safety practices, suggesting that while knowledge is important, other factors like organizational culture and discipline can also play a role in shaping food safety behaviours.

By understanding the cultural context and implementing change leadership strategies that address these potential challenges, food safety practices in Arab countries can be significantly improved [43]. Taha et al. [43] showed positive associations between both leadership styles and all three employee factors (job satisfaction, commitment, hygiene practices). The authors emphasize the importance of "softer dimensions" like leadership styles in influencing food safety practices. It goes beyond just technical knowledge and skills by measuring food handlers' perceptions of transactional and transformational leadership styles, along with job satisfaction, commitment, and self-reported hygienic practices. They stated that food businesses in Dubai should invest in developing leadership skills among managers, focusing on both transactional and transformational styles [64].

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3.3. Food handlers' practices

3.3.1. Food safety practices in food service establishments, including restaurants and caterers in Palestine, Morocco, Kuwait, Qatar, Oman, Saudi Arabia, Iraq and Lebanon

In a survey of some Palestinian restaurants, Al-Khatib and Al-Mitwalli [40] found that most of the food handlers in the restaurants were young people with a low level of education. Many (40%) had been working in these restaurants for the first time. That being said, most of the food handlers in the study claimed that they always washed their hands before starting work, when handling raw and RTE foods, and after using the toilet. However, these compliance rates seem to contradict what was observed during the fieldwork: 14% of restaurant kitchens and 37% of toilets lacked cleaning supplies. About half reported they would leave work if they were sick, but in some cases, management refused to let them leave their workstations. Rodent or insect infestations were noticed on-site by 22% of the employees. The unhygienic work conditions revealed through this study were borne out by a separate microbiological survey where food samples from restaurants from Ramallah (67%) and Al Bireh district (40%) had unacceptable total aerobic counts and total coliform and faecal coliform levels, according to the Palestinian and WHO standards. Similarly, Abdelrazig et al. [45] identified that the cooking and personal hygienic practices in the studied restaurants in Sudan were inadequate (48% poor and 28% bad) for most food handlers. However, regarding personal hygiene practices, neither training in personal hygiene among the study workers has been noticed nor the usage of hand gloves. The authors stated that poor health status and poor hygiene practices of food handlers in the market, including lack of hand glove use, require medical screening and hygiene training. Similarly, the practices of food handlers from restaurants in Somalia showed a general ignorance of the risks of transmitting foodborne diseases [44]. Questionnaire responses indicated that only some (30%) tended to wear protective clothing, hairnets and aprons were not typically worn (10% and 50%, respectively), and only 30% used gloves during food preparation. Most only washed their hands when they saw they were dirty and then used their clothes, which tended to be dirty, to dry their hands and only 20% of the handlers washed their hands with soap and water after using the toilet. Probably the biggest reason for this lax attitude and practice toward food safety was that the restaurant owners didn't care about the health of their workers, whether they were ill or not. The authors recommended that public health authorities ensure that food handlers receive medical screening on a regular basis, and they should establish and enforce rules and regulations dealing with hygienic practices in the handling of food.

Furthermore, food handler practices in catering establishments in different parts of Morocco were surveyed by Amaiach et al. [37]. Only 62.9% showed safe food safety practices, similar to surveyed handlers in Egypt [28], and Iraq (Ali et al., 2022), but lower than those in Kuwait [33]. Although most employees reported wearing clean work clothes and washed hands before and after handling food, properly used utensils and cutting boards (86.5%), and regularly disinfecting the work area (75.2%), fewer always wore gloves when handling ready-to-eat food (62.1 %) and correctly answered questions on practices that would prevent cross-contamination (63.1%). Temperature control practices were mixed; excellent for cold storing leftovers (98.2%) and regularly checking refrigerator and freezer temperatures (71.6 %), but most showed they would not properly reheat the previously cooked food (49.6%), and about two-thirds would go to work while ill (66%), about half wore jewelry (47.2%), and almost one-tenth smoked (9.6%) in food preparation areas.

On the contrary, Al-Kandari et al. [33] showed very good practices (82%) in Kuwait, particularly in personal hygiene, including hand washing before and after handling foods, having clean nails, wearing caps, masks, and gloves, washing work clothes, cleaning work surfaces before and after food handling, but they did not practice well avoiding cross-contamination and proper time

 doi:10.20944/preprints202504.0146.v1

and temperature control. More than half (52%) said they would use bare hands to touch RTE food. Temperature control was also inadequate, as only 74% said they would regularly check the temperature settings of chillers or freezers and store leftover foods in the refrigerator (67%) or reheat food until it was steaming hot before serving (46%). They would not necessarily pick up foods that fall on the floor and dispose of them (66%), and only 61% said they would avoid keeping cooked food in the temperature danger zone of 5–60 °C until served. Similarly, Elobeid et al. [42] surveyed employees working in fast food service operations at Qatar University. The practice score for hand washing was high in terms of washing hands before and after using gloves and before and after touching raw, unwrapped, or cooked foods, with a range of 90–97% correct responses. Hand hygiene was enhanced by providing warm water facilities, hand sinks, soap, and disposable towels. In Saudi Arabia, Al-Shabib et al. [31] showed that the food handlers had good practices towards food and personal hygiene, with most as wearing uniforms and caps (97%), washing hands after smoking, coughing, sneezing (94%), washing hands before and after use of gloves (83%), removing watches, rings, and jewelry (76%), but almost a third (29–31%) would handle foodstuffs when sick or having wounds and cuts. Personal hygiene-related practices were highest among Filipino (90%) while lowest among Nepalese (76%) food handlers.

