

Surveillance trends of the 2009 influenza A(H1N1) pandemic in Europe

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We describe the epidemiology and virology of the official length of the 2009 pandemic (68 weeks from April 2009 to August 2010) in the 27 European Union Member States plus Norway and Iceland. The main trends are derived from published literature as well as the analysis and interpretation of data provided to the European Centre for Disease Prevention and Control (ECDC) through the European Influenza Surveillance Network (EISN) and data collected by the ECDC itself. The 2009 influenza A(H1N1) pandemic started in Europe around week 16 of 2009 (although the World Health Organization (WHO) declared only in week 18). It progressed into an initial spring/summer wave of transmission that occurred in most countries, but was striking only in a few, notably the United Kingdom. During the summer, transmission briefly subsided but then escalated again in early autumn, just after the re-opening of the schools. This wave affected all countries, and was brief but intense in most, lasting about 14 weeks. It was accompanied by a similar but slightly delayed wave of hospitalisations and deaths. By the time the WHO declared the pandemic officially over in August 2010 (week 32), Europe had experienced transmission at low level for about 34 weeks.

Objectives

This review article provides a broad epidemiological overview of the entire official period of 68 weeks of the 2009 pandemic, from week 18 (end April) 2009 to week 32 (mid-August) 2010, in the 27 European Union (EU) Member States plus Norway and Iceland (in the following called EU+2). It is linked to a more extensive document developed with the help of national surveillance experts that provides further background on influenza epidemics and pandemics, notably their variability and unpredictability [1]. The review also identifies some initial lessons learnt, especially relating to surveillance needs in a pandemic, as discussed and agreed at the annual expert meeting of the European Influenza Surveillance Network (EISN) held in Sofia, Bulgaria, in June 2010 [2].

Data collection

The main surveillance trends and information presented here are derived from epidemiological analyses of the primary care and virological data (Table 1) reported to the European Centre for Disease Prevention and Control (ECDC)'s European Surveillance System (TESSy) by the European Influenza Surveillance Network (EISN; for more information on this network see: <http://ecdc.europa.eu/en/activities/surveillance/EISN/Pages/home.aspx>). Building on the existing reporting systems, new surveillance mechanisms were developed to meet additional needs for the pandemic, especially of capturing data on severe and fatal cases of influenza (Table 1). These were collected and reported in one of the Weekly Influenza Surveillance Overviews (WISO) published by ECDC during the pandemic [3,4].

Concurrently, epidemic intelligence [5] and targeted science watch methods (experts scan scientific journals and grey literature and summarise significant publications with public health relevance, significant developments or upcoming meetings) were employed to determine, as early as possible, the important parameters needed for risk assessment, adjusting projections and informing counter-measures in areas where the routine EU surveillance systems are less informative.

Early pandemic

Following its emergence in Mexico in March 2009 [6], the pandemic influenza A(H1N1)2009 virus appears to have started circulating in Europe around week 16 of 2009, initially in travellers returning from Mexico, or their direct contacts (Figures 1 and 2). Early on it was clear that this virus met the previously agreed criteria for a pandemic strain (see summary at: http://www.ecdc.europa.eu/en/healthtopics/H1N1/Documents/100503_health_topics_pandemic_definition_of_a_pandemic.pdf). In response to the threat, EU/EEA countries started to submit detailed case-based reports to the ECDC in May 2009, using an ad hoc database hosted on the secure Early Warning and Response (EWRS) platform. The earliest validated date

of onset of a European case was 19 April 2009 (week 16). When country representatives agreed in week 39 that central collection of case-based data was no longer justified, the database contained 11,275 individual records (11,207 of which were laboratory-confirmed) submitted by 28 countries. A detailed analysis of these first cases is available elsewhere [7].

The surveillance data, supplemented by the ECDC epidemic intelligence and targeted science watch activities, helped to quantify the main pandemic parameters resulting in a ‘dynamic scientific risk assessment that was updated 10 times in 2009 as more information became available [8]. For example, the reproductive number R_0 for the infection was estimated with 95% confidence intervals between 1.1 and 1.4 [9] (95% confidence interval) [9], a serial interval between 2.2 and 2.3 days [10], a mean generation time between 2.5 and 3 days [9] and a mean incubation period of 1.5 to 2 days. These figures are consistent with those found for previously circulating influenza strains [9].

There was a paucity of reliable data early on but even so, organisations such as the ECDC and WHO agreed that this was not a severe pandemic. For example, the ECDC interim risk assessment issued on 12 June 2009 [8] concluded:

“The current ECDC threat assessment for Europe is that the new influenza A(H1N1)v virus will continue to spread. Though it seems that most of those infected in the US and in Europe experience a mild and self-limiting infection, this picture is still unclear as there has not been enough transmission to judge the effects, especially in those more at risk.”

