A serologic study with simultaneous self-administered questionnaire regarding infection control (IC) practices and other risks of influenza A (H1N1) pdm09 (2009 H1N1) infection was performed approximately 1 month after the first outbreak among frontline healthcare professionals (HCPs). Of 256 HCPs, 33 (13%) were infected. Self-reported adherence to IC practices in >90% of exposure events was 82.1%, 73.8%, and 53.5% for use of hand hygiene, masks, and gloves, respectively. Visiting crowded public places during the outbreak was associated with acquiring infection (OR = 3.1, P = 0.019). Amongst nurses, exposure to HCPs with influenza-like illness during the outbreak without wearing a mask was the only identified risk factor for infection (OR = 2.3, P = 0.039).

Keywords: 2009 H1N1 pandemic, Thailand, healthcare workers, seroprevalence, hemagglutination assay

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2009, approximately 1 month after the end of the outbreak. An anonymous self-administered questionnaire was administered prior to a single blood draw for assessment of hemagglutination inhibition (HI) titer. The questionnaire consisted of demographic information, medical history, and factors that may be associated with community-acquired and occupational-acquired influenza. Adherence to hand hygiene (alcohol-based hand rub and/or hand washing with water) and using mask and gloves when in contact (defined as having activities or procedures that potentially resulted in contact or droplet transmission) with patients with suspected 2009 H1N1 were categorized as: every time or >90–100%, mostly or 70–90%, and <60%, respectively. The wards were classified as isolation wards (1–three patients in a room, PPE practice for airborne and contact precautions when entering the patients’ room), semi-open ward (share up to 12 patients in a room, PPE practice for airborne and contact precaution when entering patients’ area), and open ward or emergency room (large ward hold up to 24 beds or walk-in patients, PPE practice for contact and droplet precaution as needed). There was no verification of the accuracy of responses in the questionnaire.

HI assay was performed using the protocol previously described.3,4 We defined an HI titer ≥40 as seropositive and a marker of acquiring recent infection assuming that none of the HCPs had been infected with the 2009 H1N1 virus prior to the outbreak and that pre-existing HI antibody to 2009 H1N1 was uncommon.

**Statistical analysis**

Descriptive analysis was performed on the demographic and other variables associated with risk of influenza infection. Univariate analysis was performed using a binomial test. Multiple logistic regression analysis was used for multivariate analysis of self-reported factors including the IC practices associated with an HI titer ≥40. Stata (Version 9.2, College Station, TX, USA) was used for the data analysis.

**Results**

There were 256 HCPs, 93% female, who participated in this study. The median (range) age was 34 (20–61) years. The majority (81.3%) were nurses and nurse assistants. Of the 198 HCPs working in specific wards, 72 (36.4%) were working in isolation wards, 57 (28.8%) in semi-open wards, and 69 (34.8%) in open wards or emergency rooms. The majority (82%) had received seasonal influenza vaccines (Southern Hemisphere strain 2008) between April 2008 and May 2009, at least 1–2 months before the outbreak started. Adherence to IC practices in >90% of the exposure events when in contact with patients with suspected 2009 H1N1 infection was 82.1%, 73.8%, and 53.5% with hand hygiene, using a mask, and using gloves, respectively. One hundred and twenty (47.1%) HCPs reported a history of respiratory tract infection (RTI) during the outbreak.

Thirty-three (13%) HCPs had a serum HI titer ≥40 suggesting acquisition of 2009 H1N1 infection during the outbreak. The proportions seropositive in HCPs aged <25, 25–49, and ≥50 years were 20.9%, 12.9%, and 2.8%, respectively. HCPs with a history of RTI during the outbreak tended to have a higher proportion seropositive than those who had no history of RTI (16.7% versus 8.9%, P = 0.06). The proportions seropositive among nurses and nurse assistants in different patient care areas were not different: 12.5% versus 19.3% versus 11.6% (P = 0.411) in isolation, semi-open, and open wards, respectively.

The univariate analysis revealed that a younger age (<25 years) and visiting crowded public places during the outbreak were associated with acquiring infection. In multivariate analysis, the only risk factor was visiting crowded public places during the outbreak (odds ratio = 3.1, 95% CI = 1.2–8.1, P = 0.019, Table 1). The rates of adherence to IC practices were not associated with acquisition of infection. The HCPs with adherence to hand hygiene and mask use at 70–90% of exposure events had a similar rate of infection to those with adherence >90–100%. In a sub-group analysis of 198 nurses and nurse assistants, there was a weak association between acquisition of 2009 H1N1 infection and close contact with HCPs with influenza-like illness (ILI) during the outbreak without wearing a mask (odds ratio = 2.3, 95% CI 0.9–5.6, P = 0.039).

