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Review Article

Exploring Pathogenesis, Clinical Manifestations, and Management of Human Metapneumovirus Infection

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ABSTRACT

Human Metapneumovirus (HMPV), identified in 2001, is an emerging respiratory virus. Within the Pneumoviridae family, genus Metapneumovirus. This RNA virus is now recognised as a substantial cause of both upper along lower Respiratory Tract Infections (RTIs), affecting individuals belonging to all ages. While this virus may impact healthy adults, the most vulnerable populations include young children, infants, elderly adults, as well as immunocompromised individuals. Pathophysiology of HMPV involves its entry into respiratory epithelial cells, facilitated by viral Fusion (F), attachment (G) proteins. After entering the host cell, HMPV replicates in the cytoplasm, leading to the production of new virions that further propagate the infection. Both innate along adaptive components are essential to the complicated immune response to HMPV. Innate immunity, including pattern recognition receptors and natural killer cells, provides the first line of defence, while the adaptive immune response, consisting of T cells, antibodies, and B cells, is responsible for clearing the virus and offering long-term immunity. However, in severe cases, immune responses may contribute to lung injury, airway remodelling, and fibrosis, especially in individuals with pre-existing conditions or those experiencing prolonged infections. Clinically, HMPV infection varies from mild symptoms like cough, fever, as well as sore throat to more severe manifestations, for example, pneumonia, bronchiolitis, and respiratory failure. Supportive care, which includes hydration, is the main emphasis of management and rest, though antiviral treatments, for example, intravenous immunoglobulin, ribavirin, along with monoclonal antibodies, may be considered in severe cases.

Keywords: Fusion Protein (Human Metapneumovirus) HMPV, Immunoglobulins, RNA Interference, Respiratory syncytial virus, Ribavirin.

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INTRODUCTION

HMPV initially distinguished itself from other common respiratory viruses when it was discovered in respiratory secretions of twenty-eight young children in the Netherlands in the year 2001 by Bernadette G. van den Hoogen and associates (Kahn, 2003; Schuster and Williams, 2014). Since then, HMPV has emerged as a major contributor to the upper and lower RITs in people of all ages. Specifically, infants account for 5-7% of HMPV infections.

Transmission of HMPV occurs similarly to other common cold viruses, mainly through infectious respiratory particles spread through the air from an infected person to others. This can happen when someone is near a sick individual or shares a confined space with them. Additionally, the virus can enter the body through coming into touch with contaminated surfaces, like doorknobs, then by touching eyes, nose, or mouth (Schildgen *et al*., 2011). HMPV is an RNA virus, closely connected to avian pneumovirus, and is classified within the family Pneumoviridae and genus Metapneumovirus. A negative-stranded, enveloped, non-segmented virus is this (Amarasinghe *et al*., 2018; Pan *et al*., 2020).

Its almost 13 kb genome has eight genes that code for 9 distinct proteins, that is, Matrix protein (M), Fusion protein (F), Large polymerase protein (L), Phosphoprotein (P), Glycoprotein (G), Nucleoprotein (N), Small Hydrophobic (SH) protein, along with matrix-2 proteins (M2-1 and M2-2) (Ye *et al*., 2023; Pan *et al*., 2020). HMPV strains are categorised into 4 genotypes (A1, A2, B1, and B2) and 6 lineages (A1, A2a, A2b, A2c, B1, and B2) as per the genetic characteristics of F and G genes (Decool *et al*., 2021; Yi *et al*., 2019). ARTIs (Acute respiratory tract infections), for example, those resulting from HMPV, are responsible for significant morbidity and mortality worldwide (Pan *et al*., 2020).

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METHODOLOGY

A comprehensive literature search was conducted to identify relevant studies on Human Metapneumovirus (HMPV). Databases including PubMed, Web of Science and Google Scholar were searched for articles. Search terms used alone or in combination included Human metapneumovirus, HMPV, Respiratory tract infections, pathogenesis, epidemiology, diagnosis, treatment and vaccine development.

Inclusion and Exclusion criteria

Studies were included if they:

- Addressed epidemiology, pathogenesis, immune response, clinical features, and diagnosis, management, or prevention of HMPV.
- Included original research articles, systematic reviews, narrative reviews and clinical studies.
- Were published in English.

Studies were excluded if they:

- Were conference abstracts, editorials, or letters without primary data.
- Study Selection and Data Extraction.

Titles and abstracts of retrieved articles were screened for relevance. Full-text articles were reviewed when necessary. Key information was extracted, including study design, population characteristics, virological findings, clinical manifestations, diagnostic methods, treatment approaches, and outcomes. Data were qualitatively synthesised to provide an integrated overview of current knowledge.