The pandemic waves spring/summer and autumn/winter

Following the detection of the initial cases imported from North America into Europe, there was a spring and summer wave of transmission in Europe which affected most countries. Figure 1 shows the weekly percentage of influenza-like illness (ILI) notifications over the total number of reports throughout the whole reporting period, accumulated for all reporting countries. However, the wave and burden on the health services was only striking in very few European countries, especially the United Kingdom (UK) [11,12] and to a lesser extent Spain [13]. Transmission subsided as the summer progressed, in temporal association with the closure of schools [12,14]. However, transmission accelerated again following the re-opening of the schools, this time affecting all countries, as an early autumn/winter wave started around week 43 of 2009 (Figures 1 and 3) and progressed from west to east across the EU. The modal peak week for the 24 countries consistently reporting their sentinel ILI consultations in the season 2009/10 was week 48, 2009 (six countries), as opposed to week 4, 2009 (seven countries) for the previous season 2008/09. In most countries, the autumn/winter wave of disease was short and intense, lasting about 14 weeks and resembling the epidemic curve seen in the 1957 pandemic in Europe [15].

A similar wave of hospitalisations and deaths followed soon after (Figure 4), although these data on deaths and especially hospitalisation are less readily available because surveillance of severe disease attributable to influenza is not routine in most countries. For the whole pandemic period of 68 weeks (week 18, 2009 to week 35, 2010), the EISN experts reported 925,861 cases of ILI (25 reporting countries) and 7,202,014 cases of acute respiratory infections (ARI) (16 reporting countries) attending their clinics. This is just a small proportion of the true number of cases in the

TABLE 1

Data collected for the EU+2 Weekly Influenza Surveillance Overview

Type of data	Includes
Sentinel syndromic surveillance of influenza-like illness (ILI)/acute respiratory infection (ARI)	Subjective assessment of intensity and degree of geographic spread as well as reporting of aggregated cases
Virological surveillance	Laboratory data of the results of tests requested by sentinel physicians, and of tests done on non-sentinel respiratory specimens collected, describing virus type and subtype, the predominant strains, their antigenic and genetic characteristics and antiviral susceptibility
Hospital sentinel surveillance of severe acute respiratory infection (SARI)	Case-based data of the more severe forms of acute respiratory infection including influenza and other causes
Influenza deaths	Both case-based deaths resulting from SARI and aggregated deaths reported by the countries ^a
Qualitative reporting ^b	Planned to become the principle routine data to be collected should surveillance systems become overwhelmed and unable to generate the other data: includes subjective assessment of geographic spread, intensity, trend (as for ILI and ARI above), and impact

EU+2: the 27 European Union (EU) Member States plus Norway and Iceland.

^a This was complemented by active monitoring of official national public health websites for announcements of deaths (see Figure 4).

^b It was not necessary to activate this element.

Source: [3].

FIGURE 1

Percentage of weekly reported sentinel ILI caseload of the overall reports, cumulated for 25 EU+2 countries, week 40, 2008–week 34, 2010

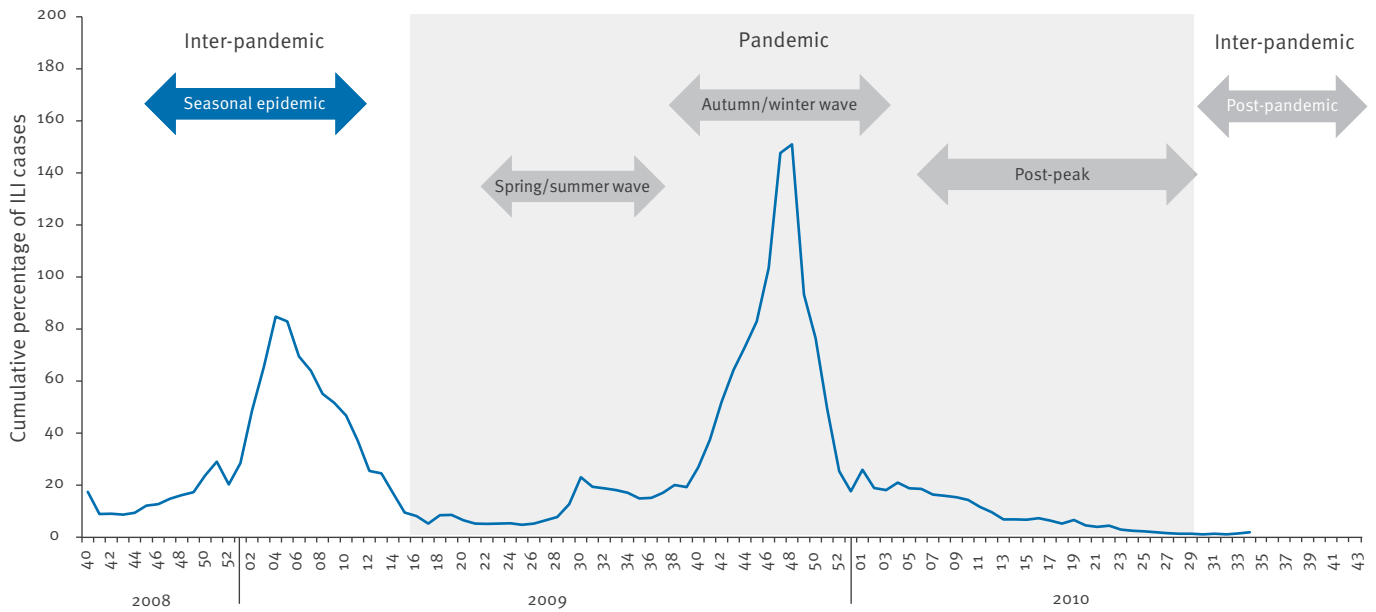
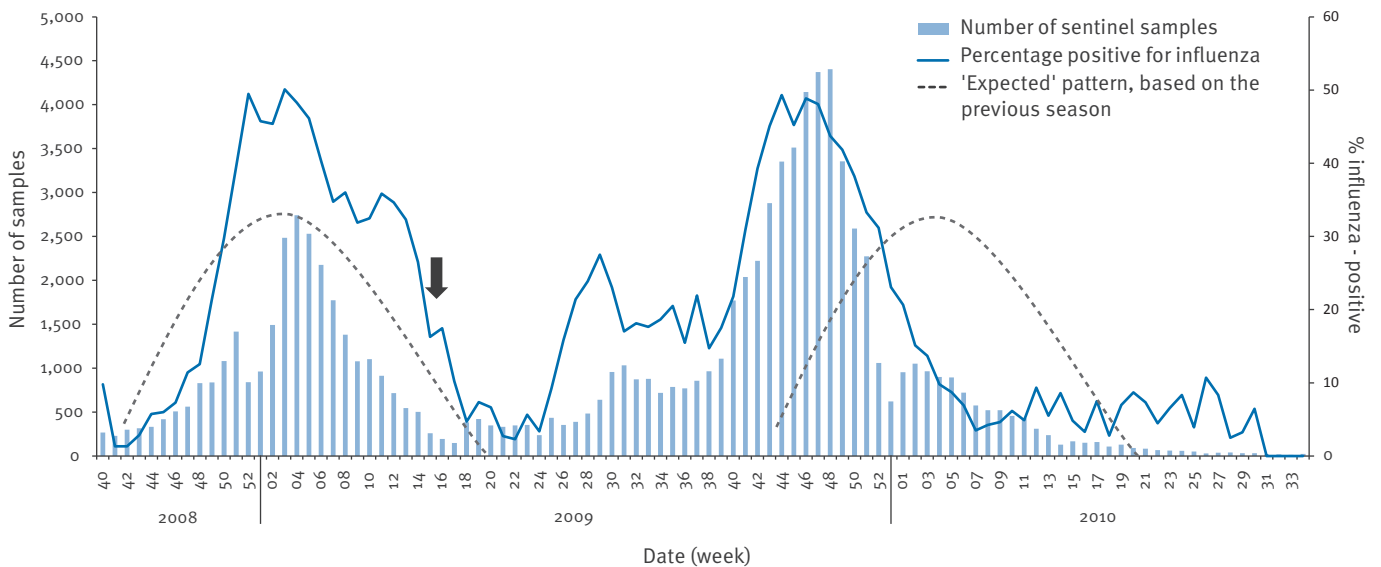


