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Original Article

Post-Pandemic Seroprevalence of 2009 Pandemic Influenza A (H1N1) Virus in Shandong Province, China

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SUMMARY: The purpose of this study was to understand the geographic extent, risk factors, and attack rate of the 2009 pandemic influenza A (H1N1) virus [A(H1N1)pdm09] infection in Shandong Province, China and to identify the influencing factors. A randomized serological survey of A(H1N1)pdm09 infection was carried out in August and September 2010. A total of 4,549 participants involved in the survey had their antibody levels tested by hemagglutination-inhibition assay. The overall seropositive rate for A(H1N1)pdm09 antibodies was 25.85%. The seropositive rate was 25.89% for the unvaccinated group, with statistically significant differences among individuals of different age groups, occupations, and cities. The highest seropositive rate was observed in young children aged 0–5 years and elderly people aged ≥60 years. Multivariate logistic regression revealed that subjects in rural areas had significantly higher odds ratio of A(H1N1)pdm09 seropositivity than those in the capital city. Individuals belonging to all professions, except for teachers, had significantly lower odds ratio of A(H1N1)pdm09 seropositivity compared with children in family care. Our data indicated that almost 26% of the residents in Shandong Province had appropriate antibody titers against A(H1N1)pdm09. This seroepidemiology study provides valuable data for understanding the epidemiology of the 2009 pandemic influenza and for planning future intervention strategies; moreover, it highlights the significance of seroprevelance studies.

INTRODUCTION

The 2009 pandemic influenza A (H1N1) virus [A(H1N1)pdm09] was initially identified in Mexico and the United States over March and April of 2009. It was subsequently transmitted in communities across North America within weeks and identified in many areas of the world by May 2009 (1–5). On June 11, 2009, the World Health Organization (WHO) declared a global pandemic (6). Worldwide transmission of A(H1N1)pdm09 continued, and most countries experienced one or two epidemic waves before the end of the pandemic (7–10). As of August 10, 2010, WHO declared that the influenza A pandemic had ended; more than 206 countries and overseas territories or communities had reported laboratory-confirmed cases of A(H1N1)pdm09, and there were over 6,250 deaths. In Shandong Province, China, the first laboratory-confirmed case was identified on May 12, the first severe case was reported on September 23, and the first fatal case was reported on November 16. As of August 31, 2010, a total of 4,034 laboratory-confirmed A(H1N1)pdm09 cases and 231 laboratory-confirmed severe cases were reported to the Shandong Center for Disease Prevention and Control, and 50 patients with severe infection died. The main wave of the pandemic occurred in weeks 41 to 52 of 2009. In response to the influenza pandemic, a free vaccination program was implemented in Shandong Province starting in October 2009.

If corrected for vaccination status, data from seroprevalence studies of antibodies against A(H1N1)pdm09, performed after the pandemic (August 10, 2010), allow for a much better estimation of the cumulative incidence of A(H1N1)pdm09 infections than case surveillance data (11). A seroepidemiololgy study was performed from August 20, 2010 to September 10, 2010 to better understand the population's immunity against A(H1N1)pdm09 in Shandong Province after the pandemic and to investigate factors influencing the risk for seropositivity. Moreover, this may provide useful information for national public health authorities in preparing for future influenza outbreaks.

MATERIALS AND METHODS

Epidemiology survey and speciman collection: The cross-sectional studies were conducted in August and September of 2010. Multistage stratified random sampling methods were used for subject selection. There are 17 districts in Shandong Province. For this study, two city districts and one countryside district were randomly selected from different geographic locations using a random digits table. The remainder of the multistage random sampling method was carried out by each district.

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The method was carried out according to the method used by Xu et al. (12).

Informed consent was obtained from study participants or guardians. The survey questionnaire included the subject's age, gender, type of residence, family members (whether they had children in school), history of respiratory tract infections, presence/absence of influenza-like symptoms, and vaccination history of both seasonal influenza (from 2007 to 2009) and pandemic H1N1; the questionnaire was completed by a trained interviewer and the blood samples were collected.

