ORIGINAL ARTICLE 10.1111/j.1469-0691.2010.03171.x

A review of the dynamics and severity of the pandemic A(H1N1) influenza virus on Réunion Island, 2009

E. D'Ortenzio[1], P. Renault[1], M. C. Jaffar-Bandjee[2], B. A. Gaüzère[3], M. Lagrange-Xélot[4], A. Fouillet[5], P. Poubeau[6], A. Winer[7], A. Bourde[8], F. Staikowsky[9], P. Morbidelli[10], E. Rachou[11], F. Thouillot[1], A. Michault[12] and L. Filleul[1]

1) *Regional Office (Cire Réunion-Mayotte) of the French Institute for Public Health Surveillance (Institut de veille Sanitaire, InVS), Réunion*, 2) *Laboratory for Microbiology, Centre Hospitalier Régional de La Réunion, site Hôpital Félix Guyon, Saint-Denis*, 3) *Intensive Care Unit (Service de Réanimation), Centre Hospitalier Régional de La Réunion, site Hôpital Félix Guyon*, 4) *Infectious Diseases Unit (Unité des Maladies Infectieuses), Centre Hospitalier Régional de La Réunion, site Hôpital Félix Guyon, Saint-Denis*, 5) *Département de Coordination des Alertes et des Régions, Institut de Veille Sanitaire, Saint-Maurice*, 6) *Infectious Diseases Unit (Unité des Maladies Infectieuses)*, 7) *Intensive Care Unit (Service de Réanimation), Centre Hospitalier Régional de La Réunion, site Groupe Hospitalier Sud Réunion, Saint-Pierre*, 8) *Emergency Department (Service des Urgences, Centre Hospitalier Régional de La Réunion, site Hôpital Félix Guyon, Saint-Denis*, 9) *Emergency Department (Service des Urgences), Centre Hospitalier Régional de La Réunion, site Groupe Hospitalier Sud Réunion, Saint-Pierre*, 10) *Emergency Department (Service des Urgences), Centre Hospitalier Gabriel Martin, Saint-Paul*, 11) *Regional Health Observatory (Observatoire Régional de la Santé), Saint-Denis, Réunion and* 12) *Laboratory for Bacteriology, Parasitology, Virology and Hospital Hygiene (Laboratoire de Bactériologie, Parasitologie, Virologie et Hygiène Hospitalière), Centre Hospitalier Régional de La Réunion, site Groupe Hospitalier Sud Réunion, Saint-Pierre, France*

Abstract

On Reunion Island, in response to the threat of emergence of the pandemic influenza A(H1N1)2009 virus, we implemented enhanced influenza surveillance from May 2009 onwards in order to detect the introduction of pandemic H1N1 influenza and to monitor its spread and impact on public health. The first 2009 pandemic influenza A(H1N1) virus was identified in Réunion on July 5, 2009, in a traveller returning from Australia; seasonal influenza B virus activity had already been detected. By the end of July, a sustained community pandemic virus transmission had been established. Pandemic H1N1 influenza activity peaked during week 35 (24–30 August 2009), 4 weeks after the beginning of the epidemic. The epidemic ended on week 38 and had lasted 9 weeks. During these 9 weeks, an estimated 66 915 persons who consulted a physician could have been infected by the influenza A(H1N1)2009 virus, giving a cumulative attack rate for consultants of 8.26%. Taking into account the people who did not consult, the total number of infected persons reached 104 067, giving a cumulative attack rate for symptomatics of 12.85%. The crude fatality rate (CFR) for influenza A(H1N1)2009 and the CFR for acute respiratory infection was 0.7/10 000 cases. Our data show that influenza pandemic did not have a health impact on overall mortality on Réunion Island. These findings demonstrate the value of an integrated epidemiological, virological and hospital surveillance programme to monitor the scope of an epidemic, identify circulating strains and provide some guidance to public health control measures.

Keywords: A(HINI) 2009, emergence, epidemiological surveillance, estimation, influenza, lethality, pandemic, Reunion Island, virus
Invited article
Editor: X. de Lamballerie
Article published online: 28 January 2010
Clin Microbiol Infect 2010; **16:** 309–316

Corresponding author and reprint requests: Eric D'Ortenzio, MD, MSc, Regional office (Cire Réunion-Mayotte) of the French Institute for Public Health Surveillance (Institut de veille sanitaire, InVS), Saint-Denis, Réunion Island, France
E-mail: eric.dortenzio@sante.gouv.fr and ericdortenzio@gmail.com

Introduction

Following its emergence in March 2009 [1], the pandemic A(H1N1) virus spread rapidly throughout the world, leading to the declaration of an influenza pandemic by the World Health Organization (WHO) on 11 June 2009 [2]. The pandemic A(H1N1) virus was first detected in April in the USA [3] and was shown to be responsible for outbreaks in Mexico in March and April [4,5]. As of 27 November 2009, worldwide more than 207 countries and overseas territories or communities had reported laboratory confirmed cases of pandemic influenza H1N1 2009, including over 7820 deaths [6]. In the Southern hemisphere, the emergence of pandemic H1N1 influenza coincided with the winter seasonal influenza activity which began to increase in June 2009. Pandemic

A(H1N1) activity increased rapidly in many of these countries and activity peaked in July in some regions, falling to low levels by August or September in South Africa, Brazil, Peru, Australia, and New Zealand [7–11]. In some other southern hemisphere tropical areas in the Americas and Asia, the pandemic A(H1N1) influenza virus was still circulating in September in some places.

