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Human Metapneumovirus (HMPV): A Comprehensive Review of its Impact on Pediatric and General Populations

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Abstract

Human metapneumovirus (HMPV) is a leading cause of respiratory tract infections worldwide, particularly affecting pediatric, elderly, and immunocompromised populations. Since its discovery in 2001, HMPV has been recognized as a significant pathogen with clinical manifestations ranging from mild upper respiratory symptoms to severe bronchiolitis and pneumonia. Recently, surges in HMPV cases in China and Malaysia have highlighted its potential for widespread outbreaks. This review explores the virology, epidemiology, clinical features, diagnostic approaches, treatment, and prevention strategies for HMPV, with a special focus on its recent outbreaks and implications for global health. Evidence-based insights from recent studies provide a comprehensive understanding of this virus, emphasizing the need for enhanced surveillance, diagnostic capabilities, and vaccination efforts.

Keywords: Human Metapneumovirus (HMPV); Pediatric Infections; Respiratory Tract Infections; Bronchiolitis; Epidemiology; Antiviral Therapy; Vaccination; Public Health.

Introduction

Human metapneumovirus (HMPV), a member of the Paramyxoviridae family, is a major viral pathogen responsible for respiratory illnesses. Discovered in 2001 in the Netherlands, HMPV is closely related to respiratory syncytial virus (RSV) and primarily affects children under five years, elderly individuals, and those with underlying health conditions. Its clinical spectrum, epidemiological patterns, and seasonal variations have drawn increasing attention due to severe outbreaks, most notably the recent surges in China and Malaysia following the COVID-19 pandemic.

This review aims to provide an evidence-based analysis of HMPV, addressing its virology, clinical burden, diagnostic challenges, therapeutic strategies, and public health implications.

Virology and Pathogenesis

HMPV is an enveloped, non-segmented, negative-sense RNA virus with two primary subgroups: A and B. These subgroups are further divided into four genetic lineages: A1, A2, B1, and B2. Key structural proteins include:

- **Fusion protein (F)**: Facilitates viral entry and syncytium formation.
- **Attachment protein (G)**: Mediates host cell receptor binding.
- **Matrix protein (M)**: Plays a role in viral assembly.

The virus targets the respiratory epithelium, triggering inflammation and cytokine release. Severe cases

often involve bronchiolitis or pneumonia, with histopathological findings showing epithelial damage, mucus plugging, and immune cell infiltration.

Epidemiology

HMPV circulates globally, with seasonal peaks in late winter and early spring. Studies estimate that nearly 100% of children are seropositive for HMPV by age five, highlighting its ubiquitous nature. The burden of disease is highest among:

- **Pediatric Populations**: Infants and toddlers under two years are particularly vulnerable to severe disease.
- **Elderly Individuals**: Increased risk due to immunosenescence.
- **Immunocompromised Patients**: Including those with cancer, transplant recipients, and individuals with chronic lung or heart conditions.

Recent Outbreaks

The recent HMPV outbreak in China has spread to neighboring Malaysia, where a surge in cases has prompted government-issued health advisories. These outbreaks underscore the virus's potential for rapid transmission and highlight the importance of regional collaboration in addressing public health crises.

Clinical Manifestations

HMPV infections range from asymptomatic to life-threatening, with the severity influenced by age, comorbidities, and immune status. Common clinical features include:

- **Mild Symptoms**:
  - Rhinorrhea
  - Cough
  - Low-grade fever
- **Severe Illness**:
  - Bronchiolitis
  - Pneumonia
  - Acute respiratory distress syndrome (ARDS)

In children, HMPV is a leading cause of bronchiolitis, second only to RSV. In the elderly, it often exacerbates chronic obstructive pulmonary disease (COPD) and heart failure. Coinfections with other respiratory pathogens, including RSV and influenza, are common and contribute to increased morbidity.

Diagnostic Approaches

Accurate diagnosis of HMPV is critical but remains challenging due to overlapping clinical features with other respiratory viruses. Diagnostic modalities include:

1. **Molecular Methods**:
   - Reverse transcription-polymerase chain reaction (RT-PCR): Gold standard for detecting HMPV RNA.
   - Multiplex PCR panels: Enable simultaneous detection of multiple pathogens.
2. **Serological Testing**:
   - Detects HMPV-specific IgM and IgG antibodies.
3. **Antigen Detection**:
   - Rapid tests targeting the F protein are under development but have lower sensitivity compared to PCR.
4. **Imaging**:

- Chest X-rays and computed tomography (CT) scans may show hyperinflation or consolidation in severe cases.

Treatment Strategies

There is no specific antiviral therapy approved for HMPV. Management is primarily supportive, focusing on symptom relief and prevention of complications:

- **Oxygen Therapy**: For hypoxemic patients.
- **Bronchodilators**: Limited evidence supports their use in wheezing patients.
- **Corticosteroids**: May be considered in severe cases with significant airway inflammation.
- **Ribavirin**: Used off-label in immunocompromised patients with severe disease.

Clinical trials evaluating monoclonal antibodies targeting the F protein are underway and may provide future therapeutic options.

Prevention

Preventive measures for HMPV are critical, particularly in high-risk populations. Current strategies include:

1. **Infection Control**:
   - Hand hygiene
   - Mask usage
   - Isolation of infected individuals
2. **Vaccination**:
   - Experimental vaccines targeting the F protein are in early phases of development. These include subunit, vector-based, and live-attenuated vaccines.
3. **Immunoprophylaxis**:
   - Monoclonal antibodies, similar to those used for RSV, are being studied for HMPV.

Recent Outbreaks in China and Malaysia

China

The HMPV outbreak in China resulted in a significant increase in hospitalization rates, particularly among children and elderly patients. Overwhelmed healthcare facilities highlighted gaps in diagnostic and treatment capabilities, emphasizing the urgent need for enhanced surveillance and resource allocation.

Malaysia

Following the outbreak in China, Malaysia experienced a surge in HMPV cases. The government issued advisories to the public, urging preventive measures such as mask usage and early testing. Collaborative efforts between healthcare institutions in Malaysia and international organizations aim to curb the spread of the virus.

Global Implications

The resurgence of HMPV in China and Malaysia serves as a warning for other nations. Key priorities include:

1. **Enhanced Surveillance**:
   - Integration of HMPV into routine respiratory virus monitoring programs.
2. **Public Health Campaigns**:

- Awareness initiatives on respiratory hygiene and early symptom recognition.

3. **Research Investments**:
   - Accelerating vaccine and therapeutic development through international collaborations.

Conclusion

HMPV is an underestimated pathogen with significant implications for pediatric and general populations. Its ability to cause severe respiratory illnesses, particularly in vulnerable groups, necessitates heightened awareness and robust public health measures. The recent outbreaks in China and Malaysia underscore the importance of regional and global collaboration in surveillance, diagnostic capabilities, and preventive strategies. Continued research into vaccines and antiviral therapies will be pivotal in mitigating the impact of HMPV globally.

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