Original Study

Outbreak of Human Metapneumovirus in a Nursing Home: A Clinical Perspective

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ABSTRACT

Keywords:
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Objectives: To describe a human metapneumovirus (hMPV) outbreak occurring in a nursing home for older adults and to identify the risk factors associated with the clinical infection.
Design: A retrospective, case-controlled study.
Setting and participants: A French nursing home for older adults between December 27, 2014 and January 20, 2015. Probable cases were residents presenting at least 1 respiratory symptom or 1 constitutional symptom. Confirmed cases identified in the same way as probable cases but with a positive RT-PCR test for hMPV. Controls were residents with no symptoms of respiratory infection.
Measures: Identification of hMPV was realized on nasal swab samples by RT-PCR.
Results: Seventy-eight older people were resident at the time of the outbreak. Three of the 4 tested were positive for hMPV by RT-PCR and negative for 13 other viruses or bacteria. All probable infected residents presented cough; other symptoms were scarcer. An inflammatory response was present, with median C-reactive protein at 50 mg/L. The median duration of the illness was 7 days. The rate of infection among residents was high (51%), with 5 hospitalizations (12.5%) and 1 death (2.5%). In multivariate analysis, vaccination against influenza virus appeared to emerge as associated with a probable hMPV infection, but this might be an artifact, as the proportion of unvaccinated residents was low (15%). A clear infected population profile was hard to define, although limited autonomy and low ADL score may play a role. Basic hygiene precautions were reinforced, but droplet precautions seemed difficult to apply rigorously to this population.
Conclusions/Implications: Clinical and biological presentations were nonspecific. The rate of infection was high, highlighting the need for the rapid introduction of strict precautions to contain the infection.

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Identified in 2001 in the Netherlands, human metapneumovirus (hMPV) is an enveloped single-stranded RNA virus of the class *Pneumovirinae* similar to human Respiratory Syncytial Virus (hRSV).

Distributed worldwide, hMPV predominantly affects young, older, and immunocompromised patients.[1–16] The main symptoms are acute respiratory tract infection (ARI) with a significant overlap with the symptoms of other respiratory viruses.[2,5−7,9−11]

Indeed, coinfection with other viruses such as hRSV may augment the severity of an hMPV infection. Moreover, coinfection with *Streptococcus pneumoniae* and *Staphylococcus aureus* can lead to severe respiratory failure. The need for hospitalization due to hMPV infection may be decreased by vaccination with a conjugate pneumococcal vaccine.[17]

Outbreaks of hMPV infection have been reported among older adults living in long-term care facilities such as nursing homes.[17–24] However, data on such outbreaks is limited because until the last decade the diagnosis was challenging, needing expensive assays. In addition, the dynamic and the clinical picture of the infection is still debated.

Objectives

We describe an hMPV outbreak occurring in January 2015 in a nursing home (NH) and attempt to identify risk factors associated with the clinical infection.

Methods

We conducted a retrospective, case-control study including all NH residents from December 27, 2014, to January 20, 2015, considering that the incubation period for hMPV is 5-9 days.[25] The NH hosts 79 residents, in single or double rooms, on 3 floors in the same ward, with a common room for meals and activities.

We considered every resident presenting at least 1 respiratory symptom or 1 constitutional symptom as a probable case of hMPV infection. Confirmed cases of hMPV infection were residents presenting 1 respiratory symptom or 1 constitutional symptom, with a positive reverse transcriptase polymerase chain reaction (RT-PCR) test for hMPV determined from a nasal swab. The controls were all the residents without any respiratory or constitutional symptoms, such that the entire resident population of the NH was included in this study.

Nasal swabs from 4 symptomatic patients were tested locally by multiplex RT-PCR (Respifinder 2SMART PF2600-2S) for Influenza A virus (including H1N1v A), Influenza B virus, Respiratory syncytial virus (A and B), Parainfluenza viruses (1 to 4), Coronavirus (OC43,229E, NL63, HKU1), Metapneumovirus, Rhinovirus, Enterovirus, Adenovirus, Bocavirus, *Mycoplasma pneumoniae*, *Chlamydia pneumoniae*, *Legionella pneumophila*, and *Bordetella pertussis*.

Following local recommendations, standard precautions to contain the outbreak were reinforced by droplet precautions since diagnosis of the first case. Information was also given to visitors.

Droplet precautions in the NH consisted of isolation of probable or confirmed cases. Besides barrier measures, the following organizational measures were added: keeping the residents in their rooms, restrictions on visits, and use of masks for all residents when outside their bedrooms.