This study was approved by the institutional ethics review board at Shandong Center for Disease Control and Prevention.

Laboratory testing: The hemagglutination-inhibition (HI) assay using 0.5% turkey erythrocytes was used to test the serum for antibodies against A(H1N1)pdm09, according to standard protocols (13,14), with the A/California/07/2009 virus as the A(H1N1)pdm09 antigen. Serum samples were titrated in 2-fold dilutions in phosphate-buffered saline and tested at an initial dilution of 1:10. The titrations (≥1:40) were used as a marker for immunity against A(H1N1)pdm09 in this study. For assessing the within-laboratory reproducibility, 5% of serum samples randomly selected from all samples was tested.

Statistical analysis: EpiData software was used to develop the data set. Statistical analyses were performed with SPSS 17.0 software (SPSS Inc., Chicago, Ill., USA). The seropositive rates in the different groups were compared by the χ^2 test or Fisher's exact tests. The multivariate logistic regression model was used to investigate the potential correlative factors that influenced the frequency and distribution of A(H1N1)pdm09 antibodies in different groups. The significance level for entering the multivariate logistic regression model was set as 0.05, and the level for staying in the model was 0.05. A P value of <0.05 was considered to be statistically significant.

RESULTS

General information of the study subjects: In August and September of 2010, we enrolled 4,549 subjects in the cross-sectional study. All participants completed both the questionnaire and blood sample collection. There were no statistically significant differences in the distribution of the data by age group, gender, region, and community setting (capital city, urban area, or rural area) between the study subjects and the true Shandong Province population. Among the subjects, 2,099 (46.14%) reported a history of cold symptoms since May 1, 2009. There were 405 (8.9%) subjects who reported receiving the pandemic H1N1 vaccine as compared to 4,144 (91.10%) who reported not receiving the pandemic H1N1 vaccine in the study. Among the unvaccinated participants, 43.58% were kindergarten children or students, 3.43% were children in family care, 2.44% were teachers, doctors, or nurses, 18.89% were farmers, and 31.66% belonged to other professions. The detailed demographic characteristics of the subjects are listed in Table 1.

Pandemic H1N1 seropositive rate in the study subjects: In the post-pandemic period, 1,176 of the 4,549 study subjects were positive for antibodies (HI titer, ≥1:40) against A(H1N1)pdm09; the seropositive rate was 25.85% (95% confidence interval [CI], 24.58%–27.12%). Antibody titers ranged from <1:10 to 1:1,280. Table 1 shows the distribution of the seropositive rates in various age groups in the total study group. The highest seropositive rate was observed in the 0–5 years age group. The partition of χ^2 test was used to compare the differences among the different age groups, and a significant difference was found among these five groups based on a seropositive rate ($\chi^2 = 43.16$, $P < 0.01$). The seropositive rate of A(H1N1)pdm09 antibody response for the subjects who reported receiving vaccine was 25.43% (95% CI, 21.19%–29.69%), which was the same as that for subjects who did not report receiving the vaccine 25.89% (95% CI, 24.56%–27.22%) ($\chi^2 = 0.002$, $P > 0.05$). The detailed seroprevalence of A(H1N1)pdm09 is listed in Table 1.

Among the unvaccinated study population, the seropositive rates in various age groups ranged from 20.92% to 33.76% with the highest proportion seen in the 0–5 years age group; however, the seropositive rates varied greatly between age groups ($\chi^2 = 48.11$, $P < 0.001$). The seropositive rates for the male and female groups among the unvaccinated study population were 27.13% and 24.99% ($\chi^2 = 2.42$, $P = 0.120$), respectively. Furthermore, among the unvaccinated subjects, the seropositive rate in rural areas (34.29%) was statistically significantly higher than the seropositive rates in the capital city (22.02%) and other urban cities (21.93%) ($\chi^2 = 71.10$, $P < 0.001$) (Table 1). In addition, different occupational groups displayed significant variation in their seropositive rates ($\chi^2 = 132.22$, $P < 0.001$), with children in family care having the highest rate of 47.89%, followed by teachers with 36.84%, farmers with 34.23%, and kindergarten children with 31.75%. Except for fever, history of cold and cough symptoms since May 1, 2009 was not associated with increased risk for seropositivity ($\chi^2 = 4.58$, $P = 0.032$).

