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Informed Consent

Every research endeavor involving human subjects, human materials, or human data necessitates prior approval from the relevant ethical committee.

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Research Article

Environmental Lifestyle and Genetic Factors Associated with Cancer Patients in Eastern Libya: A Cross-Sectional Study

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ABSTRACT

Cancer is a growing public health problem in Libya, particularly in Benghazi. Multiple risk factors, including environmental, lifestyle, and dietary factors, contribute to the problem, along with stress. Despite the increasing incidence of cancer, research on the subject remains limited. This cross-sectional study aimed to identify factors associated with cancer among 200 cancer patients (130 women and 70 men) in Benghazi. The study was conducted from February to June 2025 at the Benghazi National Cancer Center, and consecutive patients were recruited. Data were collected through interviews with patients using a structured 35-item questionnaire. Descriptive statistics and the chi-square test were used to analyze the data. Ethical approval was obtained, and data were kept confidential. Most participants were female (65%), aged 41 years or older (60%), and 70% lived in urban areas. The proportion of smokers was 45%, whereas 70% of nonsmokers reported exposure to secondhand smoke. 30% live near industrial areas, 55% eat meat regularly, and only 35% eat fruits and vegetables daily. 25% reported a family history of cancer. The most common cancers were breast cancer (40%) followed by lung cancer (30%), with low levels of awareness. Only 20% of participants were aware of the link between smoking and cancer, and just 15% of women underwent early screening. These findings highlight the diversity of cancers and emphasise the need for smoking cessation, environmental monitoring, improved early screening, and culturally appropriate health education. However, the cross-sectional design among patients limits causal inference.

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1.Introduction

Cancer has become a major global public health problem, with an estimated 19.3 million new cases and 10 million deaths in 2020 [1]. It is the second leading cause of death worldwide after heart disease. Risk factors for cancer are multifactorial, including genetic mutations, environmental factors, and lifestyle risk factors [2], [3].

Important global risk factors include smoking, alcohol consumption, obesity, poor diet, physical inactivity, infectious diseases, and radiation exposure [4], [5], [6]. Several genetic mutations, such as mutations in the BRCA1/2 genes and abnormalities in DNA repair mechanisms, are responsible for 5 to 10% of cancer cases, underscoring the importance of genetic risk factors [7].

Early diagnosis and appropriate preventive measures can significantly reduce mortality in high-income countries. However, low- and middle-income countries experience increased cancer incidence due to poor health systems and low registration rates [8]. Libya reflects this inequality: the national cancer registry is fragmented, 70% of patients are diagnosed late [9], and environmental problems combined with conflict exacerbate the situation [9], [10]. Benghazi, Libya's second largest city, has high rates of smoking and malnutrition, [11], [12].

The study seeks to investigate cancer factors among patients in Benghazi, focusing on demographic, behavioral, environmental, nutritional, and genetic factors, with the aim of informing better public health interventions.

2.Methodology

2.1.Study design and setting

A cross-sectional study was conducted in Benghazi National Cancer Center, a major referral center for oncology in the region, for the period from February to June 2025. The center is one of the largest specialized medical facilities and one of the leading health systems in Libya.

2.2.Participants and sampling

The study included 200 cancer patients: 130 females and 70 males. Diagnoses included breast, lung, colorectal, and other cancers. A convenience sampling strategy was used for patient recruitment. This design does not include a control group, thus limiting causal inference.

2.3.Data collection tool

Data were collected using a structured questionnaire including demographic information, family/ genetic health history, lifestyle, risk factors environment, diet, and health and cancer knowledge. The questionnaire was developed for this study based on literature review but was not externally validated. Trained research assistants conducted face-to-face interviews to ensure data accuracy.

2.4.Data analysis

Data were analyzed using SPSS version 26. Descriptive statistics were used for Demographic and clinical profiles. Statistical analyzes were performed using chi-square tests to assess associations and Cramér's V to tests to determine strength of associations. It is important to note that these tests assess associations between different factors *within* this patient sample, and not with cancer diagnosis per se, as all participants had cancer.

2.5. Ethical considerations

Ethical approval was obtained from the hospital's research committee. Informed consent was obtained from all participants, and their privacy and confidentiality were protected.

3.Results

3.1.Demographic characteristics

Of the 200 participants, 65% were female and 35% were male. The age range of 41 to 50 years and over 50 years represented 30% of patients. Of these, 60% had completed high school and 40% university education. Urban residents made the majority (70%), followed by rural residents

(20%) and those living near factories or waste dumps (10%). These characteristics suggest that middle-aged women with lower education, living in urban environments, were more commonly impacted (Table 1).

3.2.Behavioral and environmental factors

Smoking Frequency: 45% of participants reported regular smoking and 25% reported heavy smoking (more than 20 cigarettes per day). Interestingly, 70% of non-smokers reported exposure to secondhand.

Environmental factors were also important: 30% of participants lived near industrial sites and 40% reported exposure to air pollution (Figure 1).

Table 1. Sociodemographic Characteristics of the Study Sample (n=200)

Variable	Category	Frequency	Percentage (%)
Sex	Male	70	35
	Female	130	65
	Total	200	100
Age (years)	≤30	40	20
	31–40	40	20
	41–50	60	30
	>50	60	30
	Total	200	100
Education	High school or less	120	60
	University or higher	80	40
	Total	200	100
Residence	Urban	140	70
	Rural	40	20
	Near factories/waste	20	10
	Total	200	100

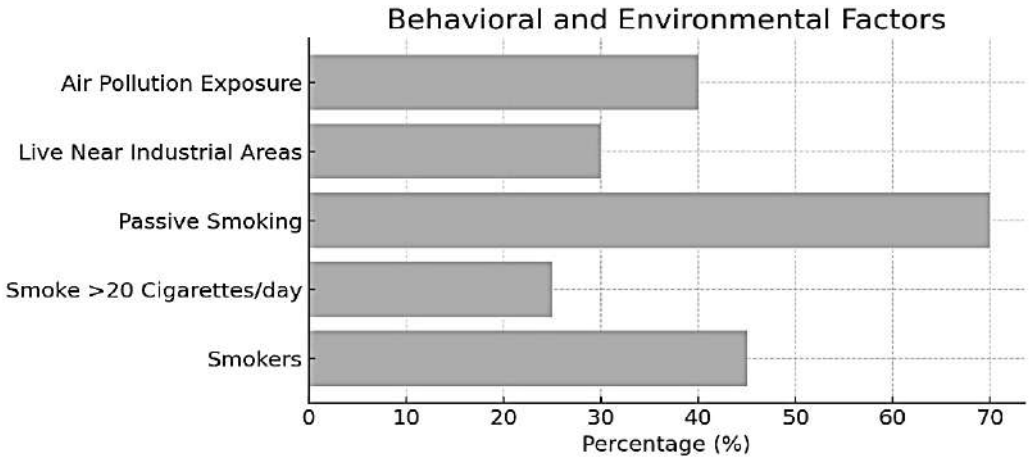


Figure 1. Prevalence of Behavioral and Environmental Risk Factors among Study Participants

3.3. Dietary habits

More than half of the study participants (55%) regularly ate processed meat, while only 35% ate fruits and vegetables daily. Another 45% ate fruits and vegetables less than three times a week (Figure 2).

3.4.Family history and cancer types

One in four (25%) reported a family history of cancer. The types of cancer included breast cancer (40%), lung cancer (30%), colon cancer (20%), and other types of cancer (10%) (Figure 3).

3.5.Awareness

Low awareness: Only 20% knew about the link between smoking and cancer, and 15% of women had their first breast cancer screening (Figure 4).

3.6.Statistical associations

A strong association has been demonstrated between cancer and Lifestyle-related factors in the literature; within our patient sample, we observed associations between certain factors. Smoking ($\chi^2 = 96.67$, $p < 0.001$, $V = 0.69$) and chronic stress ($\chi^2 = 62.34$, $p < 0.001$, $V = 0.56$) showed a strong association, while sun exposure showed a moderate association ($\chi^2 = 45.12$, $p = 0.001$, $V = 0.47$). Age ($\chi^2 = 12.45$, $p = 0.014$, $V= 0.25$) and obesity ($\chi^2 = 8.22$, $p = 0.004$, $V = 0.20$) showed weak but significant correlations (Table 2). These results paint a complex picture of cancer burden among the studied patients.

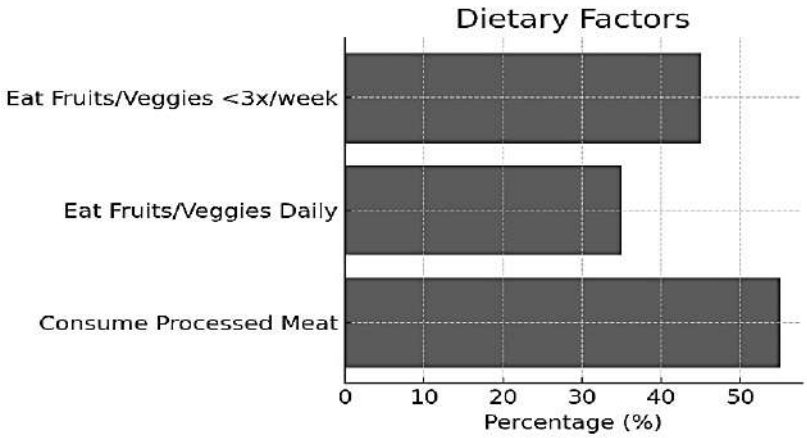


Figure 2. Prevalence of Key Dietary Factors among Study Participants

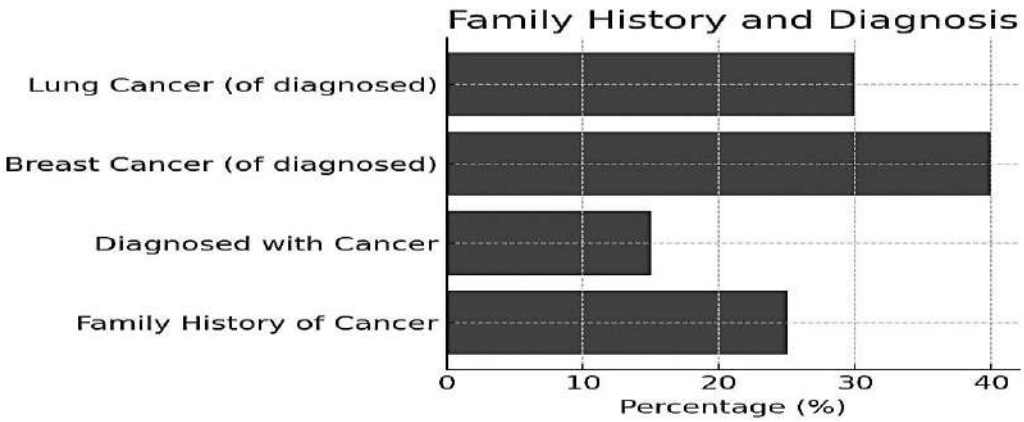


Figure 3 Prevalence of Family History of Cancer and Distribution of Diagnosed Cancer Types

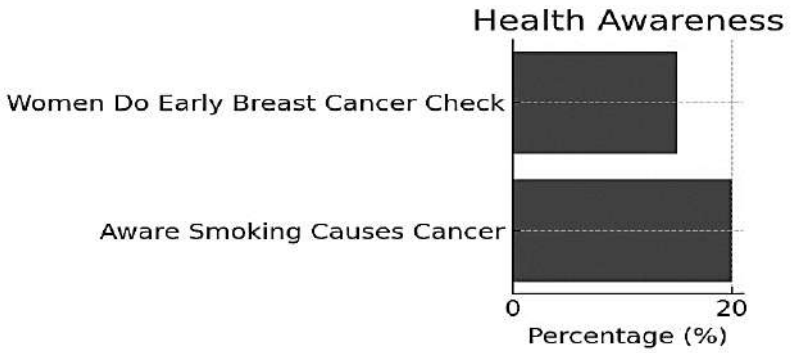


Figure 4 Level of awareness of cancer risk factors and early screening practices

Table 2. Statistical association and strength of correlation (Cramér's v) between risk factors and cancer diagnosis

Variable	χ^2	p-value	Cramér's V	Strength / Interpretation
Smoking	96.67	<0.001	0.69	Very Strong
Chronic stress	62.34	<0.001	0.56	Strong
Sun exposure	45.12	<0.001	0.47	Moderate
Age	12.45	0.014	0.25	Weak
Obesity	8.22	0.004	0.2	Weak
Living near factory	2.14	0.143	0.1	No significant association
Family cancer history	1.27	0.26	0.08	No significant association

5. Discussion

This study paints a concerning picture of cancer risk among patients in Benghazi. However, the cross-sectional design and lack of a control group preclude causal conclusions. Smoking rates were remarkably high, and exposure to second-hand smoke was widespread, revealing gaps in the enforcement of tobacco control measures [11]. Environmental conditions also played a role: living close to industrial facilities and being exposed to air pollution were both reported and may be linked to a higher likelihood of developing cancer [12].

Dietary habits stood out as another key factor. Many participants frequently consumed processed meats while eating insufficient amounts of fruits and vegetables. Such patterns are consistent with international research connecting these dietary behaviors to colorectal cancer [13], [14]. Additionally, around a quarter of the patients reported a family history of cancer, highlighting the importance of genetic susceptibility, especially in a context where genetic counselling and testing are largely unavailable [7].

Perhaps the most alarming finding was the very low level of awareness about cancer risks and the limited engagement in early screening programs, particularly among women. This points to structural gaps in preventive health initiatives. Compared to other low- and middle-income countries, residents of Benghazi face greater exposure to second-hand smoke and have lower awareness of preventive measures---a situation worsened by years of conflict and the breakdown of the healthcare system.

This cross-sectional study is one of the first comprehensive examinations of environmental, genetic, and lifestyle-related cancer risk factors in eastern Libya. It shows a high-risk profile among patients, demonstrates how modifiable

and non-modifiable factors interact, and highlights the urgent need for coordinated cancer prevention and control strategies in a post-conflict environment. Key limitations include the use of a patient-only sample, convenience sampling, and a non-validated questionnaire, which may affect generalizability and introduce bias.

5.1.Prevalence of Smoking and Exposure to Second hand Smoke

The study revealed that 45% of participants were smokers, while 70% of non-smokers reported regular exposure to second-hand smoke. This reflects weak enforcement of tobacco control policies [11] and aligns with previous research linking smoking to lung and bladder cancers [4]. The strong statistical link between smoking and cancer (V=0.69) reinforces that tobacco use remains a leading preventable risk factor in this population.

5.2. Environmental and Lifestyle Factors

Environmental risks were also significant. About 30% of participants lived near industrial areas, and 40% were frequently exposed to air pollution, both contributing to higher cancer rates [12]. Similar findings from other urban regions confirm that unregulated industrial emissions and carcinogenic pollutants are associated with increased cancer incidence [1]. Lifestyle factors were equally concerning, with 55% of participants frequently consuming processed meats and only 35% eating fruits and vegetables daily. These behaviors are well-established contributors to colorectal cancer.

5.3. Genetic Susceptibility and Family History

Approximately one in four patients had a family history of cancer, emphasizing the role of genetic predisposition. Yet, the lack of genetic counseling and testing services in Libya reflects broader disparities in global research, leaving Arab populations underrepresented [7].

5.4. Awareness and Early Detection

One of the most striking findings was the extremely low awareness of cancer risks and preventive practices, particularly among women. Only 15% of women had undergone early breast cancer screening, showing a significant gap compared to high-income countries [15]. This indicates structural shortcomings in preventive health programs, compounded by years of conflict and systemic collapse. The most common cancers observed in the sample were breast cancer (40%) and lung cancer (30%), according to the Libya National Cancer Registry (2020) [9].

6. Conclusion

The cancer burden in Benghazi among this patient sample is shaped by a combination of risk factors, most of which are preventable. Smoking, exposure to second-hand smoke, poor dietary habits, and environmental pollution all play a major role. Genetic predisposition and structural weaknesses in the healthcare system further exacerbate the situation. Without urgent and effective preventive strategies, the rates of cancer, along with related illness and mortality, are likely to keep rising. These findings, though descriptive and based on a patient sample, point to important areas for public health focus.