FIGURE 2

Distribution of the number of sentinel samples submitted and the percentage found positive for influenza, 28 EU+2 countries, seasons 2008/09–2009/10



EU+2: the 27 European Union (EU) Member States plus Norway and Iceland.

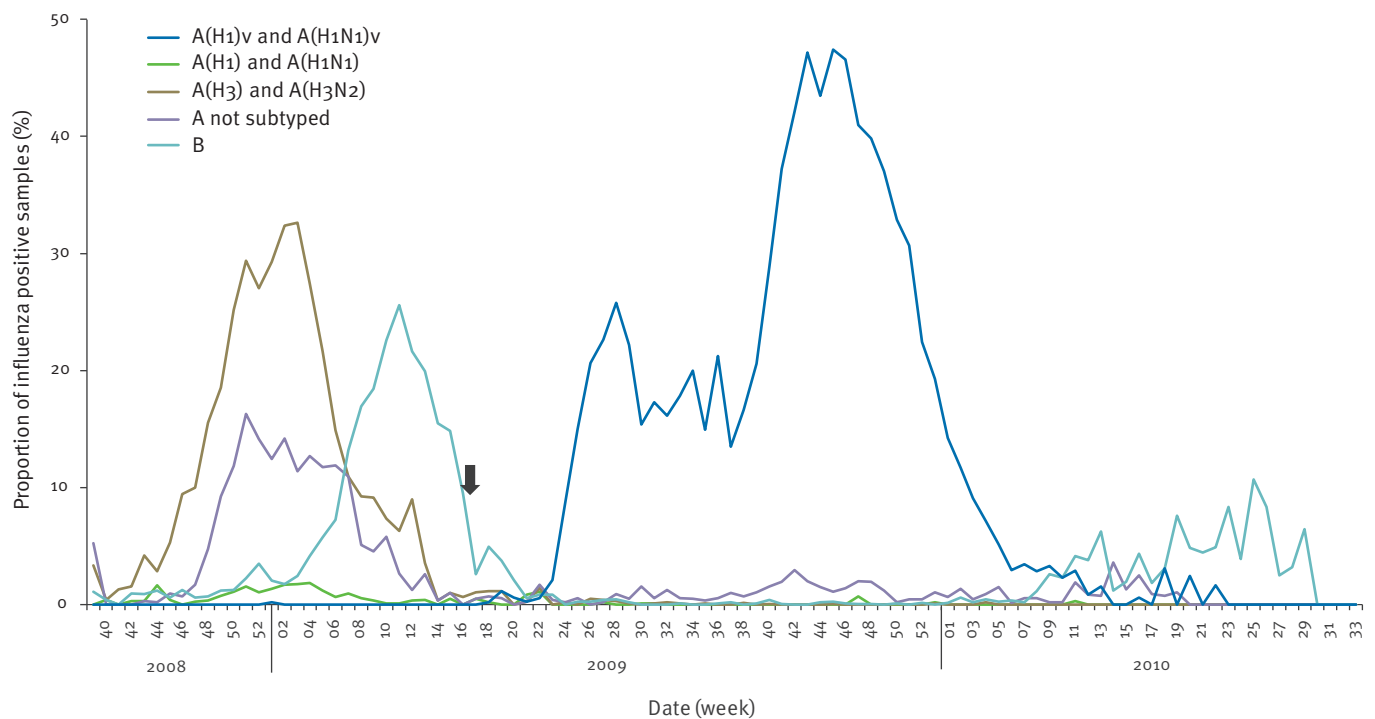
The arrow denotes the probable start of the pandemic in Europe.

