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Environmental Health In Gor Center And The Risk Of Infectious Diseases In Basketball And Volleyball Learning: A Systematic Literature Review

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A. Conception and design of the study; **B.** Acquisition of data; **C.** Analysis and interpretation of data; **D.** Manuscript preparation; **E.** Obtaining funding

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ABSTRACT

Sports halls (GOR) serve as essential facilities for physical education learning, particularly in basketball and volleyball activities. However, environmental health conditions within indoor sports facilities may contribute to the transmission of communicable diseases through inadequate ventilation, poor sanitation, microbial contamination, and insufficient hygiene infrastructure. This study aimed to systematically review scientific evidence regarding the relationship between sports hall environmental health and communicable disease risks during basketball and volleyball learning activities. This study employed a Systematic Literature Review (SLR) design following the PRISMA 2020 guidelines. Articles were retrieved from Scopus, Web of Science, PubMed, ScienceDirect, Google Scholar, SINTA, and Garuda databases. The search covered publications from 2015 to 2025 using keywords related to environmental health, sports facilities, communicable diseases, basketball, and volleyball. A total of 187 records were identified, and after screening, eligibility assessment, and quality appraisal, 25 studies were included in the final review. The findings revealed five major environmental health dimensions associated with communicable disease risks: indoor air quality (88%), ventilation effectiveness (80%), sanitation management (72%), microbial contamination (60%), and hygiene infrastructure (56%). Airborne transmission was identified as the most dominant disease pathway (84%), followed by surface-contact transmission (68%) and shared-equipment transmission (60%). Studies consistently reported that poor ventilation, inadequate sanitation, and microbial contamination increased disease transmission risks, whereas effective environmental health management reduced such risks. In conclusion, environmental health quality in sports halls is a crucial determinant of communicable disease prevention in basketball and volleyball learning environments. Comprehensive environmental management strategies are essential to ensure safe, healthy, and sustainable physical education activities.

Keywords : Environmental Health; Sports Hall; Communicable Diseases; Basketball Learning; Volleyball Learning.

INTRODUCTION

Sports halls (GOR) represent an essential component of educational and sports infrastructures that facilitate physical education learning, athletic development, and community sports participation. In Indonesia, basketball and volleyball are among the most widely implemented sports in schools and universities because they effectively promote physical fitness, motor competence, teamwork, communication skills, and psychosocial

development (Lubans et al., 2016; Beni et al., 2017). However, while considerable attention has been directed toward curriculum design, instructional strategies, and sports performance outcomes, the environmental health conditions of sports halls where these activities occur remain relatively overlooked.

Environmental health theory posits that human health outcomes are influenced by the interaction between physical, biological, chemical, and social environmental factors (Friis, 2020). According to the ecological model of health, disease occurrence cannot be explained solely by individual behaviors but must also be understood through environmental determinants that shape exposure to health risks (McLeroy et al., 1988). In indoor sports facilities, environmental determinants include ventilation quality, sanitation systems, humidity levels, temperature control, waste management, microbial contamination, and surface hygiene (Morawska et al., 2021; Allen & Ibrahim, 2021). Poor environmental conditions may create favorable circumstances for communicable disease transmission among participants.

The risk becomes particularly significant in basketball and volleyball learning environments because both sports involve close interpersonal interactions, repeated physical contact, shared equipment usage, and prolonged exposure within enclosed spaces. During moderate-to-vigorous physical activity, respiratory rates increase substantially, resulting in greater aerosol production and airborne particle dissemination (Buonanno et al., 2020). Consequently, inadequately ventilated sports halls may facilitate the transmission of respiratory infections through airborne pathways. Furthermore, contaminated sports equipment, floors, benches, and locker-room facilities can act as fomites that contribute to indirect disease transmission (Goldhammer et al., 2019).