Recommendations

- Implement and enforce comprehensive tobacco control policies, including restrictions on shisha.
- Strengthen environmental monitoring of industrial emissions and pollution.
- Expand cancer screening programs, including mobile units and genetic counseling.
- Increase public health education campaigns tailored to local cultural contexts.
- Develop a comprehensive national cancer control plan and registry.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Research Article

Antimicrobial Resistant Profile And ESBL Production in *Enterobacteriaceae* Isolated from Fresh Vegetables Sold in Markets in Benghazi City, Libya

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ABSTRACT

Fresh vegetables are widely consumed because of their high nutritional value, however, they may serve as vehicles for the transmission of pathogenic and antimicrobial-resistant bacteria. This study aimed to isolate and identify members of the *Enterobacteriaceae* from fresh vegetables sold in markets in Benghazi, Libya, and to determine their antimicrobial resistance profiles as well as the presence of Extended-Spectrum Beta-Lactamase (ESBL)-producing isolates. A total of 31 raw vegetable samples were collected from six different markets in April 2025. Samples were processed conventionally, with antimicrobial susceptibility determined via CLSI-compliant Kirby-Bauer disc diffusion on Mueller-Hinton agar. Phenotypic detection of ESBL production was performed using the synergy test with a β-lactam antibiotics. Microbial growth was detected in 26 out of 31 samples (83.9%). The most predominant are *E.coli* (22.58%), followed by *Shigella* spp. (19.35%), *Proteus* spp., *Klebsiella* spp. (16.13%), *Salmonella* spp. (12.90%), *Enterobacter* spp. (6.45%), and *Serratia* spp. (6.45%) each. Antimicrobial susceptibility testing revealed high sensitivity to imipenem, amikacin, and meropenem (100%), followed by gentamicin (96.8%) and ciprofloxacin (93.5%). In contrast, high resistance was observed to amoxicillin/clavulanic acid (87%), while moderate resistance was detected to ampicillin (38.7%) and cefotaxime and ceftriaxone (32.3%). ESBL production was confirmed in 6 isolates (19.3%).This study found that commonly consumed vegetables are contaminated with antibiotic-resistant bacteria. The notable presence of multidrug-resistant bacteria on vegetables requires immediate, effective contamination control strategies from local health authorities.

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1. Introduction

Fresh vegetables are an essential component of a healthy diet and are widely consumed around world due to their nutritional value and health benefits. Additionally, fruits and vegetables are regarded as nutrient-dense foods, offering significant nutritional value [1,2] . As a result, organizations such the World Health Organization (WHO) have advised people to eat a substantial portion every day not only for the prevention of chronic diseases such as cardiovascular disease, cancer, diabetes, and obesity, but also for the prevention and alleviation of various micronutrient deficiencies [3]. The consumption of fruits and vegetables is rising due to their correlation with the protection of specific cancer types, ophthalmic illnesses, and cardiovascular conditions [4]. However, the majority of unprocessed food, such as fresh fruits, roots, greens, and sprouts, still serves as a pathway to bacterial illnesses, including those that are resistant to the most common antibiotics [5]. Microbiological safety of vegetables and fruits is a big challenging in the food chain of modern world. These food materials get in contact with unwanted bacteria at one stage- in farming, during packing, transportation and during sale. Among the sources of contamination, both in and contact with polluted soil remain the most important, just to mention unsafe irrigation water, untreated manure and poorly treated bio solids. The poor sanitation during post-harvest handling, transport, processing and storage further compounds it. The microbial load of the produce also grows when the food is improperly handled either by the retailers, or by the consumers omitting the washing process or cooking raw foods together with cooked foods [6,7,8]. Although vegetables are popular due to their widespread acceptability and convenience of use, they are vulnerable to high levels of microbial contamination and cross-contamination, which could result in outbreaks of food-borne pathogens because they do not undergo a terminal heating step before consumption. The possibility of widespread contamination is increased by these problems, which are further exacerbated by poor handling procedures and lax food safety laws in these settings. All vegetables sold in public markets, supermarkets, and roadside stands are susceptible to contamination, which can cause serious health problems for customers and contribute to the rise in food-borne illnesses associated with vegetables in many nations [9].

It has been found that on fresh produce, both antimicrobial-resistant bacteria (ARB) and antibiotic-resistance genes (ARGs) can be detected. In Japan, as an example, the researchers have found long-spectrum b-lactamase (ESBL)-creating strains in leafy vegetables [10]. Similarly, *Escherichia coli* isolates from fresh vegetables in Czech republic have been found to contain ESBL-encoding plasmids [11]. Antimicrobial-resistant strains of *Salmonella* and *E. coli* have also been found on fresh fruit in other countries , such as the US, Canada, Australia, and Finland [12]. Furthermore, fresh produce contains opportunistic bacteria that were once thought to be non-pathogenic but can seriously infect an immune-compromised host. For instance, in various retail market contexts, opportunistic bacteria including *Klebsiella* spp. and *Enterobacter* spp. have been detected on vegetables like tomatoes, capsicum, and cabbage [13,14]. In immunocompromised people, consuming vegetables tainted with *Klebsiella* spp. can result in acute bronchopneumonia and lobar pneumonia [15].

Fresh vegetables and fruits are frequently contaminated in the stage of agricultural cultivation, especially in those cases when water used to irrigate the crops is feces-contaminated. Raw manure is sprinkled. The contamination of water with feces can bring in resistome into the food chain, e.g., $bla_{\text{CTX-M}}$, bla_{TEM}, bla_{SHV} (food safety) [16]. These ARB can readily inhabit the human bowel, following consumption, and take advantage of horizontal gene transfer to pass the resistance genes to indigenous or pathogenic microbiota [17,18].

"As He *et al*. have shown, livestock waste is a major source of antibiotic resistance genes that can enter the agricultural environment, spread

through irrigation or soil, and possibly contaminate vegetables" [19].

Food contamination poses a major environmental health challenge, impacting human well-being by affecting various food sources, including vegetables. Bacterial contamination of vegetables is particularly concerning, as consuming tainted produce can lead to severe health issues. Such contamination can occur through exposure to polluted water, contaminated soil, or poor handling practices during harvesting, transportation, and storage [20]. This study aimed to evaluate the presence of *Enterobacteriaceae* in raw vegetables sold in Benghazi markets and to identify the most prevalent species. It also sought to examine their antibiotic susceptibility patterns and detect extended-spectrum beta-lactamase (ESBL) producers.

2. Methodology

2.1. Sampling, Bacterial Culture, Antimicrobial Susceptibility Profile

This cross-sectional study was conducted in April 2025 with 31 samples of raw vegetables (lettuce, tomatoes, cucumbers, radishes, watercress, and coriander). were collected from 6 different markets in Benghazi city (Alberka, Bouatni, Old laithy, Sedi Khalifa, Alsabry, and Bo Snaib) to evaluate the most predominant strain of bacteria. The samples were processed as per standard microbiological methods. The identification of bacteria was performed by biochemical tests, antimicrobial susceptibility test (AST) was done according to Clinical and Laboratory Standard Institute (CLSI) Guidelines , M100 ,35th edition (2025). Antimicrobial susceptibility testing was performed by Kirby-Bauer disk diffusion method on Mueller Hinton agar. The presence of ESBL enzymes was confirmed by synergy of cefotaxime, ceftazidime and ceftriaxone with amoxicillin/clavulanic acid.

2.2 Statistical Analysis

Data were analysed using IBM SPSS version 26. Descriptive statistic were used to classify the data in mean and stander variation . fisher's Exact test was performed.

3. Results and Discussion

3.1. Isolation and Identification of Bacteria

During the study, 26 out of 31 vegetable samples showed microbial growth, representing 83.9% of the total samples . This high percentage indicates a considerable level of bacterial contamination among examined vegetables it also indicates inadequate hygienic practices during cultivation, harvesting, transportation , or handling of vegetables prior to consumption. . The results are in accordance with similar works, thus in Spain (2021) Pintor-Cora et al.(21) detected *Enterobacteriaceae* counts in (82.9%) of vegetable samples. also in Poland (2022) Kowalska et al. (22) the isolation of *Enterobacteriaceae* in this report was (84%). Moreover, 5 samples harboured two different strains of *Enterobacteriaceae* (16.1%), demonstrating the possibility of mixed contamination within a single sample .

The identification of the isolates have shown that 6 different gram negative bacterial species were isolated (Table1). The predominant and the highest percentage were *E.coli* accounting (22.58%) followed by *Shigella* spp. (19.35%) , *Proteus* spp, *klebsiella* spp (16.13%) each . In addition, *salmonella* spp. (12.90%). Whereas *Enterobacter* spp and *Serratia* spp each constituted (6.45%) (Figure1).

Overall, these finding highlight the diversity of bacterial contamination present in fresh vegetables and emphasize the potential public health risk associated with their consumption.

3.2 Antimicrobial Sensitivity Test

Antimicrobial susceptibility testing was conducted on all 31 bacterial isolates to determine their resistance profiles. The results showed that all isolates were highly sensitive to Imipenem, Amikacin, and Meropenem, with a Sensitivity rate of 100%. Furthermore, a marked sensitivity was observed to Gentamicin (96.8%) and Ciprofloxacin (93.5%) in addition to Levofloxacin.

Trimethoprim/Sulfamethoxazole (89.3%).

In contrast, the isolates exhibited a high resistance rate to several β- lactam antibiotics, particularly amoxicillin/clavulanic acid, with a resistance rate of (87%). Moderate resistance was recorded to Ampicillin (38.7%) and to both Cefotaxime and Ceftriaxone (32.3%). However, a lower resistance rate was observed for Ceftazidime (16.1%) (Figure 2). Overall, these findings indicate the high persistence of resistance to commonly used β-lactams, while maintaining susceptibility to Carbapenems, Aminoglycosides and Fluoroquinolones. . Consuming fresh fruits and vegetables, which possess MDR bacteria on it, can cause issues in the intestinal tract and infections that are hard to treat. A recent study showed that children with MDR bacteria had less microbial diversity, a changed intestinal microbiota, and an intestinal bacteria that was full of AMR genes. Consequently, the intestinal microbiota serves as a reservoir of resistance genes. [23].

Table 1. Occurrence of Enterobacterales in vegetables.

Type of vegetables	Contamination rate	Identified bacteria
Lettuce	13%	*Salmonella* spp., *klebsiella* spp. & *Serratia* spp.
Tomatoes	13%	*Enterobacter* spp., *E.coli. Salmonella* spp.. *Shigella* spp. & *Klebsiella* spp.
Cucumbers	16%	*E.coli, Salmonella* spp., *Shigella* spp. & *Klebsiella* spp.
Coriander	16%	*Salmonella* spp., *Shigella* spp., *Proteus* spp.& *Enterobacter* spp.
Watercress	16%	*E.coli*, *Proteus* spp., *Salmonella* spp. & *Klebsiella* spp.
Radishes	19.3%	*E.coli* , *Proteus* spp. &*Shigella* spp

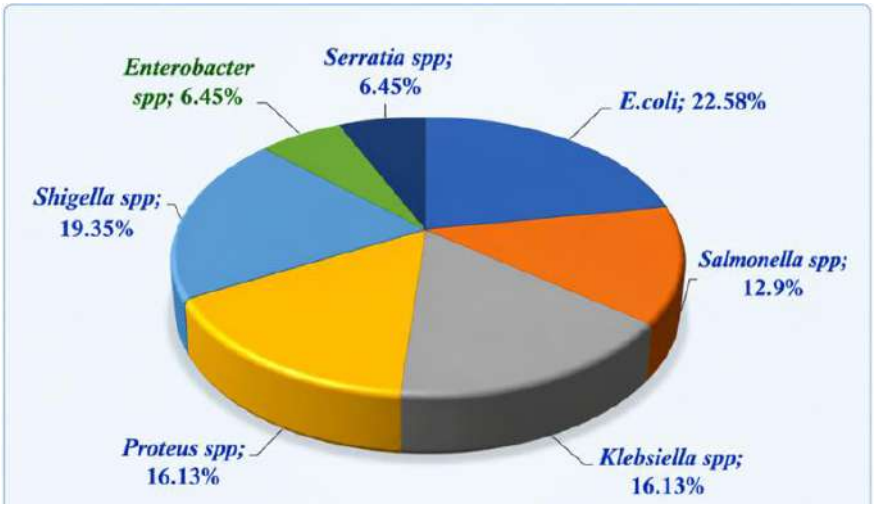


Figure 1. percentage distribution of different bacterial species isolated from vegetable samples

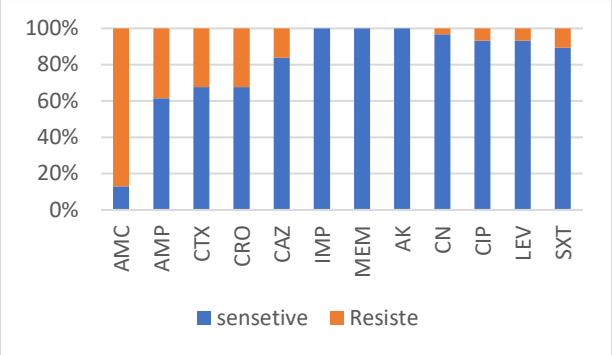


Figure 2. Antibiotic Susceptibility Pattern of *Enterobacteriaceae*

3.3 Phenotypic Detection of Extended Spectrum Beta Lactamases

The results shows the distribution of ESBL-producing isolates among the total samples tested. Out of 31 isolates of gram-negative bacteria, 6 (19.4%) were confirmed as ESBL producers, while 25 isolates (80.6%) were non-ESBL producers. *Salmonella* spp (n= 2) 33.3%, *E.coli*, *Proteus* spp., *Shigella* and *Enterobacter* each showed one isolates (16.6%) that were ESBL producers ($p > 0.05$) (Table2).

Table 2. Prevalence of ESBLs production among Enterobacteriaceae

ESBL PRODUCER	PERCENTAGE (%)
*Salmonella*s Pp	(n=2) 33.3%
Enterobacter	(n=1) 16.7%
Shigella	(n=1) 16.7%
Proteus	(n=1) 16.7%
E.coli	(n=1) 16.7%

Our results corroborate the finding of Amra et al. (2024) in Algeria[24] , where ESBL-producing bacteria were isolated at rate of (19.4%). similarly, we aligned the study of Pintor-cora et al (2021)[21] , which also reported ESBL-producing bacteria were isolated at rate of (17.8%). In contrast, a study conducted in Amsterdam, Netherlands (2014), Reuland et al. reported much lower isolation rate of ESBL-producing microbes at just (6%) [25].

The study had some limitations that should be considered. The sample size were relatively small (n=31), mainly due to limited resource and cost constraints, which the number of samples that could be collected and analysed. This may reduce the statistical power of the study and limit the generalizability of the finding. Therefore, further studies with large sample size are recommended to confirm and expand these findings.

4. Conclusions

As a result of our findings, it's clear that the contamination of vegetables with microbes was significantly high, necessitating urgent action across all stages of production. In addition, our study highlights the occurrence of ESBLs *Enterobacterales* in fresh vegetables, typically ingested raw, thus becoming a public health risk if these vegetables are insufficiently washed or undercooked. Therefore, the consumer needs to be aware about the health risks of fruits and vegetables by maintaining good hygiene at their homes.

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Conflict of interest

The authors declare that there is no conflict of interest.

