

Effective Measures for Infection Prevention and Control in Designated Hospitals During COVID-19 Public Health Emergencies: A Case Study of Baidong Hospital

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Abstract

The COVID-19 pandemic posed unprecedented challenges to healthcare systems worldwide, with designated hospitals facilities specifically established to treat COVID-19 patients serving as critical frontline settings while facing exceptionally high risks of nosocomial transmission. Despite their central role, evidence-based infection prevention and control (IPC) frameworks specifically designed for designated hospitals remain insufficiently documented, creating a critical gap that limits preparedness for future public health emergencies.

This study aimed to explore and systematically document effective IPC measures implemented at a designated hospital during a COVID-19 public health emergency, using Baidong Hospital in Baise, China as a case study, in order to generate a transferable IPC framework for similar settings. A qualitative case study design was employed, combining policy and literature review, expert consultation with 15 IPC specialists, institutional document analysis, and direct field investigation. Data were collected from policy documents, institutional records, and participant observation during February–May 2022. Content analysis guided by the PDCA (Plan-Do-Check-Act) cycle and Fishbone Diagram frameworks was applied to examine IPC implementation strategies and outcomes. Baidong Hospital successfully treated 206 confirmed COVID-19 patients over 69 days, achieving zero healthcare worker infections, zero patient deaths, and zero community transmission. Six key system components contributed to these outcomes: (1) a multi-tiered IPC organizational structure with dedicated expert teams; (2) evidence-based environmental design implementing strict zoning system; (3) comprehensive human resource management with 100% training compliance and competency verification; (4) systematic material resource allocation with intelligent

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monitoring; (5) robust institutional mechanisms including 46 standardized protocols; and (6) multi-layered surveillance with daily nucleic acid testing. Effective IPC in designated hospitals requires an integrated system encompassing organizational structure, physical infrastructure, human resource capacity, material resources, institutional mechanisms, and systematic surveillance. However, the transferability is constrained by China's centralized governance context and resource-intensive requirements.

Keywords: PDCA cycle, COVID-19, Designated hospital, Infection prevention and control

ประสิทธิผลของมาตรการในการควบคุมและป้องกันการติดเชื้อในโรงพยาบาลที่ได้รับการกำหนดสำหรับการรับมือภาวะฉุกเฉินด้านสาธารณสุขจากโควิด-19: กรณีศึกษาของโรงพยาบาลโปตง

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บทคัดย่อ

การแพร่ระบาดของ COVID-19 ก่อให้เกิดปัญหาในวงกว้างแบบที่ไม่เคยปรากฏมาก่อนต่อระบบสุขภาพทั่วโลก โดยโรงพยาบาลที่กำหนดให้รับผู้ป่วยทำหน้าที่เป็นศูนย์กลางการรักษา แต่ต้องเผชิญกับความเสี่ยงสูงของการติดเชื้อในโรงพยาบาล มาตรการป้องกันและควบคุมการติดเชื้อ (IPC) ที่มีประสิทธิผลมีความจำเป็นแต่ยังขาดการบันทึกอย่างเพียงพอในบริบทฉุกเฉิน