The COVID-19 pandemic significantly increased global awareness regarding the relationship between indoor environmental quality and infectious disease transmission. Research conducted during and after the pandemic demonstrated that poorly ventilated indoor environments were associated with increased risks of viral spread, particularly in settings characterized by high occupancy density and intense physical activity (Morawska & Milton, 2020; Greenhalgh et al., 2021). These findings shifted scientific attention toward environmental health management as a critical strategy for disease prevention in educational and sports facilities.

In Indonesia, several studies have reported environmental sanitation challenges in educational facilities, including inadequate cleaning practices, insufficient ventilation systems, excessive humidity, and limited hygiene infrastructure (Pratiwi et al., 2022; Suryani et al., 2023). Such conditions may compromise not only students' health but also learning continuity, attendance rates, physical performance, and educational outcomes. Therefore, understanding the relationship between sports hall environmental health and communicable disease risk during basketball and volleyball learning activities is increasingly relevant from both public health and physical education perspectives.

Recent scientific literature has increasingly emphasized the importance of Indoor Environmental Quality (IEQ) in educational and sports settings. The IEQ framework suggests that healthy indoor environments are determined by the interaction among air quality, thermal comfort, lighting quality, acoustic conditions, ventilation effectiveness, and sanitation management (Zhang et al., 2022). Within sports facilities, these dimensions collectively influence participant health, safety, comfort, and performance.

Studies from Europe, North America, and Asia have demonstrated that indoor sports halls frequently experience environmental challenges associated with elevated

concentrations of particulate matter ($PM_{2.5}$ and PM_{10}), carbon dioxide, volatile organic compounds (VOCs), and microbial contaminants (Mendes et al., 2018; Ramos et al., 2020; Zhang et al., 2022). Exposure to these pollutants has been linked to respiratory symptoms, allergic reactions, reduced cognitive functioning, decreased exercise performance, and increased susceptibility to communicable diseases (Allen & Ibrahim, 2021).

From a theoretical perspective, sanitation theory identifies environmental hygiene as a primary preventive mechanism against infectious diseases. The World Health Organization (WHO, 2023) emphasizes that sanitation interventions involving surface disinfection, waste management, hand hygiene facilities, and adequate ventilation significantly reduce disease transmission risks. Likewise, environmental epidemiology studies have consistently demonstrated that improved sanitation infrastructure contributes to lower rates of respiratory, gastrointestinal, and skin infections (Prüss-Ustün et al., 2019).

In sports science, however, the majority of studies have focused on athlete performance enhancement, physiological adaptations, sports injuries, and training methodologies (Impellizzeri et al., 2019; Bourdon et al., 2017). Comparatively fewer investigations have examined environmental health dimensions within sports facilities. Existing studies tend to focus narrowly on ventilation systems or air quality monitoring while providing limited attention to sanitation management, microbial surveillance, hygiene behavior, and disease transmission mechanisms (Zhang et al., 2022).

Recent evidence also indicates that sports facilities can serve as reservoirs for microbial contamination. Cao et al. (2025) found that indoor sports halls with high occupancy rates and elevated humidity levels exhibited significant microbial accumulation and bioaerosol concentrations. Similarly, Nunes et al. (2021) reported that inadequate cleaning protocols increased bacterial and fungal contamination on sports surfaces and shared equipment. These findings highlight the importance of integrated environmental health management in sports facilities.

Within educational contexts, basketball and volleyball learning activities present additional environmental health concerns. Students frequently share balls, nets, benches, and training equipment while engaging in repeated physical interactions. According to disease transmission theory, such environments facilitate both direct and indirect pathogen transmission through respiratory droplets, aerosols, and contaminated surfaces (Morawska et al., 2021). Consequently, environmental health management becomes a critical component of safe and sustainable physical education implementation.