Source: European Influenza Surveillance Network (EISN) reports.

Data reported by 28 of 27 plus 2 countries.

FIGURE 3

Distribution of virus types and subtypes detected from sentinel samples, seasons 2008/09 and 2009/10 in 28 EU+2 countries



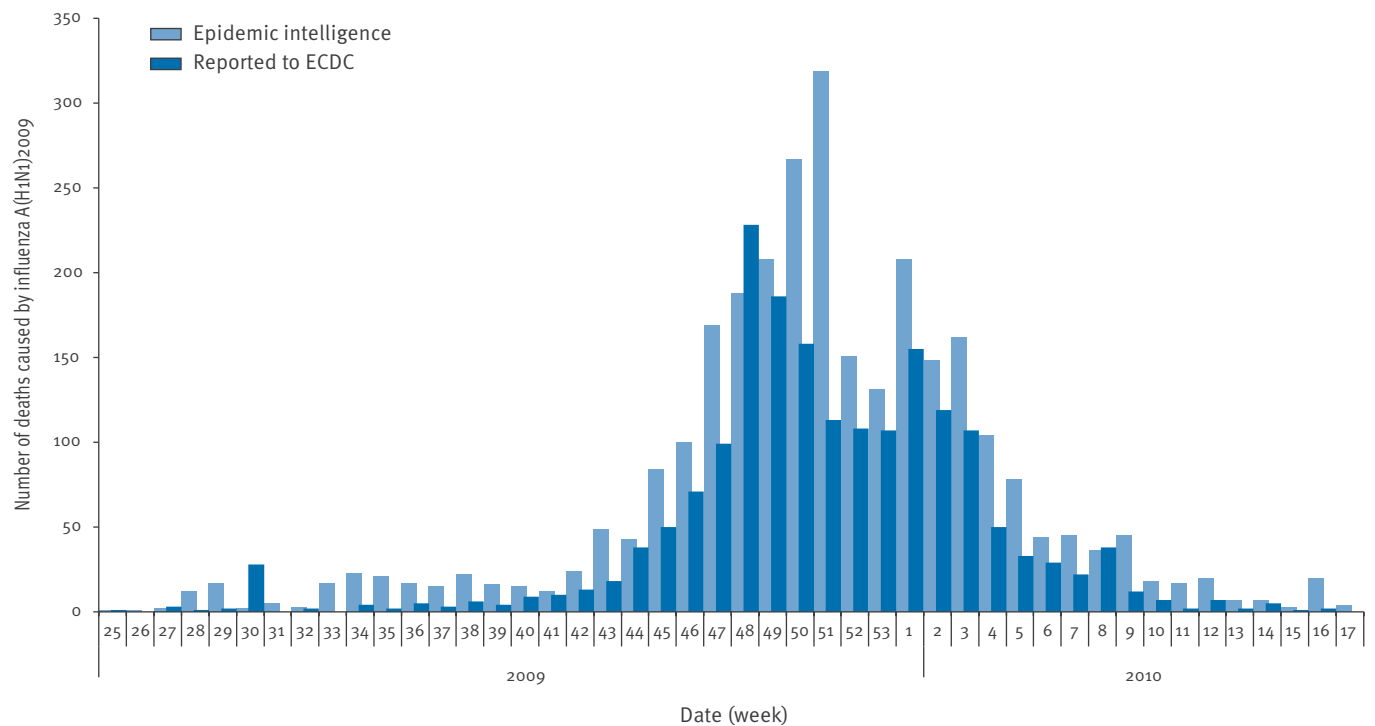
EU+2: the 27 European Union (EU) Member States plus Norway and Iceland.

The arrow denotes the probable start of the pandemic in Europe.

Source: European Influenza Surveillance Network (EISN) reports.

FIGURE 4

Officially announced and reported deaths due to pandemic influenza A(H1N1)2009 in the EU+2, by week of report, season 2009/10



ECDC: European Centre for Disease Prevention and Control; EU+2: the 27 European Union (EU) Member States plus Norway and Iceland.

Source: European Influenza Surveillance Network (EISN) reports and ECDC epidemic intelligence data collected from official national websites.

general population as the network data are collected from sentinel sites and not representative of the general population. Overall rates for the EU/EEA cannot be estimated due to the different denominators used in the different countries.