Epidemiology

HMPV spreads globally, especially causing infections during the winter. According to various studies, the peak incidence of HMPV infections takes place in the winter season, with increased frequency of hospitalisations during these periods (Hoogen *et al.*, 2001a, 2001b). HMPV affects both children and adults, but it is particularly common in young children under 5years old. Studies have documented that up to 15-20% of children with respiratory illnesses are infected with hMPV (Takeuchi and Lin, 2002). HMPV has worldwide incidence. It has been reported in several continents, including Asia, North America, Europe, along Australia. This virus is commonly detected in both developing as well as developed nations (Burrows *et al.*, 2002; Nissen *et al.*, 2002). In a few geographical regions, A considerable percentage of Lower Respiratory Tract Infections (LRTIs) in children admitted to hospitals are caused by HMPV (Jartti *et al.*, 2002). The most severe outcomes of HMPV infection occur in young children, elderly adults, and those with serious health issues, particularly immunocompromised individuals (Boivin *et al.*, 2003; Hamelin *et al.*, 2006; Wyde *et al.*, 2003).

Pathophysiology

HMPV is a negative-sense, single-stranded RNA virus that is closely connected with RSV and a member of the *Paramyxoviridae* family (Hoogen *et al.*, 2001b). In all age groups, but especially in infants, elderly individuals, along with immunocompromised patients, it is a leading cause of RTIs (Boivin *et al.*, 2007a). HMPV infection causes a spectrum of respiratory illnesses, varying from mild URTIs (upper respiratory tract infections) to severe LRTIs, including bronchiolitis and pneumonia (Kahn, 2003). The pathophysiology of HMPV infection involves viral replication in the respiratory epithelium, immune system activation, and inflammation, leading to airway obstruction and lung injury.

Viral Entry and Replication

The respiratory tract's epithelial cells are primarily infected by HMPV. The entry is facilitated by two types of glycoproteins. F (Fusion) proteins facilitate the membrane of the virus to fuse with that of the host cell (Verma *et al.*, 2025). G (Attachment) proteins execute the role of viral attachment, but are not essential for infection (Cox *et al.*, 2012). The virus binds to heparan sulfate proteoglycans and uses host receptors such as integrins to enter the cell (Akhras *et al.*, 2010). Upon entry, HMPV proliferates in the cytoplasm with the help of RNA-dependent RNA polymerase (Cox *et al.*, 2012). This leads to the development of new virions that infect other neighbouring cells.

Response of immunity to HMPV infection

First-line immune defence means activation of innate immunity. TLRs (Toll-like receptors), predominantly TLR3 and TLR7, identify viral RNA as well as start the immune response (Del Valle-Mendoza *et al.*, 2019). RIG-I and MDA5 are sensors that identify RNA of viruses and activate Interferon Regulatory Factors (IRFs), then production of interferon I and III (Del Valle-Mendoza *et al.*, 2019). HMPV infection triggers the release of proinflammatory cytokines (IL-1β, TNF-α, IL-6) along with Chemokines (CCL5, CCL2), leading to immune cells to the infection site (Guerrero-Plata *et al.*, 2005). Natural Killer (NK) Cells play a role in recognizing infected cells and inducing apoptosis (Derdowski *et al.*, 2008).

Adaptive Immune Response

This response is crucial for long-term immunity, involving CD4+ T cells help in B-cell activation along with cytokine production (Biacchesi *et al.*, 2004). CD8+ T cells, utilising perforin and granzyme pathways it directly attacks the infected cells, contribute to viral clearance, but also lung inflammation (Williams *et al.*, 2004). Neutralising antibodies (IgG and IgA) help prevent reinfection but are often short-lived, leading to recurrence of infection (Piñana *et al.*, 2024).

Inflammatory Response and Lung Injury

HMPV infection generates an inflammatory response, which can contribute to the pathology of lung infection**.** Infiltration of macrophage and neutrophil cells leads to tissue damage and increased mucus production, contributing to the obstruction of airways (Piñana *et al.*, 2024). Reactive oxygen species, responsible for oxidative stress (Cheemarla and Guerrero-Plata, 2015). Viral replication leads to cell death, disrupting the epithelial barrier and predisposing the lungs to secondary bacterial infections (Brynes *et al.*, 2024). In chronic and severe cases, inflammation can lead to fibrosis, impairing lung function (Scott *et al.*, 2024).

The severity of HMPV infection varies and depends on several host factors, immune factors, age, as well as comorbid conditions, which include COPD (Chronic Obstructive Pulmonary Disease) or asthma. HMPV infection is also connected with exacerbations of asthma along with COPD, likely due to excessive immune activation and airway remodelling (Scott *et al.*, 2024).

Clinical Features

All age groups are susceptible to HMPV infections, although young children, the elderly, and those with immunocompromised conditions are most susceptible (Hoogen *et al.*, 2001a). Mild URTIs to serious LRTIs that include pneumonia along with bronchiolitis are among the clinical manifestations (Manoha *et al.*, 2007). Some common symptoms are fever, sore throat, and runny nose (Kneyber *et al.*, 1996; Sarasini *et al.*, 2006). In chronic patients, infection may lead to breathlessness, respiratory distress (Williams *et al.*, 2004). Other symptoms include fatigue, aches and diarrhoea (Kotaniemi-Syrjänen *et al.*, 2003). Severe cases require early hospitalisation.

Diagnosis

RT-PCR (Reverse transcription polymerase chain reaction) is a Gold standard test that detects HMPV RNA with high sensitivity and specificity rapidly and is widely used in clinical settings. Viral Culture involves isolating hMPV in LLC-MK2 or Vero cells, but it is slow and less sensitive (Boivin *et al.*, 2007b). Serology (ELISA - Enzyme-Linked Immunosorbent Assay) detects IgM or IgG antibodies against hMPV, useful for epidemiological studies (Boivin *et al.*, 2007b; Ebihara *et al.*, 2003).