การศึกษานี้มีวัตถุประสงค์เพื่อสำรวจมาตรการ IPC ที่มีประสิทธิผลซึ่งดำเนินการในโรงพยาบาลที่กำหนดระหว่างภาวะฉุกเฉินด้านสาธารณสุข โดยใช้โรงพยาบาลโปตงในประเทศจีนเป็นกรณีศึกษา ใช้แนวทางการศึกษากรณีศึกษาเชิงคุณภาพ ผสมผสานการวิเคราะห์เอกสาร การให้คำปรึกษากับผู้เชี่ยวชาญ IPC จำนวน 15 คน และการสำรวจภาคสนาม เก็บรวบรวมข้อมูลจากเอกสารนโยบาย บันทึกสถาบัน และการสังเกตโดยตรงระหว่างเดือนกุมภาพันธ์-พฤษภาคม 2565 ใช้การวิเคราะห์เนื้อหาเพื่อตรวจสอบกลยุทธ์การดำเนินงาน โดยมีแนวทางจากวงจร PDCA (Plan-Do-Check-Act) และกรอบ Fishbone Diagram โรงพยาบาลโปตงรักษาผู้ป่วยยืนยัน COVID-19 จำนวน 206 รายตลอด 69 วันได้สำเร็จ โดยบรรลุผลการติดเชื้อในบุคลากรทางการแพทย์เป็นศูนย์ การเสียชีวิตของผู้ป่วยเป็นศูนย์ และการแพร่กระจายสู่ชุมชนเป็นศูนย์ องค์ประกอบหลัก 6 ประการที่มีส่วนต่อผลลัพธ์เหล่านี้ ได้แก่ (1) โครงสร้างองค์กร IPC หลายระดับพร้อมทีมผู้เชี่ยวชาญเฉพาะ (2) การออกแบบสภาพแวดล้อมตามหลักฐานเชิงประจักษ์ที่ใช้ระบบการแบ่งเขตอย่างเข้มงวด (3) การจัดการทรัพยากรบุคคลอย่างครอบคลุมด้วยการปฏิบัติตามการฝึกอบรม 100% (4) การจัดสรรทรัพยากรวัสดุอย่างเพียงพอพร้อมการตรวจสอบอัจฉริยะ (5) กลไกสถาบันที่แข็งแกร่งรวม 46 ระเบียบปฏิบัติ และ (6) การเฝ้าระวังอย่างเป็นระบบด้วยการตรวจ nucleic acid รายวัน IPC ที่มีประสิทธิผลในโรงพยาบาลที่กำหนดต้องการระบบบูรณาการที่ครอบคลุมโครงสร้างองค์กร โครงสร้างพื้นฐานทางกายภาพ ความสามารถของบุคลากร ทรัพยากรวัสดุ กลไกสถาบัน และการเฝ้าระวัง อย่างไรก็ตาม การถ่ายทอดแบบจำลองนี้มีข้อจำกัดจากบริบทการปกครองแบบรวมศูนย์ของจีนและความต้องการทรัพยากรที่เข้มข้น

คำสำคัญ: วงจร PDCA; โควิด-19, โรงพยาบาลที่ได้รับการกำหนด, การป้องกันและควบคุมการติดเชื้อ

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Introduction

The COVID-19 pandemic presented unprecedented challenges to healthcare systems worldwide. The novel coronavirus, characterized by high transmissibility and rapid mutation, posed serious threats to public health (Li et al., 2020; Martinez et al., 2021). Hospital-acquired infections emerged as a critical concern, with outbreaks reported in more than 200 countries (Gao et al., 2021; Tripathi et al., 2020). In China alone, between the outbreak and February 11, 2020, among 422 medical institutions treating COVID-19 patients, 3,019 healthcare workers reported suspected infections, with 1,716 confirmed cases (Chinese Center for Disease Control and Prevention, 2020). Early studies documented that 41% of hospitalized patients may have acquired infections through hospital transmission, including 12.3% healthcare workers (Wang et al., 2020). Designated hospitals facilities specifically established to admit and treat COVID-19 patients—faced particularly high transmission risks due to patient volume, complex staffing needs, and treatment intensity (Zhou et al., 2022). Establishing effective infection prevention and control (IPC) systems tailored to pandemic response became essential. China's "Four Concentrations" strategy (concentrating patients, experts, resources, and treatment) enabled rapid establishment of designated hospitals and effectively curtailed viral spread.

Despite the critical importance of IPC in designated hospitals, systematic documentation of effective practices remains limited. While existing literature addresses general hospital infection control (Fu, 2020; Xiao et al., 2012), and some studies have examined IPC in COVID-19 treatment settings (Chen et al., 2021; Wang et al., 2024), evidence-based frameworks specifically designed for designated hospitals during respiratory pandemics are scarce. Most available guidance focuses on standard hospital precautions rather than the unique organizational, environmental, and logistical demands of rapidly established dedicated treatment facilities. This critical gap in the literature hinders preparedness and institutional planning for future public health emergencies, where comparable facilities may need to be established at speed.

This study examines Baidong Hospital, a designated COVID-19 treatment facility in Baise, China, appointed in February 2022 during a localized outbreak. The hospital had not yet opened for clinical operations when it received the emergency mandate. Within days, it prepared to admit patients, ultimately treating 206 confirmed cases over 69 days while achieving zero healthcare worker infections, zero patient deaths, and zero community transmission. This exceptional outcome provides valuable insights into effective IPC implementation under emergency conditions.