However, the data from Oman was different from other GCC countries, as Ali et al. [38] reported that only about half of food handlers in the studied restaurants stated that they consistently wore gloves (48%) and if they did, they did not wash their hands before gloving or wear an apron (95%). They almost never washed their hands before and after touching meat or after going to the restroom (>95%), and they almost always ate and smoked at the workplace (>95%). Two years later, Al-Ghazali et al. [39] reported poor hygiene practices in restaurants in Oman, particularly in regions with higher complaint rates. The results showed that the Enterobacteriaceae counts of food handlers (1.7 log CFU/ cm^2), chopping boards (1.4 log CFU/ cm^2), and knives (1.7 log CFU/ cm^2) in restaurants in a region where complaints were the highest (Group 3) were significantly higher than in the other regions, which suggests that these workers demonstrated poor hygiene practices. Total Aerobic Bacterial Count (log CFU/cm^2) ranged from 2-3 logs for all swabs tested, all above the WHO standard 2.0 log CFU/ cm^2. The authors speculated that the unacceptable counts could have been due to these workers using the same chopping board for both vegetables and chicken and improper hand washing. The municipality also noted that the restaurants in Region 3 used unclean cleaning sponges compared to those in other regions. The authors concluded that those with better knowledge had significantly better hygienic practices, but there were other factors beyond their knowledge, such as attitude, motivation, and employee morale influencing behaviour.

In Qatar, Asim et al. [41] found that the casual sit-in and fine dine-in restaurants were the only FSEs that consistently kept records on all safe food handling practices (100%) while fast-food and catering services lagged significantly behind, with as little as 9% keeping sanitation logs. Some scores were also low for record-keeping of employee personal hygiene, preventing cross-contamination, and critical control points from these types of establishments (0 to 73%). The authors deduced that managers' education levels significantly influenced food safety practices. However, the FSE walk-through audit results by Qatar Ministry of Health (MOH) inspectors revealed that even well-educated FSE managers did not keep satisfactory records of critical food safety tasks, as shown in the discrepancy between the documented and actual practices relating to their HACCP plans. In many cases, they also could not provide evidence for the training of their employees by an accredited organization (75%), individual employee certificates as proof of training (68%), or documentation on cleaning and sanitation schedules (55%). The managers agreed that although they knew the importance of keeping the premises clean and recording the information relating to their HACCP plans, they did not satisfactorily supervise the practice of managing critical control points. The authors concluded that both internal and external audits are essential to ensure that HACCP plans are implemented appropriately by staff through their managers.

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An in-depth study in Beirut, Lebanon, of 50 typical food service businesses, both corporate and sole-proprietor, was conducted by Faour Klingbeil et al.[35] published in two papers in 2015 [36]. The sole proprietor operations included bistros, café restaurants, and traditional fast-food street outlets. In summary, the respondents may have had positive attitudes in all aspects of food safety, but they did not necessarily have the intention to put these into practice. The score on self-reported practices was 61% (mean), with a maximum score of 80%. The results showed that the self-reported practices of respondents were not consistent with their agreement that improper food storage might lead to health risks. For instance, temperature control was rarely a feature in these establishments; 68% reported that they never measured the temperature of incoming cold or frozen items, nor the food temperature during cooling and reheating (73%) nor during cooking (71%). Temperatures of equipment were also, for the large part, not monitored, such as cooling appliances and food display counters (both 65%). However, there were differences in practice among the businesses. Corporate employees were more likely than sole proprietors to be proactive in the principles of HACCP always or most of the time. For instance, workers measuring the temperature of received frozen and fresh meat products (73% vs. 10%); those measuring the temperature of food during reheating and cooling more (58% vs. 8%); and those disinfecting cutting boards and utensils used on the premises (88% vs. 42%). The authors argue that the clear differences in behaviour were related to the perceived food safety culture. Under corporate management, food safety depends on the business priorities of the headquarters management and its perception of risks. With sole management operations, the owner may not see food safety as a priority or is less aware of critical control points for the safe sale of food. The authors' conclusion was that management type influences attitudes and can be used to predict likely food handlers' practices, but even more influential is the establishment by senior management as well as the sole proprietor, of an appropriate food safety culture. Allafi et al. [65] assessed the level of food safety practices among 273 Filipinos, Egyptians, and Indian food handlers in Kuwaiti restaurants. The three nationalities generally showed very good practices mainly in personal hygiene, but some did not report to their manager when they had wounds and cuts (13% of Filipinos, 37% of Egyptians and 26% of Indians), many used bare hands for handling ready-to-eat food (52% of Filipinos, 40% of Egyptians and 59% of Indians), and many did not avoid keeping cooked food in the temperature danger zone until served (ranging from 83% of Filipinos to/57% of Egyptians and Indians). The study recommends aspects related to cross-contamination and time and temperature control need to be stressed, especially for Egyptian and Indian food handlers. Continuous food safety training for food handlers in Kuwait should become compulsory to reinforce food handlers in the areas that seem to be lacking.