Réunion island, a French overseas territory with 810 000 inhabitants (2009 estimate), is located in the southern hemisphere in the South-Western Indian Ocean. It is 700 km East of Madagascar and 200 km South-West of Mauritius, at a longitude of 55°3 East and latitude of 21°5 South, above the Tropic of Capricorn. Réunion has a health care system similar to continental France. Although acute respiratory illness activity has been monitored continuously since 1996, the circulation of influenza virus strains remains poorly documented. However, results of past monitoring suggest that influenza activity increases annually in June–July. The last reported influenza epidemic occurred in August–October 2007. Although the island is mainly exposed to seasonal influenza from the Southern hemisphere, one-third of the annual cases of influenza are reported during the northern hemisphere's influenza season between October and May. This could be explained by the links with continental France as approximately 2000 people travel each day between France and Réunion.

In response to the threat of emergence and spread of the pandemic influenza A(H1N1)2009 virus, the Regional Office (Cire Réunion-Mayotte) of the French Institute for Public Health Surveillance (Institut de veille sanitaire, InVS) on Réunion Island implemented an enhanced influenza surveillance from May 2009 onwards in order to detect the introduction of the pandemic H1N1 influenza and to monitor its spread and impact on public health [12,13]. This report summarizes the results of this surveillance and describes the dynamics and impact of the influenza pandemic on Réunion Island and the characteristics of laboratory-confirmed cases, including hospitalized, severe and fatal cases.

Methods

On Réunion Island, the enhanced influenza surveillance programme, set up in May 2009 [12], was modified after evidence of local transmission and rapid spread of the 2009 pandemic H1N1 influenza virus. We describe the new surveillance procedure started on 23 July which was based on a range of indicators available from the surveillance systems implemented before the emergence of the epidemic.

Virological surveillance

Virological surveillance was implemented in order to identify and characterize circulating influenza viruses during the winter season in Réunion Island. Specimens were collected by sentinel and emergency department practitioners. Nasal swabs were performed weekly by sentinel practitioners and daily on every first adult and paediatric patient attendance in the hospital emergency departments. In-patients with acute respiratory infections (ARIs) were also surveyed. Specimens were tested for both influenza virus A and B by a reverse-transcriptase-polymerase-chain-reaction (RT-PCR) assay. The 2009 pandemic influenza A (H1N1) was confirmed by means of a RT-PCR assay performed according to published guidelines from the US CDC. The 2009 H1N1 virus testing was conducted in local laboratories and confirmed by the National Reference Centre for Influenza (Institut Pasteur, Paris). The RT-PCR assay was performed using a Superscript™ One-Step RT-PCR with a Platinum Taq kit. (Invitrogen, Carlsbad, CA, USA). A specific RT-PCR for novel influenza A(H1N1) was performed when positive virus A specimens were identified.

Surveillance of ARI by the sentinel practitioner network

A sentinel practitioner network, comprising 23 general practitioners and three paediatricians, covering all the island and representing respectively, 3% and 10% of all private physicians for each speciality, was in charge of the prospective influenza surveillance. These physicians reported weekly the number of ARIs and the total number of consultations. They reported the percentage of consultations for ARI symptoms with the following case definition: sudden onset of fever >38°C AND (cough OR breathing difficulty). Every physician was expected to perform a nasal swab on the first two patients of the week presenting with ARI symptoms with an onset of <48 h. Weekly ARI consultation rates were compared with rates for the same periods in the past 5 years (2004–2008).

Surveillance of hospitalized patients and those with severe disease

Hospitalized patients with laboratory confirmed A(H1N1)2009 virus were reported by clinicians to the Regional Office of InVS. A standardized form was used for collecting epidemiologic, demographic and clinical data. A hospitalized patient was defined as one with a laboratory-confirmed influenza A(H1N1)2009 virus infection admitted for more than 24 h to a medical ward. A severe case was defined as a person with a laboratory-confirmed influenza A(H1N1) 2009 virus infection who was admitted to an intensive care unit (ICU) or who died.

