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Evaluating Strengths and Weaknesses in Compliance with Environmental Health Indicators in Educational Hospitals in Zanjan: An Approach to Improving Quality

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ABSTRACT

Background: Hospital environmental health is essential for preventing healthcare-associated infections and ensuring patient safety. Although national regulations exist, data on actual compliance in Iranian hospitals are limited. This study evaluated adherence to environmental health indicators in two educational hospitals in Zanjan, Iran, in 2024 and identified priority areas for improvement.

Methods: A descriptive cross-sectional design was employed using the Ministry of Health's standardized checklist covering 11 environmental health domains. Data were collected through direct observation, staff interviews, and document review. Independent t-tests were used to compare performance between the two hospitals.

Results: Both hospitals demonstrated full compliance in most domains, including human resources, waste management, water and wastewater quality, kitchen and laundry hygiene, specialized wards, laboratory and radiology safety, sterilization, and ancillary services. No statistically significant differences were observed between hospitals (*p-value* > 0.05). Notable weaknesses included outdated ventilation systems in older wards, limited space in the Central Sterile Services Department, and suboptimal storage of sterile equipment.

Conclusion: The study confirmed strong overall adherence to environmental health standards, while highlighting infrastructure and resource gaps that require attention. Continuous monitoring, targeted investment, and strategic planning are crucial for sustaining compliance and aligning hospital practices with international environmental health standards.

1. Introduction

In recent years, enhancing the quality of healthcare services has become a fundamental priority for health systems worldwide, with national and international health policies increasingly emphasizing patient safety and improving quality indicators (Kruk et al., 2018). Within this context, adherence to environmental health standards is recognized as a cornerstone for safeguarding the health of patients, healthcare personnel, and visitors in medical facilities (Ibrahim et al., 2019). Hospital environmental health (HEH) plays a critical role not only in reducing the incidence of healthcare-associated infections (HAIs) but also as a key performance indicator for evaluating hospitals in

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terms of quality improvement (Rahimi et al., 2014). Given the high population density, continuous patient turnover, and wide range of diagnostic and therapeutic activities, hospitals represent environments highly susceptible to pathogen transmission and other health-related risks. According to the World Health Organization (WHO), millions of HAIs occur annually worldwide, many of which could be prevented through strict compliance with environmental health standards in areas such as medical waste management, water quality, ventilation, surface sanitation, and food safety (Ducel et al., 2002). In Iran, environmental health indicators have also been assigned a central role within the policy framework of the Ministry of Health and Medical Education, with national guidelines such as the *National Hospital Environmental Health Guideline* emphasizing the importance of systematic monitoring and evaluation (Amiri et al., 2016; Ghozikali et al., 2013; Mehdipour et al., 2014). Zanjan Province, a key hub for specialized and subspecialized services in the northwest of the country, hosts several educational hospitals affiliated with Zanjan University of Medical Sciences. These hospitals serve a large patient population while also functioning as centers for training healthcare professionals (Doshmangir et al., 2019; Moghaddam et al., 2013). Their dual role amplifies the importance of environmental health, as high population density, rapid patient turnover, and the presence of students and trainees can increase the risk of non-compliance with health protocols (Shamsipour et al., 2020). Despite the clear policy emphasis, little empirical evidence is available regarding the actual compliance of Iranian hospitals with national environmental health standards. This gap is particularly notable in educational hospitals, where the dual mission of service delivery and medical training may pose unique challenges. Addressing this evidence gap is critical for both local and national planning.

Accordingly, this study was designed to address two central research questions: (1) To what extent do educational hospitals in Zanjan comply with national and international environmental health standards across key domains such as waste management, water and wastewater quality, ventilation, food safety, and sterilization? and (2) What are the major strengths and weaknesses in current practices that can inform corrective interventions and future policy? To answer these questions, the study employed the Ministry of Health's standardized checklist in alignment with WHO recommendations (Organization, 2023, 2024; Shamsipour et al., 2020). The findings of this research are significant for several reasons. First, they provide a comprehensive, evidence-based assessment of HEH status in Zanjan, a province that plays a pivotal role in regional healthcare delivery. Second, by identifying strengths and weaknesses, the results offer actionable insights for provincial policymakers and hospital administrators to prioritize interventions, allocate resources effectively, and reduce health risks associated with non-compliance. Ultimately, the study helps bridge the knowledge gap on environmental health compliance in Iranian educational hospitals, serving as a reference point for continuous improvement and alignment with international standards.