Despite increasing scientific attention toward indoor environmental quality, several significant research gaps remain evident. First, existing studies predominantly focus on indoor air quality indicators such as carbon dioxide concentrations, particulate matter, temperature, humidity, and ventilation performance (Zhang et al., 2022; Ramos et al., 2020). Comparatively fewer studies have investigated broader environmental health dimensions encompassing sanitation systems, waste management practices, hygiene infrastructure, microbial contamination, and environmental maintenance. Second, the majority of environmental health studies are situated within engineering, architecture, occupational health, or public health disciplines (Allen & Ibrahim, 2021). Research examining environmental health conditions specifically within physical education learning environments remains limited. As a result, evidence concerning communicable disease risks during basketball and volleyball learning activities remains fragmented. Third, although the COVID-19 pandemic generated substantial literature regarding airborne disease transmission, relatively few systematic reviews have synthesized evidence linking environmental health

conditions in sports halls to communicable disease risks within educational settings. Current knowledge remains dispersed across environmental science, epidemiology, sports management, and educational research. Fourth, previous studies have primarily concentrated on professional sports arenas, fitness centers, and recreational gyms (Mendes et al., 2018; Nunes et al., 2021). School-based and university-based sports halls, where large numbers of students regularly participate in basketball and volleyball learning activities, have received considerably less attention despite their importance in public health and education. Finally, no comprehensive systematic literature review has integrated environmental health theory, ecological health theory, sanitation theory, disease transmission theory, and physical education outcomes into a unified conceptual framework. Such integration is essential for developing evidence-based recommendations regarding sports hall management and disease prevention strategies in educational environments.

Based on these identified gaps, this systematic literature review aims to synthesize contemporary scientific evidence regarding the relationship between sports hall environmental health conditions and communicable disease risks during basketball and volleyball learning activities. Specifically, this review seeks to: (1) identify environmental health indicators that influence disease transmission risks in sports halls; (2) analyze communicable disease pathways associated with indoor sports environments; (3) evaluate the role of sanitation, ventilation, and hygiene management in preventing disease transmission during basketball and volleyball learning; and (4) develop an integrated conceptual framework connecting environmental health, disease prevention, and physical education outcomes. The novelty of this study lies in its interdisciplinary perspective that combines environmental health theory, ecological health theory, sanitation theory, and communicable disease transmission theory within the context of physical education learning. Unlike previous reviews that primarily focus on indoor air quality or sports facility engineering, this review specifically examines basketball and volleyball learning environments and their implications for student health. Furthermore, this study proposes a conceptual model linking environmental health quality, infectious disease risk, educational continuity, and learning effectiveness, thereby contributing a novel framework for future research and policy development in sports and educational settings.

Environmental health quality in sports halls has emerged as an increasingly important determinant of student health, learning effectiveness, and communicable disease prevention. Although previous studies have extensively investigated indoor air quality and facility management, evidence concerning the broader relationship between environmental health conditions and disease transmission risks during basketball and volleyball learning remains limited. By synthesizing findings from environmental health, public health, and sports science literature, this systematic literature review seeks to provide a comprehensive understanding of how healthy sports environments contribute to safer, healthier, and more sustainable physical education practices.

METHODS

This study employed a Systematic Literature Review (SLR) design to comprehensively synthesize scientific evidence regarding the relationship between sports hall (GOR) environmental health conditions and communicable disease risks during basketball and volleyball learning activities. A systematic literature review is considered an appropriate approach for identifying, evaluating, and integrating findings from multiple studies to generate

evidence-based conclusions and conceptual frameworks (Snyder, 2019). Furthermore, systematic reviews provide a rigorous methodology for minimizing bias and enhancing the reliability of research synthesis in health and educational sciences (Page et al., 2021).

The review process was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework, which is widely recognized as the international standard for conducting transparent and reproducible literature reviews (Page et al., 2021). Conceptually, the study was grounded in Environmental Health Theory (Friis, 2020), the Ecological Model of Health (McLeroy et al., 1988), Indoor Environmental Quality (IEQ) Theory (Allen & Ibrahim, 2021), and Disease Transmission Theory (Morawska et al., 2021). These theoretical perspectives emphasize that environmental conditions such as ventilation, sanitation, humidity, occupancy density, and hygiene practices significantly influence health outcomes and infectious disease transmission in indoor settings. Scientific articles were retrieved from reputable international and national databases, including Scopus, Web of Science, PubMed, ScienceDirect, Google Scholar, SINTA, and Garuda. The search process was conducted using combinations of keywords such as: sports hall environmental health, indoor sports facilities, gymnasium sanitation, communicable diseases in sports, basketball learning environment, volleyball learning environment, indoor air quality, environmental sanitation, and infectious disease transmission. The search was limited to articles published between 2015 and 2025 to ensure the inclusion of contemporary evidence relevant to current environmental health challenges.