To control for possible interactions between factors, multivariable logistic regression was used to estimate the odds ratio (OR) and 95% CI for factors associated with A(H1N1)pdm09 antibody response among subjects who had not received the pandemic H1N1 vaccine (Table 2). The OR of seropositivity to A(H1N1)pdm09 infection for rural areas (OR, 1.427; 95% CI, 1.154–1.765) were statistically significantly higher than the OR of infection in the capital city. There was no statistically significant difference in the OR of infection between urban areas (OR, 0.962; 95% CI, 0.794–1.166) and the capital city. Kindergarten children (OR, 0.566; 95% CI, 0.389–0.823), students (OR, 0.334; 95% CI, 0.231–0.481), farmers (OR, 0.527; 95%CI, 0.366–0.758), factory workers (OR, 0.362; 95% CI, 0.209–0.626), retirees (OR, 0.423; 95% CI, 0.256–0.701), and subjects with other occupations (OR, 0.275; 95% CI, 0.187–0.406) had significantly lower OR of A(H1N1)pdm09 seropositivity than children in family care. The OR of seropositivity were not statistically different by symptom (fever) (Table 2).

Table 1. Characteristics and seroprevalence of the study population of the cross-sectional survey, 2010

Demographic characteristic	Total study subjects			Unvaccinated subjects			
	No. (%) of sample tested (n = 4,549)	No. (%) of positive (n = 1,176) (25.85%)	95% CI	No. (%) of sample tested (n = 4,144)	No. (%) of positive (n = 1,073) (25.89%)	95% CI	P[1)]
Age group (yr)							
0–5	897 (19.72)	297 (33.11)	30.03–36.19	868 (20.95)	293 (33.76)	30.61–36.90	
6–15	904 (19.87)	200 (22.12)	19.42–24.83	717 (17.30)	156 (21.76)	18.74–24.78	
16–24	895 (19.67)	198 (22.12)	19.40–24.84	779 (18.80)	163 (20.92)	18.07–23.78	0.000
25–59	963 (21.17)	228 (23.68)	20.99–26.36	926 (22.35)	222 (23.97)	21.22–26.72	
≥60	890 (19.56)	253 (28.43)	25.46–31.39	854 (20.61)	239 (27.99)	24.97–31.00	
Gender							
Male	1,951 (42.89)	541 (27.73)	25.74–29.72	1,747 (42.16)	474 (27.13)	25.05–29.22	0.120
Female	2,598 (57.11)	635 (24.44)	22.79–26.09	2,397 (57.84)	599 (24.99)	23.26–26.72	
Occupation							
Children in family care	143 (3.14)	68 (47.55)	39.37–55.74	142 (3.43)	68 (47.89)	39.67–56.10	
Kindergarten children	748 (16.44)	232 (31.02)	27.70–34.33	718 (17.33)	228 (31.75)	28.35–35.16	
Student	1,380 (30.34)	317 (22.97)	20.75–25.19	1,088 (26.25)	240 (22.06)	19.59–24.52	
Teacher	42 (0.92)	14 (33.33)	19.08–47.59	38 (0.92)	14 (36.84)	21.50–52.18	
Doctor or nurse	76 (1.92)	19 (25.00)	15.26–34.74	63 (1.52)	14 (22.22)	11.96–32.49	0.000
Farmer	812 (17.85)	276 (33.99)	30.73–37.25	783 (18.89)	268 (34.23)	30.90–37.55	
Factory worker	136 (2.99)	27 (19.85)	13.15–26.56	133 (3.21)	27 (20.30)	13.46–27.14	
Retiree	199 (4.37)	51 (25.63)	19.56–31.69	182 (4.39)	44 (24.18)	17.96–30.40	
Others	1,013 (22.27)	171 (16.88)	14.57–19.19	997 (24.06)	169 (16.95)	14.62–19.28	
Urban/rural							
Capital	1,549 (34.06)	355 (22.92)	20.82–25.01	1,435 (34.63)	316 (22.02)	19.88–24.16	
Other urban areas	1,500 (32.97)	316 (21.07)	19.00–23.13	1,391 (33.57)	305 (21.93)	19.75–24.10	0.000
Rural areas	1,500 (32.97)	505 (33.67)	31.28–36.06	1,318 (31.81)	452 (34.29)	31.73–36.86	
Lives in dormitory							
Yes	498 (10.95)	133 (26.71)	22.82–30.60	353 (8.52)	85 (24.08)	19.62–28.54	0.416
No	4,051 (89.05)	1,043 (25.75)	24.40–27.10	3,791 (91.48)	988 (26.06)	24.66–27.46	
Has students or children							
Yes	708 (15.56)	196 (27.68)	24.38–30.98	660 (15.93)	184 (27.88)	24.46–31.30	0.204
No	3,841 (84.44)	980 (25.51)	24.13–26.89	3,484 (84.07)	889 (25.52)	24.07–26.97	
Vaccination of A(H1N1)pdm09 (since Oct. 2009)							
Yes	405 (8.90)	103 (25.43)	21.19–29.69				
No	4,144 (91.10)	1,073 (25.89)	24.56–27.22				
Symtom (since May 2009)							
Cold	2,099 (46.14)	544 (25.92)	24.04–27.79	1,888 (45.58)	504 (26.69)	24.70–28.69	0.289
Fever	1,174 (25.81)	322 (27.43)	24.88–29.98	1,057 (25.51)	300 (28.38)	25.66–31.10	0.032
Cough	1,526 (33.55)	385 (25.23)	23.05–27.41	1,373 (33.13)	356 (25.93)	23.61–28.25	0.970