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Research Article

Postgraduate Dental Students' Perceptions of Evidence-Based Dentistry at the University of Benghazi

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ABSTRACT

This cross-sectional study investigated perceptions, attitudes, self-reported knowledge, evidence-seeking behavior, and confidence related to Evidence-Based Dentistry (EBD) among postgraduate dental students at the Faculty of Dentistry, University of Benghazi. All 159 enrolled postgraduate students were invited to participate during October-November 2022, and 112 completed the questionnaire, giving a response rate of 70.4%. Data was collected using a self-administered questionnaire consisting of socio-demographic and educational items and the validated Knowledge, Attitudes, Access, and Confidence Evaluation (KACE) instrument. The KACE instrument comprised 35 items across four domains: knowledge, attitudes, behavior in accessing evidence, and confidence in critical appraisal. Participants showed low EBD knowledge (mean 2.7 +/- 2.2 out of 10), moderately positive attitudes (mean 5.4 +/- 2.6 out of 10), moderate evidence-seeking behavior (mean 10.7 +/- 4.0 out of 18), and fair confidence in critical appraisal (mean 6.4 +/- 3.7 out of 12). The knowledge domain showed a floor effect (21.4%), indicating limited understanding of core EBD concepts or possible item difficulty. Significant differences were observed for knowledge by postgraduate specialty (P = 0.009), attitude by prior research/statistics training (P = 0.002) and current academic level (P = 0.021), and behavior by prior research/statistics training (P = 0.049). These findings indicate a gap between awareness of EBD and its effective implementation. Integrating structured, competency-based EBD education within undergraduate and postgraduate curricula is needed to strengthen evidence-based clinical practice and improve oral health care quality in Libya.

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1. Introduction

Evidence-based practice (EBP) is a patient-centered approach to practice and make clinical decisions, and it is assumed to be the best contemporary approach to provide scientific, safe, efficient and cost-effective interventions [1]. EBP has become very widespread and considered as an essential requirement in the dental practices [2]. According to the American Dental Association (ADA), Evidence-based Dentistry (EBD) is defined as an approach to oral health care that requires the judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient's oral and medical condition and history, together with the dentist's clinical expertise and the patient's treatment needs and preferences [3].

Even though evidence-based treatments for prevention and management are known and widely spread, the available knowledge is rarely applied to improve the care practice [4]. Regarding dentistry, it delays behind many medical specialties in promoting the uptake of research-based treatments, although most dentists believe they are practicing evidence-based dentistry [5]. This gap between knowledge and practice in providing dental care can be attributed to the academic dental institutions' usual use of passive learning environments [6]. This type of learning is characterized by memorization and repetition of isolated facts, which fails to develop the critical thinking and lifelong learning of the students [5]. Also, the passive learning environment fails to prepare students to address their communities' and practices' needs in future[5,6] Thus, there is a need to enable dentists to provide evidence-based oral care by adapting undergraduate and/or postgraduate dental curricula to teach students the expertise that is necessary to gather valid conclusions from the scientific research. This includes how to evaluate the design, methodology, analysis and interpretation of clinical trials or systematic reviews [7].

The Libyan undergraduate dental curriculum is a five-year program, comprising two years of theory-based foundational basic science followed by clinical science education integrated with patient care and clinical sessions in later years [8]. At the postgraduate level, the University of Benghazi offers advanced dental studies structured across two examination parts (Part I and Part II) and a research thesis. Currently, EBD is not a formal standalone subject in either the undergraduate or postgraduate curriculum. Instead, it is introduced indirectly within research methodology courses during the undergraduate fourth year and postgraduate Part I. This ancillary approach may leave dental practitioners with only a tacit understanding of EBD principles and may limit consistent application in clinical and academic settings [9]. A review of the available published literature identified no studies specifically evaluating knowledge, attitudes, practices, and confidence related to EBD among postgraduate dental students in Libya; therefore, evidence from this setting remains limited.

Therefore, this study aimed to investigate perceptions, attitudes, self-reported knowledge, evidence-seeking behavior, and confidence related to EBD among dental postgraduate students at the Faculty of Dentistry, University of Benghazi. Specifically, it assessed students' confidence in evaluating scientific literature and their preferred sources of evidence. The findings provide baseline data on EBD engagement in this Libyan postgraduate dental education setting and may inform curriculum development.

2. Methodology

This cross-sectional study was conducted at the Faculty of Dentistry, University of Benghazi, during October and November 2022. At the time of the study, 159 postgraduate students were enrolled at the faculty, and all enrolled postgraduate students were invited to participate. Eligible participants included registered postgraduate dental students in Part I, Part II, or the research stage during the study period. Students who were not enrolled at the time of data collection or who declined participation were excluded. A total of 112

students returned complete questionnaires and were included in the analysis, yielding a response rate of 70.4% (112/159). No imputation was required because there were no missing data in the analyzed questionnaires.

Data were collected using a self-administered questionnaire distributed as hard copies by the authors. Participants were asked to complete the questionnaire within one week of the drop-off date. The questionnaire was administered in English because English is the language of dental instruction and assessment in the postgraduate program. No translation or cultural adaptation was performed because the KACE instrument had been validated in English; however, the authors reviewed the items for contextual suitability before distribution. The questionnaire had two parts. The first consisted of seven questions on socio-demographic and educational characteristics, including age, gender, year and institution of the first dental degree, practice type, previous research methods or statistics training outside the undergraduate and postgraduate curricula, specialty, and current academic level (Part I, Part II, or research stage). The second part was the validated Knowledge, Attitudes, Access, and Confidence Evaluation (KACE) instrument developed by Hendricson et al. [10]. It is an English-language questionnaire comprising 35 questions categorized into four subscales: knowledge, attitudes, behavior in accessing evidence, and confidence in critical appraisal.

2.1.Knowledge of EBP principles

This domain consists of ten multiple-choice questions with one best response for each, including the option of “I don’t know”. Each question is scored and then the number of correct answers is determined for each participant with possible values ranging from 0 to 10.

2.2.Attitudes regarding EBP

This domain used ten qualitative statements rated on a five-point Likert scale: strongly agree, agree, uncertain, disagree, and strongly disagree. For analysis and consistency with the scoring approach used in the KACE instrument, responses were dichotomized to indicate positive versus non-positive attitudes. Strongly agree and agree were awarded 1 point, whereas uncertain, disagree, and strongly disagree were awarded 0 points. Items 7 ('It has been difficult for me to practice evidence-based dentistry in the past year') and 8 ('EBP is cook-book dental care that disregards clinical experience in providing the best treatment for patients') were reverse-scored; strongly disagree, disagree, and uncertain were awarded 1 point, whereas agree and strongly agree were awarded 0 points. The overall score ranged from 0 to 10, with higher scores indicating a more positive attitude.

2.3.Behavior in accessing evidence

In this domain, participants use a five-point scale to rank frequency of their utilization of nine health care resources. A five-step Likert scale was used, as follows: Never, Rarely, Occasionally, Often, and Very frequently. The scoring was as follows: “Never and Rarely” = 0, “Occasionally” = 1, and “often and Very frequently” = 2. The overall score ranging from 0 to 18, as higher scores, indicated that postgraduate students were more utilized for health care resources.

2.4.Confidence in critical appraisal

This domain measures confidence in critical appraisal, by using a five-point scale to rate the confidence regarding a list of six components in a published research report. A five-step Likert scale was used, as follows: Not at all Confident, Not Confident, Moderately Confident, Confident, and Very Confident. The scoring was as follows: “Not at all Confident and Not Confident” = 0, “Moderately Confident” = 1, and “Confident and Very Confident” = 2. The overall score ranging from 0 to 12, with 12 being most desirable.

The collected data were analyzed using SPSS for Windows, version 25.0 (SPSS Inc.). Demographic data were summarized using frequencies and percentages. Subscale scores, descriptive statistics, and frequency distributions were generated. Ceiling and floor effects were evaluated based on the percentage of respondents with the maximum or minimum score and were considered present if the proportion was 15% or more [11]. Association among knowledge, attitude, behavior, and confidence scores were performed using

Spearman correlation coefficients. Partial correlation coefficients were also calculated after adjustment for potential confounders selected a priori, including age group, gender, year of BDS award, affiliation institution, practice type, previous research methods/statistics training, postgraduate specialty, and current academic level. Correlations below 0.20 were considered weak, 0.20-0.30 moderate, and >0.30 strong [12]. Because the data were skewed, nonparametric statistics were used (Mann-Whitney U or Kruskal-Wallis tests, as appropriate). The alpha value was 0.05.

2.5.Ethics approval and consent to participate

Ethical approval was obtained from the Research Ethics Committee of the Faculty of Dentistry, University of Benghazi (ref: 138/2022). Verbal informed consent was obtained from all participants before data collection. Participation was voluntary and anonymous, and participants were informed that non-participation would not affect their academic status.

3. Results and Discussion

A total of 112 postgraduate students completed the questionnaire, yielding a response rate of 70.4% (112/159) and a full dataset with no missing responses. The sample was predominantly female (82/112, 73.2%) and aged 30-40 years (84/112, 75.0%). Most participants were from the University of Benghazi (102/112, 91.1%), and 99/112 (88.4%) reported no prior formal training in research methods or statistics outside the undergraduate and postgraduate curricula.

Overall, participants demonstrated low knowledge levels regarding EBD, moderately positive attitudes, moderate evidence-seeking behavior, and fair confidence. Knowledge scores were slightly higher among participants specializing in pediatric dentistry, dental public health, and conservative dentistry and among those with prior research methods or statistics training.

Attitude scores were moderate and consistent across all demographic and academic subgroups. Behavior scores, indicative of EBP application, ranged from 10 to 11 out of a possible 18, suggesting a moderate level of engagement. Confidence in evaluating literature quality was also moderate overall.

A notable finding was that the highest median confidence score (8.5, IQR = 0) was reported by the subgroup with no clinical practice experience, indicating that at least 50% of these participants gave an identical high rating (Table 1).

Most comparisons across demographic and academic variables were not statistically significant ($P > 0.05$). Statistically significant findings were observed for knowledge by postgraduate specialty ($P = 0.009$), attitude by prior research/statistics training ($P = 0.002$), attitude by current academic level ($P = 0.021$), and behavior by prior research/statistics training ($P = 0.049$).

The knowledge scale showed a floor effect: 24 participants (21.4%) achieved the minimum score. This may indicate that the knowledge items were difficult or that respondents had limited EBD knowledge. No floor or ceiling effects were observed for the attitude, behavior, or confidence scales, as all corresponding values were below 15% (Table 2).

Correlation coefficients showed strong positive relationships between attitude and knowledge ($r = 0.499$), attitude and behavior ($r = 0.409$), and attitude and confidence ($r = 0.423$). Knowledge was also strongly correlated with confidence ($r = 0.343$). A weak correlation was observed between knowledge and behavior ($r = 0.155$), suggesting that knowledge alone may not translate into evidence-seeking behavior (Table 3). Adjusted correlations showed a similar pattern.

This study provides baseline evidence on postgraduate dental students' perceptions of EBD in Libya, addressing an under-studied area in dental education and highlighting the absence of EBD as a formal curricular component in the investigated setting. Overall, the findings revealed insufficient EBD knowledge, moderately positive attitudes, moderate evidence-seeking behavior, and fair confidence in critical appraisal skills.

Table 1: Knowledge, attitude, behavior, and confidence summary data, by sociodemographic characteristics of participants

Characteristics	Overall	Knowledge		Attitude		Behavior		Confidence	
	N[a] (%) (N=112)	Median (IQR)[b]	Mean (SD)[c]	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)
Gender									
Male	30(26.8)	2.0(2.3)	2.4(1.9)	5.5(3.0)	5.4(2.6)	11.0(5.3)	10.7(4.2)	7.0(4.3)	6.5(3.6)
Female	82(73.2)	2.5(4.0)	2.7(2.3)	6.0(3.0)	5.4(2.6)	10.0(5.3)	10.7(3.9)	6.0(6.0)	6.3(3.7)
Age Group (Years)									
< 30	23(20.5)	3.0(4.0)	3.2(2.3)	7.0(2.0)	5.8(2.5)	12.0(5.0)	11.4(3.4)	6.0(6.0)	5.7(3.4)
30-40	84(75)	2.0(3.8)	2.5(2.1)	6.0(4.0)	5.2(2.7)	10.0(5.0)	10.6(4.0)	7.0(5.8)	6.5(3.7)
> 40	5.0(4.5)	2.0(2.5)	2.2(1.6)	7.0(3.0)	6.6(1.8)	7.0(10.5)	8.8(6.1)	10.0(7.5)	7.8(4.7)
Year of award of dental degree (BDS)									
<2010	38(33.9)	2.0(3.0)	1.9(1.8)	6.0(4.0)	5.1(2.8)	11.0(7.3)	10.4(4.8)	6.5(6.3)	6.5(4.0)
2010-2015	49(43.8)	3.0(3.5)	2.9(2.2)	6.0(3.0)	5.6(2.4)	10.0(5.0)	10.6(3.8)	7.0(5.5)	6.3(3.7)
>2015	25(22.3)	3.0(4.0)	3.2(2.4)	6.0(2.5)	5.6(2.6)	11.0(5.0)	11.0(3.1)	7.0(4.5)	6.5(3.3)
Affiliation Institution									
University of Benghazi	102(91.1)	2.0(3.0)	2.6(2.1)	6.0(3.0)	5.3(2.6)	10.0(5.3)	10.7(4.0)	7.0(5.3)	6.5(3.7)
Other Universities	10(8.9)	2.0(3.5)	2.5(2.0)	7.0(4.3)	5.9(2.8)	10.5(5.0)	10.7(3.9)	6.0(4.3)	5.2(3.3)
Practice type									
Government	46(41.1)	2.0(3.5)	2.5(2.2)	6.0(3.0)	5.3(2.7)	10.0(7.0)	10.3(4.5)	6.5(6.0)	6.5(3.7)
Private	10(8.9)	2.5(4.0)	2.6(2.6)	3.5(4.8)	3.8(2.7)	9.0(3.5)	9.7(2.8)	6.5(6.8)	6.1(3.8)
Academic	35(31.3)	3.0(4.0)	2.9(2.3)	6.0(4.0)	5.3(2.7)	10.0(6.0)	11.4(3.7)	7.0(7.0)	6.3(4.2)
None	2(1.8)	4.5(0.0)	4.5(0.7)	7.5(0.0)	7.5(2.1)	13.0(0.0)	13.0(1.4)	8.5(0.0)	8.5(2.1)
Government and Private	8(7.1)	2.5(1.0)	2.6(1.2)	7.0(2.8)	7.1(1.5)	12.5(5.8)	12.5(3.9)	6.5(5.8)	6.5(3.8)
Academic and Private	11(9.8)	2.0(2.0)	2.1(1.8)	6.0(3.0)	5.7(2.0)	10.0(5.0)	9.5(3.9)	6.0(3.0)	6.1(2.1)
Had taken research methods/Statistics course									
Yes	13(11.6)	3.0(2.5)	3.0(1.9)	7.0(2.0)[d]	7.2(2.1)	13.0(5.0)[d]	12.7(3.4)	7.0(6.5)	7.6(3.7)
No	99(88.4)	2.0(3.0)	2.6(2.2)	6.0(3.0)	5.2(2.6)	10.0(5.0)	10.4(4.0)	6.0(5.0)	6.2(3.7)
Major of postgraduate									
Oral Medicine	20(17.9)[d]	2.5(2.8)	2.5(1.9)	5.0(5.8)	4.3(3.0)	10.0(3.0)	10.5(3.1)	7.0(6.8)	6.7(4.0)
Oral pathology	19(17)	2.0(4.0)	2.4(2.2)	4.0(6.0)	4.9(3.3)	14.0(9.0)	11.4(5.2)	7.0(8.0)	6.4(4.4)
Oral biology	11(9.8)	1.0(2.0)	1.3(1.5)	5.0(4.0)	4.8(2.8)	10.0(7.0)	9.2(4.9)	7.0(8.0)	6.6(3.9)
Dental public health	14(12.5)	3.5(3.0)	3.6(1.9)	6.5(1.0)	6.5(0.8)	10.0(5.8)	10.9(4.0)	8.0(3.5)	7.9(3.3)

Pediatric dentistry	18(16.1)	3.5(4.3)	3.9(2.5)	7.0(2.3)	6.4(2.5)	10.0(5.5)	11.2(3.1)	6.0(3.3)	6.1(2.7)
Orthodontics	5(4.5)	3.0(4.0)	2.2(2.2)	7.0(3.0)	6.2(1.9)	12.0(4.5)	12.6(2.7)	8.0(4.0)	7.2(2.2)
Dental materials	9(8)	1.0(1.5)	1.0(1.3)	4.0(3.0)	4.7(1.7)	7.0(4.5)	8.2(3.5)	4.0(6.5)	4.4(3.9)
Conservative dentistry	16(14.3)	3.0(3.0)	2.8(2.1)	6.5(2.0)	5.8(2.4)	11.0(6.5)	11.1(4.2)	6.0(5.3)	5.9(3.7)
Level of current major									
Part I	33(29.5)	2.0(3.0)	2.2(2.0)	5.0(6.0)[d]	4.4(3.0)	10.0(3.5)	10.2(4.0)	6.0(6.0)	5.3(3.5)
Part II	33(29.5)	3.0(4.5)	3.0(2.4)	7.0(2.5)	6.2(2.3)	11.0(6.0)	11.3(4.3)	7.0(3.5)	6.9(3.3)
Research	46(41.1)	2.0(3.0)	2.7(2.1)	6.0(3.0)	5.5(2.3)	10.0(5.5)	10.6(3.8)	7.0(6.5)	6.8(3.9)

[a]N, number; %, percentage; [b]IQR, interquartile range; [c]SD, standard deviation; [d]P < 0.05 from Mann-Whitney U or Kruskal-Wallis tests. Exact significant P-values were: knowledge by postgraduate specialty, P = 0.009; attitude by prior research/statistics training, P = 0.002; attitude by current academic level, P = 0.021; behavior by prior research/statistics training, P = 0.049.

