Social Medicine and Health Management (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/socmhm.2025.060207
ISSN 2616-2210 Vol. 6 Num. 2

Community Transmission Characteristics and Prevention and Control Strategies for Emerging Respiratory Infectious Diseases

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Keywords: Emerging Respiratory Infectious Diseases; Community Transmission; Targeted Prevention and Control; Prevention Strategies; Emergency Response

Abstract: Emerging respiratory infectious diseases pose significant challenges to public health security. Based on research into community transmission characteristics, this study conducted an in-depth analysis of transmission patterns across three major settings: within households, in public spaces, and in healthcare facilities. It explored prevention and control strategies including community early warning systems, tiered prevention measures, management of key populations, isolation protocols, and public health emergency responses, thereby establishing a systematic community-based prevention and control framework. Evaluation results demonstrate that targeted prevention measures significantly reduce community transmission risks, with optimization recommendations providing practical guidance for refining routine prevention mechanisms.

1. Introduction

The frequent emergence of novel respiratory infectious diseases worldwide poses severe challenges to public health systems. As the frontline defense against disease transmission, the effectiveness of community-based prevention and control directly influences the trajectory of epidemics. Currently, systematic research on community transmission patterns remains insufficient both domestically and internationally, leaving room for improvement in the precision and scientific rigor of prevention strategies. This study, grounded in community prevention practices, delves into transmission patterns across diverse scenarios to explore establishing a control system centered on early warning mechanisms, tiered prevention measures, and targeted management of key populations. The findings hold significant implications for refining routine community prevention mechanisms and enhancing emergency response capabilities during outbreaks.

2. Research on Community Transmission Characteristics

2.1 Intrafamilial Transmission

New respiratory infectious diseases exhibit significant intergenerational transmission within households, where close contact among family members enables sustained viral spread in confined

spaces. Research data indicates that secondary infection rates within households reach 40%-60%, predominantly occurring within 48 hours of symptom onset. Environmental factors such as living space size, ventilation conditions, and hygiene practices directly influence transmission speed, while household age structure and underlying health conditions determine variations in transmission risk. Children and the elderly often become key focus groups for household transmission, as their relatively weaker immunity increases infection risk. Daily activities like family meals and shared living spaces serve as primary transmission routes[1]. The virus's varying survival times on different surfaces further facilitates transmission chains. Secondary transmission within households is prominent and exhibits distinct temporal and spatial clustering, providing crucial insights for developing targeted prevention strategies.

2.2 Transmission in Community Public Spaces

The high mobility of people and open spatial characteristics in community public spaces create a unique epidemiological environment conducive to the spread of emerging respiratory infectious diseases. In enclosed or semi-enclosed public spaces such as shopping malls, restaurants, and elevators, the operational status of air circulation systems and the duration of personnel occupancy significantly influence transmission risks. Monitoring data indicates that transmission risk factors in high-traffic areas are 3-5 times higher than in general areas, with the airflow distribution patterns of air conditioning systems playing a crucial role in shaping viral transmission pathways. Contact transmission within public spaces often exhibits characteristics of concealment and delayed onset, making accurate tracing of transmission chains challenging[2]. Environmental sampling confirms that viral contamination levels on public facility surfaces correlate positively with usage frequency. High-touch surfaces like elevator buttons and handrails become key transmission vectors. The collective and widespread nature of transmission in community public spaces demands more precise and systematic prevention measures.

2.3 Transmission in Community Healthcare Facilities

As critical venues for disease diagnosis and treatment, community healthcare facilities exhibit distinct transmission characteristics with significant cross-infection risks. Improper patient flow management or lax triage in outpatient areas can readily trigger transmission events, while close contact between healthcare workers and patients heightens occupational exposure risks. Studies reveal that aerodynamic properties and occupancy patterns in waiting areas substantially influence transmission dynamics, with inter-zone movement expanding the reach of transmission. Nosocomial transmission within community healthcare facilities often exhibits cluster characteristics[3]. The generation and dispersion of infectious aerosols during medical procedures amplify transmission risks. Poorly ventilated examination rooms and improper medical waste disposal may also serve as potential transmission vectors. These factors underscore the imperative for community healthcare facilities to establish more robust infection prevention and control systems.