The sentinel ILI and ARI networks also provide data on a limited number of age groups, but not on sex. All countries showed a consistent age distribution with children under the age of 14 years affected most. The ratio of the four age groups (under 4 years, 5–14 years, 15–64 years and over 65 years) was: 8:5:2:1.

These figures represent only a small proportion of the true attack rate, i.e. those who felt unwell enough to attend a primary care practice that happened to be part of the sentinel reporting system for that country [16], and should only be used to compare with the figures and proportions of similar data collected in a normal influenza season. The proportion of those experiencing illness or infection differed considerably from what was seen outside the pandemic [17] and this is described in more detail elsewhere [1].

There was considerable geographic heterogeneity in the amount of transmission, within Europe and even within countries, especially in the spring/summer wave. While there was transmission in most countries, only Spain and the UK recorded a prevalence of infection high enough to produce substantial numbers of severely affected people [11–13]. Overall attack rates estimated by serology were higher than for seasonal influenza, although the pandemic virus affected fewer older persons (65 years and older), who had been exposed to a similar virus circulating in the 1950s and before [16,18]. There is clear evidence that there were many mild or asymptomatic cases in this pandemic, but whether they were more common than in the previously recorded pandemics is impossible to determine

because it is only in this pandemic that there has been enough accurate seroepidemiology which combined with case reporting allowed such estimates to be made [7,12,17]. Attack rates were highest in young people, with country reports revealing that the highest rates of infection occurred in school-age children [16,18] and some hospital paediatric services and intensive care services were especially stressed [19]. There was also pressure on primary care services in some areas because attack rates exceeded what was normally seen with seasonal influenza. No countries reported any pressure on critical services outside the healthcare sector, which is consistent with the WHO description of the pandemic: *this pandemic, at least in its early days, will be of moderate severity* (statement to the press by WHO Director-General Dr Margaret Chan, 11 June 2009)

Virological surveillance

The pandemic influenza A(H1N1)2009 virus displaced the previously dominant seasonal influenza A virus strains in Europe, although late in both seasons 2008/09 and 2009/10, influenza B viruses were still prevalent enough to cause significant disease (Figures 2 and 3). From week 21, 2009 to week 16, 2010, 60,827 clinical samples were submitted by the sentinel practices reporting to the EISN, of which 25,304 (41.6%) tested positive for influenza virus, almost all for the 2009 pandemic virus.

All pandemic influenza A(H1N1)2009 viruses isolated from samples submitted by the EISN sentinel practices for testing, were found to be resistant to antiviral drugs in the adamantane class, but very few of these samples (2.5%) were found to be resistant to oseltamivir (Table 2). All oseltamivir-resistant strains were accounted for by the presence of the H275Y mutation. Most of these mutations were observed following treatment of immunocompromised patients, and in Europe, resistant virus was only rarely transmitted

TABLE 2

Antiviral resistance by influenza virus type and subtype in samples collected by primary care sentinel networks in the EU+2, week 40, 2008–week 18, 2010 (n=1,454)

Influenza virus type and subtype	Resistance to neuraminidase inhibitors								Resistance to M2 inhibitors			
	Oseltamivir				Zanamivir				Isolates tested	Resistant n (%)	Isolates tested	Resistant n (%)
	Isolates tested	Resistant n (%)	Isolates tested	Resistant n (%)	Isolates tested	Resistant n (%)	Isolates tested	Resistant n (%)				
	Week 40, 2008–week 39, 2009		Week 40, 2009–week 18, 2010		Week 40, 2008–week 39, 2009		Week 40, 2009–week 18, 2010		Week 40, 2008–week 39, 2009		Week 40, 2009–week 18, 2010	
A(H3N2)	653	0	0	0	612	0	0	0	644	644 (100)	0	0
A(H1N1)	260	256 (98)	0	0	260	0	0	0	124	1 (1)	0	0
A(H1N1)v	424	0	1,453	37 (2.5%)	415	0	1,447	0	56	56 (100)	205	205(100%)
B	117	0	0	0	113	0	0	0	NA	NA	NA	NA

EU+2: the 27 European Union (EU) Member States plus Norway and Iceland; NA: not applicable, as M2 inhibitors do not act against influenza B viruses.

Source: European Influenza Surveillance Network (EISN) and Influenza Community Network of Reference Laboratories (CNRL) data in the European Centre for Disease Prevention and Control (ECDC)/European Surveillance System (TESSy).

from one human to another unlike the seasonal influenza A(H1N1) virus with the same mutation, which is readily transmitted [20]. Although the viruses circulating during the pandemic were not identical, there is little evidence of significant drift or the emergence of dominant new variants to date [21]. A previously observed influenza A(H1N1)2009 variant with a D222G mutation has been associated with more severe disease, but it is still unclear whether this is due to a higher pathogenicity or a tropism for cells in the lower respiratory tract [21].

Mortality, severe disease and risk groups

In total, 2,900 pandemic deaths were announced by Member States in the first 12 months (Figure 4). This is probably only a proportion of the true burden of deaths due to the pandemic, but it remains unclear what that proportion is for Europe overall or for individual countries [22,23]. Pooling data from eight pilot countries, the EU-funded project European Monitoring of Excess Mortality for Public Health Action (EuroMOMO) detected excess all-cause mortality only in the 5-14 year-olds in the period between weeks 27 and 51 of 2009, compared with mortality in the previous three years. This estimate is probably conservative due to delays in reporting [24].