Mortality surveillance

An analysis of all death certificates received by the Regional Public Health Authority was conducted. All certificates mentioning 'Influenza' were recorded as an influenza-associated death. Electronic death certification was also used by the Intensive Care Department of Saint-Denis hospital and analysed in real time by the Regional Office of InVS. In addition, the National Institute for Statistics (Institut National de la Statistique et des Etudes Économiques, Insee) recorded deaths from all causes in France. For several years, Insee has been monitoring and centralizing daily mortality in France, including Réunion and the other French overseas territories. This mortality was assessed using a real-time process. To assess the affect of the pandemic virus outbreak on mortality, we compared the number of deaths observed during the outbreak period with the expected number computed from the 2005–2008 historical data. We analysed the period from January 1, 2005, to October 4, 2009, but excluding the year 2006 because of the chikungunya epidemic at that time. The expected number of deaths (all causes) for 2009 was the number of deaths by age observed during 2005–2008 (except 2006) modified by an estimate of the population size for the period. Details of this method, which was used during the heat wave in France in 2003, have already been described [14]. The number of deaths in Réunion was obtained daily from 13 of 24 computerized registry offices throughout the island which represented 87% of the deaths. A preliminary study had validated this surveillance system [15].

Estimates of the number of cases

Since week 30, the number of patients consulting for pandemic influenza A (H1N1) was estimated from data from the sentinel practitioner network. The number of ARIs was extrapolated from the entire medical activity on Réunion Island by using the total number of consultations provided by the social insurance data for the week studied. The number of consultations with a A(H1N1) 2009 infection was calculated by applying the proportion of positivity for each week obtained from a random sample of patients with ARI tested by the sentinel practitioners to the total estimated number of patients with ARI in the same week.

Cross-sectional study

A cross-sectional survey designed by the Regional Office of InVS was conducted by the Louis Harris Institute in order to assess the prevalence of ARI amongst the general population and particularly in persons who did not consult a physician. This survey was conducted by telephone interviewing between 7 and 14 October 2009 among a representative sample of 420 persons living on Réunion Island.

Statistical analysis

We performed statistical analysis using Epidata Analysis® and STATA 9.0® software. We calculated descriptive statistics for all study variables. We report data for continuous variables as median and for categorical variables as percentage (with 95% confidence intervals, where appropriate). Chi-square tests or Fisher-exact tests were used when appropriate to compare categorical variables, and the Student test or the Mann-Whitney test used when appropriate to compare continuous variables.

Results

Virologic analysis (Fig. 1)

During the austral winter 2009, Influenza B virus was first detected on week 23 (starting 1 June) and was the only influenza strain detected during the following 3 weeks. A very small proportion of A(H3N2) viruses were detected in weeks 30–32 and week 35. Influenza A(H1N1)2009 was first detected on 5 July (week 27). Between week 27 and week 41 (starting 5 October), influenza A(H1N1)2009 viruses were detected by RT-PCR in 785 of 2229 nasal swabs (a 35.2% positivity rate). In week 31 (starting 27 July), the pandemic virus became the dominant circulating strain on the Island and reached a 95% positivity rate in week 34. We also identified 16 persons co-infected with both the pandemic virus and the influenza B virus.

Dynamics of the epidemic (Fig. 2)

From week 23 (starting 1 June) to week 30 (starting July 20) the weekly ARI consultation rates remained below the 2004–2008 mean rates. On 5 July 2009 (week 27), when seasonal influenza was already reported on the island, the first imported case of pandemic H1N1 influenza was detected in a traveller returning from Australia. From week 27 to week 30, no evidence of local transmission of pandemic H1N1 influenza was detected and all laboratory-confirmed cases were considered as imported or having an epidemiological link with another imported laboratory-confirmed case. On 22 July, the first autochthonous case was reported. From week 30, there was evidence of local transmission and the individual surveillance was shifted to a population-based surveillance. Then, on week 31, the ARI rate exceeded the 2004–2008 mean and increased sharply until week 35 (starting 24 August). During this peak week, ARI cases represented 20.6% of consultations reported by sentinel practitioners. This was the highest rate observed in Réunion during the previous 5 years of influenza surveillance and 65% of nasal swabs performed by sentinel

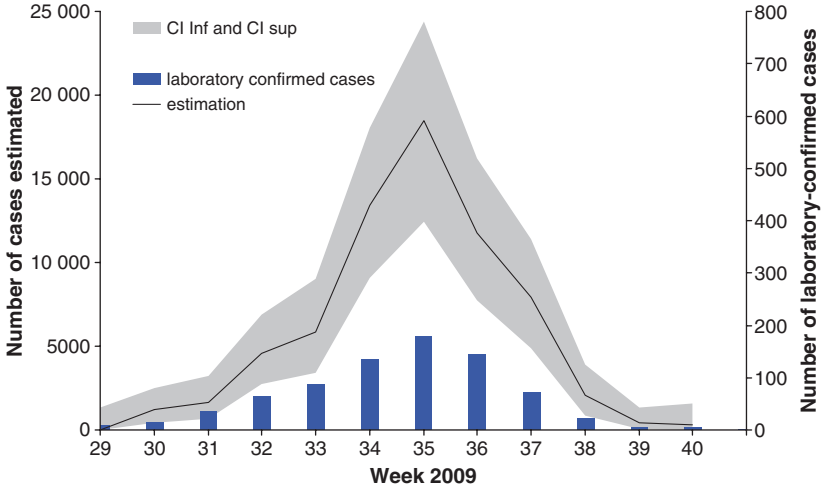

FIG. 1. Estimate of the number of consultations for patients with ARI infected with the influenza A(H1N1)2009 virus and the confidence interval (CI), Réunion Island, 2009.