For this study, data collected from electronic and paper medical records consisted of sociodemographic (age, gender, and activities of daily living [ADL] score) and medical (medical history, comorbidities, cognitive and nutritional status, dates of onset and end of the infectious period, outcome of illness, results of nasal swabs, coinfections, and vaccination status) data. For each resident, we calculated the modified Cumulative Illness Rating Scale for Geriatrics scores, developed and published by Linn et al in 1968 for the compilation and quantification of health problems in older adults. In addition, we recorded the number of drugs and the number of antibiotics for respiratory infections prescribed during the symptomatic phase. According to the French immunization schedule, an annual influenza vaccination is required for health care workers and NH residents; it is also recommended for regular visitors. Pneumococcal vaccination for at-risk NH residents is proposed at admission. In our health care setting, both influenza and pneumococcal vaccinations were made by the same nurse after a physician had checked the absence of medical contraindications.

Informed consent and approval from an institutional review board were not obtained because data were collected as part of a public health investigation. A report of grouped ARIs, defined as the onset of a cluster of at least 5 cases within 4 days among residents sharing the same living environment, was sent to the Agence Régionale de Santé, the French administrative regional health authority.

A literature review from the Outbreak Database Website https://www.outbreak-database.com/Home.aspx was used to compare this outbreak to previous ones.[26] Supplemental Table 1 and Table 3 summarize the reported outbreaks, first those in older adults with clinical descriptions for comparison (Supplemental Table 1), then in the general population from a public health point of view (Table 3).

An epidemiologic curve was used to display the new symptomatic cases, as is usually done in the event of several grouped infectious cases. Cumulative incidence was estimated by a ratio including all declared confirmed and probable cases, divided by the number of residents in the nursing home during the infectious period.

Sociodemographic characteristics and comorbidities of residents are described by median (25th and 75th percentiles) and interquartile range (IQR) for quantitative variables, and the number and percentage for categorical variables.

Groups were compared by means of the Mann-Whitney U test for continuous variables, and the Pearson chi-square test, or Fisher exact test as appropriate for categorical variables.

The potential risk factors for infection were tested by a univariate analysis. Variables with a P value less than or equal to 0.2 in univariate analysis were selected for a multivariate analysis by a logistic regression, as well as the disease status for HMPV infection, as the main criterion of interest.

For all of these tests, we used a significance level of 5%. Analyses were performed using Stata, version 12.0.

Table 1
Description of the Nursing Home Population

Characteristic (N = 78)	n (%) or Median (IQR)
Gender, female, n (%)	42 (53.8)
Age, median (IQR)	86.5 (85-88)
Comorbidities	
CIRS-G score, median (IQR)	
Total score	14 (12-20)
Severity index	1.82 (1.67-2)
Underlying conditions, n (%)	
Cardiac	36 (48.7)
Renal	33 (44.6)
Respiratory	18 (24.3)
Malignant	12 (16.2)
Diabetic	10 (13.5)
Hepatic	3 (4.1)
At least 1 of the above conditions	53 (71.6)
Functional status, ADL score, n (%)	
1-2	26 (33.3)
3-4	20 (25.6)
5-6	32 (41.1)
≤3	30 (30.4)
Vaccination, n (%)	
Influenza	64 (85)
Pneumococcus	44 (61)
Drugs (n = 77), median (IQR)	6 (4-8)
Nutritional status, median (IQR)	
Weight	60 (51-73)
BMI	24.2 (21-29)
BMI by class, n (%)	
<18.5	5 (6.4)
18.5-24.9	32 (41)
≥25	41 (52.6)
Albuminemia, median (IQR)	36 (34-40)
Albuminemia <35, n (%)	23 (29.5)
Floor, n (%)	
1st floor	24 (30.8)
2nd floor	27 (34.6)
3rd floor	27 (34.6)

BMI, body mass index; CIRS-G, Cumulative Illness Rating Scale for Geriatrics.