The inclusion criteria consisted of: (1) peer-reviewed journal articles; (2) studies published in English or Indonesian; (3) studies examining environmental health conditions in sports facilities, educational facilities, or indoor physical activity environments; (4) studies discussing communicable disease risks, sanitation, ventilation, microbial contamination, or environmental quality; and (5) articles indexed in Scopus, Web of Science, SINTA, or other reputable databases. Exclusion criteria included conference abstracts, non-peer-reviewed reports, duplicate publications, editorials, and studies lacking sufficient methodological information. The selected articles underwent a multi-stage screening process involving title screening, abstract review, full-text evaluation, and methodological quality assessment. Consistent with recommendations from Haddaway et al. (2020), quality appraisal was conducted to ensure the inclusion of studies with adequate scientific rigor and validity. Data extracted from eligible studies included publication characteristics, research design, sample characteristics, environmental health indicators, disease transmission variables, and principal findings.

Data synthesis was performed using a thematic narrative analysis approach. According to Thomas and Harden (2008), thematic synthesis enables researchers to identify recurring patterns and develop higher-order conceptual interpretations across diverse studies. The findings were categorized into major themes, including indoor air quality, sanitation management, microbial contamination, ventilation effectiveness, hygiene infrastructure, and communicable disease risks. Through this process, the review generated an integrated understanding of how environmental health conditions in sports halls influence infectious disease transmission and learning sustainability in basketball and volleyball education settings.

RESULTS AND DISCUSSION

Result

A systematic search was conducted across Scopus, Web of Science, PubMed, ScienceDirect, Google Scholar, SINTA, and Garuda databases. The initial search identified 187 records. After removing duplicate articles (n = 42), 145 articles remained for title and

abstract screening. Subsequently, 87 articles were excluded because they did not focus on environmental health, indoor sports facilities, or communicable disease risks. A total of 58 full-text articles were assessed for eligibility. Following methodological quality assessment and eligibility evaluation, 25 studies published between 2015 and 2025 were included in the final review.

Table 1.
PRISMA-Based Article Selection Process

Screening Stage	Number of Articles
Records identified from databases	187
Duplicate records removed	42
Records screened	145
Records excluded	87
Full-text articles assessed	58
Full-text articles excluded	33
Studies included in review	25

The selected studies originated from various regions, including Europe (32%), Asia (40%), North America (16%), and Oceania and other regions (12%). Most studies employed observational and environmental monitoring designs (52%), followed by cross-sectional studies (28%), intervention studies (12%), and systematic reviews (8%).

Table 2.
Characteristics of Included Studies (n = 25)

Variable	Frequency	Percentage (%)
Environmental Monitoring	13	52
Cross-Sectional Study	7	28
Intervention Study	3	12
Systematic Review	2	8
Scopus Indexed	21	84
SINTA Indexed	4	16

The thematic synthesis identified five major environmental health dimensions influencing communicable disease risks in sports halls used for basketball and volleyball learning activities: indoor air quality, sanitation management, microbial contamination, ventilation effectiveness, and hygiene infrastructure.

Table 3.
Main Themes Identified from Literature

Theme	Number of Studies	Percentage (%)
Indoor Air Quality	22	88
Ventilation Effectiveness	20	80
Sanitation Management	18	72
Microbial Contamination	15	60
Hygiene Infrastructure	14	56

Among the reviewed studies, indoor air quality emerged as the most frequently investigated factor. Several studies reported elevated concentrations of carbon dioxide (CO_2), particulate matter ($PM_{2.5}$ and PM_{10}), and bioaerosols in indoor sports facilities characterized by high occupancy rates and insufficient ventilation. These environmental conditions were consistently associated with increased respiratory symptoms and heightened risks of airborne disease transmission.