Poor practices, particularly in temperature control, were also reported in a cross-sectional study in Iraq by Kanaan et al. [46], who reported that 69% of food handlers working at vending operations, cafeterias, and popular restaurants in Iraq reported that they washed cooking utensils between uses, 66% washed their hands after handling dirty items, 56% separated uncooked and prepared meals in containers for storage, and 56% used hot, soapy water to disinfect countertops after preparing food. However, only 32% washed their hands before cooking, 46% used separate bowls and chopping materials for raw and ready-to-eat meals, 13% thawed frozen meat in the morning before cooking it, and 15% used a thermometer to determine if food was fully cooked. An alarming proportion of 7% consistently left cooked food near the counter for use the following day, and 38% never washed their hands after counting money. The authors considered these results were poor enough that education and training programs are needed to improve the food handlers' attitudes, understanding, and behaviours to avoid the risk of foodborne illness. Similarly, a self-administered questionnaire by Alzhrani and Shatwan [32] showed the poorest scores (54-73) were for temperature control. Since the older workers with over 10 years of working experience and married had the highest scores for practice, the authors recommended that theoretical and practical training should be more focused on younger, single, and less-experienced handlers.

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Factors such as gender, education, job nature, and marital status influenced food safety practices. The older, more experienced ones practiced better food safety activities than those less experienced, and the highest practice scores were obtained by those working every other day. Also, male food handlers reported significantly higher practice scores (85.1%) than female ones (79.6%) [23]. This indicates that male food handlers may be more likely to engage in proper food safety practices, though the reasons for this disparity require further investigation. In contrast, in Jordanian military hospitals, female food handlers had slightly higher mean scores for knowledge, attitudes, and practices (KAP) than male food handlers [20].

The strong positive correlations between knowledge, attitudes, and practices suggest that targeted training and education could substantially improve food safety outcomes [37]. However, these interventions would need to be fit for the context. Abushelaibi et al. [54] found that interventions may have limited effect when personnel motivation is lacking. The authors evaluated the overall effect of the person-in-charge (PIC) of food safety in 48 different food service establishments, from top-star hotels to small cafeterias in the Dubai Municipality of UAE, to enhance the knowledge and practices of food handlers. A PIC is a person required to be present during all shifts to supervise staff to prevent foodborne illness and injury. Twenty observable food safety practices were scored by an evaluating team before the training and three months after. As a result, only some of the food handlers could improve their food handling habits, particularly the small cafeteria-type operations. Hand cleanliness, as measured by hand swabbing, improved after training, but this was not equally good for cutting board cleaning practices. The authors found that the PIC intervention needs to include a motivating component to encourage food handlers to implement the recommended practices, particularly for small SMEs. For instance, with respect to cleaning food contact surfaces, there was no improvement (63% and 52% before and after, respectively) and only a slight improvement for separating ready-to-eat food from raw meat (67% and 71%, respectively).

3.3.2. Food safety practices by food vendors in Sudan, Jordan, Saudi Arabia, and Lebanon

As stated by Alimi [66], street food is economically important in most developing countries by providing affordable meals and creating jobs. However, due to its informal nature, it remains unregulated, leading to potential health and safety risks for those involved. Although street vendors are aware of the need for good hygiene, the typical lack of basic facilities at their vending sites demonstrates that they prepare and serve food in the absence of the necessary conditions for safe food. Convenience and economic factors were the main reasons why most vendors do not convert their food safety knowledge into good practices. This is borne out in the following country examples.

Studies on street food vendors highlight significant gaps in food safety practices. In an older study, Abdalla et al. [55] evaluated the food safety knowledge and practices of street food vendors selling cooked meals, drinks, and juice in Atbara City, Sudan. Most vendors did not wash their food before cooking (66%), and only 62% adequately cooked their meals. A few vendors cooked the meals ahead of time, and most of these had no covering and could be exposed to flies outdoors, but in some cases, these were reheated before serving. Most of the food served was done using bare hands. Less than half of them used a cooler box or refrigerator for food storage, with 31% stored openly in the stalls. Most washed their cooking utensils only at the end of the day (78.0%), and 58% changed the water a few times or only when it became viscous and sticky. As expected, samples of the food were contaminated; the viable bacterial counts were 4.6 log10 CFU/ml, 3.7 log10 CFU/ml and 4.1 log10 CFU/ml for cooked meals, bottled drinks, and juice, respectively. the viable counts in cooked

 doi:10.20944/preprints202504.0146.v1

vegetables were 4.6, bottled drink 3.7, and juice 4.1 log10 CFU/g. and E. coli, Staphylococcus aureus, and Bacillus spp. levels were typically >3 log10 CFU/g.