Before the autumn/winter wave of the pandemic, the EISN attempted to establish hospital-based sentinel surveillance of severe acute respiratory infection (SARI) cases, although this met with limited success [25]. During the autumn/winter wave, i.e. from week 36, 2009 to week 20, 2010, 11,904 SARI cases and 586 SARI-related fatalities were reported to ECDC by eleven EU countries (Austria, Belgium, Cyprus, Finland, France, Ireland, Malta, the Netherlands, Romania, Slovakia and the United Kingdom, France only reported pandemic influenza A(H1N1)2009 cases admitted to intensive care units) [1]. Information on those with severe disease can be ascertained partially from this data and also from focused studies in EU Member States [13,26].

Building on these findings, the EU Health Security Committee defined pregnant women, those over six months of age with chronic ill health and healthcare workers as the primary risk groups that should be offered immunisation against pandemic influenza [27,28]

Differences between the pandemic and seasonal influenza

The pandemic differed from the preceding influenza season in a number of ways (Table 3). Most notable was the difference in the age of those most severely affected. Previously, were concentrated persons aged 65 years and older accounted for 90% of deaths from seasonal influenza [29,30]. In the 2009 pandemic, nearly 80% of the deaths reported to ECDC occurred in persons under 65 years [25], probably because a sizeable proportion of older adults were protected by prior

exposure to a similar influenza virus that had been circulating before the mid-1950s [16,18]. However, not all those older than 64 years were immune, and those without immunity who were infected had the highest case fatality rate of all age groups [25,31]. While the majority of deaths occurred in persons with chronic medical conditions, especially respiratory and neurological conditions, between 20% and 30% of the deaths reported in studies occurred in previously healthy individuals [31]. A considerable proportion of deaths were caused by acute respiratory distress syndrome (ARDS, mortality rate in 612 ARDS patients: 24.5% [25]), an extremely rare condition that is difficult to treat and that requires high dependency support for several weeks [32,33]. One of the reasons may have been that the new virus has shown a tropism for receptors found in the alveolar epithelium of the lungs [33].

Serological data

To date, there has been only limited data from serological surveys. These support the surveillance data indicating high infection rates, but they also suggest higher than expected levels of asymptomatic infection [16,39]. While the serological findings do not allow reliable predictions for the influenza season 2010/11, the experience of the temperate countries in the southern hemisphere during the European summer period of 2010 would probably provide some valuable clues.

Conclusions

The pandemic influenza A(H1N1) 2009 virus started circulating in Europe around week 16 of 2009 (although the declared phase 5 only in week 18). It progressed into an initial spring/summer wave of transmission which occurred in most countries, but was striking only in a few, notably the UK. As the summer advanced, transmission briefly subsided, but then escalated again in the early autumn, just after the re-opening of the schools, this time affecting all countries. This autumn/winter wave was seen to progress from west to east across the continent. In most countries, this second wave of infection was brief but intense, lasting about 14 weeks, and was accompanied by a similar but slightly delayed wave of hospitalisations and deaths. By the time the WHO declared the pandemic officially over in August 2010 (week 32, 2010), the EU+2 had experienced transmission at a very low level for about 34 weeks.

An excess of all-cause deaths in school-age children was observed. Even though this was an influenza virus never seen previously, prior exposure to an antigenically similar influenza virus circulating before the mid 1950s meant that many older people in Europe exhibited some immunity. Although many older people appeared to be protected, persons over the age of 65 years still had the highest case fatality rate of any age group.

The pandemic virus displaced the previously dominant seasonal influenza A viruses in Europe, although influenza B viruses continued to appear at a low level late in the seasons. Few pandemic viruses were resistant

to oseltamivir, and of these, very few seemed capable of human-to-human transmission. Although the pandemic viruses are not identical, there is little evidence of significant drift or the emergence of dominant new variants to date. One variant, influenza A(H1N1)2009-D222G has been associated with more severe disease, but a causative relationship has yet to be established.

Serological data suggest that there were a higher proportion of mild and asymptomatic infections than in the preceding influenza seasons. Nevertheless, transmission rates were higher than for seasonal infection and there were sufficient amounts of severe disease and notably cases of ARDS, which put a strain on intensive care services in many places. Young children

(under five years of age) experienced the highest rates of disease, while country reports and serology indicate that the highest rates of infection (including asymptomatic) were in children at school age. These high rates of illness presented a particular burden for primary services, hospital paediatric services and especially intensive care in some areas.