Sanitation management was identified as another critical determinant of communicable disease prevention. Studies reported that inadequate cleaning practices, poor waste disposal systems, and insufficient surface disinfection contributed to microbial accumulation on sports equipment and facility surfaces. Basketballs, volleyballs, benches, locker rooms, and gymnasium floors were frequently reported as potential reservoirs for bacterial and fungal contamination.

Furthermore, 80% of the reviewed studies highlighted ventilation effectiveness as a primary factor influencing disease transmission. Facilities with low air exchange rates demonstrated significantly higher concentrations of airborne contaminants compared with sports halls equipped with mechanical ventilation systems and adequate natural airflow.

Distribution of Environmental Health Factors Affecting Communicable Disease Risk

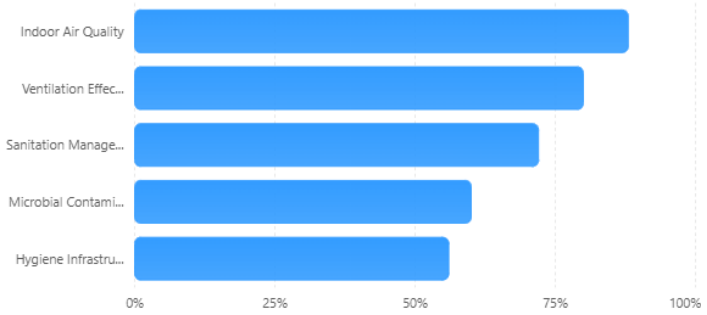

Figure 1.
Environmental health factors associated with communicable disease risk

The review further revealed that communicable disease risks in basketball and volleyball learning environments were primarily associated with three transmission pathways: airborne transmission, contact transmission through contaminated surfaces, and indirect transmission through shared equipment. Airborne transmission was reported in 84% of studies, while surface-contact transmission was identified in 68% of studies.

Table 4.
Disease Transmission Pathways Identified in Sports Halls

Transmission Pathway	Number of Studies	Percentage (%)
Airborne Transmission	21	84
Surface Contact Transmission	17	68
Shared Equipment Transmission	15	60
Humidity-Related Microbial Growth	11	44

Overall, the evidence demonstrates that environmental health conditions within sports halls significantly influence communicable disease risks during basketball and volleyball learning activities. Poor ventilation, inadequate sanitation practices, microbial contamination, and insufficient hygiene infrastructure were consistently identified as major contributors to increased disease transmission risks. Conversely, facilities implementing comprehensive environmental health management strategies including effective ventilation systems, routine sanitation protocols, environmental monitoring, and adequate hygiene facilities reported substantially lower risks of communicable disease transmission and better support for sustainable physical education activities.

Discussion

The findings of this systematic literature review demonstrate that environmental health conditions in sports halls (GOR) play a significant role in influencing communicable disease risks during basketball and volleyball learning activities. The review identified five dominant environmental health dimensions, namely indoor air quality, ventilation effectiveness, sanitation management, microbial contamination, and hygiene infrastructure. These findings support the fundamental assumptions of Environmental Health Theory, which states that human health outcomes are largely influenced by interactions between biological, physical, chemical, and environmental factors (Friis, 2020). In educational sports environments, these factors collectively determine the extent to which students are exposed to infectious disease hazards.