Table 2: Descriptive data on the knowledge, attitude, behavior, and confidence scales.

Variable	No. of Items	Mean (SD)[a]	Range	Floor effect N (%)[b]	Ceiling effect N (%)
Knowledge	10	2.7(2.2)	0 - 8	24(21.4)	0(0)
Attitude	10	5.4(2.6)	0 - 10	10(8.9)	10(8.9)
Behavior	9	10.7(4.0)	0 - 18	1(0.9)	6(5.3)
Confidence	6	6.4(3.7)	0 - 12	12(10.7)	10(8.9)

[a]SD , standard deviation, [b] N=number, (%)= percentage.

Table 3: Correlations between Knowledge, Attitude, Behavior, and Confidence.

Subscales	r[a]	Partial r[b]
Knowledge/Attitude	0.499	0.485
Knowledge/Behavior	0.155	0.112
Knowledge/Confidence	0.343	0.326
Attitude/Behavior	0.409	0.381
Attitude/Confidence	0.423	0.435
Behavior/Confidence	0.244	0.238

r^a = Spearman correlation coefficient; Partial r^b = Correlation coefficient adjusting for potential confounders which included sociodemographic characteristics.

This pattern reflects a discrepancy between awareness of EBD principles and the ability to apply them effectively in clinical and academic contexts.

The markedly insufficient level of knowledge among participants is concerning, particularly because postgraduate students are expected to be familiar with scientific literature and to apply evidence in advanced clinical decision-making. The presence of a significant floor effect in the knowledge domain further suggested that a substantial proportion of students possess very limited understanding of core EBD concepts. Similar findings have been reported among dental students and practitioners in Kuwait, Iran, and Malaysia, where insufficient knowledge was attributed to limited formal training in research methodology and biostatistics [1, 2, 9, 13]. This finding aligns with the Libyan context, where EBD is not taught as a standalone subject and is addressed only indirectly through research methods courses.

Differences in knowledge scores across postgraduate specialties, with relatively higher scores among students in pediatric dentistry, dental public health, and conservative dentistry, may reflect varying degrees of exposure to preventive, population-based, and research-oriented approaches within these disciplines. Previous studies have shown that specialties with stronger emphasis on prevention and public health tend to demonstrate higher engagement with evidence-based principles [7, 14].

Attitudes toward EBD were generally positive and consistent across most demographic groups, suggesting widespread acceptance of this approach as a valuable method in dental practice. These findings are consistent with reports from Europe and North America, where dental students have shown strong support for integrating EBD into their dental education despite their limited practical competence [5, 7, 15]. Importantly, students who attended additional courses in research methods or statistics exhibited significantly more positive attitudes, suggesting that structured educational exposure not only enhances knowledge but also fosters positive perceptions of EBD. This supports calls in the literature to move beyond passive learning environments toward active, skills-based teaching strategies [6, 16].

Regarding evidence-seeking behavior, participants demonstrated moderate use of information sources, with a clear preference for textbooks and general internet resources over high-level evidence sources such as the Cochrane Database and critically appraised topics. This pattern has been consistently reported in studies and is often attributed to issues of accessibility, time constraints, and limited training in efficient literature searching [5, 9, 17]. Although moderate behavioral scores suggest some engagement with evidence-seeking practices, the relatively low use of pooled evidence sources raises concerns about the quality of evidence underpinning clinical decisions.

Confidence in critical appraisal skills was also moderate, with low levels of confidence in identifying bias and evaluating study design. These findings are consistent with those reported by Hendricson et al. and subsequent validation studies using the KACE instrument, which confirmed that confidence in appraisal does not develop spontaneously and requires explicit training and repeated practice [10, 18]. The relatively higher confidence observed in participants without clinical experience may reflect an overestimation of their abilities, a phenomenon previously described in novice learners lacking practical experience [19].

Correlation analysis revealed meaningful relationships among EBD domains. Attitude showed strong correlations with knowledge, behavior, and confidence according to the thresholds used in this study, suggesting that positive perceptions of EBD may encourage engagement with evidence. Conversely, the weak correlation between knowledge and behavior indicates that knowledge alone is insufficient to change practice, underscoring the need for educational interventions that integrate knowledge acquisition with practical application, supervised literature searching, and clinical relevance [15,20].

Despite its strengths, including the use of a validated instrument and assessment of multiple EBD domains, this study has some limitations. The cross-sectional design does not permit causal inference, and the single-institution setting may limit generalizability. However, given that the University of Benghazi is a major provider of postgraduate dental training in Libya, the results offer valuable insights into the current state of preparedness of future specialist dentists for EBD.

These findings collectively reinforce the argument that the current educational approach is insufficient to bridge the gap between research evidence and clinical practice. Integrating structured, longitudinal, and competency-based training in EBD into undergraduate and postgraduate curricula is essential to equipping Libyan dentists with the skills necessary for lifelong learning and providing evidence-based healthcare.

4. Conclusions

Postgraduate dental students at the Faculty of Dentistry, University of Benghazi demonstrated positive attitudes toward EBD but showed low knowledge levels, moderate evidence-seeking behavior, and fair confidence in critical appraisal. These findings indicate a gap between awareness and effective implementation of EBD. Structured, competency-based EBD education should be integrated within undergraduate and postgraduate curricula to enhance evidence-based clinical practice, critical appraisal skills, and oral health care quality in Libya.

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Conflict of Interest

The authors declare no conflicts of interest. Funding: No external funding was received for this study.

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Research Article

The Impact of the Novel E-J Biomechanical Footwear System on Lower Limb Biomechanics in Recreational Female Athletes at High Risk of Non-Contact ACL Injury: A Feasibility Study

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ABSTRACT

Anterior Crucial Ligament injury is one of the most severe knee injuries that happens to young athletes who participate in sporting activities that require cutting, pivoting, and sudden deceleration. Prevention programs have proven to lower limb neuromuscular control, which would reflect on dynamic knee stability and functional performance. However, most of those programs have low compliance rates because they require a time commitment and a considerable level of intensity and complexity. The study aims to evaluate the feasibility of performing the intervention on healthy recreational female athletes with the E-J system and to review the current prototype design of the device, according to the user perspective, and finally, to observe any alterations in postural stability. The study was conducted in three phases. Of 15 potential participants, 10 female participants were recruited after being 2D video assessed at the screening phase, as they showed an FPPA exceeding 8.5 degrees while performing a single-leg squat. Participants were assessed using the Y balance test in the pre-intervention phase and after 4 weeks in the post-intervention phase. Compliance rate, Y-balance test outcomes of each limb length, reach for the right and left lower limbs in three directions each (Anterior, Posteromedial, Posterolateral). Results showed a significant (p-value < 0.05) increase in limb length of reach, along with a compliance rate of 89%. The outcomes suggest that performing an intervention with the E-J system is safe and feasible. In addition, the E-J system demonstrated that it may have potential for improving lower limb postural stability.

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1. Introduction

ACL (Anterior cruciate ligament) ruptures account for nearly half of all soft tissue knee sports injuries [1]. ACL injury is arguably one of the most severe and debilitating lower limb injuries associated with athletic participation [2]. According to Sugimoto et al. [3], non-contact mechanisms account for the majority of ACL injuries in sports like landing, cutting, and abrupt deceleration during sprinting in sports such as, football, rugby, volleyball, handball, and basketball.

Neuromuscular and biomechanical changes have been identified as possible risk factors for non-contact ACL (NCACL) injuries among female athletes [4],[5]. The disruption in neuromuscular control and the uneven recruitment of lower limb muscles during athletic movements can lead to heightened lower limb motion and stress, thereby elevating the risk of NCACL injuries in females [6]. When the muscles that govern the dynamic stability of the knee joint in the lower extremities fail to generate the necessary force, there is an increase in stress on the ACL, which raises the likelihood of its injury [7].

Female athletes are reportedly 4–7 times more likely than their male counterparts to sustain an NCACL injury [8]. They appear to have unique neuromuscular strategies when performing motor tasks that place them at a higher risk of sustaining ACL injuries [9]. During athletic movements, female athletes tend to land with a highly extended knee position and an increased knee valgus motion [10]. This lack of neuromuscular control in the lower limb in female athletes during cutting, pivoting sport manoeuvres could lead to valgus collapse, resulting in ACL injury [11].

Academic research has concentrated on developing intervention programs to decrease the frequency of knee ligament injuries, especially ACL injuries, among female players performing risky sport movements [12]. Furthermore, due to improved neuromuscular control of the lower limbs result in modified biomechanical risk variables, it has shown that changes in high-risk lower limb movement patterns resulting in decreasing the chance of sustaining ACL injury while participating in sports which include high-demanding sports manoeuvres, especially among players who show neuromuscular control deficits which may negatively impact their knee dynamic stability [13],[14].

Numerous scholarly investigations have identified a significant disparity between the findings of published research and the practical application of injury prevention strategies [15],[16],[17],[18]. This divergence was underscored by the discrepancies observed between laboratory-derived outcomes and the actual effect on the incidence of injuries among female athletes in high-risk categories [7]. A potential contributing factor to this phenomenon is that the majority of protocols for ACL injury prevention programs demand substantial time commitments, coupled with considerable complexity and intensity. These demands may deter both coaching staff and athletes from active participation, consequently leading to suboptimal adherence rates [17].

Several studies have indicated that employing balance training apparatus, including unstable surfaces and wobble boards, can substantially enhance the proprioception of lower limb joints musculature during rehabilitation [18], [19],[20]. Documentation from various studies suggests that balance and proprioception training regimens can function as supplementary training elements, offering a minimal risk of injury or fatigue, and thereby improving the neuromuscular control, resulting in better stability and biomechanics of the lower extremities [21],[22],[23],[24],[25],[26]. These programs are predicated on the understanding that the human body operates as an integrated system of interconnected muscles, joints, and linkages, with the entire limb perceived as a singular kinetic functional chain that originates from the foot and extends throughout the entire body [27],[28].

A significant number of unstable footwear designs exhibit several disadvantages. Primarily, they are constrained by the manufacturer's predetermined configuration, precluding any adjustments to lower limb alignment or joint loading [29],[30],[31]. Furthermore, these devices lack the capacity for modification or calibration to accommodate specific therapeutic requirements. A third

considerable limitation is their typically high cost, which substantially restricts their widespread application in injury prevention initiatives. Finally, it has been observed that most footwear-based balance devices are effective in influencing only a single plane of motion [32],[33],[34].

The objective of this study was mainly to explore the safety and feasibility of performing the intervention on healthy recreational female athletes wearing a prototype biomechanical device (E-J system), and reviewing the current design of the device, according to user perspective, and finally observe any alterations in postural stability in the lower limbs.

It is hypothesized that the E-J system, functioning as a wearable biomechanical device for the foot, it may foster enhanced lower limb stability. Furthermore, it is anticipated that users will be able to incorporate this device into their daily routines without disruption to their demanding schedules, potentially leading to improved adherence rates. Consequently, the E-J system may serve as a valuable component in risk mitigation programs for lower limb injuries.

2. Methodology

Repeated measurements were taken at two different times in this feasibility study. Every measurement was taken both before and after the four-week intervention. The usage of the Y balance test for measuring postural stability has been approved to be a reliable and valid method for assessing postural stability [35] and has been identified as a measurement to identify high- risk mechanics for sustaining lower limb injuries in the athletic population [36, 37,38].

2.1. Participants

All potential participants for the study needed to be aged 18 to39 years old to qualify participating in the study. They also had to engage in recreational sports involving over 30 minutes of physical activity at least three times a week consistently for the last six months [39].

None of the participants had injuries to their lower limbs in the past three months nor did they have a previous ACL or any long-term problem with their lower limb or surgeries. All participants were also required to have a Beighton score of < 4 for general laxity. Those who experienced musculoskeletal issues that kept them from their usual exercise routine for over 6 weeks before the beginning of the intervention was not included. Furthermore, participants who were already part of another injury prevention program were not permitted to take part. The study received ethical clearance from the Institutional Ethics Committee of the University of Benghazi, School of Physical Activity and Sports Science by Reference and committee: [2025-3-10/112]. All participants reviewed and signed a consent form.

2.2. Procedures

Of 15 female footballers' participants attended the screening phase of the study, performing Single-Legged Squat (SLS) in 2D video frontal plane projection angle (FPPA) [40]. Ten (10) participants were recruited as they showed (FPPA) exceeded 8.5 degrees, which may indicate poor neuromuscular control of their lower limb [1].

2.3. Calibration

Each participant received personalized calibration of their E-J system from the lead researcher before the initial data gathering. The E-J system consists of one modular component fixed to a shoe platform. This component is secured in a way that permits adaptable positioning of the foot's center of pressure. Due to intellectual property protection held by Salford University, UK and the University of Benghazi, Libya and drawings and specific calibration process cannot be disclosed in this document for confidentiality reasons. The calibration of the E-J system was directed by visual 2D FPPA for every participant to achieve as low knee valgus angle as possible during the SLS task.

2.4. First Session

Prior to the first session, participants were asked to perform five minutes of low-intensity warm-up stretching. Afterwards, participants performed the Y balance test. Participants had the chance to become acquainted with the Y balance test in order to reduce systematic bias, which typically required three or four attempts

before they were sure they were doing it correctly. It was required of each participant to complete four trials. To reduce the impact of fatigue on participant's performance, they were also given a 60-second break in between each session. A copy of the study intervention program handbook and instructions on how to follow it and document their adherence for each participant. For four weeks, the participant was required to adhere to the research intervention protocol.

2.5. Follow-Up Session

After the participant finished the study intervention program, the participant performed Y balance test as previously done in the first collection session. The data collection process adhered to all the aforementioned protocols. The entire session lasted between 20-30 minutes.

2.6. Study Intervention program.

Each of the four stages in the study's intervention program lasted for one week. The goal of the first stage was to start with basic two-legged activities, like a two-legged anterior progression exercise that involved a double-legged squat. The second stage introduced single-leg anterior exercise to create greater loads on the hip and knee joints during controlled movements with an emphasis on maintaining a deep knee hold position, such as performing a Single-Legged Squat (SLS). This required sufficient torque production and control from the nearest muscles to manage the movement's direction at the hip.

To enhance the difficulty and concentrate on the flexors and extensors of the knee and hip, the third phase had participants begin with forward lunges, followed by lateral band walks and two-legged squats using a resistance band. The final week of the intervention featured the single-leg deadlift exercise.