Table 2
Comparison of Infected and Noninfected Residents

Characteristics	Infected	Noninfected	Univariate Analysis P value	Multivariate Analysis Adjusted Odds Ratio	Multivariate Analysis P Value
Number of residents	40	38	—	—	—
Gender, female, n (%)	23 (57.5)	19 (50)	.51	—	—
Age, median (IQR)	86.7 (84.5-88.9)	86.2 (84.1-88.4)	.86	—	—
Comorbidities					
CIRS-G score, median (IQR)					
Total score	13 (11-20)	14 (12-18)	.63	—	—
Severity index	1.8 (1.7-2)	1.8 (1.7-1.9)	.31		
Underlying conditions, n (%)					
Cardiac	18 (48.7)	18 (48.7)	.99		
Renal	17 (46)	16 (43.2)	.82		
Respiratory	6 (16.2)	12 (32.4)	.1	0.28 (0.07-1.08)	.07
Malignancy	8 (21.6)	4 (10.8)	.21	3.90 (0.71-21.26)	.12
Diabetic	7 (18.9)	3 (8.1)	.17	2.48 (0.51-12.09)	.26
Hepatic	2 (5.4)	1 (2.7)	.56		
At least 1 of the above conditions	26 (70.3)	26 (70.3)	.8		
Functional status					
ADL					
1-2	14 (35)	12 (31.6)	.5		
3-4	12 (30)	8 (21.1)			
5-6	14 (35)	18 (47.3)			
≤3	14 (35)	16 (42.1)	.52	—	—
Vaccination, n (%)					
Influenza	36 (92.3)	28 (77.8)	.08	8.32 (1.16-59.62)	.035
Pneumococcus	19 (51.4)	25 (71.4)	.08	0.42 (0.13-1.38)	.15
Drugs (n = 77), median (IQR)	5.5 (4-8)	6 (4-8)	.84	—	—
Antibiotic therapy, n (%)	7 (17.5)	0 (0)	—		
Nutritional status					
Weight, median (IQR)	60 (49-69)	60 (53-72)	.75	—	—
BMI, median (IQR)	23.9 (20.5-29.5)	24.2 (21.1-28.1)	.89	—	—
BMI by class, n (%)				—	—
<18.5	3 (7.5)	2 (5.3)	.78		
18.5-24.9	15 (37.5)	17 (44.7)			
≥25	22 (55)	19 (50)			
Albuminemia, median (IQR)	36 (32-39)	37 (34-41)	.3	—	—
Albuminemia <35, n (%)	13 (32.5)	10 (26.3)	.55	—	—
Floor				—	—
1st floor	13 (32.5)	11 (28.9)	.37		
2nd floor	11 (27.5)	16 (42.2)			
3rd floor	16 (40)	11 (28.9)			

BMI, body mass index; CIRS-G, Cumulative Illness Rating Scale for Geriatrics.

Results

At the time of the outbreak, 78 residents were occupying 68 rooms of the NH, 56 in single rooms and 22 in double rooms. By the end of the outbreak, a total of 40 residents had been infected. Among the residents, 5 older adults were hospitalized and 1 died, with the cause of death attributed to hMPV infection.

Description of the Resident Population

The sociodemographic and medical data are shown in Table 1. The median age was 86.5 years (IQR 85-88), and 42 (53.2%) were women.

The median total Cumulative Illness Rating Scale for Geriatrics score was 14 (IQR 12-20), and the severity index was 1.82 (IQR 1.67-2). The most common underlying medical conditions were heart (n = 36, 48.7 %), kidney (n = 33,44.6%), respiratory (n = 18,24.3%), malignancy (n = 12, 16.2%), diabetes (n = 10, 13.5%), and chronic liver diseases (n = 3, 4.1%). Twenty-one residents had no underlying condition among those mentioned above. Sixty-four (85%) residents had been vaccinated against influenza, and 44 (61%) had been vaccinated against pneumococci.

The residents' median weight was 60 kg (IQR 51-73), and the median body mass index was 24.2 (IQR 21-29). Five (6.4%) residents presented a body mass index <18.5. Hypoalbuminemia <30 g/L was present in 23 (29.5%) residents, a sign of severe malnutrition. Most

patients displayed cognitive impairment (median Mini-Mental State Examination score = 18, IQR 14-20). Thirty (30.1%) residents had an ADL score of 3 or lower.

Epidemic Curve

The outbreak occurred from December 27, 2014, to February 5, 2015. The onset of symptoms ranged from January 5 to January 20, 2015 (Figure 1), starting with 2 symptomatic residents. The last case was declared on January 20, 2015. The rate of infection was 51%. The epidemic curve shows a propagated shape, with the diagnosis of cases increasing to reach a peak on January 12, 2015. Then the number of ongoing cases gradually decreased to the baseline level after January 20, 2015. The recovery rate was 98% (39 of 40 patients). The overall mortality rate was 2% (1 of 40 patients) and 33% (1 of 3 patients) among RT-PCR-confirmed cases. No death occurred among patients with probable but unconfirmed cases.