2. Materials and Methods

2.1 Study design

This research was conducted as a descriptive cross-sectional study with a field-documentary approach. The primary objective was to comprehensively assess the status of HEH indicators in two educational hospitals in Zanjan City-Vali-Asr Hospital and Ayatollah Mousavi Hospital-during 2024, to provide an overall picture of the current situation. The study sought to answer the key question of whether educational hospitals in Zanjan meet the desired standards in terms of essential environmental health indicators. To address this question, eleven core domains were evaluated: human resources in environmental health, encompassing the availability of qualified experts, active participation in infection control committees, and regular staff training programs; hospital waste management systems, including waste collection, separation, transportation, and final disposal; water quality and wastewater disposal systems, with emphasis on their role in preventing disease transmission; kitchen and food hygiene, covering the storage, preparation, and distribution of food; laundry facilities and procedures, focusing on washing and disinfection of hospital linen; hygiene conditions of hospital wards, including intensive care units, inpatient wards, and emergency departments; compliance with hygiene protocols in medical laboratories, identified as high-risk units; radiology and imaging safety standards, including radiation protection in radiology and MRI units; operating room hygiene and surgical instrument sterilization processes; performance of the central sterile services department (CSSD), essential for preventing HAIs; and other environmental health aspects, such as mortuary conditions, ambulance cleaning and disinfection, and the provision of safety and protective equipment.

2.2 Study population and sampling

The study population included all hospital units with environmental health priorities in the two educational hospitals mentioned above. The units of analysis were: inpatient wards (intensive care unit (ICU), coronary care unit (CCU), operating rooms), laboratory, kitchen, laundry, CSSD, radiology unit, mortuary, and water/wastewater systems. Due to the limited size of the study population, a complete enumeration (census) method was employed. Inclusion criteria were active operational status of the units during the study period and accessibility to relevant documentation.

2.3 Data collection tools and methods

Data were collected through three primary methods: (A) The Ministry of Health Standard Checklist, which consists of

11 main domains, each incorporating quantitative and qualitative indicators assessed on a five-point Likert scale, where a score of 5 indicated *excellent* (full compliance with standards), 4 denoted *good* (compliance exceeding 80%), 3 represented *average* (compliance between 50-80%), 2 signified *poor* (compliance below 50%), and 1 corresponded to *very poor* (non-compliance with standards) (Ghozikali et al., 2013). For the guideline compliance component, scoring was similarly structured: a score of 5 reflected full compliance with guidelines, 4 indicated good compliance with only minor improvements required, 3 denoted moderate compliance necessitating revision, 2 signified poor compliance, and 1 indicated complete non-compliance, (B) Field observations, conducted by the research team composed of environmental health experts, and (C) Structured interviews, with unit managers, along with document reviews, including laboratory reports, cleaning logs, and sterilization protocols.

2.4 Data collection procedure

Following the issuance of the ethics license by the Ethics Committee of Zanjan University of Medical Sciences and the assignment of an official ethics code, as well as obtaining the necessary permissions from the Vice-Chancellery for Research and coordinating with hospital management, the assessment team received standardized training to minimize observer bias. Data collection was carried out in two stages: (A) Direct observation of the physical condition of hospital units, and (B) Completion of the checklist based on interviews with responsible staff and document review.

2.5 Data analysis

Data were analyzed using SPSS software (version 26) and Microsoft Excel. Descriptive statistics were used to summarize the data, and the independent *t*-test was applied to compare mean scores between the two hospitals. A *p-value* < 0.05 was considered statistically significant.

3. Results and Discussion

This study was conducted to comprehensively assess HEH indicators in two educational hospitals in Zanjan City. The results are presented in Table 1. In general, the findings indicate that both hospitals achieved a desirable status in most key indicators, which can likely be attributed to: (1) centralized policy-making by Zanjan University of Medical Sciences for continuous monitoring of environmental health standards, (2) adequate budget allocation to environmental health departments in recent years, and (3) an organizational culture that emphasizes adherence to health protocols. The findings are noteworthy in three respects: first, they demonstrate that achieving desirable environmental health standards is possible despite economic constraints; second, they provide a model for other educational hospitals in the country; and third, they establish a basis for future longitudinal studies to monitor trends over time.