Management

Goals of Management

The management goals for Human Metapneumovirus (HMPV) infections focus on symptom relief, supportive care, and preventing complications (Boivin *et al.*, 2007b). Treatment includes antipyretics, hydration, and humidified air to ease symptoms (Nair *et al.*, 2013). Oxygen therapy, along with mechanical ventilation, might be needed in severe cases. Preventing complications like bacterial superinfection and respiratory distress is crucial, especially in high-risk groups. Infection control measures, for example, hand hygiene, isolation, help reduce transmission (Nascimento-Carvalho, 2020).

Non-pharmacologic Management

Ensuring adequate fluid intake is essential to prevent dehydration and help loosen mucus, which can improve breathing and promote recovery (Chiotos *et al.*, 2020). Adequate sleep and rest are necessary for immune function. During illness, more energy is required by the body to fight against infection, and rest helps in immune recovery (Xia *et al.*, 2020). Using a humidifier or cool mist vaporiser can help soothe irritated airways and relieve nasal congestion and cough. Moist air helps keep the respiratory tract moist and may reduce coughing (Byber *et al.*, 2021). Elevating the head while sleeping can help reduce the discomfort of nasal congestion and coughing. For patients with breathing difficulties, elevating the head of the bed may facilitate easier breathing and improve sleep quality (Bhandari *et al.*, 2022). Patients with viral infection should avoid exposure to smoke, dust, and other environmental irritants that may lead to exacerbation of symptoms (Laghari *et al.*, 2023). Saline drops can help alleviate nasal congestion and clear mucus from the nasal passages, improving airflow and comfort during HMPV infections (Wang *et al.*, 2009).

Pharmacologic Treatment for HMPV

Ribavirin

A nucleoside is a Ribavirin analogue that inhibits the synthesis of viral RNA (Kitanovski *et al.*, 2013; Wyde *et al.*, 2003). It has been used to treat viral infections, for example, HMPV, along with RSV, by interfering with the replication of these viruses (Gross and Bryson, 2015). Inhaled Ribavirin is given for severe respiratory infections in hospital settings (Avery *et al.*, 2020).

Intravenous Immunoglobulin (IVIG)

IVIG is a preparation of pooled human plasma that contains a broad spectrum of antibodies, which may help neutralise viral infections (Brunetti *et al.*, 2009). It is particularly useful in immunocompromised patients, especially beneficial in the pediatric population or those unable to mount an adequate immune response (Scheuerman *et al.*, 2016).

Monoclonal Antibodies

It has been demonstrated that monoclonal antibodies that target the HMPV fusion protein efficiently neutralise the virus and prevent it from entering host cells (Williams *et al.*, 2007).

Prophylactic (Preventive): May be considered for high-risk populations, such as those suffering from underlying respiratory conditions or weakened immune systems, to prevent infection. Research has identified monoclonal antibodies that neutralise HMPV and other paramyxoviruses (Shafagati and Williams, 2018; Williams *et al.*, 2007).

Fusion Inhibitors

Fusion inhibitors block the viral fusion protein, preventing the virus from merging with host cell membrane and entering the cell (Contreras *et al.*, 2021). Used to block viral replication as well as prevent the virus from spreading within the respiratory system. A highly effective fusion inhibitor has been identified in research studies, showing strong antiviral effects against HMPV (Deffrasnes *et al.*, 2008).

RNA Interference

DsiRNA (Dicer-substrate siRNA) or siRNA (Small interfering RNA) target the viral mRNA and inhibits the translation of proteins, such as the nucleocapsid protein, thus preventing viral replication (Darniot *et al.*, 2012). Currently, siRNA is being investigated in clinical and preclinical studies for its potential to treat hMPV by blocking key stages of the viral life cycle (Nitschinsk *et al.*, 2018; Preston *et al.*, 2012).

New small molecule inhibitors targeting the fusion mechanism and replication are preclinical investigation. This molecule blocks the viral membrane fusion and RNA synthesis.

Subunit Vaccine

Several subunit vaccines are designed for HMPV viral infection. To modulate immunity and address safety concerns, some formulations are available, including purified protein fragments, virus-like particles, and lipid nanoparticles. IVX-A12is a bivalent subunit vaccine with HMPV and RSV preF-trimers formulated with two virus-like particles (Tariq *et al.*, 2022).

CONCLUSION

A substantial and underrecognized respiratory pathogen is HMPV that predominantly affects infants, the elderly, along immunocompromised individuals. With its seasonal variations and ability to cause both URTIs and LRTIs, which include pneumonia, bronchiolitis, along with exacerbation of asthma, HMPV contributes substantially to global respiratory disease burden. Despite its widespread prevalence, many aspects of its pathogenesis, immune response, and long-term health consequences remain incompletely understood, necessitating further research to develop effective therapeutic and preventive strategies. The virus's ability to infect the respiratory epithelium and provoke a strong immune response leads to inflammation, airway obstruction, and, in severe cases, long-term pulmonary complications, particularly in high-risk populations. Given its ability to cause a spectrum of disease severity, timely diagnosis and appropriate clinical management are critical in reducing morbidity and mortality.