[1)]: P-values for association calculated by χ^2 tests or Fisher's exact tests.

DISCUSSION

The 2009 pandemic influenza was a challenge to the global public health response. However, it has been reported that many A(H1N1)pdm09 cases were mild (15–17), and many of those with infection may not have sought medical care and would not have been tested for infection. Thus, the number of reported cases does not give a true picture of the actual infection rate. Serological survey is a helpful tool for understanding the infection rates and state of population immunity after infection, especially in the post-pandemic period.

According to our results, after excluding individuals who reported receiving the pandemic H1N1 vaccine, the prevalence in the post-pandemic period was 25.89%. Thus, the prevalence is higher than that in Taiwan (18), Hong Kong (7), Australia (19), New Zealand (20), Guangdong, China (21), Ontario (22), and Greece (23); whereas, it is lower than that in Germany (24) and is the same as that in Thailand (25). Therefore, in Shandong Province, the infected population was estimated to be 23.69 million.

Our study had several limitations. First, the study was conducted 9 months after the second wave of the epidemic in Shandong Province. Antibody decay to a level lower than the defined threshold may have occurred in some subjects (22). Further, recent studies suggest that not all subjects developed seroprotection after A(H1N1)pdm09 infection and that the antibody level appears to be associated with disease severity at presentation (26,27). Second, we conducted a seroprevalence study following the post-pandemic period. We did not have baseline (pre-pandemic) data for accurately inferring the attack rates among the population in Shandong Province. However, the baseline serum samples collected from individuals in China prior to May 2009 had

Table 2. The adjusted odds ratios and 95% confidence intervals of A(H1N1)pdm09 infection among subjects who reported not receiving pandemic H1N1 vaccine (n = 4,144)