Research Objectives

1. To identify key IPC strategies implemented at Baidong Hospital during its COVID-19 response
2. To analyze how China's national policies and guidelines shaped IPC practices at the institutional level
3. To evaluate the effectiveness of organizational, environmental, human resource, and surveillance system components
4. To synthesize lessons learned into a comprehensive IPC framework applicable to designated hospitals during public health emergencies

Research Scope

1. Content Scope: This study focused on the construction and implementation of an effective hospital IPC system at Baidong Hospital during the COVID-19 pandemic. It encompassed multiple dimensions, including policy guidance in China, organizational system development, environmental renovation and optimization, personnel allocation, equipment support, training and assessment programs, institutional mechanisms, and supervision processes.

2. Regional Scope: The study involved collection and analysis of epidemiological data from China and worldwide, with focus on designated hospitals.

3. Time Range: Global and Chinese data were collected from November 2019 to December 2022; designated hospital data were collected from February to May 2022.

Methods and Materials

Research Design

This study employed a qualitative case study design to examine IPC practices at Baidong Hospital, a designated COVID-19 treatment facility. The case study method was selected because it enables in-depth exploration of complex organizational phenomena within real-world contexts, allowing examination of how and why particular IPC strategies were implemented and their observed outcomes (Yin, 2018). This approach is well suited to studying unique emergency health settings where experimental designs are not feasible. The research was conducted between February and May 2022, coinciding with the hospital's operational period as a designated facility.

Analytical Frameworks

Two complementary analytical frameworks guided data interpretation. First, the PDCA (Plan-Do-Check-Act) cycle provided a systematic lens for examining how IPC strategies were planned, implemented, monitored, and refined. This cyclical framework enabled analysis of continuous quality improvement processes. Second, the Fishbone Diagram (Ishikawa Diagram) structured the analysis of six key IPC dimensions: organizational structure, environmental factors, human resources, materials and equipment, institutional mechanisms, and supervision systems (Figure 1). These frameworks were applied as analytical tools to organize and interpret findings, not as implementation procedures.

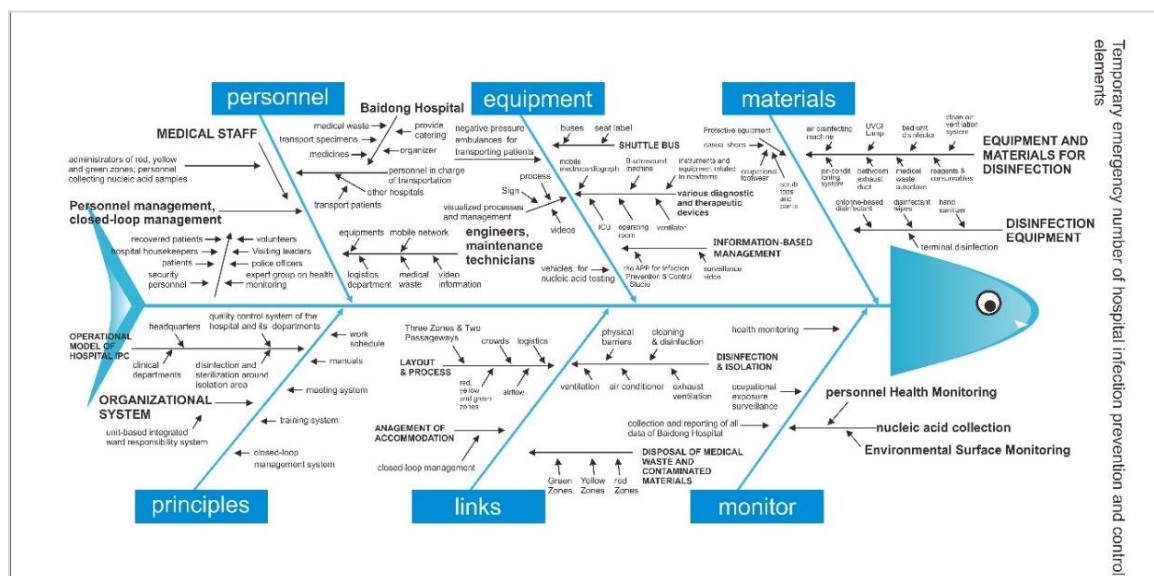


Figure 1 Bone diagram of six elements of infection prevention and control in COVID-19 Hospital

Data Collection

Data were collected from four primary sources:

1. Policy and Literature Review: Relevant national policies, technical guidelines, and academic literature on hospital IPC during COVID-19 were systematically reviewed. Sources included documents from China's National Health Commission, World Health Organization guidelines, and peer-reviewed publications accessed through CNKI and PubMed databases.

2. Institutional Documents: Hospital records, protocols, and operational data were obtained with institutional permission. These included the Infection Prevention and Control Manual for COVID-19 Response, training records, surveillance reports, assessment documentation, and meeting minutes from the Hospital Infection Management Committee.