Currently, supportive care provides the fundamental aspect of treatment, with oxygen therapy, hydration, and respiratory support playing vital roles in managing severe cases. Although antiviral agents such as ribavirin, monoclonal antibodies, and fusion inhibitors, subunit vaccines, show promise, their clinical efficacy and widespread availability remain limited. The absence of a targeted antiviral therapy or approved vaccine underscores the urgent need for further advancements in HMPV research. Understanding the molecular mechanisms governing viral entry, replication, immune evasion, and host-pathogen interactions is essential for developing novel therapeutic approaches and vaccines.

FUTURE DIRECTIONS

Research should be centralised on the molecular structure and mechanism of HMPV entry, replication mechanism, immune evasion, and host immune response activations to facilitate the development of targeted antiviral therapies. Vaccine development remains a critical priority, with various strategies being explored, including live-attenuated, protein-based, and vector-based vaccines. These approaches aim to elicit a robust and durable immune response, particularly in high-risk populations. However, challenges such as ensuring vaccine safety, optimising immunogenicity, and addressing potential cross-protection with related respiratory viruses must be carefully considered. Given the increasing incidence of HMPV infections and their contribution to respiratory-related hospitalisations, continued epidemiological surveillance is essential to track viral evolution, transmission dynamics, and emerging variants.

As the global impact of HMPV continues to grow, a comprehensive approach involving improved diagnostic tools, effective antiviral treatments, as well as the safe and efficacious vaccine development will be crucial in mitigating its health burden. Further interdisciplinary collaboration among researchers, clinicians, along public health experts will be essential in advancing our understanding of HMPV pathogenesis and enhancing prevention, along with treatment strategies. In conclusion, although considerable advancements have been achieved in acknowledging the clinical significance of HMPV, ongoing research endeavours are essential for creating focused therapies that will ultimately diminish the morbidity and death associated with this crucial respiratory infection.

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ABBREVIATIONS

HMPV: Human Metapneumovirus; **RTI:** Respiratory tract infections; **URTI:** Upper respiratory tract infections; **LRTI:** Lower respiratory tract infections; **ARTI:** Acute respiratory tract infections; **RSV:** Respiratory syncytial virus; **RNA:** Ribonucleic acid; **F Protein:** Fusion protein; **G Protein:** Attachment

glycoprotein; **M Protein:** Matrix protein; **L Protein:** Large polymerase protein; **P Protein:** Phosphoprotein; **N Protein:** Nucleoprotein; **SH Protein:** Small hydrophobic protein; **M2-1/M2-2:** Matrix 2 proteins; **TLRs:** Toll-like receptors; **RIG-I:** Retinoic acid-inducible gene I; **MDA5:** Melanoma differentiation-associated protein 5; **IRF:** Interferon regulatory factor; **NK cells:** Natural killer cells; **IL:** Interleukin; **TNF-α:** Tumor Necrosis Factor Alpha; **CCL:** C-C motif chemokine ligand; **IgG:** Immunoglobulin G; **IgA:** Immunoglobulin A; **IVIG:** Intravenous immunoglobulin; **RT-PCR:** Reverse transcription polymerase chain reaction; **ELISA:** Enzyme-linked immunosorbent assay; **COPD:** Chronic obstructive pulmonary disease; **siRNA:** Small interfering RNA; **DsiRNA:** Dicer-substrate small interfering RNA; **ROS:** Reactive oxygen species.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS CONTRIBUTIONS

Dr Gaurao S. Damre: Conceptualise the review and data strategy. **Ms Snehal Sathe:** Conducted literature review, Drafting of Manuscript. **Ms Dhanashree Shinde:** Drafting of Manuscript. Ms **Pooja R Patil:** Critical review of manuscript.

SUMMARY

Human metapneumovirus is an infection that causes respiratory tract infections globally, contributing to morbidity across all age groups, specifically among infants and in immunocompromised populations. This review focuses on current evidence on the virological characteristics, epidemiology, transmission, pathophysiologic pathways, and immune response pathways, clinical spectrum of HMPV infection. Although much is known about HMPV biology, its clinical management is still mainly supportive because no approved antiviral treatment or vaccine is available. Emerging therapeutic approaches, including monoclonal antibodies, fusion inhibitors. RNA-based strategies and subunit vaccine platforms- demonstrate promise but require further clinical validation. Continued research focused on molecular mechanism, improved diagnostics, targeted therapeutics

REFERENCES

Akhras, N., Weinberg, J. B., and Newton, D. (2010). Human Metapneumovirus and Respiratory Syncytial Virus: Subtle Differences but Comparable Severity. Infectious Disease Reports, 2(2), e12. https://doi.org/10.4081/idr.2010.e12