Clinical Presentation

All infected residents presented cough. Ten (32%) presented rhinorrhea, 9 (29%) dyspnea, and 8 (26%) asthenia. Gastrointestinal symptoms were reported in some rare cases consisting of nausea-vomiting, but no patient suffered from diarrhea. One patient developed erythematous eruptions. The median body temperature was

Table 3
Previous Reports of hMPV Outbreaks, Worldwide

Study (First Author, Year)	Country	Season	Population	Setting	Attack Rate	Mortality Rate
Hoellein, 2016	Germany	January to February 2014	Adults, seniors	A tertiary care unit, hematology/oncology	—	4 of 15 (26.7%)
Yang, 2014	Northern Japan	April 10-21, 2008	Adults	A ward housing patients with severe motor and intellectual disabilities	20 of 44 (45.5%)	—
MMWR of CDC, 2013	West Virginia	January 2012	Older adults, median 84 y	A skilled nursing facility	28 of 83 (33.7%)	4 of 28 (14%)
	Idaho	February 2012	Older adults, median age 84 y	Skilled nursing facility	29 of 80 (36%)	2 of 29 (6.9%)
Liao, 2012	Oregon, USA	Late spring to summer 2011	Older adults	A long-term care facility	16 of 44 (36%)	5 of 16 (31.3%)
Degail, 2012	East of England	July to September 2010	Older adults, median age 85 y	Community hospital	10 of 34 (29.4%)	1 of 10 (10%)
Tu, 2009	Eastern Taiwan	May 2005	Adults, mean age 54.1 y	Psychiatric ward	10 of 13 (77%)	1 of 10 (10%)
Louie, 2007	California	June to July 2006	Older adults, median age 72.5 y	Long-term-care facility	26 of 148 (18%)	0 (0%)
Kim, 2007	Korea	March to May 2007	Children, median age 1.6 y	Tertiary care hospital, hemato-oncology ward	15 of 2200 (0.7%)	—
Cheng, 2007	Hong Kong, China	July to August 2005	Adults	Inpatient care (not ICU), neurology/psychiatry	—	0 (0%)
Lee, 2010	Hong Kong, China	March 2003	Adults	Inpatient care (not ICU), internal medicine	31 of 155 (20%)	2 of 31 (6.5%)
Honda, 2006	Japan	January 2005	Older adults, mean age 79 y	Inpatient care, a hospital for older people	8 of 23 (34.8%)	0 of 8 (0%)
Boivin, 2007	Quebec City, Canada	January to February 2006	Older adults, mean age 83 y	A long-term care facility	96 of 364 (27%) Most affected ward: 31 of 43 (72%)	9 of 96 (9.4%) 6.8% (4 of 59 patients) among probable case

37°C, with an elevated temperature (≥38°C) in 8 cases (Supplemental Table 1).

The medians for C-reactive protein, white blood cell count, and neutrophil count blood levels, performed in the first 48 hours after the onset of symptoms, were respectively 50.5 mg/L (IQR 22-124), 7.5 per mm^3 (IQR 6.3-10.2), and 5.4 per mm^3 (IQR 3.8-7.5).

RT-PCR was conducted in 4 cases, which confirmed hMPV infection in 3 of the 4 samples. It was negative for other viruses and bacteria. No respiratory coinfection or case of influenza was reported during the outbreak.

Seven patients (17.5%) received a 10-day course of antibiotic therapy (IQR 8-10)—amoxicillin-clavulanic acid in 7 cases, combined with ceftriaxone in 2 cases. No specific reasons were reported to explain the use of antibiotics. None of the noninfected residents received any antibiotic treatment.

Description of Severe Cases

Five cases required hospitalization, with a median stay of 7 days. They presented clinical pictures of upper respiratory tract infection (RTI) complicated by cardiac decompensation in 3 cases and with hypotension in 1 patient, acute pulmonary distress in 3 cases, and reduced oxygen saturation in 2 cases (up to 70%). One patient presented a chronic obstructive pulmonary disease (COPD) exacerbation, and 1 had lower respiratory tract infection (bibasal pneumonia). Two patients were delirious. Body temperature was elevated in only 2 cases (38.4°C, 37.7°C). Arterial blood gas analysis revealed respiratory acidosis, with hypercapnia requiring noninvasive ventilation in 1 case and shunt fraction in 2 cases with respiratory or mixed alkalosis. In 1 case, a chest radiograph showed bibasal infiltrations. Two patients presented pleural effusion.
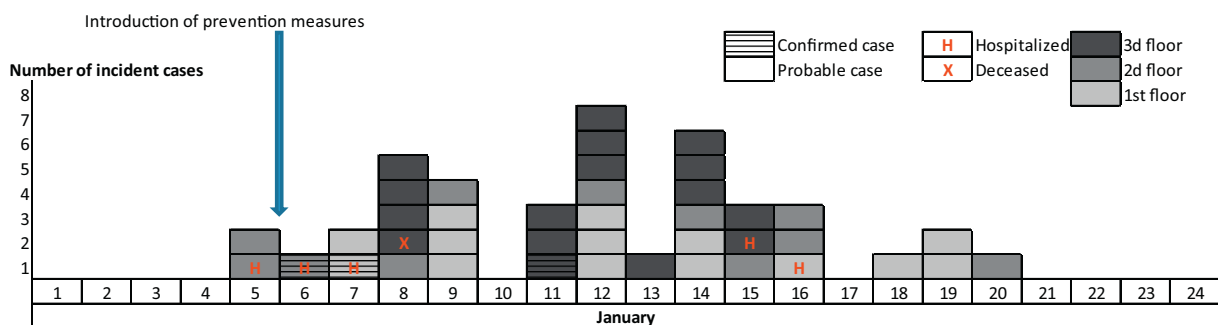

Fig. 1. Epidemic chart. The dates of the onset of symptoms are reported on the x-axis, each unit of time corresponds to 1 day, and each case is represented by a rectangle.