Each workout began with three sets of ten repetitions and was gradually increased to a maximum of six sets of ten repetitions, similar to the previous phases.

The purpose of this exercise program was to instate the right technique in both the front and sagittal planes. This intervention program was conducted five days a week over a four-week time frame. Initially, exercise utilizing both legs were introduced to safely acclimate participants to the training movements, followed by a gradual increase of single-leg activities. The intensity and difficulty of the training drills was systematically increased.

Additionally, participants were asked to wear the E-J system for 30 minutes while doing their daily routines at home. To be included in the study, participants needed to complete at least two-thirds of the study intervention program.

3. Results and Discussion

Each participant's physical activity level was 5.6 according to the Tegner Activity Scale (TAS) [42], and they were all recreationally active. Six participants were the right leg dominant, and four were left leg dominant. The participant's adherence level was 89%. The Y balance test outcomes of each limb length reach for right lower limb in three directions, each Anterior, Posteromedial, Posterolateral showed significant increase in limb length ($p = 0.04$, $p = 0.02$, and $p = 0.01$, respectively), which may reflect improvement in the limb stability crease improvement in the lower limb reaching.

Nonetheless, the outcomes of the left side also showed similar improvement in limb length reach at the Anterior, Posteromedial, Posterolateral (P values 0.02, 0.02 and 0.03 respectively). However, due to the lack of a control group, we should be cautioned to claim any improvement in the lower limb's postural stability. There exists a link between poor neuromuscular control and movement patterns that are considered high-risk, which has been shown to increase the chances of experiencing both primary and secondary NCACL injuries [43],[44].

The optimum reasoning behind the potential incorporation of a workable biomechanical device such as the E-J system in injury

Table 1. Illustrate the demographics of the study population.

Variables	Study participants
Age (year)	26.42±9.05
Weight (kg)	64.37±12.06
Hight (cm)	163.28±8.92

Table 2. Illustration the Pre and Post Intervention Y balance test results (cm) for right side lower limb.

Variables	Mean	Std. Deviation	Mean diff	Std. Deviation	*P value*
Anterior/ Pre	85.857	8.529	8.52	2.27	0.04
Anterior / Post	91.571	7.449	7.44	1.99	
Posteromedial/ Pre	80.357	6.766	6.76	1.81	0.02
Posteromedial/ Post	84.357	5.197	5.19	1.38	
Posterolateral /Pre	80.071	8.203	8.21	2.19	0.010
Posterolateral/ Post	85.012	7.980	7.98	2.13	

Table 3. Illustration the Pre and Post Intervention Y balance test results (cm) for left side lower limb.

Variables	Mean	Std. Deviation	Mean diff	Std. Deviation	*P value*
Anterior/ Pre	84.502	8.52	8.52	2.27	0.02
Anterior / Post	91.21	7.87	7.87	2.10	
Posteromedial/ Pre	79.357	7.67	7.67	2.05	0.02
Posteromedial/ Post	83.64	6.05	6.05	1.61	
Posterolateral /Pre	81.153	7.54	7.54	2.07	0.03
Posterolateral/ Post	86.07	7.47	7.47	2.09	

prevention programs are underlined by its flexibility, potentially enhancing its use and wearability, serving as a more time-effective intervention method, while still providing crucial improvements in neuromuscular control. The design of the E-J system aims to adjust lower limb alignment by modifying the foot's center of pressure, which subsequently induces a manageable destabilization. Thus, challenging the muscles responsible for stabilizing the knee dynamically. This change in how the lower limb muscles are activated may enable users to improve their lower limb motor control sufficiently to sustain higher dynamic loads on the knee passive restraints, especially sport activity which require cutting, pivoting and sudden deceleration. [1].

The main consideration tackled in this research was mainly health and safety, which included the safe usage of the E-J system while participants engaged in the designated exercise during the research timeline. No injuries or

main issues were reported to the researcher. The only concern was muscle discomfort noted during the first week of the study program, which subsided as participants became accustomed to the program. The other considerations are reviewing data collection methods, follow-up effectiveness, dropout rates, and overall acceptability. Additionally, the components of the program were assessed for their efficiency and safety [45],[46]. Moreover, the complete feasibility trial and its design were evaluated in relation to biomechanical outcomes, including the intervention's effect on the lower limb dynamic stability.

The two-dimensional video analysis utilizing FPPA for assessing the knee joint motion proved to be an appropriate and effective method for swiftly screening participants and was convenient for most potential candidates [47],[48],[49],[50]. Furthermore, the researcher employed this 2D video analysis as a tool for calibration purposes. Moreover, each participant required 10 to 15 minutes for calibration, a timeframe they found acceptable.

Each evaluation session spanned twenty to thirty minutes, which participants regarded as reasonable concerning the study intervention, the progressive method and exercise type were found to be suitable by the participants involved in the program that utilized the E-J system. The participants observed that completing the program exceeded fifteen minutes, and sometimes they could not finish all walking trials. Nevertheless, there were no reports of participants dropping out, and the adherence rate, in terms of sessions and time spent, exceeded 89%. Every participant was given a follow-up sheet at the beginning of the trial to monitor their commitment to the study intervention program.

The preliminary results from this feasibility study (Tables 2 and 3) indicated considerable improvements in the Y balance test results for each limb's reach on the right lower limb in all three directions [36]. This might imply that the E-J system has the ability to challenge lower limb stability sufficiently to stimulate improvements in dynamic neuromuscular control, which was believed to be a crucial factor affecting lower limb risk of sustaining injuries [37],[38] which may be related to muscle activation patterns improvement [34].

The findings from this study may lead us to propose that the E-J system may have the ability to alter the lower limb center of pressure, which explain the improvement observed in post-Y test outcomes. Therefore, it may be proposed that it could have an influence on the lower limb postural stability which would justify future studies on the prototype and comparing it in study with the control group.

4. Limitations.

The study findings may have a number of limitations. Firstly, these results pertain solely to young adult females who participate in recreational sports. The findings cannot be generalized to adolescent females' athletes with different skill levels. Secondly, the experiment only explored the immediate effects of the E-J system, a biomechanical device; the duration of its benefits remains unclear. Nonetheless, due to its simple structure and low intensity, it can suggest that users might be able to use the device both in the preseason and throughout the season. Thirdly, there was no control group for comparison included in this research. Lastly, the E-J system, being a prototype, was developed with limited resources, which could have influenced the exploration of it.

Finally, even though there were changes in Postural stability,. However, this must be taken with caution due to the nonstatistical testing adopted in this feasibility study and also whether the exercise program alone, rather than the E-J system, was responsible, which needs to be assessed. Nevertheless, the additional effect of the exercise component needs to be investigated without the E-J system. However, this would be beyond the scope of the present study.

5. Conclusions.

The study outcomes suggest that performing the intervention on healthy recreational female

athletes with the E-J system is safe and feasible. The participant's reviewing the current prototype design of the device was positive, as they found it particular and easy to use. Moreover, the methodology applied would be suitable for conducting future studies. Finally, the E-J system demonstrated it may have a potential influence on the lower limb postural stability, which would justify future studies on the prototype and improving it.

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Conflict of interests

NO affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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Research Article

Use of Social Media as a Source of Nutritional Information Among Health Science Students at Benghazi University

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ABSTRACT

Social media is challenging as an information-sharing community because there is no formal review process before the information is published. University students rank among the most engaged users of social media and have demonstrated difficulty in assessing credible information on the internet. The study aims to explore the use of social media as a source of nutritional information among health science students at Benghazi University, Libya. A Descriptive, cross-sectional study was conducted between January and May 2024. The study sample consisted of 434 health science students (377 females and 57 males). Data were collected using an online, self-administered questionnaire via Google Forms. A chi-square test was utilized to analyze the relationship between demographic characteristics and the use of social media for sourcing nutrition information. Results indicated that 81.6% of students utilized nutrition information, with 25.8% actively following a specific diet. Participants primarily searched for general nutrition tips and disease-specific dietary information. Approximately half of the respondents (50.5%) considered social media platforms to be their most reliable source of nutrition information. Statistical analysis revealed a significant correlation between gender and several factors, including social media usage, preferred content types, qualifications of followed pages, and the perceived accuracy and helpfulness of the information. Additionally, the students' specific faculty was significantly associated with their use of social media for nutrition information and their perception of page credibility. This study has shown that social media is the most common source of nutritional information among students. This study indicates that Facebook is the preferred social media platform among a majority of students.

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1. Introduction:

Social media refers to any internet-based platform focused on community contribution, interaction, sharing of content, and/or collaboration, which is utilized for online social networking (1). Social media are widely popular across different age groups. However, the recent rise in popularity of social media platforms has introduced a new option for finding information online. Consequently; can be considered the social media as the most influential part of receiving information about their daily needs. As a social media have become more mainstream, their impact has extended to the health domain (2). Social media in health fields have experienced growing participation of users and are increasingly considered a credible form of communication. Recently, interest in nutrition, sports, and a healthy lifestyle is become vast and searching for nutritional information online is also become prevalent. (3) Evidence from the study found that a majority of participants (>70%) utilized internet-based platforms for dietary information. (4).

College students, in particular, have been found to be at risk for being exposed to a wide dissemination of unreliable and misleading health information through social media due to their lack of skills to properly judge online health information. The evidence shows that college students are especially vulnerable to negative consequences from seeking health information online because they lack the necessary skills to evaluate the information accurately (5). Furthermore, Medical students play a crucial role in shaping the future of healthcare, and their understanding of nutrition is vital for promoting healthy lifestyles among patients.

The increased use of social media for nutrition information by health science students raises concerns about exposure to uncontrolled and perhaps inaccurate content. However, there is limited research on how students at the University of Benghazi use and analyze this content. This study attempts to fill that gap by presenting relevant evidence on digital nutrition knowledge. It will also assist create educational and public health policies that promote the use of trustworthy nutrition information.

The aim of this study is to investigate the pattern of social media use as a source of nutrition information among medical students in the University.

Specific Objectives:

1- Explore the type of nutrition information gathered.

2- Understand whether the students consider the social media as a reliable source of nutritional information.

3- How students rate the accuracy of the information obtained from the social media.

2. Methodology:

2.1. Study design:

A Descriptive, cross-sectional study was undertaken between January to May 2024 in Benghazi university.

2.2. Study Population

Medical undergraduate students who were enrolled in Benghazi University in Libya were conducted among 434 students including Medical, Dental, public health, pharmacy, and biomedical science.

2.3. Sampling and sampling technique

A stratified sampling technique was employed; The study population was stratified by academic discipline, where each health science faculty (Medicine, Pharmacy, Dentistry, and Public Health) constituted a distinct stratum. Students were then selected from each stratum to ensure representation across all faculties. the sample size was 434 student (377 female and 57 male). The percentage and number of students from every faculty represented in the sample were calculated according to the total number of students given by the register office of each faulty.

2.4. Data collection procedure and tools

Data were collected using online self-administered questionnaire using Google forms was made available online. The questionnaire had been sent out electronically to student groups that were connected to the faculties that

were being targeted. Participants received explicit information regarding the study and provided informed consent prior to their participation. The questionnaire took roughly 10 minutes to complete and consisted of 18 multiple-choice and open-end questions. Each questionnaire was coded with a unique number representing each respondent. The data in the questionnaire classified into sections: Socioeconomic characteristic: This comprises information on age, sex, faculty, academic year, family information like paternal and maternal occupation and monthly family income. Utilizing social-media related data: This segment measures students‟ regular social media usage, regardless of whether using a computers or mobile devices.

2.5. Data analysis and statistics used

The data was checked manual for completeness and analyzed by using the statistical package for social sciences (SPSS, ver.23) software. Descriptive statistics in form of frequencies, percentages, range, means, and standard deviations were used. The chi-square test was used to investigate the associations between demographics characteristics and use of social media for nutrition information.

2.6. Ethical Considerations

Ethical approval was obtained from Benghazi University, informed consent was obtained from to protect the confidentiality of the collected data, all questionaries and participants were anonymous.

3. Results and Discussion

3.1. Demographic and Socioeconomic Characteristics of the Participants

The average age was 23.8 ± 2.39 years (with a range of 18–36), and the majority of participants were aged between 24 and 29 years (53%), followed by those aged 18 to 23 years (44%). Close to half of the students were from the Faculty of Medicine (49.3%), with the largest segment being in their fourth year of study (45.9%). In terms of socioeconomic status, 43.8% of participants indicated a monthly family income of over 2000, while 40.1% reported an income between 1000 and 2000. Regarding parental occupations, most fathers were either employed (37%) or engaged in other types of work (50.9%), while the majority of mothers were housewives (53.5%) or teachers (37.3%). A comprehensive overview of the demographic and socioeconomic details can be found in Table1.

3.2. Using of social media

3.2.1. Availability of Internet Access Among Participants:

Figure (1) illustrates the distribution of internet access among participants, showing that the majority (388; 89%) reported easy and fast connectivity.

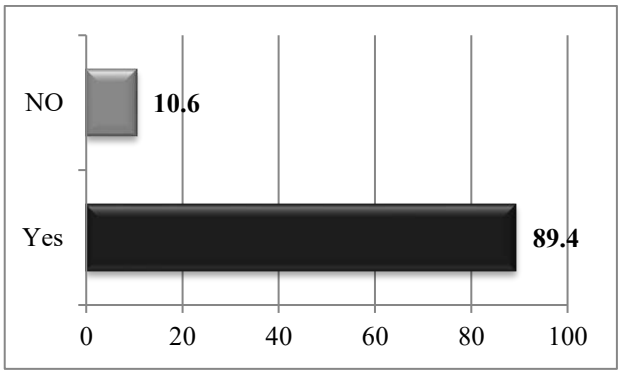


Figure1: Distribution of internet access *speed and ease* among participants

3.2.2. Online searching for nutritional information:

The Figure (2) illustrates that a majority of students, specifically 293 (67.5%), expressed an interest in seeking nutrition information online.

3.2.3 Frequency of using as a source of nutrition information:

The results revealed that (n=76,17.5 %) of students always use social media platforms as a source of nutritional information, while the largest proportion of students (n=330, 76%) indicated that they occasionally rely on social media for such information and only (n=28, 6.5%) of students reported never utilizing social media as a source of nutritional guidance. there also is compelling international evidence that the higher education sector has

been an enthusiastic adopter of social media. (6)

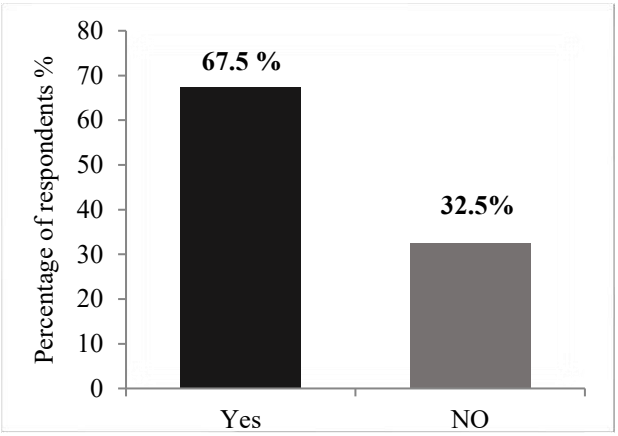


Figure 2. The distribution of students is based on their interest in searching for nutrition online.

3.2.4. Most common platform used by student: The data presented in Figure (4) indicates that Facebook is the preferred social media platform among a majority of students (n=224, 51.6%), Instagram is reported to be used by (n=106, 24.2%) of the students, followed by TikTok (n=67, 15.4%) of the students, while Snapchat used by (n=20, 4.6%) of the students. Twitter sees a smaller percentage of usage at (n=17,3.9%).

These findings are consistent with previous research, which reported that Facebook is extensively utilized throughout adults, although Instagram, Snapchat, and TikTok are more widespread among younger users (7).