Pandemic planning will now need to be revisited as the occurrence of this pandemic does not exclude the possibility of an influenza A(H5) or (H7) pandemic emerging in the future. The next generation of plans need to include more flexibility for reacting to different severity of disease and different combinations of epidemiological parameters. In this context it would be useful to reach

TABLE 3
Comparing influenza seasons 2000/01–2008/09 with 2009 pandemic influenza

	Seasonal influenza 2000/01– 2008/09	2009 pandemic influenza
Circulating influenza viruses	Two influenza A viruses: A(H1N1) and A(H3N2), and some influenza B viruses; the mix varies with the season	Almost exclusively the pandemic influenza A(H1N1)2009, a few influenza A(H3N2) viruses and increasing numbers of influenza B viruses towards the end of the season
When waves occurred	In season, in recent years most often starting after Christmas	Started out of season with a spring/summer wave, then an early autumn/winter wave in Europe
Levels of transmission	Variable from year to year, with local heterogeneity, but estimated to be 5–15% annually	Hard to estimate, local heterogeneity, estimated to be over 15% through serological studies in New Zealand [34] and in the United Kingdom [16]
Setting for transmission	Probably any setting where people come together	Schools considered especially important, along with household transmission
Experiencing severe disease	Those in clinical risk groups and older people	Young children, pregnant women and those in clinical risk groups; about 30% with severe disease were outside risk groups; many born before the mid-1950s were immune, but people in this age group who were not immune experienced severe disease outcomes [31]
Premature deaths	Around 90% considered to have occurred in people 65 years or older	In confirmed reported deaths, around 80% were under 65 years of age Increase in all-cause deaths in children detected across eight EU countries by EuroMOMO system[24]
Mortality and years of potential life lost	Few confirmed deaths reported each year in official statistics; estimates of up to 40,000 in a bad year using statistical methods	Substantial numbers of confirmed deaths announced by EU+2 Member States (n=2,900, Figure 4) but recognised to be an underestimate Only estimated in one EU Member State (the Netherlands, 35 disability-adjusted life years per 100,000 population) [35], but estimated in the United States with considerably higher levels [36]
Acute respiratory distress syndrome	Extremely rare	Uncommon, but recorded in many countries, even in young fit adults; partially explained by the tropism of the pandemic virus for epithelial receptors that predominate in the alveoli of the lung, while the previous seasonal viruses bind best to receptors found predominately in the upper airways [33]
Pathological findings	Viral pneumonia rare, but secondary bacterial infections more common in fatal cases	Fatal viral pneumonias relatively common with alveolar lining cells, including type I and type II pneumocytes the primarily infected cells; more than 25% of fatalities also involved bacterial infections [33,37]
Antiviral resistance	Common and transmissible oseltamivir resistance in influenza A(H1N1) emerged in season 2007/08 [38]	Observed most often following antiviral treatment of susceptible individuals; however, as of July 2010, only transmitted very rarely under certain circumstances [33]; resistant seasonal influenza A(H1N1) seemingly displaced by the new influenza, at least for now

ECDC: European Centre for Disease Prevention and Control; EU: European Union; EU+2: the 27 European Union (EU) Member States plus Norway and Iceland; EuroMOMO: project European Monitoring of Excess Mortality for Public Health Action; WHO: World Health Organization. This table lists ten characteristics in which the new pandemic influenza differs from the 'old' seasonal influenza, especially as they appeared in more recent years (seasons 2000/01–2008/09).

Source: http://ecdc.europa.eu/en/activities/sciadvise/Lists/ECDC%20Reviews/ECDC_DispForm.aspx?List=512ff74f%2D77d4%2D4ad8%2Db6d6%2Dbf0f23083f30&ID=911&RootFolder=%2Fen%2Factivities%2Fsciadvise%2FLists%2FECDC%20Reviews

a European consensus on describing and assessing the severity of a pandemic, and matching the response with the different scales and characteristics. These plans must also provide for the consolidation and sustainability of the influenza surveillance systems that were introduced to meet the demands of the 2009 pandemic, in particular SARI, attributable mortality, and seroepidemiological surveillance. This surveillance work needs to be prioritised, given the right level of resources and allowed to develop and be tested during the inter-pandemic period so that the systems will be more resilient and effective in a future public health crisis.

At an early stage, it was appreciated that this pandemic was much less severe than what many European countries had feared and prepared for. This was highlighted in the first ECDC Risk Assessments (available at: http://ecdc.europa.eu/en/healthtopics/H1N1/risk_threat_assessment/Pages/risk_threat_assessment.aspx), WHO reports and briefings given by ECDC to national and European authorities. With low rates of absenteeism, there was also little impact on services outside the health sector. In conclusion this pandemic was a mild one for Europe [40], testing the flexibility of existing preparedness plans in many countries. The greatest challenge during this pandemic was in the area of risk communication, as both the professionals and the general population expected something more severe [41].

The pandemic occurred at a time when diagnostic tests could be made available quickly, as well as preventive pharmaceutical countermeasures (antiviral drugs for a virus with little resistance to the neuraminidase inhibitors but almost complete resistance to the older adamantanes) and when appropriate vaccines were developed and made available faster than ever before. The occurrence of cases of ARDS when many intensive care units were already busy put particular pressure on the system without the ability to redeploy hospital staff internally, even though the rest of the hospitals were not that stressed [33]. The rapidly produced pandemic vaccines showed such a good immunological response that several formulations only required a single dose in adults [42]. They have also proved to be effective and relatively safe [42], although post-marketing surveillance still needs to be maintained to determine exactly how safe they are and to investigate initial signals of adverse events following immunisation (AEFIs) [43]. There were still delays in the production of vaccines, so that even countries with advance purchase agreements received too little vaccine too late to have any real impact at the population level. However, the high vaccine efficacy and targeting of risk groups may have saved lives of European citizens. Where vaccines were made available, they were greeted with varying degrees of enthusiasm among health professionals. That these vaccines were not widely accepted was partly due to the difficulty in transmitting the complex risk communication message. On the one hand the chance of severe disease following infection was very low unless the individual belonged to a risk group

(young children, people with chronic ill health and pregnant women [33]). On the other hand, there was a small but real risk of severe disease and death from the pandemic in all healthy persons. The challenge of communicating this risk was considerable.