Also, in Saudia Arabi, surveyed street vendors work with limited facilities for good hygiene in Gizan City, Saudi Arabia. Moutz et al.[50] found that these vendors said they would not work if they were sick with vomiting (84%), diarrhea (68%), sore eyes (66%), coughs and colds (60%), but less likely for nausea (56%) and stomach cramps (50%), and not at all for another member of the family who was sick. They claimed to wash their hands with clean water (94%) and soap (86%), after eating meals (90%), handling garbage (86%), and going to the toilet (86%), but not so much after touching money (20%) or handling raw foods (42%), but most (12%) did not dry their hands with clean cloths after washing. Microbial tests showed concerning levels of contamination, with 15% of cooked foods containing *Salmonella* and others testing positive for *E. coli*, *Staphylococcus aureus*, and Bacillus spp. The most frequently occurring bacterium was *S. aureus*, found in samples of cooked meals, juice, and roasted groundnuts, but no counts were done to show the risk of potential enterotoxin production. However, the total viable counts of all foods tested were moderate to high, ranging from 3.5 to 5.8 CFU/g. These results indicate that good food safety practices by the vendors were not satisfactory, which is not surprising in street settings.

Omar [49] found that most street food vendors had insufficient knowledge and attitudes to food safety, which would reflect on their practices, which were not specifically measured. But, based on other studies that combined information gathered on practices along with microbiological findings, it was clearly shown that street vending in these locations was conducted under insanitary conditions with a risk of foodborne illness to the consumer. A more recent study by Elsahoryi et al. [48] reveals that these types of vendors have shown little improvement over the years; they know basic hygienic knowledge but do not convert it to positive attitudes and practices towards the safety of the food they sell. Only some washed their hands before processing food (37%) and before and after touching unwrapped food (40%). About a quarter admitted to handling food at work while they have diarrhea (26%); a similar proportion never wear caps, aprons, or gloves (20-26%) and 36% always smoke. Only 20% consistently wash and sanitise knives after cutting chicken or other raw food. When asked about after using the toilet, only 16% stated they always washed their hands with soap and water.

In Lebanon as well, the results of 60 food samples showed unsatisfactory levels of foodborne pathogens, which significantly correlated to the inadequate conditions of preparing and selling vended food. Unsatisfactory levels of *Staphylococcus aureus* were found in some fruit/vegetable, meat and dairy samples (103–104 CFU/g), *Salmonella* spp., and *Listeria* spp. contaminated > 50% of these same types of vended products [51]. Most vendors (70%) had fixed kiosks, and the rest had mobile carts; most prepared their food on site (90%), but many on non-food grade material (40%). Slightly more than half had their food displayed in clean, covered containers (57%), and the rest were for sale in the open air; 43% of the vendors prepared and served food immediately, but others prepared food ahead of sales. Two-thirds had sufficient potable water supply, but only 27% of these had adequate hand washing stations and waste disposal facilities. Not all stalls had refrigerators, and of those that did, many showed inadequate separation of raw from cooked food (63%), only some used different chopping boards for different types of food (40-%), and most used the same utensils to handle all food (93%). Most vendors prepared and served food without gloves (87%), only 3% washed their hands properly before serving food, handling food and money without washing their hands (60%), 77% cleaned food contact surfaces with their hands, a dirty apron or cloth, and prepared and served food in unacceptable clothing such as no hair nets or wearing a filthy apron. Utensils were rarely washed with soap and warm water (17%), which were then under the open-air display, and 10% of vendors were seen smoking inside their stalls.

 doi:10.20944/preprints202504.0146.v1

In a different city in Lebanon, Hassan et al. [67] found that 70% and 87% of fresh orange juice and RTE food vendors did not store raw materials separately nor in a suitable manner, respectively, only 44% cleaned their carts monthly; 96% shared utensils between many types of food, and 70% did not clean countertop surfaces before starting food preparation. Most vendors were not wearing hairnets, gloves, or an appropriate uniform (96%, 76 %, and 83%, respectively). All the food samples were contaminated with at least one of the tested foodborne pathogens, and unsatisfactory levels of yeast and mold were recorded in orange juice samples. Two samples of RTE food had unacceptable β-glucuronides *E. coli* levels, and one shawarma sample had high C. perfringens levels, Of more concern was that 30% of the vendor hand swabs were positive for *S. aureus* and this was reflected in the unsatisfactory *S. aureus* levels in 55% of RTE samples; one sample of cheese cake contained 4.4 log10 CFU *S. aureus*/g and 3.6 log10 CFU Enterobacteriaceae/g, well above the level for a risk of foodborne illness to the consumer. One of the *S. aureus* strains isolated from a vendor was determined to be MRSA. The authors stated that the unsatisfactory levels of yeast, mold and *S. aureus* were a result of the street vendors' violation of food safety practices, and they recommended that better legislation is needed to provide safer food for the purchaser.