network physicians were positive for A(H1N1)2009. During the 9-week epidemic period (week 30–38), the number of cases of patients with A (H1N1) 2009 infections who consulted a physician was estimated at 66 915. During the peak week (week 35), an estimated 18 473 [CI 95%: 12 447–24 404] persons were infected by the pandemic virus. At the end of the epidemic (week 38), the estimated cumulative attack rate for symptomatic persons who consulted was 8.26%. In the cross-sectional study, 28.5% of the people questioned reported symptoms of ARI during the period. Among these, 35.7% did not consult a physician. Using this proportion of symptomatic people who did not consult, an estimate of 104 067 infected persons was made. Therefore, the final cumulative attack rate for symptomatic people was 12.85%.

Laboratory-Confirmed Cases of Influenza A(H1N1)2009

Characteristics and symptoms of patients (Table 1)

From 5 July through 18 October, a total of 785 confirmed cases of patients infected by influenza A(H1N1)2009 virus were reported to the Regional office of InVS. The sex ratio M/F was 0.7 and the median age was 17.7 years. A total of 67.5% of patients were between the ages of 5 and 50 years and 24% were <5 years old. The most common symptoms were fever (91%), cough (88%), coryza (63%), fatigue (52%) and sore throat (49%). In addition, 18% of patients had vomiting and 8% had diarrhoea. Among 330 patients for whom treatment status

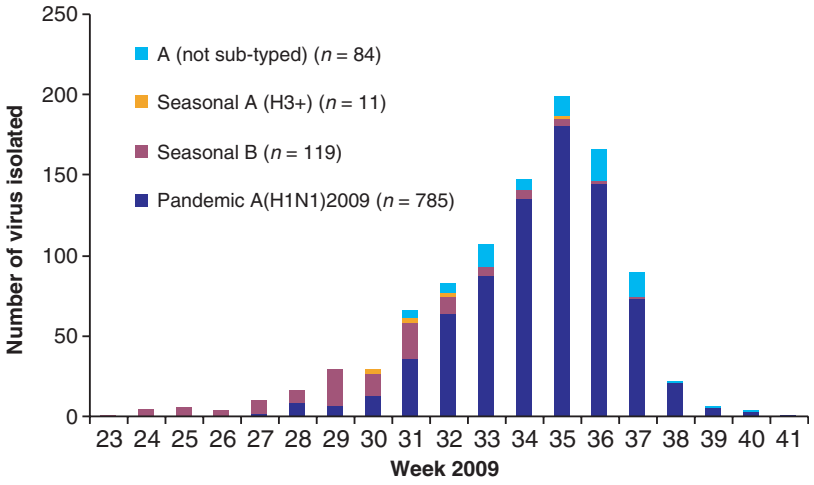

FIG. 2. Influenza virus epidemic curve, Réunion Island, 2009.

TABLE 1. Characteristics, symptoms and underlying medical conditions of the 785 patients with laboratory-confirmed A(H1N1)2009 virus, Réunion Island, 2009