3.1 Analysis of key HEH indicators

3.1.1 Human resources

Both hospitals achieved full scores for human resources indicators, including the presence of environmental health experts, participation in infection control committees, and continuous staff training. This finding aligns with the study by Sadeghi-Moghaddam et al. (2015) in Tehran hospitals, which demonstrated that regular staff training reduced the incidence of hospital-acquired infections by 40%.

3.1.2 Waste management

Waste management in both hospitals was satisfactory, with daily collection, separation, and disinfection conducted according to standards, including daily disinfection of waste bins. These results are consistent with the studies of Aziz et al. (2022) and Salmasi et al. (2020), which emphasized source separation. In contrast, Anicetus et al. (2022) reported that only 75% of healthcare facilities fully adhered to waste disposal protocols.

3.1.3 Water and wastewater systems

Drinking water quality and wastewater disposal systems in both hospitals met national standards (Nos. 1053 and 1011), with monthly sampling conducted from various points in the water network. Similar results were reported by Taghiloo et al. (2017) in Zanjan. However, Chawla et al.'s (2016) study indicated that only 65% of hospitals in developing countries had access to safe water.

3.1.4 Kitchen and laundry hygiene

Food storage and linen washing were maintained at satisfactory hygiene levels, with daily monitoring of refrigerator temperatures and the use of industrial laundry machines. The hazard analysis and critical control points (HACCP) system was not implemented for food control. While the present study reports full compliance, do Rosario and Walton (2019) found that 30% of hospital kitchens had deficiencies in storing protein-based foods.

3.1.5 Special units

ICUs, CCUs, and operating rooms in both hospitals demonstrated proper cleaning and ventilation. Surgical instruments were sterilized and stored appropriately, with new operating rooms providing 12 air changes per hour, ICU environments monitored online, and sterilization performed using Class B autoclaves. Almaspoor Khangah et al. (2016) confirmed that special unit standards in Iran are comparable to those in developed countries, although Vaez et al. (2024) reported deficiencies in the storage of sterile equipment.

3.1.6 Radiology and laboratory

Full compliance was observed with radiation protection standards and hazardous waste disposal protocols. Staff used

personal dosimeters, microbiology laboratories had dedicated ventilation systems, and sharps were disposed of in secure containers. These results align with international atomic energy agency (IAEA) guidelines and the findings of Atamaleki et al. (2019) and Martin et al. (2019), while Soiklom & Piyamongkala (2021) reported that 25% of laboratories experienced difficulties in chemical waste disposal.

3.1.7 Other indicators

Mortuary facilities and ambulance sanitation were also evaluated as satisfactory. Both hospitals had mortuaries equipped with digital temperature control systems, ambulances disinfected after each mission, and advanced fire detection and suppression systems. While the present study reported optimal conditions, Narayanan et al. (2019) study indicated that only 40% of ambulances in middle-income countries adhered fully to disinfection standards.

3.2 The SWOT (strengths, weaknesses, opportunities, and threats) analysis of the environmental health indicators

As shown in Table 2, a systematic analysis of the study findings revealed a dual performance pattern in the environmental health status of educational hospitals in Zanjan. On the one hand, several indicators, such as the advanced waste management system (score 5), specialized human resources (score 5), and water quality control (score 5), demonstrated full compliance with national and international standards. These achievements reflect the effectiveness of policies implemented in recent years. On the other hand, challenges such as outdated ventilation systems in older wards (score 3.5) and the lack of proper separation between contaminated, clean, and sterile areas in the central sterilization unit, along with the shortage of advanced and up-to-date equipment, highlights the need for a reassessment of resource allocation and the prioritization of renovation projects (Shamsipour et al., 2020). Key insights from Table 2 include: (1) a shared pattern of strengths, namely staff training, the use of modern monitoring systems, and adherence to national standards; (2) a shared pattern of weaknesses, challenges related to equipment deterioration, aging of buildings and facilities in older wards, shortage of physical space, and dependence on external systems outside the hospital; and (3) indicators requiring urgent attention, such as upgrading equipment and devices, strengthening human resources particularly support staff expanding the physical space of the CSSD and storage areas, and implementing automation systems for continuous monitoring. Table 2 presents a comprehensive SWOT analysis of the environmental health indicators in the two educational hospitals of Zanjan City. Strengths and weaknesses were identified based on direct observations, structured interviews, and document reviews across key domains, including human resources, waste management, water and wastewater systems, kitchen and laundry hygiene, special units, radiology and laboratories, and other critical areas such as the morgue and ambulances. Opportunities and threats were further incorporated to highlight external factors and potential risks that could influence compliance with environmental health standards. The analysis demonstrates that while both hospitals exhibit strong performance in areas such as staffing, waste segregation, and sterilization processes, challenges remain in older infrastructure, outdated ventilation systems, and limited physical space in certain units. This SWOT framework provides a strategic overview to guide resource allocation, prioritize corrective measures, and support continuous improvement in HEH management.