Demographic characteristic	Positive rate (%)	Adjusted OR (95%CI)	P
Occupation			
Children in family care	47.89	1	
Kindergarten children	31.75	0.566 (0.389–0.823)	0.003
Student	22.06	0.334 (0.231–0.481)	0.000
Teacher	36.84	0.747 (0.355–1.573)	0.443
Doctor or nurse	22.22	0.387 (0.195–0.771)	0.007
Farmer	34.23	0.527 (0.366–0.758)	0.001
Factory worker	20.30	0.362 (0.209–0.626)	0.000
Retiree	24.18	0.423 (0.256–0.701)	0.001
Others	16.95	0.275 (0.187–0.406)	0.000
Urban/rural			
Capital city (municipalities)	22.02	1	
Other urban areas	21.93	0.962 (0.794–1.166)	0.692
Rural areas	34.29	1.427 (1.154–1.765)	0.001
Symptom (fever)			
Yes	28.38	1.093 (0.930–1.285)	0.281
No	25.04	1	

shown a very low positive rate (1.2%) against A(H1N1)pdm09 (12). Third, the HI assay may not be the most sensitive assay for detecting low levels of A(H1N1)pdm09 (e.g., when compared to microneutralization); thus, we may have underestimated seropositivity in the serological survey samples. Finally, the study was conducted in three regions of Shandong Province, and the seroprevalence data may not be generalized to the entire population of Shandong Province. We noted that the seropositivity rate varied significantly from region to region. However, the impact of these geographic differences was controlled in the multivariate analysis of epidemiological risks.

Unlike studies in other countries such as Germany, Greece, and Australia, our study showed that the preschool population had the highest attack rates of A(H1N1)pdm09, which is consistent with the influenza-like illness (ILI) in Shandong Province. According to the ILI data of Shandong Province from May 2009 to September 2010, the age-specific ILI was 40.76% (0–5 years), 24.85% (5–14 years), 17.22% (15–24 years), 13.90% (25–59 years), and 3.253% (>60 years). The seropositive rate (27.99%) was higher in the ≥60 years age group than that in other age groups; however, the seropositive rate was not higher than that in the 0–5 years age group. These results are consistent with those reported in Ontario (33.3%) (22) and Pittsburgh (40%) (28), which showed a higher seropositive rate in the ≥60 years age group at the end of the influenza season and October 2010. However, the results were discordant with those of reports from Taiwan (11.8%) (18) and Greece (14.4%) (23) that were carried out in September and June 2010. Overall, the study showed that the highest percentage of individuals with antibodies to A(H1N1)pdm09 were children. Those aged >60 years may have cross-reactive antibodies to A(H1N1)pdm09 (29–31).

The survey showed that the seroprevalence of A(H1N1)pdm09 infection was higher in the rural areas as compared to that in the capital city and other urban areas. It was also higher among children in family care and farmers, which was discordant with data from Beijing and Greece. The main reason is that Shandong Province is an agricultural province, and farmers account for 70% of the population. Second, the A(H1N1)pdm09 outbreak was transmitted from the city to rural areas. The time interval between infection with the virus to serum sample collection was short; hence, the antibody titer may have been within the defined threshold. The incidence of infection among doctors, nurses, and teachers was higher than that reported from Hong Kong (32), but lower than that reported from Greece. The seropositivity of unvaccinated and vaccinated subjects was similar because 82.3% of vaccinated subjects had received 1 dose of pandemic H1N1 vaccine prior to January 2010; therefore, antibody decay resulted in an antibody level that was lower than the defined threshold after 6 months.

Multivariate logistic regression revealed that the rural areas had significantly higher OR of A(H1N1)pdm09 seropositivity than the capital city and other urban areas. Individuals of all professions, except for teachers, had significantly lower OR of A(H1N1)pdm09 seropositivity than children in family care; this was discordant with the report of Xu et al. (12). In addition, the symptoms (cold, fever, and cough) were not significantly associated with the seropositive rate.