Comparison of Cases vs Unaffected Residents

In univariate analysis (Table 3), we found no factor to be significantly associated with hMPV infection.

In multivariate analysis (Table 2), influenza vaccination (odds ratio 7.58, confidence interval 1.25-45.91, *P* = .028) was the only factor independently associated with hMPV infection adjusted on underlying respiratory, malignant, and diabetic conditions and pneumococcus vaccination.

Preceding Reports of hMPV Outbreaks

Few studies have been conducted involving institutionalized older adults (Supplemental Table 1) or in the general population (Table 3).[21,25,27] In nursing homes, rates of infection ranged from 18%[18] to 72 %.[23] Most of the studies were conducted in Asia,[21–23,28–31] 2 concerned Europe,[25,27] and 2 in North America.[19,23]

Our outbreak occurred in winter, corresponding to its usual appearance, which takes place during the winter to spring period in temperate regions and in the late spring to early summer period in subtropical regions.[21] The high incidence of infection in our outbreak might be due to coinfections by other agents (eg, RSV, coronavirus, and adenovirus) occurring during the epidemic phase, because the shape of the curve spreads out over a long period.

Discussion

In this study, we observed a high rate of hMPV infection (51%) in older NH residents. This highlights the need for awareness to rapidly enhance basic hygiene precautions. Nevertheless, though droplet precautions were implemented, they seemed difficult to apply to this older adult population. Clinical and biologic presentations were not very specific, with C-reactive protein levels—often used as an argument for introducing antibiotic therapy—at 50.5 mg/L (median) with wide variability. In some cases, we observed an unfavorable clinical evolution, requiring hospitalization and 1 death among these patients.

Compared to previous studies focusing on outbreaks among older adults (Supplemental Table 1), we note that our clinical description was based on a greater number of symptomatic residents. Illness duration was not different from previous studies, and fever was a little less frequent. All infected residents presented coughs, whereas many of them had rhinorrhea, dyspnea, and asthenia, which is consistent with previous studies.[18–24]

Concerning the clinical picture, almost all ill residents presented upper or lower respiratory tract infection (90% of documented probable cases), whereas in the other reports there were more diagnoses of pneumonia. In all cases, the mortality rate remained low.

Blood tests showed a moderate elevation of C-reactive protein with normal or near-normal total leukocyte counts, consistent with the study of Honda et al,[31] normal or near-normal neutrophil counts, and negative procalcitonin.

The clinical picture of hMPV infection is similar to that of bacterial pneumonia, particularly in an older population, in which symptoms appear to be less specific. Some studies have shown that C-reactive protein with a cut-off at 60 mg/L has a sensitivity of only 82% to detect any bacterial infection in hospitalized older adults.[32,33] According to Wipf et al,[34] a diagnosis of bacterial pneumonia made only by a physical examination has a specificity of between 58% and 75% and a sensibility of between 47% and 69%. Thus, residents without a blood test may have been misdiagnosed herein.

In this context, any antibiotic therapy during the outbreak may have in reality treated a bacterial pneumonia. Although 17.5% of the infected residents received an antibiotic, this proportion is quite low compared with the usual rate of antibiotic use in cases of laboratory-confirmed influenza.[35] No specific risk factor has been reported to explain the use of antibiotics, though the severity of the clinical features might be an explanation. None of the noninfected residents received any antibiotic in the same period.

Outbreaks have been described in other institutionalized adult populations, such as psychiatric inpatients, with infection rates from 25%[21] to 56%,[22] and in a rehabilitation center for alcoholics with an incidence rate of 73%.[20] Such high rates of infection can be explained by the particular living conditions in institutions such as NHs. Indeed, this closed environment, as well as the often dependent and multipathologic profile of the residents, and possibly the short incubation period are factors favoring the transmission of infectious agents.[17,25,36] Moreover, infection control measures seem difficult to apply because of the prevalence of cognitive impairment (Mini-Mental State Examination score = 18) and possible associated behavioral disorders, like wandering.