3. Expert Consultation: A panel of 15 hospital infection control experts with specialized knowledge in epidemic response was consulted. These experts reviewed preliminary findings, validated key IPC indicators, and provided critical feedback on the proposed framework. The expert panel included members from provincial and national IPC professional associations.

4. Field Investigation: Direct observation was conducted by the research team within designated hospital areas. Researchers participated in IPC supervision rounds, attended coordination meetings, and documented implementation processes across clinical, medical-technical, and administrative-logistical units. Field notes recorded environmental conditions, workflow patterns, compliance behaviors, and emerging challenges. All observations followed ethical protocols and maintained confidentiality.

Data Analysis

Content analysis was employed to systematically examine IPC implementation strategies and outcomes. The analytical process proceeded in four stages. First, all collected documents, field notes, and institutional records were organized chronologically and thematically. Data were coded according to the six dimensions identified in the Fishbone framework: organizational structure, environmental design, human resources, material allocation, institutional mechanisms, and surveillance systems. Second, framework-based analysis applied the PDCA cycle to examine how each IPC component was planned, implemented, monitored, and adjusted revealing adaptive management patterns and iterative refinement processes. Third, descriptive statistics were calculated for quantitative indicators including training participation rates, compliance assessment scores, nucleic acid testing frequencies, and infection incidence rates, providing objective evidence of implementation fidelity and outcomes. Fourth, triangulation enhanced validity by cross-comparing findings across four data sources: policy documents (intended standards), institutional records (actual implementation), expert consultation (professional validation), and field observations (real-world practice). Convergence among these sources strengthened confidence in findings, while divergences prompted deeper investigation, ensuring methodological rigor.

Ethical Considerations

This study was approved by the Medical Ethics Committee of the Second Affiliated Hospital of Guangxi Medical University (Approval No. 2025-KY(002), dated August 7, 2025). The research did not involve disclosure of patient privacy or identifiable health information. All institutional data were accessed with appropriate permissions and used solely for

research purposes. Participants in field observations provided informed consent, and confidentiality was maintained throughout data collection and reporting.

Results

The following section presents findings from content analysis of policy documents, institutional records, expert consultation, and field observations. Data are organized according to the six IPC dimensions identified in the Fishbone analytical framework, with quantitative indicators provided where available to support objective assessment of outcomes.

Multi-Tiered IPC Organizational System

Baidong Hospital established a three-tier IPC management framework comprising the Hospital Infection Management Committee, a Temporary Joint IPC Office, and ward-based IPC expert teams. This hierarchical structure enabled coordinated decision-making and rapid response to emerging challenges. The Hospital Infection Management Committee, led by hospital senior leadership, provided strategic oversight and policy direction. National IPC experts served as consultants and technical advisors to ensure alignment with current scientific evidence.

The Temporary Joint IPC Office, staffed by provincial-level IPC specialists, functioned as the operational hub. This office recruited and coordinated professional teams responsible for spatial zoning, workflow regulation, environmental modification, and protocol development. An independent ward-based IPC management model assigned two dedicated experts to each of the eight designated wards. These experts conducted daily supervision, provided real-time guidance, and ensured systematic implementation of control measures. This multi-tiered structure created clear lines of authority while enabling flexible response to frontline needs.

Evidence-Based Environmental Design and Physical Barriers

The hospital implemented strict physical segregation based on China's "three zones and two passageways" standard, augmented with an additional third passageway for enhanced material flow control. This system established clear separation among contaminated zones (patient treatment areas), potentially contaminated zones (transition spaces), and clean zones (administrative and logistics areas). Each zone maintained physical barriers with floor-to-ceiling partitions and controlled access points marked by prominent signage.

Three independent passageways managed distinct traffic flows: a patient-only entrance from the hospital main gate to isolation wards, a separate healthcare personnel entrance from a side gate, and a dedicated exit route for contaminated materials located at the facility's rear. The walls separating zones extended from floor to ceiling, allowing for rapid functional conversion between routine and emergency use, and significantly minimizing cross-infection risk. All areas, passageways, and rooms were marked with prominent signage. Detailed zoning and passageway routes are illustrated in Figures 2, 3, and 4.