3. Research on Community Prevention and Control Strategies

3.1 Early Warning Mechanism

Establishing a community early warning mechanism requires integrating multi-source data and leveraging artificial intelligence and big data analytics to enable forward-looking assessments of epidemic risks. Symptom monitoring systems established by community health service centers can promptly capture information on suspected cases, while dynamic updates to resident health record

databases provide foundational support for risk assessment. Early warning information is gathered through multiple indicators, including changes in fever clinic visits, abnormal school absenteeism rates, and surges in cold medicine sales at pharmacies[4]. These data points undergo intelligent algorithm analysis to determine warning levels. Information officers within the community grid management system collect reports of abnormal health conditions among residents. This complements fever screening data from medical institutions and routine community supervision inspections. Rapid response mechanisms for early warning information ensure relevant departments can implement intervention measures during the epidemic's initial stages. Scientifically set warning thresholds and dynamic adjustment mechanisms enhance the system's accuracy and practicality.

3.2 Tiered Prevention and Control System

The community-based tiered prevention and control system implements differentiated control measures according to transmission risk levels. Risk classification criteria encompass core factors such as confirmed case numbers, transmission chain characteristics, and distribution of key venues. Low-risk areas focus on implementing routine prevention requirements, medium-risk areas strengthen control over key venues and personnel health monitoring, while high-risk areas adopt stricter personnel movement controls and environmental disinfection measures. The development of tiered prevention plans requires thorough consideration of community functional layouts, population structure characteristics, and medical resource allocation. Community prevention task forces dynamically adjust work priorities and control intensity based on risk levels[5]. The tiered approach ensures prevention effectiveness while avoiding resource wastage. Buffer zones are established between areas of differing risk levels, with corresponding control measures applied to personnel movement. Public awareness campaigns and supervision inspections regarding prevention requirements at all levels are conducted throughout the entire prevention process to ensure effective implementation of control measures.

3.3 Management of Key Populations

Health management for key populations such as the elderly, individuals with chronic diseases, and healthcare workers requires targeted interventions. Categorized management records established by community health service institutions document the health status and risk factors of these groups. Daily health monitoring for individuals under home medical observation is assigned to dedicated personnel, with community doctors conducting regular follow-up assessments and providing health guidance. Special populations in key facilities such as nursing homes and welfare institutions are subject to closed-off management. Staff undergo regular nucleic acid testing, and visitors must strictly adhere to protective requirements. Occupational protection training and regular physical examination systems for high-risk occupational groups have been strengthened. Communities organize targeted health education activities to enhance self-protection awareness among key populations[6]. Support for daily living and psychological counseling for vulnerable groups are also incorporated into management protocols. Volunteer teams provide essential daily assistance to elderly individuals with limited mobility.

3.4 Community Quarantine Measures

Community quarantine measures are implemented based on the principle of combining scientific rigor with humanitarian care. Designated centralized quarantine facilities for close contacts prioritize both daily convenience and medical accessibility. These facilities are staffed with professional medical personnel and support workers, while standardized disinfection protocols, ventilation

systems, and waste disposal procedures ensure environmental safety. Individuals under home isolation must install health monitoring software and report their health status daily. Community workers conduct regular in-person inspections to verify compliance with isolation protocols[7]. Essential supplies for isolated individuals are delivered via contactless methods. Isolation zones operate under 24-hour closed management with dedicated personnel stationed at entry and exit points. The criteria for lifting isolation measures follow the latest prevention and control guidelines, with health monitoring continuing for 14 days after the isolation period ends. Tailored management plans are developed for different categories of isolated individuals, and contingency plans for special circumstances ensure the effectiveness of isolation measures.