3.3 Comparison of compliance of HEH indicators in Zanjan educational hospitals with environmental health guidelines

The results of comparing the status of selected HEH indicators in Zanjan educational hospitals with relevant environmental health guidelines are presented in Table 3. The findings can be summarized and discussed as follows:

3.3.1 Compliance with environmental cleaning guidelines

The assessment revealed that both hospitals adhered to national standards for floor cleaning, including daily cleaning with disinfectants such as 0.1% sodium hypochlorite and proper separation of waste bins. However, in high-traffic areas such as emergency departments, the cleaning frequency needs improvement. For wall and ceiling cleaning, both hospitals maintained regular schedules; nonetheless, in Vali-Asr Hospital, small cracks in the walls of older wards increased the risk of contamination, emphasizing the need for periodic renovations in accordance with hospital space standards (Hassanien et al., 2021).

3.3.2 Medical equipment management

Evaluation of suction devices and laryngoscopes indicated that disinfection after each use was performed according to guidelines. However, oxygen flowmeter maintenance required improvement, as weekly cleaning protocols were not followed in 20% of cases (Chaskar et al., 2017; Liming et al., 2014).

3.3.3 Hygiene in special units

In operating rooms, compliance with gowning guidelines, including surgical gowns, masks, and protective goggles, was complete. In the CSSD, while sterilization of instruments was carried out, the storage conditions of sterile items required improvement in some cases, aligning with the recommendations of the hospital disaster management program design guidelines to prevent secondary contamination (Nekoie-Moghadam et al., 2016; Vafaee et al., 2011).

3.3.4 Ventilation systems

Ventilation system assessments showed that although central systems were available in both hospitals, in the older

wards, due to inefficient filters and the absence of HEPA systems in operating rooms, the air changes per hour (ACH) did not reach the recommended level of 12 per hour. This finding underscores the direct link between ventilation quality and the reduction of hospital-acquired infections (Berlanga et al., 2018; Memarzadeh & Xu, 2012).

Table 1. Analysis of HEH indicators in educational hospitals of Zanjan City

Specific objective	Evaluation indicators	Mean score (Vali-Asr)	Mean score (Ayatollah Mousavi)	Score difference	Significance level (*p-value*)	Notes / documentation
Human resources	Presence of an environmental health expert in the hospital	5.0	5.0	0.0	> 0.05	
	Membership of the environmental health expert in the infection control committee	5.0	5.0	0.0	> 0.05	Continuous participation in infection control committee meetings
	General health training for staff	5.0	5.0	0.0	> 0.05	Training certificates are documented in personnel files.
Waste management	Daily waste collection	5.0	5.0	0.0	> 0.05	
	Separation of wastes	5.0	5.0	0.0	> 0.05	
	Cleaning and disinfecting waste bins after emptying	5.0	5.0	0.0	> 0.05	
Water and wastewater	Drinking water quality (in accordance with Standards No. 1053 and 1011)	5.0	5.0	0.0	> 0.05	Results of microbial and chemical tests
	Hygienic wastewater disposal system	5.0	5.0	0.0	> 0.05	No leakage of wastewater into the environment
Kitchen hygiene	Compliance with hygienic standards for food storage	5.0	5.0	0.0	> 0.05	Expiry date, temperature, and storage conditions monitored.
	Cleaning and disinfection of kitchen equipment	5.0	5.0	0.0	> 0.05	
	Personal hygiene and building conditions	5.0	5.0	0.0	> 0.05	Possession of a valid health certificate by individuals
Laundry	Washing and disinfecting patient and staff clothing	5.0	5.0	0.0	> 0.05	Use of disinfectants
	Separation of contaminated and clean clothing	5.0	5.0	0.0	> 0.05	
	Building structure and equipment	5.0	5.0	0.0	> 0.05	
Ward hygiene conditions	Cleaning and disinfection of wards (ICU, CCU, operating rooms)	5.0	5.0	0.0	> 0.05	Documented infection control program
	Presence of an appropriate ventilation system in the wards	5.0	5.0	0.0	> 0.05	
Laboratory	Disposal of hazardous laboratory waste	5.0	5.0	0.0	> 0.05	Use of yellow bags
	Disinfection of laboratory surfaces and equipment	5.0	5.0	0.0	> 0.05	
Radiology	Compliance with radiation protection standards (MRI, CT-Scan)	5.0	5.0	0.0	> 0.05	Use of lead aprons
	Periodic inspection of radiology devices	5.0	5.0	0.0	> 0.05	
Operating room	Sterilization of surgical instruments	5.0	5.0	0.0	> 0.05	Availability of the autoclave and quality control
	Cleaning and disinfection of the operating room after each surgery	5.0	5.0	0.0	> 0.05	
Central sterilization	Availability of a well-equipped CSSD unit	5.0	5.0	0.0	> 0.05	Compliance with the sterilization cycle
	Proper storage of sterilized equipment	5.0	5.0	0.0	> 0.05	
Other	Condition of the morgue (hygiene and disinfection)	5.0	5.0	0.0	> 0.05	
	Cleaning and disinfection of ambulances	5.0	5.0	0.0	> 0.05	