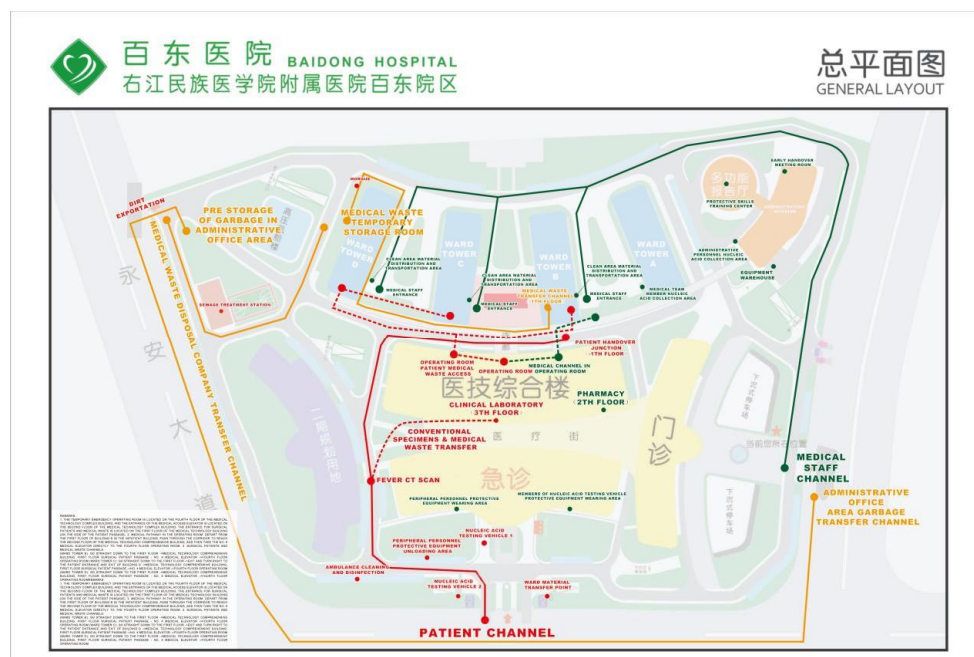


Figure 2 Layout of Baidong Hospital

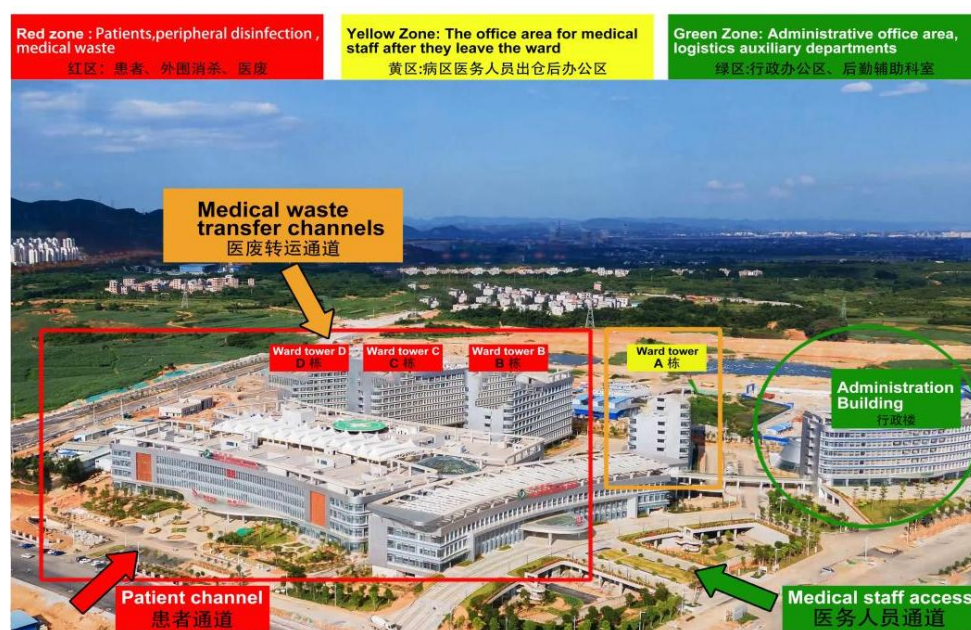


Figure 3 Schematic diagram of "three districts and three channels" in Baidong Hospital

“Three Zones and Two Passageways” Management in Isolation Ward: Each isolation ward was divided into a clean zone (green), semi-contaminated zone (yellow), and contaminated zone (red). Each isolation ward included a dedicated sanitary transition area. The walls separating the three zones extended from floor to ceiling, allowing for rapid functional conversion between routine and emergency use, and significantly minimizing the risk of cross-infection between patients and healthcare personnel. All areas, passageways, locations, and rooms were marked with prominent signage for clear identification and operational guidance. Detailed zoning and passageway routes for the isolation wards are presented in Figure 4.