Characteristics	A(H1N1)2009 (*n* = 785) *N* (%)	Seasonal B (*n* = 119) *N* (%)	p-Value
Sex			
Male	310/785 (39.5)	45/119 (37.8)	0.73
Female	471/785 (60.5)	74/119 (62.2)	
Age			
Median (Range)	17.3 (1 month–89 years-old)	19.9 (2 months–62 years-old)	0.049
Age groups			
0–23 months	125/776 (16.1)	12/114 (10.5)	<0.001
2–4 years-old	62/776 (8)	29/114 (25.4)	
5–18 years-old	229/776 (29.5)	70/114 (61.4)	
19–50 years-old	295/776 (38)	3/114 (2.6)	
>50 years-old	65/776 (8.4)	0/114 (0)	
Clinical signs			
Fever	684/755 (90.6)	104/117 (88.9)	NS
Cough	662/756 (87.6)	100/117 (85.5)	NS
Rhinorrhoea	479/756 (63.4)	90/117 (76.9)	0.004
Asthenia	396/756 (52.4)	74/117 (63.2)	0.03
Pharyngitis	373/756 (49.3)	63/117 (53.8)	NS
Myalgia	348/756 (46)	70/117 (59.8)	0.005
Headache	297/756 (39.3)	58/117 (49.6)	0.03
Shortness of breath	205/756 (27.1)	23/117 (19.7)	NS
Arthralgia	205/756 (27.1)	43/117 (36.8)	0.03
Vomiting	139/756 (18.4)	21/117 (17.9)	NS
Abdominal pain	103/756 (13.6)	9/117 (7.7)	0.07
Conjunctivitis	97/756 (12.8)	23/117 (19.7)	0.04
Diarrhoea	60/756 (7.9)	5/117 (4.3)	NS
Adenopathy	52/756 (6.9)	7/117 (6.0)	NS
Risk factors			
Children <1 year-old	57/260 (21.9)	NA	NA
Chronic respiratory disease	56/259 (21.6)	NA	NA
Pregnancy	48/267 (18)	NA	NA
Diabetes	24/259 (9.3)	NA	NA
Congenital heart disorder	11/259 (4.2)	NA	NA
Immunodeficiency	10/259 (3.9)	NA	NA
Obesity	9/269 (3.5)	NA	NA
Cardiac insufficiency or severe valvular disease	8/259 (3.1)	NA	NA
Cystic fibrosis	6/259 (2.3)	NA	NA
Nephrotic syndrome	5/259 (1.9)	NA	NA
Bronchopulmonary dysplasia	5/259 (1.5)	NA	NA
Sickle cell anaemia	3/259 (1.2)	NA	NA
Severity signs			
Badly tolerated clinical symptoms	35/81 (43.2)	NA	NA
Co-infection (confirmed or suspected)	22/81 (27.2)	NA	NA
Acute respiratory distress syndrome	19/81 (23.5)	NA	NA
Pre-existing illness failure	11/81 (15.6)	NA	NA
Neurological complication	8/81 (9.9)	NA	NA
Cardiac complication	5/81 (6.2)	NA	NA
Under respiratory assistance	2/81 (2.5)	NA	NA
Multi-organ failure	1/81 (1.2)	NA	NA
Hospitalization			
Hospitalized patients	282/653 (43.2)	22/91 (24.2)	<0.001
Hospitalization in an intensive care unit	24/282 (8.5)	1/91 (1.1)	0.01
Severe cases[a]	25/282 (8.9)	1/91 (1.1)	0.01
Cured	17/25	1/1	
Died	6/25	0/1	
Still hospitalized	2/25	0/1	
Curative treatment			
Oseltamivir	208/327 (63.6)	24/35 (68.6)	NS

NA, non applicable; NS, not significant.
[a]Patient who was admitted to an intensive care unit or died.

was known, 218 (66%) received oseltamivir. Seasonal influenza vaccinations in 2008 were reported by 19/681 patients (2.8%). Co-infection with influenza B virus was diagnosed in 16 patients. Forty-nine cases were pregnant women. Of 42 for whom hospitalization status was known, 21 (50%) were hospitalized, including one in an ICU. Among 40 pregnant women for whom the underlying medical condition was known, three (7.5%) had other co-morbidities.

Hospitalized patients (Table 2)

Of the 653 patients with confirmed influenza A(H1N1)2009 infection for whom hospitalization status was known, 282 (43%) required hospitalization. The median age of these patients was 18.9 years (range, 2 months to 89 years). The median time from the onset of illness to hospital admission was 1 day (range, 0–17 days). Of the 180 patients for whom the underlying medical condition was known, 117 (65%) had at least one condition, including 54% of children <18 years

TABLE 2. Characteristics of hospitalized patients who were not admitted to an intensive care unit (ICU) and survived and patients who were admitted to an ICU or died, Réunion Island, 2009