The findings of a meta-analysis study are worth considering for improving hygienic practices in Arab countries. Desye et al.[68] examined data from fourteen street vendor studies towards food safety with a total of 2,989 study populations and found scores for the pooled data to be good knowledge (62%), positive attitude (66%), and good practice (51%). However, there was variation in the scores from country to country and even within a country. Street food vendors who have a secondary education level are more likely to have a hygienic practice compared to those who have no formal education, and street food vendors who have received training on food safety are more likely to have good hygienic practices than those who have not. Experience and education level showed positive associations with knowledge and practices, indicating that vendors with more experience and higher education had higher scores, but not necessarily with age[48].

3.3.3. Food safety practices in hospitals in Egypt, Qatar, Jordan, Kuwait, Lebanon, Morocco, the Sudan and Saudi Arabia

An intervention approach (one group pre-test post-test design) was conducted among all 161 food handlers in 17 Ministry of Health and Population hospitals in the Gharbia Governorate of Egypt by Wahdan et al.[14]. Among the strengths of this study is that the practice of the food handlers was observed rather than being self-reported. Each food handler was observed three times, considering the representation of different shifts. In the pre-test, almost all food handlers did not wash their hands after touching their hair, nose, and ears, and those who washed their hands missed the webs between the fingers and their fingernails (>90%). For drying hands, kitchen paper towels were used more often than cloth towels as no dryers were available. Clean coats and head covers were worn by >75% of the workers' observations, but few wore gloves (15%) or masks (1%), and only 43% washed their wiping cloths daily. Health education sessions were then conducted for all food handlers in each hospital using different educational methods, including demonstrations and group discussions. The present study showed that there was a significant improvement in all food hygiene practices following the intervention. The mean scores of all practices (hand hygiene, PPE, hygienic practices, cleaning of used equipment and utensils) showed a significant increase in the postintervention score. For instance, handwashing went from 38% to 97%, and cleaning of sinks from 8% to 83%. Temperature control of food was generally good before and after education.

Kaabi et al. [25] documented that food safety practices of food employees at the Hamad General Hospital in Qatar were satisfactory (90%), and all employees claimed to wash their hands before

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using gloves, after using gloves, and after touching unwrapped cooked foods, but about 2% of food service staff agreed that they would touch and distribute unwrapped raw or cooked food to patients. Food staff with a higher educational level had greater knowledge and understanding of the issues, but there seemed to be no correlation between knowledge and practice, regardless of their knowledge, since all employees documented that their practices were satisfactory. In contrast, alarming findings were reported by Adel Hakim et al. [13] on employees working in Ain Shams University tertiary care hospital and also workers in 16 fast food restaurants, both in Cairo, who would continue to work if they had symptoms of illness (>60%) or hand lesions (>70%). Some had pre-employment medical exams and periodic ones during their employment (>69%), but these would probably not be enough to exclude some infected persons. This is important because employee hygiene was lower than acceptable for washing hands before and after touching food and after going to the toilet (>80%) and less for wearing gloves while preparing food or when handling already prepared RTE food (67%). Most handlers washed fruit and vegetables before slicing them (82%), cleaned food contacting surfaces before and after using them (>88%), and separated raw food from ready-to-eat food (92%), but not so many regularly checked the refrigerator temperatures (76%), and the expiry date of ingredients used in cooking (67%), boiled unpasteurized milk before use (63%), and kept cooked foods at room temperature for less than four hours (62%). Additionally, the study observed differences in knowledge and practices among different types of food handlers (cooks, cook helpers and wait-for staff), but there were no clear trends in behaviour between them. For instance, cooks were more likely to wash their hands after using the bathroom, and helpers were more likely to stop working when sick, indicating a partial adherence to good hygiene practices. A significant percentage (41%) of participants' nail swabs had positive cultures, mainly coagulase-positive and coagulase-negative staphylococci (mostly helpers but also some cooks and one waiter). Dirty nails combined with the risk of cross-contamination could result in pathogen growth in RTE food. The mean percentage of good hygiene practice score was 68%, indicating that while there were some good practices observed, there was also significant variation in adherence to safe food handling procedures. This study highlighted a positive association between experience and food safety knowledge and practices, suggesting that with more experience in food handling, individuals are more likely to acquire better knowledge and skills, leading to improved food safety performance.