Table 2. SWOT analysis of HEH indicators in the educational hospitals of Zanjan City

Evaluation indicator	Strengths	Weaknesses	Opportunities	Threats
Human resources	- Full-time presence of environmental health experts - Active membership in the infection control committee - Implementation of seasonal training courses	- Lack of evaluation of training effectiveness - Staff shortage during non-office shifts - Absence of a motivational system for personnel	- Availability of national training guidelines - Potential for e-learning and continuous professional development	- Risk of staff turnover due to workload - Limited recruitment under financial constraints
Waste management	- Complete separation of wastes - Daily disinfection of bins - Electronic recording system in Mousavi Hospital	- Insufficient supervision of final waste disposal (responsibility of the Environmental Protection Organization)	- National emphasis on sustainable waste management - Increasing availability of advanced waste treatment technologies	- Dependence on external contractors for disposal - Risk of infection spread if disposal is mismanaged
Water and wastewater	- Water quality in accordance with Standard No. 1053 - Advanced wastewater treatment plant - Monthly sampling	- Aging pipelines in old infrastructure - Water wastage in some departments	- Existence of national water quality monitoring programs - Potential for upgrading systems through targeted investment	- Contamination risk during infrastructure failure - Budget limitations for full pipeline replacement
Kitchen and laundry hygiene	- Implementation of the HACCP system - Industrial washing machines - Daily monitoring of refrigerator temperature	- Lack of automated temperature recording - Use of traditional methods in some processes - Insufficient food storage space	- Availability of modern automation technologies - Policy support for food safety programs	- Increased foodborne infection risk if monitoring fails - Rising costs of modernizing facilities
Special units (ICU, operating room)	- Ventilation with 12 ACH in new wards - Online monitoring of environmental conditions - Sterilization with Class B autoclave	- Outdated ventilation systems in older wards - Inadequate separation of hospital departments in Vali-Asr Hospital - Non-compliance of some equipment with modern standards	- Existence of WHO and MoHME guidelines for critical areas - Opportunities for international benchmarking	- High infection risk in case of equipment malfunction - Costly upgrades for infrastructure
Radiology and laboratory	- Use of personal dosimeters - Dedicated ventilation in the microbiology laboratory - Safe disposal of sharps	- Lack of automated systems for sample recording	- National programs for radiation safety - Availability of digital laboratory information systems	- Radiation hazards from inadequate monitoring - Chemical risk exposure due to poor storage
Other (Morgue, ambulance)	- Regular disinfection of ambulances - Fire detection and suppression system	- Outdated safety equipment in older sections - Absence of an isolation room for contaminated ambulances	- Availability of national emergency response protocols - Increasing awareness of disaster preparedness	- Risk of cross -contamination during patient transfer - Infectious disease outbreaks increase workload - Limited funding for facility upgrades - Dependence on external emergency services

3.3.5 Waste management

Waste separation, including general, infectious, chemical, pharmaceutical, and sharps waste, was appropriately performed in both hospitals. The temporary storage area complied with guidelines and provided adequate capacity for 48 to 72 hours (Ali et al., 2017).