Table1. Demographic and Socioeconomic Characteristics of the Participants:

Variable	Category	N (%)
Gender	Female	377 (96.9)
	Male	57 (13.1)
Age group (years)	18-23	191 (44)
	24-29	230 (53)
	30-36	13 (3)
Faculty	Medicine	214 (49.3)
	Public Health	54 (12.4)
	Dentistry	83 (19.1)
	Pharmacy	42 (9.7)
	Biomedical Sciences	41 (9.4)
Year of study	First year	44 (10.1)
	Second year	51 (11.8)
	Third year	91 (21)
	Fourth year	199 (45.9)
	< fourth year	49 (11.3)
Monthly family income	< 1000	70 (16.1)
	1000-2000	174 (40.1)
	< 2000	190 (43.8)
Father's occupation	Employee	159 (37)
	Teacher	37 (8.5)
	Medical profession	17 (9.3)
	other	221 (50.9)
Mother's occupation	Employee	29 (6.7)
	Teacher	162 (37.3)
	Medical profession	8 (1.8)
	Housewife	232 (53.5)

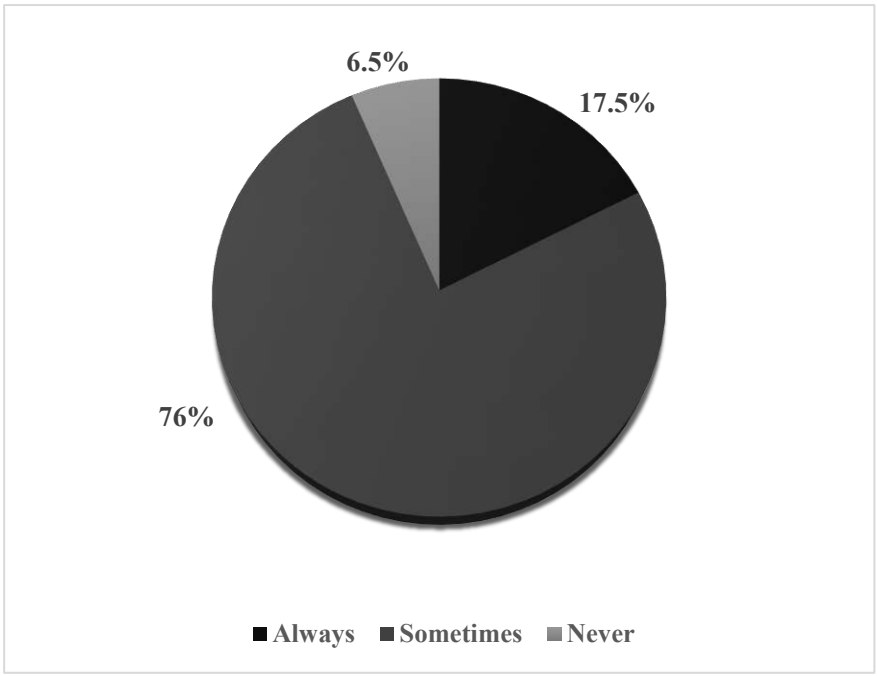


Figure 3. Frequency of using as a source of nutrition information

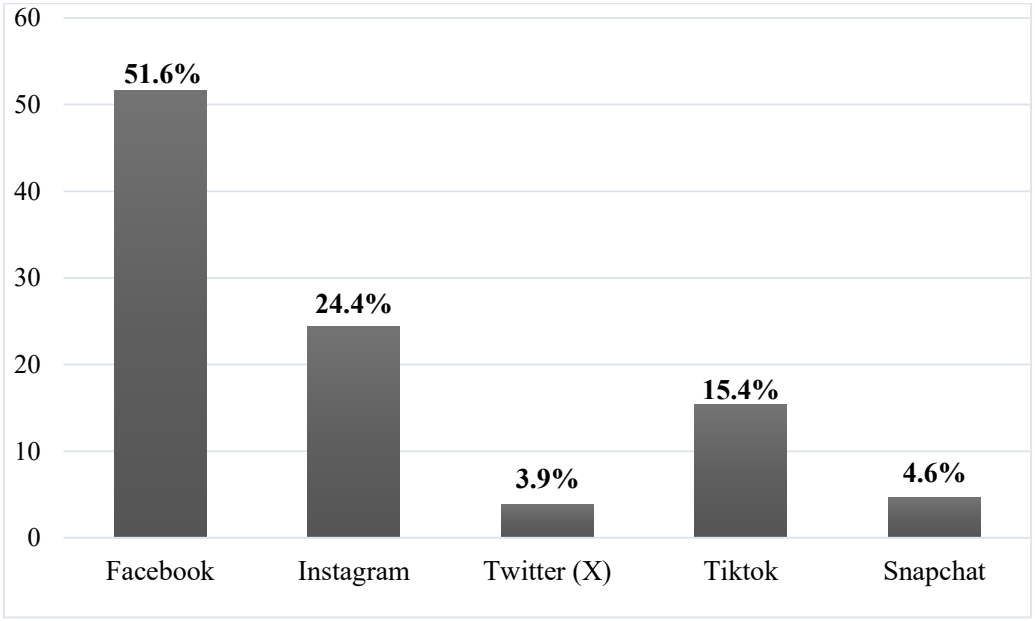


Figure 4. Distribution of the most commonly used social media platforms for accessing nutrition related information.

3.2.5. *The type of content preferred by participants:*

The preferences of students in regards to their choice of media consumption. A substantial majority of students (n= 324, 75%) reported a preference for short-form video. In comparison, a smaller proportion of students, representing (n=89,20.5%) of the total, expressed a preference for reading written information. The remaining students exhibited a preference for other sources of media consumption. This pattern is consistent with recent empirical research demonstrating a considerable change in digital media consumption among university students toward brief, visually engaging formats. For instance, Omar and Dequan noticed that TikTok users are most often motivated by entertainment and information-seeking behaviours, with short-form video material being particularly effective in catching attention and sustaining engagement among young people (8). Similarly, Kaye et al found that TikTok has moved beyond entertainment into an informal learning tool, particularly among Generation Z users, who increasingly rely on short videos for quick and accessible information learning (9).

3.2.6. *Type of nutrition information searched:*

A sum of (n=110, 25.3%) students reported seeking general tips on healthy eating, while a comparable percentage (n=108,24.9%) searched for disease-specific nutrition information. A significant proportion of students also searched for captions of posts/pictures(n=71,16.4%), recipes (n=68,15.7%), and "what I eat in a day" posts/videos (n=41, 9.4%). Notably, only (n=36, 8.3%) of the students searched for scientific articles (Table.2). This result is in line with the Vraga et al. (2019) study, which found that young adults mostly use social media platforms to get general nutritional advice (10). In particular, students indicate a strong preference for engaging and easily consumable formats such as food photographs, “what I eat in a day” material, and recipe-based postings, which coincides with the present findings. Furthermore, available evidence reveals that only a tiny proportion of students actively examine scientific articles for nutrition advice, demonstrating a persisting gap between academic knowledge and public information-seeking behavior (11)

Table 2. The type of content preferred by participants

Type of information	Frequency
Scientific Articles.	36 (8.3%)
Captions of posts / pictures	71 (16.4%)
General tips on healthy eating	110 (25.3%)
Recipes	68 (15.7%)
what I eat in a day post / video	41 (9.4%)
Disease specific nutrition information pertaining to condition	108 (24.9%)
Total	**434**

3.2.7. *Type or qualification of the page followed:*

Whether it concerns the people they choose to follow, a significant proportion of participants show different preferences. In particular, the research shows that 33% of users follow physicians, 29.5% follow nutritionists, 29% follow influencers, 5.5% follow health coaches, and 2.3% follow athletes. This finding was comparable with a result obtained previously in a South-western University in the United States by (10) where 15% of participants reported that receiving nutrition related information from healthcare specialists, 31% from doctors, 21% from nutritionists, 8.9% of respondents listed the personal trainer as a source of nutrition information. Moreover, a study carried out in Saudi Arabia wherein 23.7% of the population did not trust their online health care providers. (12)

3.2.8. Rate the accuracy of data:

The analysis showed that a small percentage (n=21,4.8%) of students considered the information obtained from social media to be very accurate, while (n=34,7.8%) found it to be inaccurate. The majority of students (n=379, 87.3%) expressed that the accuracy of

information depends on the source. This aligns with Pew Research Centre research demonstrating that trust in online information is heavily reliant on the perceived reliability of the source rather than the platform itself. (13)

3.2.9. Apply the nutrition information:

In terms of application and utilization of the nutrition advices, it can be observed that 11.5% of the surveyed students exhibited a lack of interest in nutritional information. Furthermore, a majority of the students, accounting for 81.6%, indicated that they occasionally utilize such information, with a mere 6.9% stating that they consistently implement it in their lives. This practice reflects the growing awareness among population study of the credibility of nutritional content across social media platforms. Klassen et al. (2018) also found that although young adults often seek nutrition information via social media, its influence on lasting dietary habits is still limited and variable. (14)

3.2.10. More useful source of information:

The finding documented that approximately half of the students surveyed (50.5%) deemed social media platforms as the most reliable source of nutrition information. In comparison, 44.7% of students placed their trust in visiting nutritionists, with only 4.8% relying on alternative sources for information. This pattern indicates the significant divert in the searching of nutrition information toward the social media platforms where it characterized by their convenience and easy accessibility nature.This finding somewhat conflicts with Kreft et al. (2023), who observed that although social media is frequently used source of nutrition information, students typically place more trust in qualified health care providers like dietitians, indicating that professional credibility is a critical factor influencing trust in nutrition information. (15)

3.2.11. Determinants of social media use for nutritional information:

Table 2 displays the relationship between demographics and aspects of utilizing social media for nutritional information among participants. Significant associations were identified between several demographic variables and outcome measures. Gender showed a significant correlation with social media usage for nutrition information ($p = 0.009$). favored content types ($p < 0.001$), qualifications of followed pages ($p = 0.010$), perceived informational accuracy ($p < 0.001$), and the information deemed most helpful ($p = 0.001$), this pattern is consisting with prior study in Saudi Arbia wherein social media usage for nutrition information is frequently found to be significantly predicted by female gender (16). These findings reveal that male and female significantly varied in their interactions with nutrition-focused social media content. Faculty was notably linked to the use of social media for nutrition information ($p = 0.002$) and the credibility of followed pages ($p = 0.001$), this is in the line with previous study that demonstrating that the student's field effect on their interaction with the online nutrition content (17). Indicating that students' educational history might affect their dependence on social media and their selection of information sources. Additionally, the academic year was notably linked to the chosen type of content ($p = 0.001$) and the type of information viewed as the most beneficial ($p = 0.010$), indicating that the advancement in education might affect students' preferences and perceptions regarding nutritional information.

The strong correlation between academic year and seeking for nutrition information on social media constitute a novel contribution to the literature; since the prior studies (18,19) have examined the educational level rather than academic year. In contrast these associations, age showed no significant correlation with any of the outcome variables ($p > 0.05$), indicating similar behaviors in social media nutrition information across various ages in the sample. Likewise, no associations were identified between various demographic factors and the commonly used medium, as all p-values exceeded the significance threshold.

Overall, the findings indicate that factors such as gender, academic department, and grade level have a more significant influence on social media behaviors regarding nutrition information than age.

4. Conclusions:

This study observed that social media represents a primary source of nutrition information for students, exhibiting considerable variation contingent upon the qualifications of the followed sources. The results additionally indicate that the participants had a hard time deciding out how reliable the information was and finding qualified experts. Students usually search for general nutrition topics and topics about specific diseases. These results show that healthcare professionals need to use social media, share reliable sources of information, and make videos and other engaging content. The increasing preference for multimedia content indicates a transformation in educational methodologies, necessitating further research to comprehensively understand students' utilization of social media for health information.

Limitations:

This study has a several limitations. First: The cross-sectional design precludes the verification of causal relationship. Second: The results may not be as applicable to other groups because the participants were restricted to medical college students. Third: The accuracy rating was based on the students' subjective opinion of the evaluation of nutritional information on social media, rather than an objective comparison with evidence-based dietary standards. As a result, perceived and real accuracy may differ. Finally: Self-reporting questionnaires that may have response and social desirability bias were used to collect the data.

Recommendations:

Based on the results, this study introduces a subsequent recommendation:

- Public health authorities and educational institution to create and implement organized nutrition media literacy.
- Rise in public awareness of the critical importance of consulting reliable and contextually relevant sources for health-related information; it also recommends the healthcare professionals to have an informed and active social media presence.
- Encourages incorporating nutrition information into content that users already enjoy viewing, such as videos, to increase engagement.

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Conflicts of interest

No conflict of interest.

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Research Article

The Role of Nursing in Enhancing Care for Patients with Cardiovascular Diseases

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ABSTRACT

Cardiovascular diseases are among the leading causes of morbidity and mortality worldwide and represent a major public health challenge. Nurses play a crucial role in providing health education and comprehensive care to cardiac patients, which may contribute to improving patient outcomes and satisfaction. This study aimed to evaluate the role of nursing in health education and improving the quality of care provided to cardiac patients. The results showed that the most represented age group was 30-45 years, with males outnumbering females. A significant proportion of participants also held university degrees, and most had been living with the disease for one to five years. Regarding nursing health education, the results showed a good-to-high level, with an overall average of 3.9, indicating the effectiveness of the nursing role in enhancing patients' knowledge of the disease, its risk factors, and prevention. The results also showed that the nursing role in providing comprehensive care was strong, with an overall average of 3.76, particularly in psychological support. Regarding patient satisfaction, the level was relatively high, with a satisfaction rate of 65% and an overall average score of 3.8. The results also revealed a statistically significant positive correlation between health education and patient satisfaction ($r = 0.62$). The study further demonstrated statistically significant differences in health literacy levels attributable to educational attainment. It can be concluded that nursing health education plays a pivotal role in improving health literacy and increasing patient satisfaction.

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1. Introduction

Due to the continuous rise in cardiovascular disease rates globally, cardiovascular conditions remain a leading cause of morbidity and mortality, placing a substantial burden on health systems. Within this context, nursing plays a central role in improving the quality of care for cardiac patients. The role of nursing extends beyond the technical performance of clinical procedures to include patient education, psychosocial support, and long-term follow-up, all of which are essential components of effective cardiac care.

At the preventive level, evidence-based nursing interventions such as individualized patient education, counseling on risk factor modification (including hypertension control, dietary changes, smoking cessation), participation in cardiac rehabilitation programs, and support for treatment adherence have demonstrated significant effectiveness in reducing the burden of cardiovascular disease [1]. The success of these interventions is strongly influenced by nurses' level of training, clinical competence, and access to continuing professional development [1].

Community-based nursing interventions have also been shown to enhance patients' self-care capacity and improve disease-related knowledge [2]. In addition, these interventions contribute to measurable improvements in clinical indicators such as blood pressure and lipid profiles, as well as healthier behavioral outcomes, particularly when empowerment-based approaches are used. Such approaches emphasize patient and family engagement and often include home-based follow-up and continuity of care [3].

Continuity of care after hospital discharge is a critical component in the management of patients with coronary artery disease. Evidence indicates that structured nursing follow-up is associated with improvements in quality of life, psychological well-being, self-efficacy, and self-care behaviors, alongside reductions in blood pressure and lipid levels [4].

In the field of cardiac rehabilitation, particularly among patients with heart failure, recent evidence supports the effectiveness of nurse-coordinated, home-based rehabilitation programs. A 2023 scoping review highlighted that these models contribute to improved physical functioning, better quality of life, and enhanced symptom management [5].

Beyond physical care, nursing also plays an important role in providing psychological and holistic support, addressing emotional needs and improving patient-centered outcomes [6]. At an advanced level of practice, the expansion of nurses' roles—particularly advanced practice nurses in cardiology—has been associated with improved patient outcomes, reduced hospital length of stay, and lower healthcare costs, although further high-quality evidence is still required to strengthen these findings [7].

Despite these advancements, several barriers continue to limit the full implementation of advanced nursing roles in cardiovascular care. These include high workload, insufficient specialization in cardiac nursing, limited access to continuous training, and resource constraints, particularly in low- and middle-income settings [8].