Characteristics	Patients who were not admitted to an ICU and survived (*n* = 258) *N* (%)	Patients who were admitted to an ICU or died (*n* = 25) *N* (%)	p-Value
Sex			
Male	94/258 (36.4)	11/25 (44)	0.45
Female	164/258 (63.6)	14/25 (56)	
Age			
Median (Range)	17.9 (2 months- 89 years-old)	39.1 (4 months- 78 years-old)	<0.001
Age groups			
0–23 months	64/258 (24.8)	2/25 (8)	0.005
2–4 years-old	15/258 (5.8)	0/25 (0)	
5–18 years-old	55/258 (21.3)	6/25 (24)	
19–50 years-old	89/258 (34.5)	7/25 (28)	
>50 years-old	35/258 (13.6)	10/25 (40)	
Risk factors			
Children <1 year-old	31/108 (28.7)	1/25 (4)	0.01
Pregnancy	20/110 (18.1)	1/25 (4)	NS
Asthma or Chronic respiratory disease	17/108 (15.7)	10/25 (40)	0.01
Diabetes	13/108 (12)	4/25 (16)	NS
Congenital heart disorder	6/108 (5.55)	0/25 (0)	NS
Cardiac insufficiency or severe valvular disease	5/108 (4.6)	4/25 (16)	NS
Immunodeficiency	4/108 (3.7)	1/25 (4)	NS
Obesity	3/108 (2.7)	1/25 (4)	NS
Bronchopulmonary dysplasia	2/108 (1.85)	0/25 (0)	NS
Sickle cell anaemia	2/108 (1.85)	0/25 (0)	NS
Nephrotic syndrome	1/108 (0.9)	0/25 (0)	NS
Others	12/108 (11.1)	10/25 (40)[a]	NA
Severity signs			
Badly tolerated clinical symptoms	23/58 (39.6)	25/25 (100)	NA
Co-infection (confirmed or suspected)	13/58 (22.4)	11/25 (44)	0.047
Acute respiratory distress syndrome	11/58 (19)	17/25 (68)	<0.001
Pre-existing illness failure	7/58 (12.1)	11/25 (44)	0.003
Neurological complication	7/58 (12.1)	4/25 (16)	NS
Cardiac complication	3/58 (5.2)	3/25 (12)	NS
Under respiratory assistance	1/58 (1.7)	8/25 (32)	0
Multi-organ failure	0/58 (0)	4/25 (16)	0.01
Others	10/58 (17.2)	2/25 (4)[b]	NA
Antiviral treatment			
Any	73/152 (48)	19/19 (100)	
≤2 days after onset of symptoms	39/144 (27.1)	0/19 (0)	
Days (median) from onset of symptoms to initiation (Range)	1 (0–34)	8 (3–16 days)	<0.001

NA, non applicable; NS, not significant.
[a]Chronic high blood pressure (*n* = 7), encephalopathy (*n* = 2), Hodgkin's disease (*n* = 1), adrenal insufficiency (*n* = 1), epilepsy (*n* = 1).
[b]Encephalitis (*n* = 1), disseminated intravascular coagulation (*n* = 1).

and 46% of adults; 10.6% had at least two conditions. The hospitalization rate for influenza A(H1N1)2009 was 30/10 000 during the epidemic.

Severe and fatal cases (Table 2)

A total of 25 patients with severe infection (admission to an ICU or death) were reported. Of the 282 hospitalized patients, 24 (8.5%) were admitted to an intensive care unit (ICU) and seven died (six in an ICU and one in a medical ward). The median age of the 25 severe cases was 39.1 years (range, 4 months to 78 years) and sex ratio M/F was 0.8. Of the 25 severe cases, 19 (76%) had an underlying medical condition. Of the 24 patients admitted to an ICU, 13 (54%) had acute respiratory distress syndrome (ARDS), 15 required mechanical ventilation and three required Extra Corporeal Membrane Oxygenation (ECMO). Among these severe patients, the median time from the onset of illness to the initiation of antiviral therapy was 8 days (range, 3–16 days). The hospitalization rate in an ICU (*n* = 24) using the estimated total number of persons infected with A(H1N1)2009 virus as denominator (*n* = 104,067) was 2.3/10 000.

Of the 282 hospitalized patients, seven (2.5%) with a laboratory-confirmed influenza A(H1N1)2009 virus infection died. Six had been admitted to an ICU and required mechanical ventilation, including two who required ECMO. The median age of the seven fatal cases was 32 years (range, 5–78 years).

They included four women (5, 18, 28 and 78 years old) and three men (32, 54 and 69 years old). Six of these patients presented with an underlying medical condition, including chronic cardiac insufficiency (*n* = 3), chronic respiratory disease (*n* = 2), diabetes mellitus (*n* = 2), malignant haemopathy (*n* = 1) and congenital encephalopathy (*n* = 1). The seventh patient was a 32-year-old man with no identified underlying medical condition who had chronic alcohol consumption without liver dysfunction. The median time from the onset of illness to death was 16.5 days (range, 7–75).

Lethality and mortality

Using these seven laboratory-confirmed influenza A(H1N1)2009 deaths as numerator and the estimated total number of A(H1N1)2009 influenza cases as denominator, the crude fatality rate (CFR) for influenza A(H1N1)2009 was of 0.7/10 000 cases. In addition, health authorities received seven other death certificates mentioning influenza with no laboratory investigation. Using the total of 14 deaths as numerator, the CFR for ARI was 0.7/10 000 cases.

During the study period in 2009, the weekly deaths remained within the expected range of statistical variation. No excess deaths were observed during the epidemic period (week 30–38); the expected number of deaths was 669 whereas 611 deaths were reported. The weekly mean [range] of observed deaths due to all causes was 68 [55–84] (standard deviation 12) vs 74 [72–78] (SD 11) for expected deaths.