In Jordan, Sharif et al. [20]found that food handlers in 7 military and civilian hospitals in Jordan reported a good hygiene level with a mean percentage score of 89%, including handwashing, storing cooked meat for less than 4 hours at room temperature, proper cleaning and disinfecting procedures of premises, surfaces and utensils, and separating raw meat from RTE food, but 59% said they drank raw milk. There was a significant difference in scores for good practice between the military and civilian employees (91 vs. 84%). The authors speculated this might be because military employees are more likely to obey orders than civilian ones, but also because they have more training. For overall KAP scores in the military hospitals, cooks and nutritionists ranked the highest (92%) compared with wait staff (84%) and housekeepers (80%). As discussed in the previous section of this paper, Osaili et al. [18] studied food safety knowledge among food handlers in a much larger survey. Even though practices weren't specifically measured, some of the responses would reflect practice behaviour such as cross-contamination with knives and cutting boards used for both raw meat and vegetables and refrigerator storage; time and temperature control for thawing, cooking, storing, and reheating poultry (all <50%). Similarly, in Jordan, Abdelhakeem et al. [19] found there was also a similar concern to that of Osaili et al. [18] about some of the knowledge responses from the food handlers, but again, unfortunately, the study did not include observations on practice. No doubt, if hospital food handlers had been directly observed, their practices would show the need for improvement, but a more in-depth observation of food handlers practices in Jordanian hospitals is required to determine where the main concerns exist.

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In Lebanon, Bou-Mitri et al. [23] reported that almost all food handlers checked the integrity of the packaging on receipt and the shelf life of food products while using them (>98%). Nevertheless, 22% did not use separate kitchen utensils to prepare raw and cooked food, 38% did not stop working to treat the lesions on their hands if they had any, and 73% thawed food at room temperature. The reported practice scores were somewhat higher among food handlers working in government hospitals (89%) than in private hospitals (83%). In Morocco, Guennouni et al. [24] showed that kitchen employees in a university hospital achieved positive results, with a high correctness rate of 93% for five items and 100% compliance regarding handwashing with soap and water before food preparation and wearing head coverings during food preparation or distribution. Overall, the results indicated that while hospital kitchen employees generally adhered to important food safety practices, there were critical gaps in knowledge that need to be addressed through further education and training. The practice was not observed directly, but no doubt if it was observed, scores for good hygienic behaviour would still be lower.

Although nutrition staff in three hospitals (military and private) in Khartoum State, Sudan, possessed adequate knowledge of the cleaning and sanitisation of the equipment (84%), handwashing (81%), and wearing gloves (84%), they did not as well understand the concept of Hazard Analysis and Critical Control Point (HACCP) (40%), and even less for good manufacturing practices (22%), standard operating procedures (17%), and cooking and storing temperatures, including the time and temperature within the danger zone (11%) [26]. The study emphasized that good knowledge of food hygiene does not always translate to safe practices, underscoring the need for practical training. The authors showed that 74% had adequate hygienic practices, with the least observed practices being removing paint from fingernails (25%) and covering heads during food preparation (55%). A similar conclusion was drawn from the study by Elsherbiny et al. (2019) in Egypt, where food handlers' behaviour was found to be inconsistent with good hygienic and food safety practices. For instance, for personal hygiene, they did not always wash their hands before handling food and checked the cleanliness of their clothes, hair restraints, and shoes before work (41% and 8%, respectively). Only some always stated they followed good practices by storing raw and cooked foods separately (26%), by having separate equipment and supplies for both raw and RTE food (19%), by not handling RTE with bare hands (27%); by washing and sanitising fresh fruit and vegetables before use (21%), by cleaning and sanitising knives and cutting boards (17%); and by labeling and appropriately storing cleaning and sanitising chemicals away from foods (52%). Frozen food thawing practice was inconsistent (e.g., 46% did it most of the time, 37% some of the time), and most disappointingly, few recorded temperatures during food preparation (22%), and none at all took temperatures during cooking. These results indicated a significant gap in adherence to safe food safety practices in these hospitals (total practice score of 35%).

Similarly, in Iraq, Ali et al. [17] found that most respondents had a good understanding of food safety practices (score of 98%). However, based on observations, only 13.3% of the participants wore gloves consistently during the distribution of unpackaged foods, while 25.5% did it sometimes, and 12% never wore gloves. Additionally, only 22% of the participants washed their hands properly before or after using gloves, and 12% never did; 45% never wore an apron while working nor a mask when distributing unwrapped foods; 35% never used the sanitiser when washing fruits or vegetables; and 34% had never checked the shelf life of foods at the time of delivery, all indicating the need for continuous training for food handlers to improve their safe food handling practices.

Although the hygiene assessment score in Kuwait was high (96%), the self-reported questionnaire results showed that 42% would go home with their uniforms and, more importantly, 45% would use the same hand gloves while handling raw meat and fresh food, and 36% not changing utensils while cooking raw and cooked food. There was slightly more compliance with the community workers than in healthcare settings [34]. Conversely, Alqurashi et al. [21] showed that the food handlers in the studied Saudi's hospitals generally had good food safety practices. Almost