In the Libyan context, where healthcare systems face structural and resource-related challenges, there is limited published evidence regarding the role and effectiveness of nursing interventions in cardiovascular disease management. This gap highlights the need for further research to evaluate nursing contributions within local clinical settings and to inform evidence-based improvements in cardiac care services.

Therefore, the aim of this study is to evaluate the role of nursing in enhancing care for patients with cardiovascular diseases in [study setting], Libya.

2. Methodology

The present study adopted a descriptive analytical design, which is appropriate for examining relationships and describing phenomena as they occur in real-life clinical settings.

2.1. Participants and Sampling

The study was conducted between January 12 and April 15, 2026, allowing sufficient time for

data collection and analysis in accordance with the study objectives.

The study was carried out at the Sabratha Heart Surgery and Treatment Center, a specialized medical facility that receives patients from different age groups and provides advanced cardiac care services. This setting was selected due to its accessibility, the availability of an adequate number of patients, and its relevance to the topic of cardiovascular nursing care.

The population consisted of 30 patients, who were selected using a convenience sampling technique based on their availability and willingness to participate during the data collection period. Although the sample size was relatively small, it was considered appropriate for an exploratory descriptive study conducted within a specialized clinical setting.

A structured questionnaire was used as the main data collection instrument. It was developed based on an extensive review of relevant literature and previous studies related to nursing care in cardiovascular disease management.

2.2.Validity and Reliability

Content validity of the instrument was ensured by submitting the questionnaire to a panel of experts in nursing and scientific research methodology to assess the clarity, relevance, and appropriateness of the items in relation to the study objectives. Modifications were made based on expert feedback to improve the final version of the tool. Reliability was assessed using Cronbach's Alpha coefficient. The results indicated high internal consistency across all domains. The Cronbach's Alpha values ranged between 0.86 and 0.89, while the overall reliability coefficient was 0.88, indicating a high level of stability and internal consistency of the instrument.

Table 1. Components and structure of the study questionnaire

Section	Content	Number of paragraphs	Type of scale
First	Demographic data	6	Optional
Second	Health education and knowledge	5	Likert scale (1–5)
Third	Nursing follow-up and care	5	Likert scale (1–5)
Fourth	Satisfaction with quality of care	5	Likert scale (1–5)
Fifth	Challenges and obstacles	2	Multiple choice
Total	—	23 paragraphs	—

Table 2. Reliability Coefficients of the Questionnaire

Axis	Number of paragraphs	Reliability Coefficient (Cronbach's Alpha)
Health Education	5	0.86
Nursing Care	5	0.87
Satisfaction with Care	5	0.89
Overall Stability	15	0.88

2.3.Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS), with both descriptive and inferential statistical methods applied. First, descriptive statistics were used, including frequencies, percentages (%), means, and standard deviations (SD). Second, inferential statistics were conducted, utilizing the Pearson Correlation coefficient to examine the relationship between health education and patient satisfaction, a One-Sample t-test to compare mean scores against a hypothetical value, an Independent Samples t-test to examine differences according to gender, and a One-way ANOVA to examine differences according to educational level. Finally, a significance level of ($p \leq 0.05$) was adopted to determine the statistical significance of the results.

3. Results and Discussion

The results of the descriptive data analysis showed Figure 1that most individuals in the sample were within the age group (30–45 years) at a rate of (35%), followed by the group (46–60 years) at a rate of (30%), while the percentage of those under 30 years was (20%), and over 60 years was (15%).

Through the results presented in Figure 1, the age group (30–45 years) represented the highest proportion of participants. This finding suggests that cardiovascular risk factors are increasingly affecting middle-aged individuals, who are often exposed to lifestyle-related risks such as stress, poor diet, and reduced physical activity. This trend is consistent with WHO reports indicating that cardiovascular diseases are no longer confined to older populations but are increasingly prevalent among younger and middle-aged groups [9].

The results presented in Figure 2 also showed that the level of nursing health education was generally good, with a mean score of 3.9, which is above the hypothetical mean. This indicates a relatively positive perception of the educational role of nurses in improving patients' knowledge about disease management and treatment adherence. Such findings may reflect the effectiveness of nursing education programs in enhancing patient awareness, as supported by previous studies that emphasize the importance of health education in improving self-management behaviors.

Similarly, the role of nursing in providing comprehensive care was rated positively, with a mean score of 3.76. The One-Sample t-test indicated statistically significant differences at the 0.05 level, suggesting that patients had a favorable evaluation of nursing care. This may be attributed to the presence of psychological support, coordination within the healthcare team, and continuous patient follow-up, which are essential components of high-quality nursing care. These findings are consistent with previous literature reporting that effective nursing care contributes to improved patient outcomes and satisfaction.

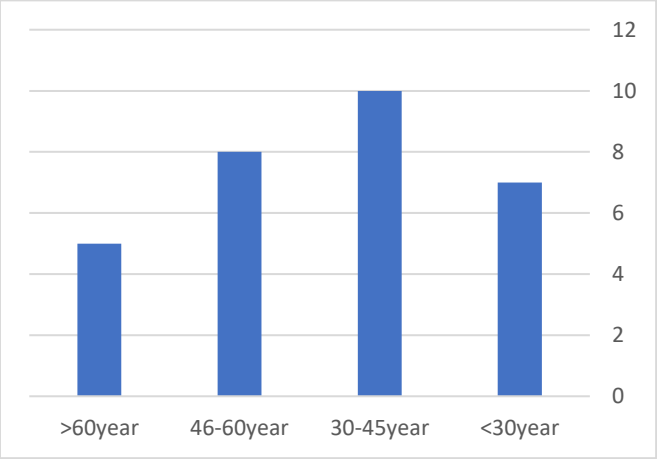


Figure 1. illustrates the age distribution

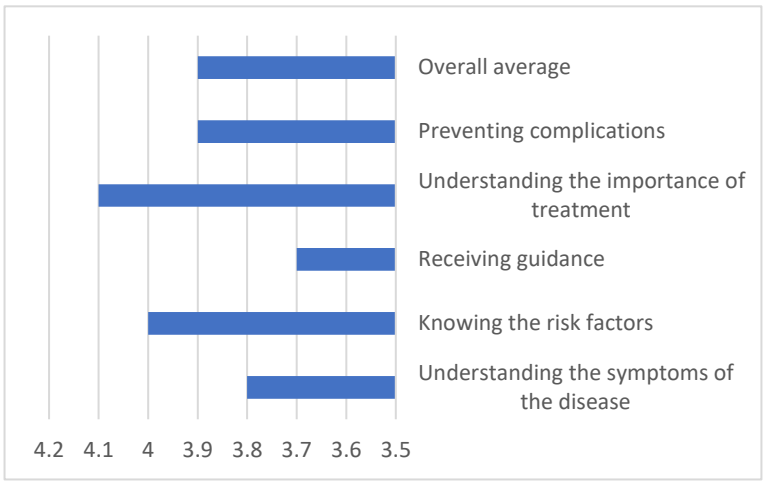


Figure 2. Arithmetic mean of health education levels among nursing staff

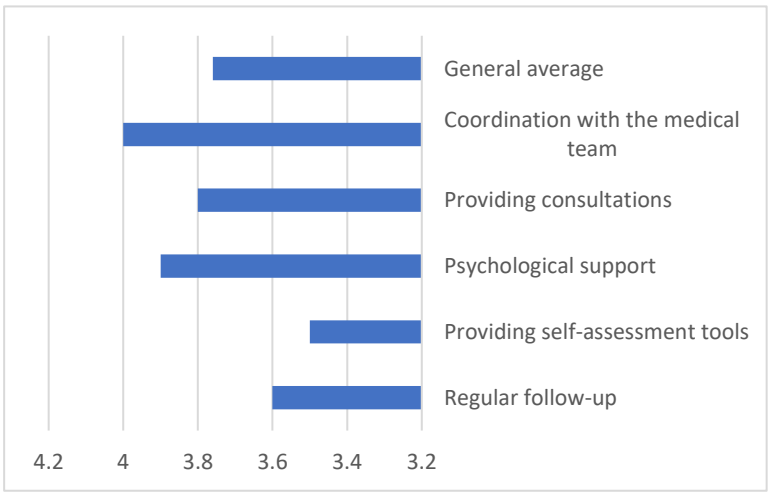


Figure 3 illustrates the role of nursing in providing comprehensive care

This result is consistent with the study [10], which confirmed that the quality of nursing care is directly related to improved patient outcomes and reduced complication rates.

The level of patient satisfaction with the quality of care being high (good + excellent) reached (65%), indicating a good level of satisfaction with the quality of nursing care Table 3. The overall satisfaction average also reached (3.8), which indicates that patients have a positive impression of the nursing services provided.

Table 3. Level of patient satisfaction with the quality of nursing care provided

Satisfaction level	**(%)** Percentage
Very poor	5%
Poor	10%
Acceptable	20%
Good	40%
Excellent	25%

The Table 4 showed that the main challenges facing patients were the low number of nurses and work pressure, which may affect the quality of care provided. It also appeared that lack of resources and weak communication are important factors that limit the effectiveness of nursing care.

Table 4. Level of challenges and obstacles faced by patients

The challenge	(%) Percentage
Shortage of nurses	45%
Work pressure	40%
Lack of resources	35%
Weak communication	30%
Difficulty in implementing instructions	28%
Lack of family support	25%

The most prominent challenges were represented by the shortage of nurses and work pressure, which are common problems in health systems. This result agrees with the study [11], which indicated that a shortage of nursing staff leads to an increased workload and decreased quality of care.

There is a statistically significant positive direct correlation between health education and patient satisfaction, where the correlation coefficient reached (0.62) at a significance level of less than (0.01). This indicates that the higher the level of health education provided by nursing, the higher the patients' satisfaction with the quality of nursing care. Table 5

Table 5. The relationship between health education and satisfaction with nursing care

Variables	Correlation coefficient (r)	P-value	Type of relationship
Health education × Patient satisfaction	0.62	<0.01	Moderate positive

There is a positive direct relationship between health education and patient satisfaction, indicating that an increase in the level of education leads to improved patient satisfaction. This result is consistent with the study [12], which confirmed that patient education is among the most important factors affecting their satisfaction with health services.

This study has several limitations that should be considered when interpreting the findings. First, the sample size was relatively small (n = 30), which may limit the generalizability of the results to a broader population. Second, the study was conducted in a single specialized cardiac center (Sabratha Heart Surgery and Treatment Center), which may not fully represent other healthcare settings in Libya. Third, the use of a convenience sampling technique may introduce selection bias. Finally, the cross-sectional nature of the study limits the ability to establish causal relationships between the studied variables.

Despite these limitations, the study provides useful preliminary insights into the role of nursing in cardiovascular care within the Libyan context.

4. Conclusions

The results showed that the level of nursing health education provided to patients was good to high, reflecting the effectiveness of the nursing awareness role in improving patients' knowledge about the nature of the disease and its associated risk factors. It was found that nursing plays a pivotal role in providing comprehensive care, as this care included therapeutic, educational, and psychological aspects, enhancing the quality of health services provided to heart patients. The study showed that the level of patient satisfaction with nursing care was relatively high, which is a positive indicator of the quality of nursing performance within the healthcare institution. The results revealed a statistically significant positive relationship between the level of health education and patient satisfaction, indicating that improving health education

directly contributes to increasing patient satisfaction.

Conflict of Interest

The authors declare no conflict of interest

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Research Article

Assessment of Vaccine Handlers' Knowledge and Cold Chain Management in Primary Health Care Facilities in Tripoli, Libya

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ABSTRACT

Vaccination is one of the most effective public health interventions for preventing infectious diseases. In Libya, particularly in Tripoli, challenges related to infrastructure, training, and supervision may affect the effectiveness of vaccine storage and handling practices. The Knowledge, Attitudes, and Practices (KAP) assessment framework provides a structured approach to evaluating provider-level performance in immunization services, yet limited evidence exists from primary health care facilities in Tripoli. A descriptive cross-sectional study was conducted in August 2024 across 65 primary health care vaccination sites in six municipalities of Tripoli, Libya. Using a total population sampling approach, all 65 vaccination providers were assessed. Data were collected using structured questionnaires and observational checklists adapted from WHO Effective Vaccine Management (EVM) guidelines. Standardized categorical scoring thresholds were applied to evaluate provider knowledge, attitude, and practice, alongside overall facility performance. Most facilities possessed functional cold chains with adequate refrigeration (96.9%) and temperature monitoring (98.5%), though operational gaps remained in guideline availability and emergency alarms. While providers overwhelmingly demonstrated positive attitudes (98.5%), good practices (96.9%), and moderate-to-good overall knowledge (93.8%), specific deficiencies were identified regarding mild illness contraindications, vaccine distinctions, batch number recording, and post-vaccination observation times. The study concluded that despite functional cold chains and experienced staff, operational gaps in training, documentation, and emergency preparedness threaten vaccine quality in Tripoli. Addressing these through continuous training, supportive supervision, and enhanced monitoring is essential for safe immunization.

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1. Introduction

Vaccination is one of the most cost-effective public health interventions and has significantly reduced morbidity and mortality worldwide. The Expanded Programme on Immunization (EPI), established in 1974, has substantially improved global immunization coverage; however, the full potential of vaccines can only be realized when their potency is preserved throughout the supply chain [1,2].

Vaccines are temperature-sensitive biological products that must be stored within a strict range of 2-8°C. Exposure to inappropriate temperatures may irreversibly reduce vaccine potency and effectiveness, leading to inadequate immune responses and potentially leaving vaccinated individuals unprotected against vaccine-preventable diseases (VPDs) [3,4]. The cold chain system—a series of storage and transport links designed to keep vaccines within acceptable temperature ranges from manufacture to administration—is therefore fundamental to the success of any immunization program [5,6].

The KAP (Knowledge, Attitudes, and Practices) assessment framework is a well-established methodology used in public health to evaluate healthcare provider performance. In the context of vaccine management, KAP studies assess whether providers possess adequate knowledge of storage requirements and cold chain procedures, hold supportive attitudes toward immunization, and translate this knowledge into consistent daily practice [7]. Prior KAP studies from Ethiopia, Nigeria, Malaysia, and Uganda have consistently documented knowledge gaps—particularly around vaccine contraindications, VVM interpretation, and temperature monitoring—as well as practice weaknesses in documentation and post-vaccination observation [8-11].

Cold chain failures are common in many low- and middle-income countries, including those in the Middle East and North Africa (MENA) region, and are driven by inadequate infrastructure, power instability, lack of training, and weak supervision [12,13]. In Libya, the national vaccination program immunizes against 17 infectious diseases and represents a major public health achievement; however, the program faces contextual challenges including infrastructure limitations and health system fragmentation [14]. Previous studies from Benghazi and Sabha have documented cold chain management gaps, but evidence from Tripoli—Libya's capital and most populous city—remains limited [15,16].

The rationale for conducting a KAP and cold chain assessment in Tripoli is therefore well grounded: the selection of a cross-sectional descriptive study design was appropriate given the need to simultaneously characterize provider-level knowledge, attitudes, and practices alongside facility-level infrastructure conditions. This design enables the identification of current gaps and the generation of evidence for targeted interventions, while recognizing its inherent limitation in establishing causal relationships [17].

This study aimed to: (1) assess the knowledge, attitudes, and practices of vaccination providers regarding vaccine handling and cold chain management; (2) evaluate the status of the cold chain system in primary health care facilities across six municipalities of Tripoli; and (3) identify operational gaps to inform evidence-based improvements in immunization service quality.that it is innovative, it is used in the section "Research Method" to describe the step of research and used in the section "Results and Discussion" to support the analysis of the results.

2. Methodology

2.1. Study Design and Setting

A descriptive cross-sectional study was conducted in August 2024 in the peripheral vaccination units of primary health care (PHC) facilities across six municipalities of Tripoli, Libya: Souq Aljuma, Ain Zara, Tajoura, Tripoli Center, Hay Al-Andalus, and Abu Salim. These municipalities were selected because they represent all administrative subdivisions of Tripoli and collectively encompass the full range of urban and peri-urban facility types in the capital. The six municipalities serve a

combined population of approximately 1.2 million residents, with facility densities varying from high-density urban centers (Tripoli Center) to more dispersed peri-urban areas (Ain Zara, Tajoura).