In summary, the overall seroprotection rate increased to approximately 25.85% in the whole population and to 25.89% in the unimmunized population after the post-pandemic period, with statistically different rates among the different age groups, occupations, and regions. Young children aged 0–5 years and elderly people aged ≥60 years showed the highest seropositive rate. The findings of this seroepidemiology study provide valuable data for understanding the epidemiology of the 2009 pandemic and planning future intervention strategies. In addition, it highlights the significance of seroprevelance studies at the country level.

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Conflict of interest None to declare.

REFERENCES

1. Centers for Disease Control and Prevention (2009): Swine influenza A (H1N1) infection in two children—Southern California, March–April 2009. Mobid. Mortal. Wkly. Rep., 58, 400–402.
2. Centers for Disease Control and Prevention (2009): Outbreak of swine-origin influenza A (H1N1) virus infection—Mexico, March–April 2009. Morbid. Mortal. Wkly. Rep., 58, 467–470.
3. European Centre for Disease Prevention and Control Technical Emergency Team (2009): Initial epidemiological findings in the European Union following the declaration of pandemic alert level 5 due to influenza A (H1N1). Euro Surveillance, 14, 1–4.
4. European Centre for Disease Prevention and Control Technical Emergency Team (2009): Pandemic phase level 4: human cases of the novel influenza A/H1N1 strain confirmed in Scotland and Spain. Euro Surveillance, 14, pii: 19185.
5. Centers for Disease Control and Prevention (2009): Swine-origin influenza A (H1N1) virus infections in a school—New York City, April 2009. Mobid. Mortal. Wkly. Rep., 58, 470–472.
6. World Health Organization (2009): World Now at the Start of 2009 Influenza Pandemic; statement to the press by WHO Director-General Dr Margaret Chan. Online at 〈http://www.who.int/mediacentre / news / statements / 2009 / h1n1_pandemic_phase6_20090611/en/index.html〉. Accessed 15 March 2010.
7. Wu, J.T., Ma, E.S., Lee, C.K., et al. (2010): The infection attack rate and severity of 2009 pandemic H1N1 influenza in Hong Kong. Clin. Infect. Dis., 51, 1184–1191.
8. Zimmer, S.M., Crevar, C.J., Carter, D.M., et al. (2010): Seroprevalence following the second wave of pandemic 2009 H1N1 influenza in Pittsburgh, PA, USA. PLoS ONE, 5, e11601.
9. Tilston, N.L., Eames, K.T., Paolotti, D., et al. (2010): Internet-based surveillance of influenza-like-illness in the UK during the 2009 H1N1 influenza pandemic. BMC Public Health, 10, 650.
10. European Centre for Disease Prevention and Control Technical Emergency Team (2009): Progression and impact of the first winter wave of the 2009 pandemic H1N1 influenza in New South Wales, Australia. Euro Surveillance, 14, pii = 19365.
11. Miller, E., Hoschler, K., Hardelid, P., et al. (2010): Incidence of 2009 pandemic influenza A H1N1 infection in England: a cross-sectional serological study. Lancet, 375, 1100–1108.
12. Xu, C., Bai, T., Iuliano, A.D., et al. (2010): The seroprevalence of pandemic influenza H1N1 (2009) virus in China. PLoS One, 6, e17919.
13. World Health Organization Collaborating Centers for Reference and Research on Influenza and United States. Dept. of Health and Human Services (1982): Concepts and Procedures for Laboratory-Based Influenza Surveillance. p. 17–35.
14. Word Health Organization (WHO): WHO Manual on animal influenza diagnosis and surveillance WHO/CDS/CSR/NCS/2002. 5. Online at 〈http://www.who.int/csr/resources/publications/influenza/whocdscsrncs20025rev.pdf〉.