Amarasinghe, G. K., Aréchiga Ceballos, N. G., Banyard, A. C., Basler, C. F., Bavari, S., Bennett, A. J., Blasdell, K. R., Briese, T., Bukreyev, A., Caì, Y., Calisher, C. H., Campos Lawson, C., Chandran, K., Chapman, C. A., Chiu, C. Y., Choi, K.-S., Collins, P. L., Dietzgen, R. G., Dolja, V. V., … Kuhn, J. H. (2018). Taxonomy of the order Mononegavirales: Update 2018. Archives of Virology, 163(8), 2283-2294. https://doi.org/10.1007/s00705-018-3814-x

Avery, L., Hoffmann, C., and Whalen, K. M. (2020). The Use of Aerosolised Ribavirin in Respiratory Syncytial Virus Lower Respiratory Tract Infections in Adult Immunocompromised Patients: A Systematic Review. Hospital Pharmacy, 55(4), 224-235. https://doi.org/10.1177/0018578719836646

Bhandari, A. P., Nnate, D. A., Vasanthan, L., Konstantinidis, M., and Thompson, J. (2022). Positioning for acute respiratory distress in hospitalised infants and children. Cochrane Database of Systematic Reviews, 2022(6). https://doi.org/10.1002/14651858.CD003645.pub4

Biacchesi, S., Skiadopoulos, M. H., Yang, L., Lamirande, E. W., Tran, K. C., Murphy, B. R., Collins, P. L., and Buchholz, U. J. (2004). Recombinant Human Metapneumovirus Lacking the Small Hydrophobic SH and/or Attachment G Glycoprotein: Deletion of G Yields a Promising Vaccine Candidate. Journal of Virology, 78(23), 12877-12887. https://doi.org/10.1128/JVI.78.23.12877-12887.2004

Boivin, G., De Serres, G., Côté, S., Gilca, R., Abed, Y., Rochette, L., Bergeron, M. G., and Déry, P. (2003). Human Metapneumovirus Infections in Hospitalized Children1. Emerging Infectious Diseases, 9(6), 634-640. https://doi.org/10.3201/eid0906.030017

Boivin, G., Serres, G. D., Hamelin, M.-E., Cote, S., Argouin, M., Tremblay, G., Maranda-Aubut, R., Sauvageau, C., Ouakki, M., Boulianne, N., and Couture, C. (2007a). An Outbreak of Severe Respiratory Tract Infection Due to Human Metapneumovirus in a Long-Term Care Facility. Clinical Infectious Diseases, 44(9), 1152-1158. https://doi.org/10.1086/513204

Boivin, G., Serres, G. D., Hamelin, M.-E., Cote, S., Argouin, M., Tremblay, G., Maranda-Aubut, R., Sauvageau, C., Ouakki, M., Boulianne, N., and Couture, C. (2007b). An Outbreak of Severe Respiratory Tract Infection Due to Human Metapneumovirus in a Long-Term Care Facility. Clinical Infectious Diseases, 44(9), 1152-1158. https://doi.org/10.1086/513204

Brunetti, L., Di Noto, R., Abate, G., Gorrese, M., Gravetti, A., Raia, M., Scalia, G., Pascariello, C., Camera, A., and Del Vecchio, L. (2009). CD200/OX2, a cell surface molecule with immuno-regulatory function, is consistently expressed on hairy cell leukaemia neoplastic cells. British Journal of Haematology, 145(5), 665-667. https://doi.org/10.1111/j.1365-2141.2009.07644.x

Brynes, A., Zhang, Y., and Williams, J. V. (2024). Human metapneumovirus SH protein promotes JAK1 degradation to impair host IL-6 signaling. Journal of Virology, 98(11), e01104-24. https://doi.org/10.1128/jvi.01104-24

Burrows, A., Burgasser, A. J., Kirkpatrick, J. D., Liebert, J., Milsom, J. A., Sudarsky, D., and Hubeny, I. (2002). Theoretical Spectral Models of T Dwarfs at Short Wavelengths and Their Comparison with Data. The Astrophysical Journal, 573(1), 394-417. https://doi.org/10.1086/340584

Byber, K., Radtke, T., Norbäck, D., Hitzke, C., Imo, D., Schwenkglenks, M., Puhan, M. A., Dressel, H., and Mutsch, M. (2021). Humidification of indoor air for preventing or reducing dryness symptoms or upper respiratory infections in educational settings and at the workplace. Cochrane Database of Systematic Reviews, 2021(12). https://doi.org/10.1002/14651858.CD012219.pub2

Cheemarla, N., and Guerrero-Plata, A. (2015). Immune Response to Human Metapneumovirus Infection: What We Have Learned from the Mouse Model. Pathogens, 4(3), 682-696. https://doi.org/10.3390/pathogens4030682

Chiotos, K., Hayes, M., Kimberlin, D. W., Jones, S. B., James, S. H., Pinninti, S. G., Yarbrough, A., Abzug, M. J., MacBrayne, C. E., Soma, V. L., Dulek, D. E., Vora, S. B., Waghmare, A., Wolf, J., Olivero, R., Grapentine, S., Wattier, R. L., Bio, L., Cross, S. J., … Nakamura, M. M. (2020). Multicenter Initial Guidance on Use of Antivirals for Children With Coronavirus Disease 2019/Severe Acute Respiratory Syndrome Coronavirus 2. Journal of the Pediatric Infectious Diseases Society, 9(6), 701-715. https://doi.org/10.1093/jpids/piaa045