The statistical association between influenza vaccination and hMPV infection seems surprising and has not been reported before, but this could be coincidental or due to an unidentified methodologic bias. We tested the interaction between influenza vaccination and respiratory condition and found no significant interaction. The fact that more than a quarter of the residents had no major underlying condition may be an explanation, even though there was no significant difference between those who became ill and the others. It seems difficult to pinpoint a standard infected population profile, although limited autonomy and low ADL score may play a role, particularly because an association has been shown between low ADL and nosocomial infections.[37]

The pattern of the spread of infection within the NH may be an explanation for the high infection rate, although the floor on which successive cases occurred was not associated.

A major limitation of our study is the fact that RT-PCR was not conducted on all suspected cases, leading to a severe classification bias. Rapid tests have been developed for hMPV,[38] although in France testing is not recommended for every resident of NHs. When investigating a respiratory outbreak in an NH, French national recommendations do not clearly define indications for RT-PCR tests. Nevertheless, in 2012 the French Public Health authority recommended the microbiological testing of an ARI if it was severe, had an unfavorable course, and/or concerned an outbreak in a nursing home. In the latter case, it is recommended to make 3 swabs. This recommendation was adhered to in the outbreak reported here. Partly to limit costs, residents who subsequently presented an ARI were considered as probable cases.

The role of health care workers in the spread of the virus should be considered. During this outbreak, 10 health care workers developed a respiratory viral infection, of which 5 had received the annual influenza vaccination. Although no vaccination against hMPV currently exists, some organizational measures can be taken to prevent or contain outbreaks, such as reinforcing the nursing skills and better education of health care workers,[39,40] upgrading NH admission criteria for improved medical surveillance, and training in measures for infection control.[41] Kossover et al[41] showed some discrepancies in practices within the American facilities they studied. Harmonization may permit a better sharing of anti-infectious strategies, including the systematic use of masks by all health care workers and NH staff throughout this type of outbreak.

Conclusions and Implications

Several hMPV outbreaks, occurring in different countries, have been the subject of reports in the literature. To our knowledge, the outbreak reported here is 1 of the largest occurring in an NH, allowing us to attempt a more precise description of this infection in the institutionalized older adults with predominantly upper and lower

respiratory tract infections. The major limitation was that because of public health policy, swabs for viral identification were not taken in every symptomatic case. Precautions to prevent transmission seem difficult to apply to this population and need to be improved. As a low ADL score has been shown to be associated with risk of infection, the care of older adults with infections should be approached through the prism of capacity trajectory. Interestingly, influenza vaccination appeared to be statistically associated with a higher risk of hMPV infection—an observation that requires further investigation.