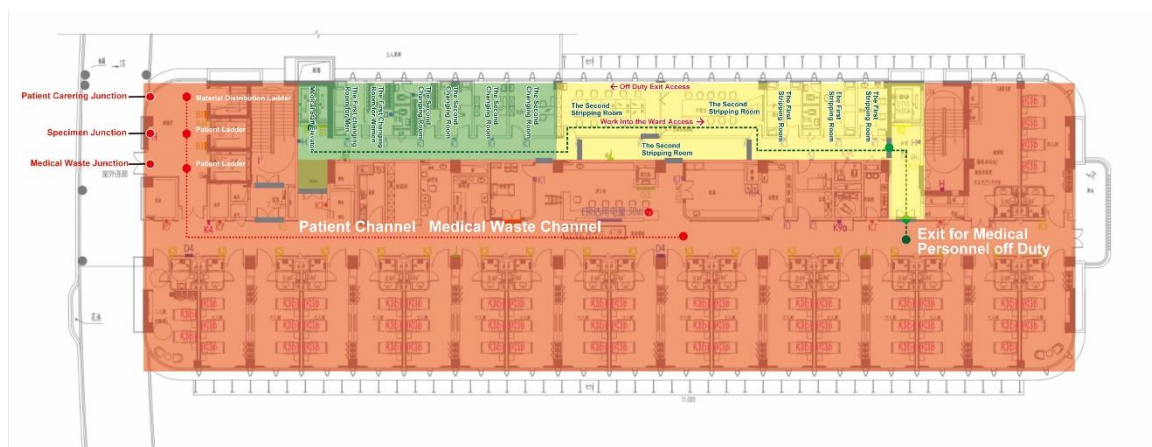


Figure 4 Distribution diagram of the three zones of the isolation ward

Human Resource Management and Workflow Control

Personnel movement adhered to strict flow separation principles. All cross-zone movement was prohibited, with three physically separated entrances managing access for patients, healthcare workers, and waste transport respectively. Medical staff accessed designated areas through staff-only entrances, while patients entered through a separate pathway that included immediate fever screening and chest CT examination before elevator transport to isolation wards.

Each ward operated under independent team management. Medical teams worked autonomously with dedicated staff, equipment, and transportation, preventing inter-ward contact. Patient meals and medications were delivered through the patient passageway by contaminated-zone personnel, while clean supplies moved through the staff passageway. Medical waste handling involved designated personnel using dedicated elevators and strict disinfection protocols in compliance with national standards.

Material Resources and Equipment

Equipment and supply allocation followed systematic planning based on national emergency protocols. Personal protective equipment (PPE), disinfection devices, and chemical agents were categorized and inventoried to ensure adequate stockpiles matched anticipated demand. The hospital installed 105 intelligent voice-interactive surveillance cameras providing comprehensive coverage of isolation wards, nurse stations, and clinical work areas, enabling continuous supervision of IPC measure implementation and rapid identification of compliance gaps.

Environmental and surface disinfection protocols were rigorously enforced. The medical vacuum negative pressure system received particular attention given its potential for aerosol transmission. Specialized disinfection procedures targeted water vapor in the central negative pressure suction facility to minimize infection risk associated with turbulent airflow. All medical equipment underwent standardized cleaning and disinfection according to established protocols.

Training and Competency Assessment

Comprehensive training programs addressed both theoretical knowledge and practical skills. All 588 personnel completed online theoretical training via an infection control mobile application, covering IPC principles and the hospital's COVID-19 response manual, achieving 100% participation and pass rates.

Practical skill training occurred in two cycles. Cycle 1 involved 533 participants completing 621 assessments, with an initial pass rate of 91% (485/533); all 48 who initially failed passed upon reassessment after additional training. Cycle 2 targeted 81 newly recruited personnel with 91 assessments and an initial pass rate of 87.3% (71/81); the remaining 10 passed in the second round. Additionally, 21 personnel identified through video surveillance as demonstrating inadequate protective technique were temporarily removed from duty, underwent intensive retraining, and all subsequently passed (100% pass rate). Ward-based IPC experts also conducted supplementary donning/doffing training, assessing 264 individuals, all of whom passed (100% pass rate). This multi-layered approach ensured universal competency verification before clinical deployment.