Contreras, E. M., Monreal, I. A., Ruvalcaba, M., Ortega, V., and Aguilar, H. C. (2021). Antivirals targeting paramyxovirus membrane fusion. Current Opinion in Virology, 51, 34-47. https://doi.org/10.1016/j.coviro.2021.09.003

Cox, R. G., Livesay, S. B., Johnson, M., Ohi, M. D., and Williams, J. V. (2012). The Human Metapneumovirus Fusion Protein Mediates Entry via an Interaction with RGD-Binding Integrins. Journal of Virology, 86(22), 12148-12160. https://doi.org/10.1128/JVI.01133-12

Darniot, M., Schildgen, V., Schildgen, O., Sproat, B., Kleines, M., Ditt, V., Pitoiset, C., Pothier, P., and Manoha, C. (2012). RNA interference in vitro and in vivo using DsiRNA targeting the nucleocapsid N mRNA of human metapneumovirus. Antiviral Research, 93(3), 364-373. https://doi.org/10.1016/j.antiviral.2012.01.004

Decool, H., Gonnin, L., Gutsche, I., Sizun, C., Eléouët, J.-F., and Galloux, M. (2021). Interactions between the Nucleoprotein and the Phosphoprotein of Pneumoviruses: Structural Insight for Rational Design of Antivirals. Viruses, 13(12), 2449. https://doi.org/10.3390/v13122449

Deffrasnes, C., Hamelin, M.-È., Prince, G. A., and Boivin, G. (2008). Identification and Evaluation of a Highly Effective Fusion Inhibitor for Human Metapneumovirus. Antimicrobial Agents and Chemotherapy, 52(1), 279-287. https://doi.org/10.1128/AAC.00793-07

Del Valle-Mendoza, J., Orellana-Peralta, F., Del Valle, L. J., Verne, E., Ugarte, C., Weilg, C., Silva-Caso, W., Valverde-Ezeta, J., Carrillo-Ng, H., Peña-Tuesta, I., Palomares-Reyes, C., Cornejo-Tapia, A., and Aguilar-Luis, M. A. (2019). Detection of human Metapneumovirus infection in children under 18 years old hospitalized in Lima-Peru. PeerJ, 7, e7266. https://doi.org/10.7717/peerj.7266

Derdowski, A., Peters, T. R., Glover, N., Qian, R., Utley, T. J., Burnett, A., Williams, J. V., Spearman, P., and Crowe, J. E. (2008). Human metapneumovirus nucleoprotein and phosphoprotein interact and provide the minimal requirements for inclusion body formation. Journal of General Virology, 89(11), 2698-2708. https://doi.org/10.1099/vir.0.2008/004051-0

Ebihara, T., Endo, R., Kikuta, H., Ishiguro, N., Yoshioka, M., Ma, X., and Kobayashi, K. (2003). Seroprevalence of human metapneumovirus in Japan. Journal of Medical Virology, 70(2), 281-283. https://doi.org/10.1002/jmv.10391

Gross, A. E., and Bryson, M. L. (2015). Oral Ribavirin for the Treatment of Noninfluenza Respiratory Viral Infections: A Systematic Review. Annals of Pharmacotherapy, 49(10), 1125-1135. https://doi.org/10.1177/1060028015597449

Guerrero-Plata, A., Baron, S., Poast, J. S., Adegboyega, P. A., Casola, A., and Garofalo, R. P. (2005). Activity and Regulation of Alpha Interferon in Respiratory Syncytial Virus and Human Metapneumovirus Experimental Infections. Journal of Virology, 79(16), 10190-10199. https://doi.org/10.1128/JVI.79.16.10190-10199.2005

Hamelin, M.-È., Prince, G. A., and Boivin, G. (2006). Effect of Ribavirin and Glucocorticoid Treatment in a Mouse Model of Human Metapneumovirus Infection. Antimicrobial Agents and Chemotherapy, 50(2), 774-777. https://doi.org/10.1128/AAC.50.2.774-777.2006

Jartti, T., Van Den Hoogen, B., Garofalo, R. P., Osterhaus, A. D., and Ruuskanen, O. (2002). Metapneumovirus and acute wheezing in children. The Lancet, 360(9343), 1393-1394. https://doi.org/10.1016/S0140-6736(02)11391-2

Kahn, J. S. (2003). Human metapneumovirus: A newly emerging respiratory pathogen: Current Opinion in Infectious Diseases, 16(3), 255-258. https://doi.org/10.1097/00001432-200306000-00012

Khan Laghari, I., Nawaz, T., Mustafa, S., Jamali, A. A., and Fatima, S. (2023). Role of multi-strain probiotics in preventing severity and frequency of recurrent respiratory tract infections in children. BMC Pediatrics, 23(1), 505. https://doi.org/10.1186/s12887-023-04338-x

Kitanovski, L., Kopriva, S., Pokorn, M., Dolničar, M. B., Rajić, V., Stefanović, M., and Jazbec, J. (2013). Treatment of Severe Human Metapneumovirus (hMPV) Pneumonia in an Immunocompromised Child with Oral Ribavirin and IVIG. Journal of Pediatric Hematology/Oncology, 35(7), e311-e313. https://doi.org/10.1097/MPH.0b013e3182915d2d