3.3.6 Ambulance and emergency services

Ambulance cleaning and disinfection were conducted after each patient transfer; however, in some instances, the required 30 min disinfection period specified in guidelines was not observed. This shortcoming aligns with Farhadloo et al.'s (2018) findings on time management challenges in emergency settings.

3.3.7 Patient and staff safety

For fall prevention, both hospitals used beds equipped with protective rails. Patient safety officers regularly conducted educational sessions for staff, and related documentation was maintained in the quality management office (Montero-Odasso et al., 2021).

3.3.8 Positive Points of Environmental Health Indicators

The results highlighted three main points: (A) Common strengths effective waste management (score 5) and proper disinfection of medical equipment (score 5) in both hospitals; (B) Areas for improvement ventilation upgrades in older wards and adherence to standard ambulance disinfection times; and (C) Key differences Ayatollah

Mousavi hospital demonstrated a more advanced sterilization quality control system, while Vali-Asr Hospital required improvement in fall prevention measures. Table 3 thus provides a comprehensive picture of compliance with environmental health guidelines and can serve as a basis for planning interventions to improve hospital standards. The assessment of environmental health indicators revealed that both Vali-Asr and Ayatollah Mousavi hospitals demonstrated high levels of compliance across most domains, with several notable strengths specific to each hospital. In Vali-Asr Hospital, key positive points included strict adherence to floor cleaning protocols using surface disinfectants and hypochlorite for bedpans and urinals, complete separation of hospital wastes, and effective disinfection of medical equipment, ensuring minimal risk of contamination. The hospital also maintained a functional ventilation system in newer wards and implemented quality control in sterilization processes. Ayatollah Mousavi hospital, meanwhile, exhibited particularly strong performance in interim cleaning of high-traffic areas, superior ventilation in new operating rooms (ACH = 12), enhanced sterilization procedures with consistent quality control, and the use of dedicated protective clothing in the CSSD. Additionally, ambulance disinfection procedures in Mousavi hospital fully met the 30-min standard, highlighting its commitment to patient safety. Therefore, both hospitals achieved scores of 4.0 or higher across most indicators, reflecting a robust culture of environmental health compliance, though some areas, such as older ward ventilation in Vali-Asr Hospital, require targeted improvements.

Table 3. Comparison of compliance of Zanjan educational hospitals with environmental health guidelines

Evaluation indicator	Reference guideline	Vali-Asr Hospital	Ayatollah Mousavi Hospital	Score (1–5)	Remarks
Floor cleaning	Floor cleaning guideline (Section 3-2)	Surface disinfection using standard solutions: hypochlorite for bedpans and urinals.	Cleaning performed according to standardized protocols, including interim cleaning in high-traffic areas	Vali-Asr: 4.5 Mousavi: 5	Increased cleaning frequency is needed in the emergency department
Wall and ceiling cleaning	Vertical surface cleaning guideline (Section 4-1)	Monthly inspections and washing procedures	Presence of small cracks in older wards	Vali-Asr: 4 Mousavi: 4.5	Renovation is required for deteriorated sections.
Waste management	Waste separation and disposal guideline (Section 5)	Complete separation	Complete separation	Vali-Asr: 5 Mousavi: 5	–
Ambulance disinfection	Vehicle cleaning and disinfection guideline	Disinfection time: 25 min	Disinfection time: 35 min	Vali-Asr: 4 Mousavi: 5	Non-compliance with the standard 30-min requirement in Vali-Asr
Ventilation	Ventilation system guideline (Annex 2)	ACH = 10 (operating room)	ACH = 12 (new operating room)	Vali-Asr: 3.5 Mousavi: 4	System upgrade needed in the older wards
Sterilization	Sterilization methods (ISO 17665)	Quality control implemented according to protocols and standards	Quality control procedures were conducted as per guidelines	Vali-Asr: 4.5 Mousavi: 5	–
CSSD hygiene	Staff Protective Clothing Guideline	Use of a gown	Sterile gown + dedicated cap	Vali-Asr: 5 Mousavi: 5	–
Equipment disinfection	Suction device disinfection guideline	Disinfection according to protocols and documented when necessary	Disinfection according to protocols and documented when necessary	Vali-Asr: 5 Mousavi: 5	–
Patient safety	Fall prevention guideline	Bed rails installed on beds	Bed rails installed on beds	Vali-Asr: 4 Mousavi: 4.5	Continuous staff training is required.