References

1. Van den Hoogen BG, de Jong JC, Groen J, et al. A newly discovered human pneumovirus isolated from young children with respiratory tract disease. Nat Med 2001;7:719–724.
2. Zhang C, Zhu N, Xie Z, et al. Viral etiology and clinical profiles of children with severe acute respiratory infections in China. PloS One 2013;8:e72606.
3. Çiçek C, Arslan A, Karakuş HS, et al. Prevalence and seasonal distribution of respiratory viruses in patients with acute respiratory tract infections, 2002-2014 [in Turkish]. Mikrobiyol Bul 2015;49:188–200.
4. Silva RC, Mendes Gda S, Rojas MA, et al. Frequency of viral etiology in symptomatic adult upper respiratory tract infections. Braz J Infect Dis 2015;19:30–35.
5. Fabbiani M, Terrosi C, Martorelli B, et al. Epidemiological and clinical study of viral respiratory tract infections in children from Italy. J Med Virol 2009;81:750–756.
6. Feuillet F, Lina B, Rosa-Calatrava M, Boivin G. Ten years of human metapneumovirus research. J Clin Virol 2012;53:97–105.
7. García-García ML, Calvo C, Martín F, et al. Human metapneumovirus infections in hospitalised infants in Spain. Arch Dis Child 2006;91:290–295.
8. Guido M, Quattrocchi M, Campa A, et al. Human metapneumovirus and human bocavirus associated with respiratory infection in Apulian population. Virology 2011;417:64–70.
9. Hara M, Takao S, Fukuda S, et al. Human metapneumovirus infection in febrile children with lower respiratory diseases in primary care settings in Hiroshima. Japan. Jpn J Infect Dis 2008;61:500–502.
10. Ji W, Wang Y, Chen Z, et al. Human metapneumovirus in children with acute respiratory tract infections in Suzhou, China 2005-2006. Scand J Infect Dis 2009;41:735–744.
11. Kahn JS. Human metapneumovirus: A newly emerging respiratory pathogen. Curr Opin Infect Dis 2003;16:255–258.
12. Ren L, Gonzalez R, Wang Z, et al. Prevalence of human respiratory viruses in adults with acute respiratory tract infections in Beijing, 2005-2007. Clin Microbiol Infect 2009;15:1146–1153.
13. Wang Y, Chen Z, Yan YD, et al. Seasonal distribution and epidemiological characteristics of human metapneumovirus infections in pediatric inpatients in Southeast China. Arch Virol 2013;158:417–424.
14. Lu Y, Wang S, Zhang L, et al. Epidemiology of human respiratory viruses in children with acute respiratory tract infections in Jinan, China. Clin Dev Immunol 2013;2013:210490.
15. Zhang Q, Yang X, Zhao Y, Zhao X. High seroprevalence of human metapneumovirus infection in children in Chongqing, China. Chin Med J (Engl) 2008;121:2162–2166.
16. Hamada H, Ogura A, Hotta C, et al. Epidemiological study of respiratory viruses detected in patients under two years old who required admission because of lower respiratory disease [in Japanese]. Kansenshogaku Zasshi 2014;88:423–429.
17. Berry M, Gamieldien J, Fielding BC. Identification of new respiratory viruses in the new millennium. Viruses 2015;7:996–1019.
18. Louie JK, Schnurr DP, Pan C, et al. A summer outbreak of human metapneumovirus infection in a long-term-care facility. J Infect Dis 2007;196:705–708.
19. Liao RS, Appelgate DM, Pelz RK. An outbreak of severe respiratory tract infection due to human metapneumovirus in a long-term care facility for the elderly in Oregon. J Clin Virol 2012;53:171–173.
20. Laine O, Laine J, Säilä P, et al. An outbreak of human metapneumovirus in a rehabilitation center for alcoholics in Tampere, Finland. Infect Dis (Lond) 2015;47:499–503.
21. Tu CC, Chen LK, Lee YS, et al. An outbreak of human metapneumovirus infection in hospitalized psychiatric adult patients in Taiwan. Scand J Infect Dis 2009;41:363–367.
22. Cheng VC, Wu AK, Cheung CH, et al. Outbreak of human metapneumovirus infection in psychiatric inpatients: Implications for directly observed use of alcohol hand rub in prevention of nosocomial outbreaks. J Hosp Infect 2007;67:336–343.
23. Boivin G, De Serres G, Hamelin ME, et al. An outbreak of severe respiratory tract infection due to human metapneumovirus in a long-term care facility. Clin Infect Dis 2007;44:1152–1158.
24. Centers for Disease Control and Prevention (CDC). Outbreaks of human metapneumovirus in two skilled nursing facilities—West Virginia and Idaho, 2011-2012. MMWR Morb Mortal Wkly Rep 2013;62:909–913.
25. Degail MA, Hughes GJ, Maule C, et al. A human metapneumovirus outbreak at a community hospital in England, July to September 2010. Euro Surveill 2012;17:20145.
26. Vonberg RP, Weitzel-Kage D, Behnke M, Gastmeier P. Worldwide Outbreak Database: The largest collection of nosocomial outbreaks. Infection 2011;39:29–34.
27. Hoellein A, Hecker J, Hoffmann D, et al. Serious outbreak of human metapneumovirus in patients with hematologic malignancies. Leuk Lymphoma 2016;57:623–627.
28. Yang Z, Suzuki A, Watanabe O, et al. Outbreak of human metapneumovirus infection in a severe motor-and-intellectual disabilities ward in Japan. Jpn J Infect Dis 2014;67:318–321.
29. Kim CK, Choi J, Callaway Z, et al. Clinical and epidemiological comparison of human metapneumovirus and respiratory syncytial virus in Seoul, Korea, 2003-2008. J Korean Med Sci 2010;25:342–347.
30. Lee N, Chan PKS, Yu IT, et al. Co-circulation of human metapneumovirus and SARS-associated coronavirus during a major nosocomial SARS outbreak in Hong Kong. J Clin Virol 2007;40:333–337.
31. Honda H, Iwahashi J, Kashiwagi T, et al. Outbreak of human metapneumovirus infection in elderly inpatients in Japan. J Am Geriatr Soc 2006;54:177–180.
32. van Duin D. Diagnostic challenges and opportunities in older adults with infectious diseases. Clin Infect Dis 2012;54:973–978.
33. Liu A, Bui T, Van Nguyen H, et al. Serum C-reactive protein as a biomarker for early detection of bacterial infection in the older patient. Age Ageing 2010;39:559–565.
34. Wipf JE, Lipsky BA, Hirschmann JV, et al. Diagnosing pneumonia by physical examination: Relevant or relic? Arch Intern Med 1999;159:1082–1087.
35. Hernes SS, Hagen E, Quarsten H, et al. No impact of early real-time PCR screening for respiratory viruses on length of stay and use of antibiotics in elderly patients hospitalized with symptoms of a respiratory tract infection in a single center in Norway. Eur J Clin Microbiol Infect Dis 2014;33:359–364.
36. Omura T, Iizuka S, Tabara K, et al. Detection of human metapneumovirus genomes during an outbreak of bronchitis and pneumonia in a geriatric care home in Shimane, Japan, in autumn 2009. Jpn J Infect Dis 2011;64:85–87.
37. Mazière S, Couturier P, Gavazzi G. Impact of functional status on the onset of nosocomial infections in an acute care for elders unit. J Nutr Health Aging 2013;17:903–907.
38. Hamada N, Hara K, Matsuo Y, et al. Performance of a rapid human metapneumovirus antigen test during an outbreak in a long-term care facility. Epidemiol Infect 2014;142:424–427.
39. Gravenstein S, Ambrozaitis A, Schilling M, et al. Surveillance for respiratory illness in long-term care settings: Detection of illness using a prospective research technique. J Am Med Dir Assoc 2000;1:122–128.
40. Richards CL Jr. Infection control in long-term care facilities. J Am Med Dir Assoc 2007;8:S18–S25.
41. Kossover RA, Chi CJ, Wise ME, et al. Infection prevention and control standards in assisted living facilities: Are residents' needs being met? J Am Med Dir Assoc 2014;15:47–53.