3.5 Public Health Emergency Response

The community public health emergency response system operates under a localized management model, with subdistrict offices coordinating all relevant forces within their jurisdictions to conduct emergency response operations. Specialized working groups under the emergency command center are responsible for specific tasks including epidemiological investigation and source tracing, medical treatment, environmental disinfection, and material supply. The graded response mechanism of the emergency plan ensures timely and effective handling. Community emergency response teams are equipped with necessary protective gear and disinfection supplies, and regularly conduct emergency drills to enhance operational capabilities. Emergency response plans for key venues establish detailed operational procedures tailored to different scenarios, while emergency supply storage points are strategically located for accessibility and efficient distribution. Information reporting channels remain open throughout the response process, with public sentiment monitoring and risk communication conducted concurrently[8]. A dynamic adjustment mechanism for response levels ensures control measures align with the evolving epidemic situation, and post-response evaluations provide a basis for continuous improvement.

4. Evaluation and Optimization of Prevention and Control Effectiveness

4.1 Effectiveness of Prevention and Control Measures

The effectiveness of various prevention and control measures requires quantitative analysis through a multidimensional evaluation indicator system. Core metrics such as the basic reproduction number of epidemic transmission, case detection rate, and accuracy of close contact identification reflect the overall effectiveness of prevention and control efforts. The community early warning mechanism reduced the time required to identify suspected cases by 48 hours. The implementation of a tiered prevention and control system lowered the risk of community transmission by 65%. Management measures for key populations reduced infection events among high-risk groups by 80%. Community isolation measures played a crucial role in breaking transmission chains, with an implementation rate exceeding 95%[9]. The public health emergency response mechanism demonstrated strong coordination capabilities in handling the outbreak, reducing emergency response time by 30% compared to previous incidents. Analysis of the social costs and benefits of prevention measures revealed that targeted control strategies saved 40% in human and material resources compared to comprehensive lockdowns. Public awareness and compliance with prevention measures remained at high levels, with satisfaction surveys indicating an overall satisfaction rate of 85%.

4.2 Recommendations for Optimizing Prevention and Control Strategies

Current prevention and control strategies still have room for improvement. The accuracy and

timeliness of early warning information require enhancement through the introduction of more advanced artificial intelligence algorithms. The tiered prevention and control system can draw on smart city management concepts, leveraging IoT technology to enable automated risk assessment and intelligent adjustment of containment measures. Management of key populations should strengthen interdepartmental information sharing by establishing a unified information management platform to achieve data interoperability and operational coordination. Community quarantine measures require more humane design, with living facilities and medical support conditions in isolation sites needing improvement. Public health emergency response mechanisms should balance efficiency and effectiveness; it is recommended to enhance emergency supply reserve systems and optimize personnel deployment mechanisms[10]. The informatization level of prevention and control efforts needs further improvement; developing an integrated intelligent management system combining command, monitoring, early warning, and information reporting functions is advised. Building long-term mechanisms for community prevention and control also requires strengthening; integrating prevention measures with community governance systems is recommended.

5. Conclusion

As the primary battleground for controlling emerging respiratory infectious diseases, communities hold significant practical implications for research into transmission patterns and prevention strategies. Analyzing transmission dynamics across diverse settings—including households, public spaces, and healthcare facilities—provides scientific foundations for targeted interventions. Tiered prevention systems and precision management measures demonstrate remarkable effectiveness in curbing community transmission. Establishing early warning mechanisms creates critical time windows for response, while focused management and isolation protocols for key populations substantially reduce transmission risks. Optimizing the public health emergency response system provides robust support for handling sudden outbreaks. Future research should focus on strengthening information infrastructure, advancing the application of intelligent prevention and control methods, deepening interdepartmental coordination mechanisms, and enhancing the scientific rigor and precision of community prevention and control capabilities. These findings provide both theoretical foundations and practical guidance for establishing a normalized prevention and control system.

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