This study demonstrates a high level of compliance with environmental health indicators (EHIs) in Zanjan's educational hospitals, particularly in critical domains such as waste management, water quality, and sterilization. These findings are consistent with national prioritization models, including the Fuzzy AHP framework proposed by Shahbod et al. (2017), which identified solid waste management as the most critical EHI. Access to safe drinking water and hygienic wastewater collection systems emerged as notable strengths, in line with previous reports from Tabriz, where 99.89% of water samples met national microbiological standards and all hospitals were equipped with proper wastewater disposal systems (Ghozikali et al., 2013). Effluent quality, measured in terms of biochemical oxygen demand (BOD5) and chemical oxygen demand (COD), was within acceptable limits, indicating effective wastewater management practices. Nevertheless, challenges remain in areas such as environmental hygiene in schools and public spaces, medical waste disposal, and noise pollution, which have been identified as key issues requiring targeted intervention (Ghozikali et al., 2013). The results suggest that focused policy-making, adequate resource allocation, and continuous monitoring-as implemented under the oversight of Zanjan University of Medical Sciences-can lead to

substantial improvements in environmental health performance, even in resource-limited settings. However, persistent infrastructural weaknesses, such as outdated ventilation systems in older wards and limited physical space in the Central Sterile Services Department, highlight ongoing challenges that mirror broader national and international trends. Similar observations have been reported by Vaez et al. (2024) in other Iranian hospitals and align with critiques by Tisch et al. (2014), emphasizing that many EHI programs often neglect the built environment, which is crucial for effective infection control. In conclusion, while the high compliance with key EHIs is commendable, it underscores rather than diminishes the need for systemic investments in infrastructure modernization and the expansion of monitoring frameworks to include direct health outcomes, such as healthcare-associated infection rates. Future strategies should aim to bridge the gap between compliance-focused indicators and actual patient safety impacts, ensuring that environmental health management contributes directly to improving care quality across all healthcare facilities in Iran.

3.4 Limitations

This study had several limitations that should be acknowledged. First, the cross-sectional design provides a snapshot of HEH indicators at a single point in time and may not reflect temporal variations in compliance. Second, despite prior training of the research team, observer bias cannot be entirely excluded. Third, limited access to certain internal hospital documents may have restricted the comprehensiveness of the evaluation. Fourth, the scope of the study was confined to two educational hospitals in Zanjan, which may limit the generalizability of the findings to other hospitals in Iran. Finally, resource constraints may have affected the depth of data collection and assessment in certain domains. Nonetheless, the combined methodology integrating direct observation, structured interviews, and review of documented records enabled a relatively comprehensive and objective evaluation of HEH indicators. Future research should aim to overcome these limitations by employing longitudinal study designs, including a larger and more diverse sample of hospitals, and utilizing enhanced assessment tools to provide a more detailed and representative analysis of environmental health practices in Iranian healthcare settings.

4. Conclusion

The results of this study demonstrated that both educational hospitals in Zanjan City in 2024 achieved desirable compliance with most key HEH indicators, including human resources, waste management, water and wastewater quality, kitchen and laundry hygiene, special wards, laboratory and radiology, sterilization, and other related domains. This favorable status is likely the outcome of effective policymaking by Zanjan University of Medical Sciences, adequate resource allocation, a supportive organizational culture, and continuous monitoring of standard implementation. However, certain structural shortcomings, such as outdated ventilation systems in older wards, limited physical space in the CSSD, and a lack of some standard sterilization equipment, were identified as areas requiring improvement. Sustained regular monitoring of HEH indicators, the adoption of modern monitoring and data recording technologies, and infrastructure renovation can further enhance the quality of the hospital environment. Moreover, applying the findings of this study as a model for other similar healthcare centers could serve as an effective step toward improving environmental health standards and reducing health risks at the national level. Therefore, the findings highlight the necessity of continuous investment in HEH as an integral component of healthcare quality assurance systems.

Authors' Contributions

Nastaran Noori: Investigation; Data curation; Writing original draft. **Fatemeh Masaebi:** Conceptualization; Formal Analysis. **Farahnaz Mozafari:** Investigation; Visualization. **Esrafil Asgari:** Supervision; Conceptualization; Visualization; Writing-review & editing. **Abolfazle Bayat:** Investigation; Writing-original draft.

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Conflicts of Interest

The authors have declared no competing interests.

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Ethical considerations

The article is extracted from the project with the ethics code of IR.ZUMS.REC.1403.360.

Using Artificial Intelligence

No type of artificial intelligence was used.

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