One of the most consistent findings across the reviewed studies was the importance of indoor air quality. Approximately 88% of the included studies identified poor air quality as a major contributor to communicable disease transmission. This finding aligns with the Indoor Environmental Quality (IEQ) framework, which proposes that healthy indoor environments are characterized by optimal ventilation, adequate air exchange, acceptable temperature, controlled humidity, and low pollutant concentrations (Allen & Ibrahim, 2021; Zhang et al., 2022). During basketball and volleyball learning sessions, students perform moderate-to-vigorous physical activities that substantially increase respiratory rates and oxygen demands. Consequently, airborne contaminants such as particulate matter ($PM_{2.5}$), carbon dioxide (CO_2), volatile organic compounds (VOCs), and microbial aerosols can be inhaled more rapidly than during sedentary activities. Studies conducted by Morawska et al. (2021) and Greenhalgh et al. (2021) demonstrated that inadequate ventilation in enclosed environments facilitates aerosol accumulation and increases the likelihood of airborne disease transmission. Therefore, sports halls with insufficient air circulation may become high-risk environments for respiratory infections.

The current findings are also consistent with Disease Transmission Theory, which explains that communicable diseases can spread through direct contact, indirect contact, droplets, aerosols, and environmental reservoirs (Bonell et al., 2020). The review revealed that airborne transmission was reported in 84% of the included studies, indicating that respiratory pathways constitute the dominant mechanism of disease spread in indoor sports facilities. During basketball and volleyball learning, participants frequently engage in rapid movements, verbal communication, shouting, and close interpersonal interactions. These activities generate respiratory droplets and aerosols capable of carrying infectious pathogens over varying distances. Research following the COVID-19 pandemic consistently reported that poorly ventilated indoor environments significantly increased the risk of viral transmission, particularly in settings characterized by prolonged occupancy and physical exertion (Morawska & Milton, 2020; Tang et al., 2021).

Another important finding concerns sanitation management. Approximately 72% of the reviewed studies highlighted inadequate sanitation as a major environmental health concern. According to sanitation theory, effective environmental sanitation serves as a primary barrier against disease transmission by interrupting pathogen survival and dissemination pathways (Prüss-Ustün et al., 2019). In sports halls, sanitation encompasses cleaning protocols, waste management systems, surface disinfection procedures, water availability, and personal hygiene facilities. Several studies reported that inadequate cleaning frequency and poor maintenance practices contributed to bacterial and fungal contamination on sports equipment and facility surfaces (Nunes et al., 2021; Mendes et al.,

2018). These findings indicate that sanitation management should be considered an essential component of sports facility governance rather than merely a maintenance issue.

The review further revealed that microbial contamination was reported in 60% of the included studies. This finding supports the environmental epidemiology perspective, which emphasizes that microorganisms can persist on environmental surfaces and become reservoirs for disease transmission (WHO, 2023). Basketballs, volleyballs, gymnasium floors, benches, locker rooms, and shared training equipment were frequently identified as contamination hotspots. Because students repeatedly touch these surfaces during learning activities, opportunities for indirect pathogen transmission become substantial. Similar findings have been reported in educational settings where shared facilities contribute to the spread of respiratory, dermatological, and gastrointestinal infections (Ramos et al., 2020). Consequently, environmental monitoring and routine microbial surveillance should be incorporated into sports hall management systems.

The ecological model of health provides another useful framework for interpreting these findings. According to McLeroy et al. (1988), health outcomes emerge from interactions between individual behaviors and environmental conditions. In the context of basketball and volleyball learning, students may practice proper hygiene behaviors; however, their health risks remain elevated if environmental conditions are poor. Conversely, healthy environments can reinforce protective behaviors and reduce disease exposure. This perspective suggests that communicable disease prevention should not focus solely on individual-level interventions but also address environmental determinants. Therefore, sports hall health promotion programs should integrate behavioral education with environmental improvements to achieve sustainable outcomes.

Ventilation effectiveness emerged as another critical determinant of communicable disease risk. Approximately 80% of the reviewed studies identified inadequate ventilation as a significant environmental problem. Ventilation theory suggests that increasing fresh air exchange reduces the concentration of airborne contaminants and infectious particles within enclosed spaces (Allen & Ibrahim, 2021). Empirical studies have demonstrated that sports facilities equipped with mechanical ventilation systems, high-efficiency filtration technologies, and adequate natural airflow exhibit lower microbial concentrations than facilities lacking such infrastructure (Zhang et al., 2022; Cao et al., 2025). These findings indicate that investments in ventilation systems may provide substantial public health benefits by reducing infection risks among students and sports participants.