Discussion

The first 2009 pandemic influenza A(H1N1) virus was identified on Réunion Island on 5 July 2009 in a traveller returning from Australia; seasonal influenza B virus activity had already been detected. By the end of July, a sustained community pandemic virus transmission had been established. The pandemic virus became the predominant circulating influenza virus on Réunion within 4 weeks following its first detection. Pandemic H1N1 influenza activity peaked during week 35 (24–30 August), 4 weeks after the beginning of the epidemic. The epidemic ended on week 38 and had lasted 9 weeks. During those 9 weeks, an estimated 66 915 persons who consulted a physician were infected by the influenza A(H1N1)2009 virus, giving a cumulative attack rate of 8.26%. Taking into account those who did not consult a physician, the total number of symptomatic infected persons reached 104 067, giving a cumulative attack rate of 12.85%. Our data show that the influenza A(H1N1)2009 outbreak had no impact on overall mortality on Réunion Island.

The epidemiological situation has also been well described in other countries of southern hemisphere [16]. The 4-week delay before the appearance of the pandemic virus was also observed in New Zealand [11]. In South Africa, the first case was detected on week 29 and the peak week was reached on week 32, 3 weeks before the Réunion peak [7]. The pandemic appears to have been remarkably similar in Australia, New Zealand and Réunion [11,17]. Despite considerable geographical and demographical differences between them, the pandemic showed a consistent pattern of infection across these countries [16].

Our results showed that 67.5% of laboratory-confirmed persons were between the age of 5 and 50 years and seem to confirm observations of other studies [1]. The low number of infected persons >50 years is consistent with the hypothesis suggested in other studies that a persistent immunity could protect older people. However, the high proportion of children under 2 years in our study should be considered with caution. Indeed, French authorities recommended special attention to children presenting with ARI symptoms.

Data concerning the number of admissions of pregnant women should also be interpreted with caution. Indeed, health-care providers might be more likely to admit a pregnant woman than a non-pregnant one presenting with similar symptoms, leading to an over representation of pregnant women among hospitalized patients. However, unlike other observations [18], a very limited number of pregnant women were admitted to an ICU (1/24) and none died. This could be explained by knowledge of the potential severity of the disease during pregnancy and early management in hospital.

According to the WHO (conclusion of the meeting at the headquarters of the Pan American Health Organization in Washington, DC on 14–16 October 2009), the risk of severe or fatal illness is highest in three groups: pregnant women, especially during the third trimester of pregnancy, children younger than 2 years of age, and people with chronic lung disease, including asthma. Neurological disorders can increase the risk of severe disease in children. Although the exact role of obesity is poorly understood at present, obesity and especially morbid obesity have been present in a large portion of severe and fatal cases [19]. In our study, vulnerable groups included mainly diabetic persons and those with chronic respiratory disease, including asthma. This could be explained by a relatively high asthma symptom prevalence (21.5% on a 13–14 years population) [20] and a high prevalence of type 2 diabetes (20%) [21] on Réunion Island. On the other hand, our data showed a low proportion of obesity in severely ill patients although a high prevalence of obesity has been described on Réunion Island [21]. In a large US case series of hospitalized patients with 2009 H1N1 virus infection, underlying medical conditions were found in 67% of patients admitted to an ICU, including asthma or chronic obstructive pulmonary disease (in 28%), immunosuppression (in 18%) and neurological disease (in 18%) [22]. In our series, patients who were admitted to an ICU and those who died were older and had a longer time between the onset of illness and the initiation of antiviral therapy compared with patients who were not admitted to an ICU. These results confirm those of the US study [22].

The cumulative incidence of hospitalization and cumulative incidence of death has shown wide variation by country in the southern hemisphere [16]. The cumulative incidence of hospitalization ranged from 2.0 to 31.8 per 100 000 of popu-

lation, and the cumulative incidence of death ranged from 0 to 36.1 per million population. On Réunion, the definitive cumulative incidence of hospitalization was 34.8/100 000 and the mortality rate for A(H1N1) virus infection was 8.6/1 000 000. A report from New Zealand estimated that approximately 7.5% of the population had symptomatic illness, suggesting that 10–15% may have been infected with a CFR <0.01%. On Réunion, a quite similar cumulative symptomatic attack rate of 12.85% was seen with a CFR of 0.7/10 000 cases. The impact of the pandemic in the Réunion population has not been severe and hospitals and health care centres have not been overwhelmed.

Réunion Island is also exposed to seasonal influenza from the northern hemisphere because of its links with continental France. Therefore, a second wave of A(H1N1) 2009 influenza cannot be excluded following the pandemic wave expected in northern hemisphere countries. Thus, ongoing surveillance will continue to detect a second wave of the epidemic and to monitor and characterise potential virus changes. These findings demonstrate the value of using an integrated epidemiological, virological and hospital surveillance programme in order to monitor the scope of an influenza epidemic, identify circulating strains and provide some guidance for public health control measures. These results could provide relevant information for northern hemisphere countries for their own management of their ongoing epidemic and control measures.