Kneyber, M. C., Brandenburg, A. H., Rothbarth, P. H., De Groot, R., Ott, A., and Van Steensel-Moll, H. A. (1996). Relationship between clinical severity of respiratory syncytial virus infection and subtype. Archives of Disease in Childhood, 75(2), 137-140. https://doi.org/10.1136/adc.75.2.137

Kotaniemi-Syrjänen, A., Vainionpää, R., Reijonen, T. M., Waris, M., Korhonen, K., and Korppi, M. (2003). Rhinovirus-induced wheezing in infancy-The first sign of childhood asthma? Journal of Allergy and Clinical Immunology, 111(1), 66-71. https://doi.org/10.1067/mai.2003.33

Manoha, C., Espinosa, S., Aho, S.-L., Huet, F., and Pothier, P. (2007). Epidemiological and clinical features of hMPV, RSV and RVs infections in young children. Journal of Clinical Virology, 38(3), 221-226. https://doi.org/10.1016/j.jcv.2006.12.005

Nair, H., Simões, E. A., Rudan, I., Gessner, B. D., Azziz-Baumgartner, E., Zhang, J. S. F., Feikin, D. R., Mackenzie, G. A., Moïsi, J. C., Roca, A., Baggett, H. C., Zaman, S. M., Singleton, R. J., Lucero, M. G., Chandran, A., Gentile, A., Cohen, C., Krishnan, A., Bhutta, Z. A., … Campbell, H. (2013). Global and regional burden of hospital admissions for severe acute lower respiratory infections in young children in 2010: A systematic analysis. The Lancet, 381(9875), 1380-1390. https://doi.org/10.1016/S0140-6736(12)61901-1

Nascimento-Carvalho, C. M. (2020). Community-acquired pneumonia among children: The latest evidence for an updated management. Jornal de Pediatria, 96, 29-38. https://doi.org/10.1016/j.jped.2019.08.003

Nissen, M. D., Mackay, I. M., Withers, S. J., Siebert, D. J., and Sloots, T. P. (2002). Evidence of human metapneumovirus in Australian children. Medical Journal of Australia, 176(4), 188-188. https://doi.org/10.5694/j.1326-5377.2002.tb04354.x

Nitschinsk, K. M., Clarke, D. T., Idris, A., and McMillan, N. A. (2018). RNAi Targeting of Human Metapneumovirus P and N Genes Inhibits Viral Growth. Intervirology, 61(3), 149-154. https://doi.org/10.1159/000491927

Pan, J., Qian, X., Lattmann, S., El Sahili, A., Yeo, T. H., Jia, H., Cressey, T., Ludeke, B., Noton, S., Kalocsay, M., Fearns, R., and Lescar, J. (2020). Structure of the human metapneumovirus polymerase phosphoprotein complex. Nature, 577(7789), 275-279. https://doi.org/10.1038/s41586-019-1759-1

Piñana, J. L., Tridello, G., Xhaard, A., Wendel, L., Montoro, J., Vazquez, L., Heras, I., Ljungman, P., Mikulska, M., Salmenniemi, U., Perez, A., Kröger, N., Cornelissen, J., Sala, E., Martino, R., Geurten, C., Byrne, J., Maertens, J., Kerre, T., … De La Camara, R. (2024). Upper and/or Lower Respiratory Tract Infection Caused by Human Metapneumovirus After Allogeneic Hematopoietic Stem Cell Transplantation. The Journal of Infectious Diseases, 229(1), 83-94. https://doi.org/10.1093/infdis/jiad268

Preston, F. M., Straub, C. P., Ramirez, R., Mahalingam, S., and Spann, K. M. (2012). siRNA against the G gene of human metapneumovirus. Virology Journal, 9(1), 105. https://doi.org/10.1186/1743-422X-9-105

Sarasini, A., Percivalle, E., Rovida, F., Campanini, G., Genini, E., Torsellini, M., Paolucci, S., Baldanti, F., Marchi, A., and Graziarevello, M. (2006). Detection and pathogenicity of human metapneumovirus respiratory infection in pediatric Italian patients during a winter-spring season. Journal of Clinical Virology, 35(1), 59-68. https://doi.org/10.1016/j.jcv.2005.05.010

Scheuerman, O., Barkai, G., Mandelboim, M., Mishali, H., Chodick, G., and Levy, I. (2016). Human metapneumovirus (hMPV) infection in immunocompromised children. Journal of Clinical Virology, 83, 12-16. https://doi.org/10.1016/j.jcv.2016.06.006

Schildgen, V., Van Den Hoogen, B., Fouchier, R., Tripp, R. A., Alvarez, R., Manoha, C., Williams, J., and Schildgen, O. (2011). Human Metapneumovirus: Lessons Learned over the First Decade. Clinical Microbiology Reviews, 24(4), 734-754. https://doi.org/10.1128/CMR.00015-11

Schuster, J. E., and Williams, J. V. (2014). Human Metapneumovirus. Microbiology Spectrum, 2(5), 2.5.25. https://doi.org/10.1128/microbiolspec.AID-0020-2014