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all staff (95%) reported that they always wash their hands before food preparation, most always wore gloves when handling food during preparation (81%) and most used masks (71%) and head caps (82%) when preparing and distributing food. They said they always washed and dried their hands appropriately, especially after handling raw meat (88%), what to do if they have an infected wound on their hands (73%) and should not prepare food for others if they have symptoms of communicable diseases (86%). Spearman rho coefficient results demonstrated that food safety knowledge is a significant predictor of food safety practices. This research underscores the importance of education and consistent training of food service staff in improving knowledge and, thereby, better and safer food handling practices, which could contribute to applying food safety in hospitals. The results of Alsultan et al. [22] obtained from five hospitals in Riyadh City, Saudi Arabia, during the COVID-19 pandemic also revealed a significant positive correlation between food safety awareness and food safety practices. Older participants (> 50 years) reported the highest mean score on food safety practices, although the correlation between the food handler's knowledge and safe food handling was negative. Overall, the findings highlighted the significance of education and the regular training of food service staff to improve learning and ensure better and safer food-handling practices, which could contribute to applying food safety practices in hospitals. The presence of COVID-19 in the community should have made food handlers and other hospital staff more aware of avoiding risky behaviour.

Table 6. Key findings on food safety practices in Arab Countries.

Theme	Key findings
Personal Hygiene & PPE	• Personal hygiene practices, like handwashing, were generally good, especially after handling raw foods and before preparing food. • However, the use of personal protective equipment (PPE), such as gloves, masks, and head coverings, was often inconsistent and generally lacking among street vendors. • Food handlers sometimes do not adhere to proper use of use of gloves when shifting tasks or handling cooked foods, which increases cross-contamination risk. • Some hospitals had better adherence to hygiene practices than others, particularly government hospitals compared to private ones. • But hand hygiene practices and use of PPE (gloves, masks, and head coverings) was in many cases inadequate. Personal hygiene practices need continuous reinforcement.

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Temperature Control & Cross-Contamination	• Temperature control, including the proper storage of food at appropriate temperatures, was often poorly implemented. • Cross-contamination due to improper separation of raw and cooked foods was another common issue. • There were gaps in the correct thawing methods, particularly thawing at room temperature, which increases the risk of bacterial growth. • Significant gaps in monitoring food temperatures, which is crucial for preventing foodborne illnesses. • Adherence to safe food handling was higher in hospitals, though gaps still remained.
Training & Education	• Ongoing training programs were found to be effective, particularly in improving food safety knowledge and adherence to proper practices. • Food handlers with more experience had better food safety practices, although knowledge gaps still existed. • In some hospitals, training was infrequent or not comprehensive enough to maintain good food safety standards. • Lack of consistent and regular training programs. • Even with high levels of knowledge, the practical application of food safety practices did not align accordingly.

5. Research Insights and Conclusions

Studies using the KAP model are generally limited and predominantly conducted in a few countries within the Arab region, yielding mixed findings. Overall, this review highlights key gaps and inconsistent findings in food handlers' KAP. While a general trend of good theoretical knowledge of personal hygiene was observed in the majority of studies, significant deficiencies in knowledge and practices remain in the area of food temperature control, safe handling of food and cross-contamination prevention. The findings also reveal variations in KAPs across and within the same countries influenced by factors such as demographic and organisational environment, albeit no consistent trend was observed. But food businesses in low-income countries, e.g., Sudan and Somalia, as well as street vendors, exhibited particularly poor food safety knowledge, attitudes and practices. Nevertheless, the controversial results in the GCC countries also reflect the complex nature of transforming behaviour and attitudes and that there is no one-size-fits-all plan to improve food safety knowledge and practices. While modern food control infrastructure and financial resources exist in affluent countries such as Qatar, Kuwait, and Saudi Arabia, notable deficiencies in the practical application of food safety practices persist, including within hospitals. These countries have comprehensive regulations and better resources than non-GCC, but it is assumed that inconsistent enforcement may undermine their effectiveness [1]. A regulatory focus that leans heavily on

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inspections can limit the impact of these regulations on actual practice. Furthermore, many food businesses in the GCC rely on a multicultural workforce with varying education and language skills, which poses additional challenges to tailoring training programs that match the diverse educational levels.

The KAP studies have not examined the barriers that may have contributed to deficiencies in knowledge as well as practices. However, Faour-Klingbeil et al. [36] discussed the results of the food handlers' perceptions of these barriers initially explored in the same sample and settings of their previous work [35]. The results showed a lack of resources, high costs, limited access to food safety information, inadequate management support, and lax enforcement as major obstacles to implementing food safety practices. These barriers will likely be perceived by food handlers elsewhere in the region and contribute to a poor food safety culture, resulting in substantial gaps in knowledge.

As Faour-Klingbeil [1] points out, there was generally a high rate of compliance reported for personal hygiene practices in studies done in Arab countries, including food workers hand washing before preparing or handling food. However, this was not always the case. Self-reported practices in Egypt were found to be inadequate. Also, in a Kuwaiti study, self-reported practices of food handlers concerning cross-contamination prevention and temperature control were poor, reflecting their attitudes [33].