Acknowledgements

We are very thankful to all the sentinel network practitioners. We thank all the clinicians for their participation in providing clinical data. We are very grateful to J. C. Desenclos (InVS) for his collaboration on this manuscript.

Transparency Declaration

The work described was funded by the Institut de Veille Sanitaire as part of its surveillance mission; InVS is funded by the French Ministry of Health. The authors declare no conflict of interest.

References

1. Dawood FS, Jain S, Finelli L *et al.* Emergence of a novel swine-origin influenza A (H1N1) virus in humans. *N Engl J Med* 2009; 360: 2605–2615.
2. World Health Organization. *World now at the start of 2009 influenza pandemic*. WHO, Geneva, 2009.
3. Centers for Disease Control and Prevention. Swine influenza A (H1N1) infection in two children – Southern California, March–April 2009. *MMWR Morb Mortal Wkly Rep* 2009; 58: 400–402.
4. Centers for Disease Control and Prevention. Update: novel influenza A (H1N1) virus infection – Mexico, March–May, 2009. *MMWR Morb Mortal Wkly Rep* 2009; 58: 585–589.
5. Centers for Disease Control and Prevention. Outbreak of swine-origin influenza A (H1N1) virus infection – Mexico, March–April 2009. *MMWR Morb Mortal Wkly Rep* 2009; 58: 467–470.
6. World Health Organization. *Pandemic (H1N1) 2009 – update 76*. WHO, Geneva, 2009.
7. Archer B, Cohen C, Naidoo D *et al.* Interim report on pandemic H1N1 influenza virus infections in South Africa, April to October 2009: epidemiology and factors associated with fatal cases. *Euro Surveill* 2009; 14: 12–16.
8. Oliveira W, Carmo E, Penna G *et al.* Pandemic H1N1 influenza in Brazil: analysis of the first 34,506 notified cases of influenza-like illness with severe acute respiratory infection (SARI). *Euro Surveill* 2009; 14: 17–22.
9. Gomez J, Munayco C, Arrasco J *et al.* Pandemic influenza in a southern hemisphere setting: the experience in Peru from May to September, 2009. *Euro Surveill* 2009; 14: 23–28.
10. New South Wales Public Health Network. Progression and impact of the first winter wave of the 2009 pandemic H1N1 influenza in New South Wales, Australia. *Euro Surveill* 2009; 14.
11. Baker MG, Wilson N, Huang QS *et al.* Pandemic influenza A(H1N1)v in New Zealand: the experience from April to August 2009. *Euro Surveill* 2009; 14: 184–189.
12. D'Ortenzio E, Do C, Renault P, Weber F, Filleul L. Enhanced influenza surveillance on Réunion Island (southern hemisphere) in the context of the emergence of influenza A(H1N1)v. *Euro Surveill* 2009; 14: 56–59.
13. Thouillot F, Do C, Balleydier E *et al.* Preliminary analysis of the pandemic H1N1 influenza on Réunion Island (Indian Ocean): surveillance trends (July to mid-September 2009). *Euro Surveill* 2009; 14: 8–11.
14. Pirard P, Vandentorren S, Pascal M *et al.* Summary of the mortality impact assessment of the 2003 heat wave in France. *Euro Surveill* 2005; 10: 153–156.
15. Josseran L, Paquet C, Zehgnoun A *et al.* Chikungunya disease outbreak, Réunion Island. *Emerg Infect Dis* 2006; 12: 1994–1995.
16. Baker M, Kelly H, Wilson N. Pandemic H1N1 influenza lessons from the southern hemisphere. *Euro Surveill* 2009; 14: 3–7.
17. Kelly H, Grant K. Interim analysis of pandemic influenza (H1N1) 2009 in Australia: surveillance trends, age of infection and effectiveness of seasonal vaccination. *Euro Surveill* 2009; 6: 14. 31).
18. Jamieson DJ, Honein MA, Rasmussen SA *et al.* H1N1 2009 influenza virus infection during pregnancy in the USA. *Lancet* 2009; 374: 451–458.
19. World Health Organization. *Clinical features of severe cases of pandemic influenza*. WHO, Geneva, 2009.
20. Ait-Khaled N, Odhiambo J, Pearce N *et al.* Prevalence of symptoms of asthma, rhinitis and eczema in 13- to 14-year-old children in Africa: the International Study of Asthma and Allergies in Childhood Phase III. *Allergy* 2007; 62: 247–258.
21. Favier F, Jaussent I, Moullec NL *et al.* Prevalence of Type 2 diabetes and central adiposity in La Réunion Island, the REDIA Study. *Diabetes Res Clin Pract* 2005; 67: 234–242.
22. Jain S, Kamimoto L, Bramley AM *et al.* Hospitalized Patients with 2009 H1N1 Influenza in the United States, April–June 2009. *N Engl J Med* 2009; 361: 1935–1944.