Scott, I. C., Zuydam, N. V., Cann, J. A., Negri, V. A., Tsafou, K., Killick, H., Liu, Z., McCrae, C., Rees, D. G., England, E., Guscott, M. A., Houslay, K., McCormick, D., Freeman, A., Schofield, D., Freeman, A., Cohen, E. S., Thwaites, R., Brohawn, Z., … Wilkinson, T. (2024). IL-33 is associated with alveolar dysfunction in patients with viral lower respiratory tract disease. Mucosal Immunology, S1933021924001247. https://doi.org/10.1016/j.mucimm.2024.12.001

Shafagati, N., and Williams, J. (2018). Human metapneumovirus-What we know now. F1000Research, 7, 135. https://doi.org/10.12688/f1000research.12625.1

Takeuchi, T., and Lin, D. N. C. (2002). Radial Flow of Dust Particles in Accretion Disks. The Astrophysical Journal, 581(2), 1344-1355. https://doi.org/10.1086/344437

Tariq, H., Batool, S., Asif, S., Ali, M., and Abbasi, B. H. (2022). Virus-Like Particles: Revolutionary Platforms for Developing Vaccines Against Emerging Infectious Diseases. Frontiers in Microbiology, 12, 790121. https://doi.org/10.3389/fmicb.2021.790121

Van Den Hoogen, B. G., De Jong, J. C., Groen, J., Kuiken, T., De Groot, R., Fouchier, R. A. M., and Osterhaus, A. D. M. E. (2001a). A newly discovered human pneumovirus isolated from young children with respiratory tract disease. Nature Medicine, 7(6), 719-724. https://doi.org/10.1038/89098

Van Den Hoogen, B. G., De Jong, J. C., Groen, J., Kuiken, T., De Groot, R., Fouchier, R. A. M., and Osterhaus, A. D. M. E. (2001b). A newly discovered human pneumovirus isolated from young children with respiratory tract disease. Nature Medicine, 7(6), 719-724. https://doi.org/10.1038/89098

Verma, M., Panchal, N. S., and Yadav, P. K. (2025). Exploring Chemical Space to Identify Partial Binders Against hMPV Nucleocapsid Protein. Journal of Cellular Biochemistry, 126(1), e30618. https://doi.org/10.1002/jcb.30618

Wang, Y.-H., Yang, C.-P., Ku, M.-S., Sun, H.-L., and Lue, K.-H. (2009). Efficacy of nasal irrigation in the treatment of acute sinusitis in children. International Journal of Pediatric Otorhinolaryngology, 73(12), 1696-1701. https://doi.org/10.1016/j.ijporl.2009.09.001

Williams, J. V., Chen, Z., Cseke, G., Wright, D. W., Keefer, C. J., Tollefson, S. J., Hessell, A., Podsiad, A., Shepherd, B. E., Sanna, P. P., Burton, D. R., Crowe, J. E., and Williamson, R. A. (2007). A Recombinant Human Monoclonal Antibody to Human Metapneumovirus Fusion Protein That Neutralizes Virus in vitro and Is Effective Therapeutically in vivo. Journal of Virology, 81(15), 8315-8324. https://doi.org/10.1128/JVI.00106-07

Williams, J. V., Harris, P. A., Tollefson, S. J., Halburnt-Rush, L. L., Pingsterhaus, J. M., Edwards, K. M., Wright, P. F., and Crowe, J. E. (2004). Human Metapneumovirus and Lower Respiratory Tract Disease in Otherwise Healthy Infants and Children. New England Journal of Medicine, 350(5), 443-450. https://doi.org/10.1056/NEJMoa025472

Wyde, P. R., Chetty, S. N., Jewell, A. M., Boivin, G., and Piedra, P. A. (2003). Comparison of the inhibition of human metapneumovirus and respiratory syncytial virus by ribavirin and immune serum globulin in vitro. Antiviral Research, 60(1), 51-59. https://doi.org/10.1016/S0166-3542(03)00153-0

Xia, W., Shao, J., Guo, Y., Peng, X., Li, Z., and Hu, D. (2020). Clinical and CT features in pediatric patients with COVID-19 infection: Different points from adults. Pediatric Pulmonology, 55(5), 1169-1174. https://doi.org/10.1002/ppul.24718

Ye, H., Zhang, S., Zhang, K., Li, Y., Chen, D., Tan, Y., Liang, L., Liu, M., Liang, J., An, S., Wu, J., Zhu, X., Li, M., and He, Z. (2023). Epidemiology, genetic characteristics, and association with meteorological factors of human metapneumovirus infection in children in southern China: A 10-year retrospective study. International Journal of Infectious Diseases, 137, 40-47. https://doi.org/10.1016/j.ijid.2023.10.002

Yi, L., Zou, L., Peng, J., Yu, J., Song, Y., Liang, L., Guo, Q., Kang, M., Ke, C., Song, T., Lu, J., and Wu, J. (2019). Epidemiology, evolution and transmission of human metapneumovirus in Guangzhou, China, 2013-2017. Scientific Reports, 9(1), 14022. https://doi.org/10.1038/s41598-019-50340-8

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