Institutional Mechanisms and Systematic Surveillance

The hospital developed a comprehensive Infection Prevention and Control Manual for COVID-19 Response containing 46 regulations and protocols with 70 annexes, totaling approximately 20,000 words, covering supervision, disinfection, isolation procedures,

terminal disinfection, infection surveillance, and reporting. Regular coordination meetings and daily data monitoring facilitated timely problem identification and resolution.

Surveillance operated through multiple mechanisms. Nucleic acid testing frequency was adjusted based on epidemiological conditions and national policy, ranging from daily testing of all personnel and environmental samples to targeted testing under specific circumstances; all test results remained negative throughout the operational period. Daily health monitoring tracked body temperature and symptoms for all staff, with immediate reporting and duty suspension for individuals showing abnormalities. Real-time infection monitoring tracked incidence rates, affected body systems, departmental patterns, and risk factors. Closed-loop personnel management restricted all staff and support workers to "two-point-one-line" movement (residence to hospital only), with enhanced cleaning, disinfection, and exit protocols at accommodations.

Summary of Outcomes

During 69 days of operation, Baidong Hospital admitted and treated 206 confirmed COVID-19 patients. All patients fully recovered and were discharged. The hospital achieved zero healthcare worker infections, zero patient deaths, and zero community transmission. These outcomes reflect the integrated functioning of all six IPC system components operating simultaneously, with each dimension reinforcing the others. The multi-tiered organizational structure enabled rapid protocol deployment; physical zoning constrained transmission pathways; training ensured behavioral compliance; material resources supported safe operations; institutional mechanisms provided standardized guidance; and surveillance enabled proactive rather than reactive management.

Discussion

The findings demonstrate that hierarchical IPC organizational structures constitute a critical determinant of epidemic management effectiveness in designated hospitals. Baidong Hospital's three-tier system enabled simultaneous top-down policy implementation and bottom-up problem identification, creating adaptive feedback loops essential for managing rapidly evolving situations. This organizational model aligns with China's broader emergency governance framework, which emphasizes centralized coordination combined with distributed operational authority (Wan & Wang, 2009). The presence of a high-capacity professional IPC team at each organizational level ensured that national standards were not merely adopted but actively translated into context-appropriate practices. Without this

specialized expertise embedded throughout the institutional hierarchy, even well-designed protocols may fail during implementation under pressure.

Physical infrastructure emerged as the foundational layer upon which all other IPC measures depend. The strict "three zones and three passageways" implementation created spatial barriers that physically constrained potential transmission pathways. This finding aligns with recent evidence emphasizing architectural infection control engineering for respiratory pathogens (Chen Q.Z. et al., 2021). However, the effectiveness of spatial design extends beyond mere physical separation: signage clarity, workflow logic, and operational practicality determine whether spatial barriers function as intended or create bottlenecks that inadvertently increase exposure risks. The hospital's pragmatic decision to add a third passageway specifically for contaminated material exit demonstrates that infrastructure effectiveness requires both regulatory compliance and operational feasibility.

Achievement of zero staff infections provides compelling evidence that human resource capacity, rather than physical resources alone, determines IPC outcomes. The hospital's intensive training program achieving 100% competency verification through iterative assessment and remediation — transformed policy into practice. This finding supports recent literature indicating that healthcare worker capability, not merely equipment availability, constitutes the decisive factor in infection control success (Gan et al., 2022). The use of video surveillance to identify personnel with inadequate technique, followed by mandatory retraining before return to duty, demonstrates precision-based competency management. However, this approach requires significant institutional investment in monitoring infrastructure and operational flexibility that may limit transferability to resource-constrained settings.

The development of a 20,000-word operational manual encompassing 46 regulations and 70 annexes within an emergency timeframe reflects remarkable institutional capacity. This manual served not as a static document but as a living framework subject to continuous PDCA-based refinement, enabling the system to remain responsive to emerging evidence and operational experience. Such adaptive institutional mechanisms represent a critical but under-recognized component of emergency preparedness. Organizations capable of rapidly generating, disseminating, and updating detailed operational guidance possess structural advantages in managing novel threats though this capability typically derives from pre-existing institutional culture and administrative capacity rather than resources that can be quickly mobilized during emergencies.

Surveillance mechanisms functioned as the early-warning system enabling proactive rather than reactive management. Daily nucleic acid testing combined with continuous

health monitoring and real-time infection data analysis created multiple overlapping detection layers redundancy that proved essential given the potential for asymptomatic transmission and long incubation periods. However, this finding must be contextualized within China's broader epidemic control environment, where extensive community-level surveillance and movement restrictions reduced baseline exposure risks, meaning the surveillance system's effectiveness cannot be evaluated independently of these external factors.