**Discussion**

This study revealed a rate of 2009 H1N1 infection among frontline HCPs of 13%, indicated by a serum HI titer ≥40, after the first outbreak in Bangkok. This result was consistent with a previous report of 18% of HCPs in a large hospital in Bangkok who became sick with the 2009 H1N1 infection during the same outbreak,5 and higher than the 7% reported among healthy blood donors in Bangkok around the same period of this study,6 suggesting that HCPs had a higher risk of getting 2009 H1N1 infection than the general population.

A report of the 2009 H1N1 outbreak in England found that 42%, 20%, and 6% of the general population age 5–14, 15–24, and 25–44 years in London and West Midlands had an HI titer against 2009 H1N1 of ≥32.7 This evidence of higher prevalence in a younger age group correlated well with a large study of the 2009 H1N1 outbreak in the US in which 40% and 35% of the patients were in the age groups 10–18 and 19–50 years, respectively, and only 5% occurred at age ≥50 years.8 This age bias was probably due to the increased number of social or institutional gathering.
Table 1. Factors associated with serologic evidence of recent infection defined by hemagglutination inhibition (HI) titer ≥40

| Characteristics                        | No. (%) Cases with HI ≥ 40 | No. (%) Cases with HI <40 | Crude odds ratio (95% CI) | P-value | Adjusted odds ratio (95% CI) | P-value |
|----------------------------------------|-----------------------------|---------------------------|---------------------------|---------|-------------------------------|---------|
| Age (years)                            |                             |                           |                           |         |                               |         |
| <25                                    | 43 (16.8)                   | 9 (27.3)                  | 34 (15.2)                 | 0.019*  | 5.7 (0.7-49.0)                | 0.111   |
| 25–49                                  | 178 (69.5)                  | 23 (69.7)                 | 155 (69.5)                | 0.14*   | 4.3 (0.6-33.6)                | 0.163   |
| 50–64                                  | 35 (13.7)                   | 1 (3)                     | 34 (15.3)                 | 1       |                               |         |
| Body Mass Index                        |                             |                           |                           |         |                               |         |
| ≥25                                    | 44 (17.3)                   | 4 (12.1)                  | 40 (18.1)                 | 0.47*   |                               |         |
| <25                                    | 210 (82.7)                  | 29 (87.9)                 | 181 (81.9)                | 1       |                               |         |
| Career                                 |                             |                           |                           |         |                               |         |
| Physician                              | 30 (11.7)                   | 3 (9.1)                   | 27 (12.1)                 | 1       |                               |         |
| Nurse or nurse assistant               | 208 (81.3)                  | 28 (84.8)                 | 180 (80.7)                | 1       |                               |         |
| Others                                 | 18 (7)                      | 2 (6.1)                   | 16 (7.2)                  | 1       |                               |         |
| Received the seasonal influenza vaccine between April 2008 and May 2009 |                             |                           |                           |         |                               |         |
| Yes                                    | 205 (82)                    | 27 (84.4)                 | 178 (81.7)                | 1       |                               |         |
| No                                     | 45 (18)                     | 5 (15.6)                  | 40 (18.3)                 | 1       |                               |         |
| Living with children younger than 5 years |                             |                           |                           |         |                               |         |
| Yes                                    | 52 (20.4)                   | 8 (24.2)                  | 44 (19.8)                 | 1       |                               |         |
| No                                     | 203 (79.6)                  | 25 (75.8)                 | 178 (80.2)                | 1       |                               |         |
| Living with children age 5–15 years    |                             |                           |                           |         |                               |         |
| Yes                                    | 59 (23.3)                   | 4 (12.1)                  | 55 (25.0)                 | 1       |                               |         |
| No                                     | 194 (76.7)                  | 29 (87.9)                 | 165 (75.0)                | 1       |                               |         |
| Having household member sick with respiratory tract infection during the outbreak |                             |                           |                           |         |                               |         |
| Yes                                    | 117 (46.2)                  | 12 (36.4)                 | 105 (47.7)                | 1       |                               |         |
| No                                     | 136 (53.8)                  | 21 (63.6)                 | 115 (52.3)                | 1       |                               |         |
| Visiting crowded public places during the outbreak |                             |                           |                           |         |                               |         |
| Yes                                    | 149 (58.2)                  | 27 (81.8)                 | 122 (54.7)                | 1       |                               |         |
| No                                     | 107 (41.8)                  | 6 (18.2)                  | 101 (45.3)                | 1       |                               |         |
| Mask type used when caring for patients with suspected/confirmed 2009 H1N1 |                             |                           |                           |         |                               |         |
| N95 respirator                         | 142 (59.4)                  | 16 (53.3)                 | 126 (60.3)                | 1       |                               |         |
| Surgical Mask                          | 78 (32.6)                   | 10 (33.3)                 | 68 (32.5)                 | 1       |                               |         |
| Use either mask                        | 19 (8)                      | 4 (13.4)                  | 15 (7.2)                  | 1       |                               |         |
| Frequency of hand hygiene before and after caring for patients with suspected/confirmed 2009 H1N1 |                             |                           |                           |         |                               |         |
| All the time (>90–100%)                | 202 (82.1)                  | 27 (84.4)                 | 175 (81.8)                | 1       |                               |         |
| Most of the time (70–90%)              | 43 (17.5)                   | 5 (15.6)                  | 38 (17.8)                 | 1       |                               |         |
| Sometimes (<60%)                       | 1 (0.4)                     | 0                        | 1 (0.4)                   | 1       |                               |         |
| Frequency of mask use when caring for patients with suspected/confirmed 2009 H1N1 |                             |                           |                           |         |                               |         |
| All the time (>90–100%)                | 180 (73.8)                  | 24 (75.0)                 | 156 (73.6)                | 1       |                               |         |
| Most of the time (70–90%)              | 56 (23)                     | 8 (25)                    | 48 (22.6)                 | 1       |                               |         |
| Sometimes (<60%)                       | 8 (3)                       | 0                        | 8 (3.8)                   | 1       |                               |         |
| Frequency of glove use when caring for patients with suspected/confirmed 2009 H1N1 |                             |                           |                           |         |                               |         |
| All the time (>90–100%)                | 131 (53.5)                  | 19 (59.4)                 | 112 (52.6)                | 1       |                               |         |
| Most of the time (70–90%)              | 69 (28.2)                   | 8 (25)                    | 61 (28.6)                 | 1       |                               |         |
| Sometimes (<60%)                       | 45 (18.3)                   | 5 (15.6)                  | 40 (18.8)                 | 1       |                               |         |
| Having respiratory tract infection during the outbreak |                             |                           |                           |         |                               |         |
| Yes                                    | 120 (47.1)                  | 20 (62.5)                 | 100 (44.8)                | 1       |                               |         |
| No                                     | 135 (52.9)                  | 12 (37.5)                 | 123 (55.2)                | 1       |                               |         |