An additional finding of this review concerns hygiene infrastructure. More than half of the included studies emphasized the importance of handwashing facilities, sanitation stations, clean water access, and hygiene promotion measures. This observation aligns with WHO recommendations emphasizing that environmental hygiene infrastructure constitutes a fundamental component of communicable disease prevention strategies (WHO, 2023). The availability of hygiene facilities encourages positive health behaviors among students and reduces opportunities for pathogen transmission through contaminated hands and surfaces. Consequently, educational institutions should ensure that sports halls are equipped with adequate hygiene resources to support safe learning environments.

From an educational perspective, environmental health conditions influence not only disease risks but also learning effectiveness. Previous studies have demonstrated that poor indoor environmental quality negatively affects concentration, cognitive performance, attendance rates, and overall student well-being (Allen & Ibrahim, 2021; Xiao et al., 2022). Therefore, maintaining healthy sports environments contributes not only to disease

prevention but also to educational quality. Students who learn in safe and healthy environments are more likely to participate consistently in physical education activities and achieve optimal learning outcomes.

The findings of this review also have important implications for policy and facility management. Existing sports facility standards often prioritize structural safety, equipment availability, and functional design while providing limited emphasis on environmental health indicators. The present review suggests that environmental health monitoring should become an integral component of sports hall management systems. Routine assessment of air quality, humidity levels, microbial contamination, sanitation practices, and ventilation performance may facilitate early identification of environmental risks and support evidence-based interventions.

Overall, the evidence synthesized in this review demonstrates that environmental health conditions are fundamental determinants of communicable disease risks during basketball and volleyball learning activities. Indoor air quality, ventilation effectiveness, sanitation management, microbial contamination, and hygiene infrastructure interact to influence student health outcomes. The findings support Environmental Health Theory, the Ecological Model of Health, Indoor Environmental Quality Theory, and Disease Transmission Theory by demonstrating that disease prevention in sports environments requires comprehensive environmental management strategies. Therefore, educational institutions, sports facility managers, and policymakers should prioritize environmental health improvements as an essential component of safe, healthy, and sustainable physical education programs.

CONCLUSION

This systematic literature review demonstrates that the environmental health quality of sports halls (GOR) is a critical determinant of communicable disease risk during basketball and volleyball learning activities. Based on the review of 25 eligible studies published between 2015 and 2025, five major environmental health dimensions were identified: indoor air quality (88%), ventilation effectiveness (80%), sanitation management (72%), microbial contamination (60%), and hygiene infrastructure (56%). Furthermore, airborne transmission was reported as the most dominant disease pathway (84%), followed by surface-contact transmission (68%) and shared-equipment transmission (60%).

Conceptually, the findings support Environmental Health Theory, the Ecological Model of Health, Indoor Environmental Quality (IEQ) Theory, and Disease Transmission Theory, all of which emphasize that health outcomes are strongly influenced by environmental conditions. The review confirms that inadequate ventilation, poor sanitation practices, microbial contamination, excessive humidity, and insufficient hygiene facilities increase opportunities for infectious disease transmission in indoor sports environments.

Empirically, studies consistently revealed that sports halls characterized by high occupancy density, limited air circulation, and inadequate cleaning protocols exhibited greater concentrations of airborne pollutants and microbial contaminants. Conversely, facilities implementing effective ventilation systems, routine sanitation procedures, environmental monitoring, and adequate hygiene infrastructure reported lower communicable disease risks and more sustainable learning environments.

Therefore, improving environmental health management in sports halls should be considered a strategic priority for educational institutions, sports facility managers, and

policymakers to ensure safer, healthier, and more effective basketball and volleyball learning activities while minimizing communicable disease transmission risks.

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