Limitations of the EU+2 data

The data used here were subject to limitations and the results should be interpreted with a degree of caution. The reported ILI or ARI surveillance data were not comparable between countries as there was variability in the data sources, size and representativeness of the networks. The ILI/ARI epidemic curves were also distorted because several countries, at different points in time, actively recommended that anyone with influenza-like symptoms should stay at home and not approach their primary care provider, (contrary to what the patients would do in a normal influenza season), thus excluding them being reported. In addition, there are indications from specialist studies that the usual patterns of seeking care were distorted during the pandemic and that this varied over time as the perception of risk changed [17].

The virological data are derived from samples sent for laboratory testing and confirmation. They represent only a selected subset of the cases, usually the more severely affected seeking medical help. The sentinel samples were representative of patients attending general practices, while the non-sentinel samples derive from a varying mix of general practitioners' diagnoses not included in the sentinel system and more seriously affected cases that were admitted to hospital. Therefore the non-sentinel data were a mixture of mild and severe cases, which can differ by country. One important aspect of laboratory-based surveillance that was missing at the European level was routine seroprevalence monitoring. Although a few countries carried out local studies that provided valuable information [16,18,44,45], this work was not carried out in a standardised and comparable manner early on in the pandemic. Also, the results were made available too late to be of use and it was not clear if the information they provided could be extrapolated to other countries.

The systems for collecting data on the more severe cases (SARI) or deaths were introduced in response to the pandemic, after the pandemic had already reached Europe. This is not the optimal time to introduce a new system, as the countries' surveillance systems had to adapt or introduce new processes at a time when their resources were already stretched. There seem to be difficulties in capturing data on SARI cases in many European hospitals because it is not a diagnosis recognised by clinicians as it encompasses young children with bronchiolitis, older people with pneumonia and ARDS. Some countries found it easier to collect data on people hospitalised with an influenza diagnosis. Also, there was variability in what different sites reported as SARI as well as in providing reliable estimates of the denominators and the representativeness of the data, shedding doubt on the estimated rates.

Not only reported cases were underestimated, but also deaths due to the 2009 pandemic influenza, especially in the elderly where influenza is known to be frequently masked by other conditions as the underlying cause of death [46]. Presently, only ad hoc studies can attempt to estimate influenza-related mortality more accurately, and while such studies have been done in the United States [47], there have not been any in Europe

New characteristics of the 2009 influenza pandemic

Nevertheless, the EU/EEA surveillance data permit us to conclude on a number of new characteristics of this pandemic (Box), notably the reliance on clinicians to deliver the most powerful countermeasures. Much prominence was given to the doubts expressed by the professionals in some countries on the value of the countermeasures. Moreover, the role of the media in this pandemic was unprecedented and this was not always positive, for example when vaccine opponents and pandemic skeptics were given the same platform as expert opinions.

Lessons learnt for surveillance

The fact that the 2009 influenza A(H1N1) pandemic was less of a threat than what many countries had prepared for, tested the flexibility of existing plans. Nevertheless no country appears to have over-responded, while the systems developed by the European Commission, WHO and ECDC for discussing and sharing information and analyses proved resilient and useful. On balance, the EU+2 managed the response to the pandemic well [49], although this can be further improved. The EISN virological and primary care-based surveillance in particular worked well, and served to augment the data emerging from the ECDC epidemic intelligence and targeted science watch sources. Establishing surveillance in hospitals and sharing analyses from the first affected countries were

Box

New characteristics about the 2009 pandemic in Europe

- The first pandemic with instant communication so that early impressions (such as the experience in Mexico and the Ukraine) were transmitted ahead of any reasonable or thoughtful analysis;
- The first pandemic that took place within the context of a set of International Health Regulations [48] and global governance, although essentially untried;
- The first pandemic with early diagnostic tests which led to rapid diagnosis but also an early overly strong focus by the media and policymakers on the numbers of infected people;
- The first pandemic with antiviral drugs available which led to an expectation that the pandemic might be containable and the invention of a containment phase by some countries
- The first pandemic in which effective countermeasures (antiviral drugs and vaccines) could be provided by clinicians, which meant the confidence of those doctors and nurses had to be earned and retained;
- The first pandemic in a setting with effective intensive care and thus with a (false) expectation that everyone could be treated and cured;
- The first pandemic which received uncontrolled coverage in blogs that policy makers needed to monitor closely.

less successful. It was fortunate that data and analyses were quickly available from North America and the southern hemisphere. Lessons to be learnt include:

- Routine ‘severe end’ surveillance of hospitalised cases and deaths due to severe respiratory infection should be established in Europe.
- In the future, the process for sharing early analyses from the first affected countries can work better, possibly by increasing the faith of expert colleagues in the confidentiality and security of certain communication systems and the discretion of other experts in the country not to pass on provisional data.
- Much work, including research and development, needs to take place to make seroepidemiology available in real time.

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