Appendix

Supplemental Table 1
Clinical Features and Outcomes, and Comparison Between Reported Outbreaks in the Institutionalized Older Adults

Features	La Bâtie (n = 32*)	West Virginia (n = 28*)	Idaho (n = 29*)	Quebec (n = 59*)	England (n = 10*)	Oregon (n = 16*; n = 6†)	California (n = 26*)	Japan (n = 8†)
Illness duration, d, median (IQR)	7 (3.5-12)	21 (3-43)	4.5 (1-14)	8.2 (1-22)	7.6 (1-18)	12.5 (2-18)	—	4 (0-6)
Fever, n (%)	9 (22.5%)	11 (39%)	7 (24%)	18 (31%)		6 (100%)	Present	7 (88%)
Symptoms (n = 32), n (%)								
Cough	32 (100%)	25 (89%)	29 (100%)	51 (86%)	8 (80%)	6 (100%)	Present	8 (100%)
Rhinorrhea	10 (32.3%)	3 (11%)	4 (14%)	21 (36%)	1 (10%)	—	Present	8 (100%)
Dyspnea	9 (29%)	4 (14%)	8 (28%)	7 (12%)	4 (40%)	4 (67%)	Present	2 (25%)
Asthenia	8 (26%)	—	—	24 (41%)	2 (20%)	—	Present	—
Vomiting	3 (9.7%)	—	—	—	—	—	—	—
Anorexia	2 (6.5%)	—	—	—	2	—	—	—
Eruption	1 (3.2%)	—	—	—	—	—	—	—
Myalgia	0	—	—	—	—	—	—	—
Diarrhea	0	—	—	—	—	—	—	—
Clinical features (n = 32*), n (%)								
URTI	14 (43.8%)	1 (4%)	4/29 (14%)	14 (23%)	—	—		
LRTI/ILI	15 (46.9%)	26 (93%)	19 (66%)	2 (3%)	—	—	8 (31%)	2 (25%)
Bronchitis	14 (43.8%)				—	—		
Pneumonia	1 (3.1%)	18 (64%)	7 (24%)	—	—	Infiltrates in 4 (67%) cases	8 (31%)	
Exacerbation of COPD	1 (3.1%)	—	—		—	—	—	
Asthmatic exacerbation	0 (0%)	—	—		—	—	—	
Cardiac decompensation	3 (9.4%)	—	—		—	Infiltrates in 4 (67%) cases	—	
Biology (n = 25*)								
C-reactive protein, mg/L	Median 50.5 (IQR 22-124)		—	—	—	—	—	Mean 25.7 (range 1.7-52.9)
Leukocytes, × 10⁹ cells/L	Median 7.5 (IQR 6.3-10.2)	—	—	—	—	—	—	Mean 4.1, (range 2.3-6.5)
Neutrophil, × 10⁹ cells/L	5.4 (3.8-7.5)	—	—	—	—	—	—	—
Procalcitonin (n = 13), mg/L, median (IQR)	0.11 (0.07-0.16)	—	—	—	—	—	—	—
Outcome (n = 40*), n (%)								
Hospitalization	5 (12.5%)	4 (14%)	5 (17%)	—	1 (10%)	4 (67%)	2	Inpatients
Death	1 (2.5%)	4 (14%)	2 (7%)	4 (6.8%)	1 (10%)	31.3%* 33.3%†	0	0

LRTI, lower respiratory tract infection; URTI, upper respiratory tract infection.
The n values within parentheses in column 1 indicate the number of cases for which data are available.
*Probable cases.
†Confirmed cases.