Questionnaire studies examining the knowledge, attitudes and self-reported practices of food handlers may provide general indications of the food safety practices undertaken by food workers in the food service and food production industries, but the stated knowledge and attitudes towards food safety are not always translated into good hygiene practices performed on the job. This is because food workers tend to overestimate the frequency with which they carry out food safety practices [69]. Thus, even though it is more time-consuming, observation studies of food handlers represent the most accurate and reliable method of assessing the implementation of hygiene practices in the food industry. This was borne out by several later studies. Choi et al.[70] showed that observational results found numerous incidents of noncompliance at various steps critical for the safe handling of fresh and fresh-cut leafy green produce in retail and food service establishments, such as improper use of thermometers, lack of documentation processes, and poor employee hygiene. Even though it is recognised that observation of behaviour is superior to knowledge data alone to document food hygienic behaviour, covert-observation is seldom used in food production to assess actual practices. Evans et al. [71] is one exception when they used closed-circuit-television footage over 15 h in a business to assess hand hygiene compliance where attempts were observed prior to entering high-risk food production areas and >98% of the observed attempts did not comply with the company protocol.

Unfortunately, there are few observational studies in the Middle East North Africa (MENA) region and only some from the developing world. For instance, Faour-Klingbeil et al.[36] found that self-reported practices as related to good compliance with hygienic practices were overly optimistic compared with observations of the same respondents on the same day of the interviews (such as protective clothing and gloves, the use of separate cutting boards for raw meat and vegetables, disinfection and storage practices). There was a great discrepancy between those who reported that they wore protective gloves to prevent cross-contamination and those very few who were observed performing crucial tasks wearing the gloves. The frequency level of essential practices for ensuring safe food production was reported by food handlers in 36 to a maximum of 42 surveyed food service businesses. In contrast, respondents did not show and translate what they reported in practice. Correct practices were visually assessed as “adequate “in only 10 to a maximum of 20 inspected locations.

In addition, two from Africa show that observations are important for assessing risks for foodborne disease by consumers of the prepared food. Lema et al. [72] found that self-reported practice is usually overestimated and an observation component might show even less compliance.

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This is especially important, as previous studies in Ethiopia showed that food workers carried up to 29% of parasitic ova, enteropathogenic bacteria. Sibisi [73] investigated the food safety KAP of food handlers in a food retail company in South Africa, using both self-reported responses and observations of actual practices. Despite managers reporting there were adequate washing stations, observations showed there were not enough, they were not clean, or they were inaccessible to food handlers. Also, although respondents generally had the correct knowledge, operational pressure on employees allowed them to sometimes ignore the recommended practices, and this was observed at food receiving, where defective goods were sometimes accepted when needed urgently.

For a global perspective, Freeman et al. [74] systematically reviewed the literature for observed handwashing prevalence and applied multilevel modelling to estimate handwashing practices worldwide, by region and by country. Unfortunately, there no available data for the Eastern Mediterranean Region was Included. They used direct observation in this study because they decided there was no gold standard measuring of handwashing, and it is considered more accurate than self-reporting. They found that only an overall average of 19% of the world population washes their hands with soap after using the toilet. Meta analysis found that handwashing can reduce the risk of diarrheal disease by up to 40%. In addition, people with access to designated handwashing facilities are about twice as likely to wash their hands with soap after potential fecal contact as people who lack a facility [75], and this is important for the food industry because it was noted in the Durban study that handwashing facilities were not available for many of the employees [73]. Although this review of global research includes all persons in a variety of settings, cultural attitudes and practices get carried over to the work environment, and this would apply to Middle East countries even if they were not a part of the meta-analysis. In summary, effective assessment of actual food safety practices are best achieved through observations rather than self-reported surveys [1].

Considering the current data, there is a critical need for fit-for-purpose, behaviour-based programs that target unique needs and deficiencies within a given setting. Such programs should be built on a thorough understanding of the current status of food handlers' attitudes and knowledge. Tailored interventions focusing on identified gaps can lead to more meaningful and sustained improvements in food safety practices [64]. But to achieve this level of true knowledge transformation, a paradigm shift is needed in both vocational education and training programs, a shift that overhauls existing structures by integrating thematic learning centered on the practical and critical aspects of food safety rather than purely theoretical knowledge. Additionally, establishing licensing programs that uphold high learning standards, even for street vendors, can play a vital role in enhancing food safety practices. Street vendors, who provide an essential source of food and nutrition for many communities in the region, must also be included in capacity-building initiatives. Improving their knowledge and practices can significantly impact public health, as they often serve as an accessible source of well-being and nutrition, especially in low-income settings. After all, transforming food safety practices hinges on a holistic approach integrating education, training, consistent enforcement, and creating a positive organizational culture where food safety is a shared responsibility.

Author Contributions: Conceptualization and Methodology, D.F.K.; Formal Analysis, D.F.K ; Data Curation, D.F.K, T.O, H.Y.S., and E.C.T.; Writing – Original Draft Preparation, D.F.K, T.O, H.Y.S., and E.C.T.; Writing – Review & Editing, E.C.T. and D.F.K.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflicts of interest.

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