2.2. Study Population and Sampling

This study focused on the peripheral level of the cold chain system, including all functional vaccination storage sites and all vaccination providers. A total population sampling (census) approach was used, as the target population of vaccine handlers was relatively small, well-defined, and accessible in its entirety. All 65 functional vaccination facilities within the six municipalities were included in the facility assessment. All 65 vaccination providers working in these facilities and present during the August 2024 data collection period were invited to participate.

Inclusion criteria: functional vaccination storage units within the selected municipalities; healthcare workers directly involved in vaccination, storage, and cold chain management; providers present and actively working during data collection; and individuals who provided informed consent. Exclusion criteria: non-functional or closed facilities at the time of data collection; providers absent during data collection; healthcare workers not involved in vaccination or cold chain activities; and those who declined to participate.

2.3. Data Collection Tools

Data were collected using two instruments adapted from WHO Effective Vaccine Management (EVM) guidelines [18]: (1) a structured self-administered questionnaire assessing provider KAP, and (2) a facility-level observational checklist assessing cold chain infrastructure and conditions.

The KAP questionnaire comprised four sections: (i) socio-demographic characteristics (age, sex, education, profession, years of experience, municipality, training status); (ii) 15 knowledge questions with dichotomous correct/incorrect responses covering vaccine storage temperatures, VVM interpretation, contraindications, and vaccine-disease relationships; (iii) 7 attitude statements scored on a 3-point Likert scale (Agree=3, Neutral=0, Disagree=1), with a maximum score of 21 points; and (iv) 14 practice questions with Yes/No responses assessing temperature monitoring, documentation, safe administration, and post-vaccination procedures.

The observational checklist assessed cold chain infrastructure across domains including vaccine supply management, guideline availability, physical environment, record-keeping, refrigerator conditions, temperature monitoring, vaccine storage practices, transport equipment, emergency preparedness, and infection prevention.

Content validity was established by expert review from community medicine and public health specialists, and face validity was confirmed through pilot testing on a small group of providers not included in the final study.

2.4. Scoring System

Knowledge scores (out of 15): Good ≥12 points; Moderate 9-11 points; Poor <9 points. For the combined moderate-to-good category reported in results, a score ≥9 was used. Attitude scores (out of 21): Positive ≥15 points; Negative/Neutral <15 points. Practice scores (out of 14): Good ≥11 points; Poor <11 points. Facility-level performance: Very Good/Good ≥80%; Satisfactory 60-79%; Moderate 50-59%; Poor <50%.

2.5 Data Collection Procedures

Data collection was conducted in August 2024 by the principal investigator (M.A.E.), a trained community medicine physician, with the assistance of two field coordinators who received standardized training prior to data collection. Questionnaires were administered individually to each provider in the vaccination room or an adjacent private area. The facility assessment was conducted simultaneously through direct observation using the standardized checklist. Data entry was performed by the principal investigator using SPSS version 25.

2.6. Statistical Analysis

Descriptive statistics were computed for all variables. Frequencies and percentages were reported for categorical variables; mean ± standard deviation (SD) for continuous variables (age, years of experience, knowledge score, attitude score, practice score). Inferential analysis using independent t-tests (two groups,

e.g., sex) and one-way ANOVA (three or more groups, e.g., educational level) was applied to assess differences in mean KAP scores between demographic subgroups. A p-value <0.05 was considered statistically significant.

2.7 Ethical Considerations

Ethical approval was obtained from the Libyan Board of Medical Specialties and relevant health authorities prior to data collection. Official permission was secured from municipal health offices and facility management. Informed consent was obtained from all participants. Confidentiality and anonymity were maintained throughout; no identifying personal information was recorded. All data were used solely for research purposes.

3. Results

3.1. Demographic Characteristics of Study Participants and Facilities

A total of 65 vaccination providers and 65 facilities were included. The demographic profile of participants is summarized in Table 1. The workforce was predominantly male (98.5%; n=64), and largely composed of nurses (73.8%; n=48). Secondary education was the most common educational level (70.8%; n=46). Nearly two-thirds of participants (64.6%; n=42) had 16 to 37 years of employment experience, indicating a highly experienced workforce. Importantly, all participants (100%; n=65) reported having received immunization-related training. Facilities were distributed across the six municipalities, with Abu Salim contributing the largest proportion (23.1%; n=15).

3.2. Cold Chain Infrastructure Assessment

Results of the facility-level cold chain assessment are summarized in Table 2. All facilities had a designated vaccination coordinator (100%) and ordered vaccines monthly. Vaccine needs estimation relied predominantly on previous consumption (93.8%) rather than target population forecasting. Regarding guidelines, only 47.7% of facilities had storage and handling protocols available, while 50.8% of providers were uncertain of their availability; vaccination schedules were prominently displayed in 78.5% of facilities.

Physical conditions were generally satisfactory: vaccination rooms were clean in all facilities (100%), air-conditioned in 95.4%, and secured with locked storage in 96.9%. However, 56.9% of facilities combined vaccination and storage rooms rather than maintaining separate spaces. Record-keeping was strong, with vaccination registers present in 92.3% and legible entries in 93.8%; however, vaccination cards were not consistently issued to all recipients (69.2%).

Refrigerator conditions were among the strongest findings: 96.9% used ice-lined refrigerators, 98.5% had temperature monitoring devices, and 100% maintained vaccines at appropriate positions with adequate spacing and FEFO (First-Expiry, First-Out) arrangement. Notable gaps included: warning signs ('Do Not Unplug') absent in 67.7% of facilities; coil and motor cleanliness unknown in 47.7% of cases; and expired vaccines found in 13.8% of facilities.

Emergency preparedness showed significant weaknesses: alarm systems were available in only 32.3% of facilities and verified as functional in 30.8%; emergency drugs (adrenaline, antihistamines, hydrocortisone) were available in fewer than 17% of facilities. Standby generators were present in 84.6%, though only 61.5% operated automatically.

3.3. Knowledge Assessment

Table 3 presents the distribution of correct answers to individual knowledge questions. Strong performance was observed for: flu vaccine safety in pregnancy (96.9%), HBV administration technique (93.8%), HPV vaccine protection against cancer (92.3%), and HPV recommended doses (92.3%). Moderate performance was observed for: HBV recommended doses (67.7%) and who should receive HPV vaccine (98.5%). Notably poor performance was observed for: fever/mild illness as a reason to postpone vaccination (35.4% correct); BCG vaccine and TB transmission prevention (36.9% correct); pneumonia vaccine and influenza protection

Table 1. Demographic and Employment Characteristics of Study Participants (n=65)

Characteristic	Category	n	%
Sex	Male	1	98.5
	Female	64	1.5
Education	Primary	3	4.6
	Secondary	46	70.8
	University	13	20.0
	Postgraduate	1	1.5
Profession	Nurse	48	73.8
	Public Health	11	16.9
	Community Health	4	6.2
	Doctor	1	1.5
	Nurse Assistant	1	1.5
Employment Years	4-15 years	23	35.4
	16-37 years	42	64.6
Training Received	Yes	65	100.0
Municipality	Abu Salim	15	23.1
	Center Tripoli	10	15.4
	Hayy Al-Andalus	11	16.9
	Tajura	11	16.9
	Ain Zara	9	13.8
	Souq Aljuma	9	13.8

Table 2. Summary of Key Cold Chain Infrastructure Indicators in Primary Health Care Facilities (n=65)

Cold Chain Indicator	N	%
Vaccination coordinator present	65	100.0
Guidelines/protocol available	31	47.7
Guidelines availability unknown	33	50.8
Vaccination schedules prominently displayed	51	78.5
Separate vaccine storage room	28	43.1
Ice-lined refrigerator in use	63	96.9
Temperature monitoring device present	64	98.5
Temperature chart present and checked	65	100.0
'Do Not Unplug' warning sign present	21	32.3
Expired vaccines found	9	13.8
Alarm system available	21	32.3
Standby generator present	55	84.6
Generator operates automatically	40	61.5
Emergency drugs available (adrenaline)	10	15.4
Vaccination card issued to all recipients	45	69.2

Table 3. Distribution of Correct Answers to Knowledge Questions Among Participants (n=65)

Knowledge Question	Correct (n)	Correct (%)
Flu vaccine safe for pregnant women	63	96.9
How to administer the hexa vaccine	62	95.4
Who should receive the HPV vaccine?	64	98.5
HBV administration technique	61	93.8
HPV vaccine protects against cancer	60	92.3
Recommended doses of HPV vaccine	60	92.3
Who should receive the HBV vaccine?	52	80.0
HBV vaccine recommended number of doses	44	67.7
Oral vs. inactivated polio in supply shortages	43	66.2
Chickenpox vaccine vs. measles protection	37	56.9
Vaccines protect against some cancers (general)	34	52.3
Pneumonia vaccine protects against flu (misconception)	29	44.6
BCG vaccine prevents TB transmission	24	36.9
Fever/mild illness warrants postponement	23	35.4

a misconception question—(44.6% correct); and whether vaccines protect against some cancers (52.3%).

Overall knowledge classification: 41.5% (n=27) demonstrated Good knowledge, 52.3% (n=34) Moderate knowledge, and 6.2% (n=4) Poor knowledge. Combined moderate-to-good knowledge was observed in 93.8%.

3.4. Attitude Assessment

Attitude levels were overwhelmingly positive. Agreement rates exceeded 96% for six of seven attitude statements, including the importance of vaccinating healthcare workers against HBV (98.5%), vaccinating children during national campaigns (98.5%), effectiveness of HPV vaccine against cervical cancer (98.5%), and recommending the varicella vaccine for children (98.5%). The statement regarding HBV vaccine effectiveness in preventing liver cancer received slightly lower agreement (87.7%). Overall, 98.5% of participants (n=64) were classified as having a Positive attitude; only 1 participant (1.5%) was classified as Negative.

3.5. Practice Assessment

Practice performance was generally strong. All responding participants (n=64) reported washing hands between each child, checking vaccine type, dose, and expiry date before administration, identifying the correct injection site, informing parents about side effects, and checking the safety of syringe handling. Batch number recording on vaccination cards was done by only 73.4% of participants. Critically, only 26.6% (n=17) reported advising children to wait 15-20 minutes post-vaccination, representing the most significant practice gap identified. Overall, 96.9% of participants were classified as demonstrating Good practice.

Table 4. Distribution of Responses to Vaccination Practice Questions Among Participants (n=64 responding)

Practice Item	Yes (n)	Yes (%)
Wash hands between each child	65	100.0
Check vaccine type, dose before administration	64	100.0
Check expiry date of the vial	64	100.0
Identify correct injection site	64	100.0
Inform parents about possible side effects	64	100.0
Check vaccination card before giving vaccine	62	95.4
Date of next visit noted on card	61	95.3
Received hepatitis B vaccine (self-vaccination)	58	89.2
Dispose of tools in correct container	63	98.4
Clean the skin before injection	63	96.9
Batch number recorded on vaccination card	47	73.4
Advise 15-20 min post-vaccination wait	17	26.6

4. Discussion

This study provides a comprehensive assessment of cold chain management and vaccine handlers' KAP across primary health care facilities in Tripoli, Libya. The findings reveal a generally functional system with experienced, positively oriented staff, but persistent operational gaps that merit targeted intervention.

4.1. Cold Chain Infrastructure

Cold chain infrastructure in Tripoli was generally strong. Nearly all facilities used ice-lined refrigerators (96.9%) with temperature monitoring devices (98.5%), and all maintained temperature charts with reported daily checks. These findings compare favorably with assessments from Ethiopia and Nigeria, where refrigerator malfunction, absent temperature charts, and inadequate monitoring were documented [8,10]. However, important operational gaps were identified that align with findings from comparable settings.

The high proportion of providers uncertain about guideline availability (50.8%) and the absence of warning signs on refrigerators (67.7%) are concerning, as these represent basic system requirements. Studies from Cameroon and Uganda similarly documented limited availability of standard operating procedures and job aids [9,13]. Preventive maintenance awareness was low, with approximately half of facilities reporting clean coils and motors, and nearly half being unable to verify this, mirroring patterns described by Gebretnsae et al. [8] and Atwiine et al. [13].

Emergency preparedness was the weakest domain: alarm systems were present in only 32.3% of facilities, and emergency medications for managing anaphylaxis (adrenaline, antihistamines, hydrocortisone) were available in fewer than 17%. These findings represent a significant patient safety risk and contrast with WHO recommendations for post-vaccination management capacity. The 'Unknown' response rate for guideline availability (50.8%) is itself a substantive finding suggesting inadequate dissemination of reference materials at the facility level.

4.2. Knowledge

Knowledge levels in this study (93.8% moderate-to-good) were substantially higher than those reported in Ethiopia (Gebretnsae et

al.), Malaysia (Najwa et al.), and Nigeria (Adebimpe), where moderate-to-good knowledge proportions ranged from approximately 50% to 84% [8,10,11]. These differences may reflect several contextual factors specific to the Tripoli sample: universal training coverage (100%), a workforce composed predominantly of nurses—a cadre associated with stronger cold chain performance—and nearly two-thirds having over 16 years of professional experience [8,10].

Despite these strengths, specific misconceptions persisted. Only 35.4% correctly identified that mild illness or fever does not warrant vaccination postponement, 36.9% correctly understood the BCG vaccine's limited role in preventing TB transmission, and 44.6% correctly answered that pneumococcal vaccine does not protect against influenza. These patterns mirror knowledge gaps documented in Ethiopia and Nigeria [8,10], suggesting that clinical judgment-related concepts and nuanced vaccine-disease relationships require more targeted, ongoing education regardless of overall training coverage.

4.3. Attitudes

Attitude levels were exceptionally positive (98.5%), exceeding those reported across comparable studies [8,10,11]. This strong attitudinal profile likely reflects the long professional tenure of the workforce, the cultural value placed on childhood vaccination in Libyan society, and sustained participation in national immunization campaigns. Consistent with findings from Malaysia (Najwa et al.), high attitude levels in this sample appeared to correlate with high knowledge levels, suggesting a reinforcing relationship between competence and professional conviction [11].

4.4. Practices

Practice levels were strong overall (96.9% Good), with consistent adherence to critical safety procedures including hand hygiene, vaccine verification, and safe disposal. However, two important gaps were identified. First, only 73.4% consistently recorded batch numbers on vaccination cards—a WHO-required traceability measure essential for adverse event investigation and vaccine recall procedures. Second, only 26.6% consistently advised the recommended 15-20 minute post-vaccination observation period, a critical precaution for early identification and management of immediate hypersensitivity reactions [18,19].

These gaps are particularly notable because all participants reported receiving training, suggesting that the failures reflect implementation and reinforcement issues rather than lack of awareness. Studies from Ethiopia and Kenya documented similar post-vaccination practice deficiencies and incomplete documentation despite adequate training, emphasizing that knowledge alone does not guarantee practice compliance and that ongoing supervision is essential [8,12].

5. Conclusions

This study demonstrates that primary health care facilities in Tripoli maintain a generally functional cold chain infrastructure and employ an experienced, highly motivated workforce with positive attitudes toward immunization. However, significant operational gaps remain in areas critical to vaccine safety and service quality: guideline availability and dissemination, emergency preparedness including alarm systems and anaphylaxis management supplies, preventive maintenance practices, documentation of batch numbers, and post-vaccination observation compliance.

The findings suggest that Libya's immunization program in Tripoli has achieved strong structural foundations but requires investment in system-level controls and consistent supervisory oversight to reach WHO best-practice standards. Addressing these gaps through targeted refresher training, improved supervision, enhanced documentation systems, and infrastructure investment in monitoring and emergency preparedness is essential to ensure safe, effective, and sustainable immunization services and to protect the quality of Libya's national vaccination program.

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Conflict of Interest

The authors declare no conflict of interest.

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