15. Cowling, B.J., Chan, K.H., Fang, V.J., et al. (2010): Comparative epidemiology of pandemic and seasonal influenza A in households. N. Engl. J. Med., 362, 2175–2184.
16. Presanis, A.M., De Angelis, D., et al. (2009): New York City Swine Flu Investigation Team. The severity of pandemic H1N1 influenza in the United States, from April to July 2009: a Bayesian analysis. PloS Med., 6, e1000207.
17. Bin, C., Xingwang, L., Yuelong, S., et al. (2009): National Influenza A Pandemic (H1N1) 2009 Clinical Investigation Group. Clinical and epidemiologic characteristics of 3 early cases of influenza A pandemic (H1N1) 2009 virus infection, People's Republic of China, 2009. Emerg. Infect. Dis., 15, 1418–1422.
18. Chen, C.J., Lee, P.I., Chang, S.C., et al. (2011): Seroprevalence and severity of 2009 pandemic influenza A H1N1 in Taiwan. PLoS ONE, 6, e24440.
19. Gilbert, G.L., Cretikos, M.A., Hueston, L., et al. (2010): Influenza A (H1N1) 2009 antibodies in residents of New South Wales, Australia, after the first pandemic wave in the 2009 southern hemisphere winter. PLoS One, 5, e12562.
20. Bandaranayake, D., Huang, Q.S., Bissielo, A., et al. (2010): Risk factors and immunity in a nationally representative population following the 2009 influenza A(H1N1) pandemic. PLoS One, 5, e13211.
21. Zhang, X., He, J., Li, L., et al. (2011): Serologic survey of the pandemic H1N1 2009 virus in Guangdong Province, China: a cross sectional study. PLoS One, 6, e23034.
22. Achonu, C., Rosella, L., Gubbay, J.B., et al. (2011): Seroprevalence of pandemic influenza H1N1 in Ontario from January 2009–May 2010. PLoS One, 6, e26427.
23. Maltezou, H.C., Katerelos, P., Mavrouli, M., et al. (2011): Seroepidemiological study of pandemic influenza H1N1 following the 2009–2010 wave in Greece. Vaccine, 29, 6664–6669.
24. von Kries, R., Weiss, S., Falkenhorst, G., et al. (2011): Post-pandemic seroprevalence of pandemic influenza A (H1N1) 2009 infection (swine flu) among children, 18 years in Germany. PLoS One, 6, e23955.
25. Prachayangprecha, S., Makkoch, J., Vuthitanachot, C., et al. (2011): Epidemiological and serological surveillance of human pandemic influenza A virus infections during 2009–2010 in Thailand. Jpn. J. Infect. Dis., 64, 377–381.
26. Wu, U.I., Liu, M.T., Wang, J.T., et al. (2010): Serological response to H1N1 influenza virus infections in adults treated with oseltamivir. Clin. Infect. Dis., 51, 1223–1225.
27. Hung, I.F., To, K.K., Lee, C.K., et al. (2010): Effect of clinical and virological parameters on the level of neutralizing antibody against pandemic influenza A virus H1N1 2009. Clin. Infect. Dis., 51, 274–279.
28. Ross, T.M., Hairong, L., Chia, B.S., et al. (2011): Prevalence of antibodies against seasonal influenza A and B viruses during the 2009–2010 and 2010–2011 influenza seasons in residents of Pittsburgh, PA, USA. PLoS Currents Influenza, 2011 Oct 25.
29. Hancock, K., Veguilla, V., Lu, X., et al. (2009): Cross-reactive antibody responses to the 2009 pandemic H1N1 influenza virus. N. Engl. J. Med., 361, 1945–1952.
30. Huang, D.T., Shao, P.L., Huang, K.C., et al. (2011): Serologic status for pandemic (H1N1) 2009 virus, Taiwan. Emerg. Infect. Dis., 17, 76–78.
31. Rizzo, C., Rota, M.C., Bella, A., et al. (2010): Cross-reactive antibody responses to the 2009 A/H1N1v influenza virus in the Italian population in the pre-pandemic period. Vaccine, 28, 3558–3562.
32. Zhou, Y., Ng, D.M.W., Seto, W.H., et al. (2011): Seroprevalence of antibody to pandemic influenza A (H1N1) 2009 among healthcare workers after the first wave in Hong Kong. J. Hosp. Infect., 78, 308–311.