*Fisher’s exact test.
activities and less pre-existing cross-protective antibody in the younger compared with the older participants. In our study, we also found that having an HI titer ≥40 was associated with younger age and visiting crowded public places, suggesting that the outbreak spread more widely in a younger population, probably from gathering in public places.

Conducting a serologic study immediately after the first outbreak of 2009 H1N1 infection was a unique opportunity to look at the effectiveness of IC practices. Assuming from a previous study that approximately 1.4% of healthy people had an HI antibody titer to 2009 H1N1 before the outbreak, we can expect that the serologic evidence reported is primarily due to the acquisition of infection during the outbreak. The HCPs who participated in this study were the frontline personnel at highest risk of exposure to 2009 H1N1-infected patients and were well trained in using PPE and IC practices. Ideally, these HCPs should not acquire 2009 H1N1 from patient care. However, our set-up was not ideal. Aerosol-generating procedures were performed in many of the patient care areas and none of the wards had the perfect negative pressure needed to limit aerosol spread. Moreover, adherence to IC practices was not perfect in real life.

A previous report revealed that frontline HCPs were actually less likely to contract 2009 H1N1 than other HCPs, probably because of good adherence to IC practices and use of PPE. However, we found that only about half of our HCPs reported perfect adherence (>90% of exposure events) to wearing of gloves, and around 70–80% perfectly adhered to mask use and hand hygiene. Despite this imperfect adherence, it seemed that the HCPs in our study acquired infection from the community rather than from patient care. A report from the US also found acquisition from the community as a major route of infection in the younger compared with the older participants. In our study were the frontline personnel at highest risk of exposure to 2009 H1N1-infected colleagues was associated with community exposure risk, particularly in the young, as well as exposure to other HCPs with ILI without protection.

In conclusion, we found that of 2009 H1N1 infection among frontline HCPs was somewhat higher than in the general population. The risk of infection was found to be associated with community exposure risk, particularly in the young, as well as exposure to other HCPs with ILI without protection.

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