Several factors constrain the transferability of Baidong Hospital's model to other contexts. First, China's centralized governance system enabled rapid resource mobilization, including assignment of national-level experts and priority allocation of equipment and supplies mechanisms unavailable in many healthcare systems. Second, the hospital's designation as a newly constructed facility awaiting opening meant it could be comprehensively retrofitted without disrupting existing operations, a circumstance unlikely to recur elsewhere. Third, the closed-loop personnel management requiring all staff to reside in designated accommodations with restricted movement represents a level of control that may be neither feasible nor acceptable in different cultural and institutional contexts. Fourth, the resource intensity of this approach 105 surveillance cameras, daily nucleic acid testing, continuous expert supervision, and redundant systems requires substantial financial investment that may exceed available resources in many settings. Finally, the 69-day operational period during a localized outbreak with finite patient numbers differs from sustained pandemic conditions requiring long-term system operation.

Conclusion

This study concludes that effective IPC in designated hospitals during public health emergencies requires five interconnected system components functioning in integration: (1) hierarchical organizational structures with embedded professional expertise; (2) evidence-based physical infrastructure enabling spatial segregation; (3) human resource capacity verified through competency-based assessment; (4) adequate material resources with continuous monitoring; and (5) comprehensive surveillance systems providing real-time situational awareness. Consistent with the four research objectives, these components were found to operate interdependently — the absence or weakness of any single component compromises overall system effectiveness. Institutional mechanisms, including comprehensive standardized protocols subject to continuous PDCA-based refinement, serve as the connective tissue integrating all other components.

Baidong Hospital's achievement of zero healthcare worker infections, zero patient deaths, and zero community transmission during treatment of 206 confirmed COVID-19 patients demonstrates that integrated IPC systems can maintain hospital safety even under emergency conditions. However, this success occurred within China's centralized governance context, supported by national-level expert deployment, priority resource allocation, and closed-loop personnel management. These enabling conditions may not exist in other healthcare systems, limiting direct transferability.

The resource-intensive nature of this model including daily nucleic acid testing, continuous video surveillance, redundant expert supervision, and comprehensive training with iterative assessment requires substantial financial investment and administrative capacity. Healthcare systems with constrained resources may need to prioritize specific components or develop adapted models appropriate to their contexts. Future research should examine which elements prove most critical under varying resource constraints and organizational structures.

Recommendations for Practice

Based on study findings, the following recommendations are proposed for designated hospitals preparing for public health emergencies:

1. Establish unified emergency command structures that enable rapid coordination, coherent communication, and effective multi-departmental collaboration during crisis response.
2. Develop and maintain competency-based training programs for IPC personnel that emphasize both theoretical knowledge and practical skills, with mandatory verification before personnel assume clinical duties.
3. Create dynamic supply-reserve systems that maintain adequate stockpiles of PPE, disinfectants, and critical medical materials, with protocols for rapid resupply based on evolving risk assessments.
4. Integrate IPC principles into facility design and renovation planning, emphasizing spatial zoning, airflow management, and clear separation of clean and contaminated pathways.
5. Implement comprehensive surveillance and early-warning systems that combine multiple detection methods including diagnostic testing, symptom monitoring, and environmental sampling to enable timely intervention.
6. Establish systematic health-monitoring protocols for all personnel, with clear procedures for screening, reporting, temporary duty suspension, and return-to-work criteria when health concerns arise.

Recommendations for Future Research

Future research should address several key questions:

1. Comparative effectiveness studies examining how the IPC model developed in this study performs in different healthcare systems, governance structures, and resource environments would clarify transferability limitations and adaptation requirements.
2. Cost-effectiveness analyses of comprehensive IPC programs would determine financial feasibility and sustainability, particularly for healthcare systems operating under budget constraints.
3. Longitudinal studies tracking IPC system performance over extended time periods would assess whether intensive surveillance, closed-loop management, and high-frequency testing can be sustained beyond short-term emergency responses.
4. Multi-stakeholder research incorporating perspectives from frontline healthcare workers, administrators, policymakers, and patients would provide comprehensive understanding of implementation challenges, acceptability, and unintended consequences.
5. Development and validation of simulation models predicting IPC effectiveness under varying epidemic scenarios and resource conditions would support evidence-based preparedness planning and resource allocation decisions.

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