Infection (2011) 39:149–153
DOI 10.1007/s15010-011-0084-x

BRIEF REPORT

Low transmission rate of 2009 H1N1 Influenza during a long-distance bus trip

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Received: 13 August 2010 / Accepted: 20 January 2011 / Published online: 22 February 2011

Abstract
Background Current data on the risk of transmission of 2009 H1N1 Influenza in public transportation systems (e.g., public trains, busses, airplanes) are conflicting. The main transmission route of this virus is thought to be via droplets, but airborne transmission has not been completely ruled out.
Methods This is a contact tracing investigation of a young woman subsequently diagnosed with the 2009 H1N1 Influenza virus who was symptomatic during a long-distance bus trip from Spain to Switzerland. Fever and cough had begun 24 h earlier, 2 h before she stepped onto a bus for a long-distance trip. After the 2009 H1N1 virus had been confirmed in the patient, the other bus travellers were contacted by telephone on day 7 and 10 after the bus trip.
Results Of the 72 individuals travelling on the bus with the H1N1-infected young woman, 52 (72%) could be contacted. Only one of these 52 developed fever, with onset of symptoms 3 days after the bus trip, and rRT-PCR analysis of the nasopharyngeal swab showed the infection to be caused by the 2009 H1N1 virus. One other person complained of coughing 1 day after the bus trip, but without fever, and no further investigation was carried out. All other passengers remained without fever, coughing, or arthralgia. The risk of transmission was calculated as 1.96% (95% confidence interval 0–5.76%).
Conclusion The transmission rate of 2009 H1N1 Influenza was low on a long-distance bus trip.

Electronic supplementary material The online version of this article (doi:10.1007/s15010-011-0084-x) contains supplementary material, which is available to authorized users.

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Introduction

We report here a contact tracing investigation of a young woman with confirmed 2009 H1N1 Influenza who was symptomatic during a long-distance bus trip from Spain to Switzerland. Up to 10 August 2009, 56% of confirmed Swiss cases of 2009 H1N1 Influenza were due to infection outside of the country, with only 14% postulated to be due to transmission in Switzerland itself [1]. The principle transmission mode of 2009 N1N1 influenza is still under debate. Analysis of cough revealed that >99.9% of the expectorated particles are >8 μm [2] and therefore defined as droplets. Particles in the size range of 5–10 μm have to shown to be capable of penetrating deeply into the tracheobronchial region (50% of 10-μm particles), but for particles >20 μm, there is essentially no penetration beyond the trachea [3]. While aerosols remain in the air, droplets fall to the ground, with a settling velocity that is in proportion to their diameter [3]. Based on these known facts, the main transmission route of 2009 H1N1 virus is believed to be by droplet exposure of mucosal surfaces [4]. As such, the hallmarks of transmission precaution are good hand hygiene and the wearing of gloves and surgical masks [5]. However, airborne transmission by small particle aerosols may also occur [3, 6]. As with most respiratory pathogens, including influenza, the relative contribution of each of these types of transmission has not been adequately ascertained. Up to August 2010, the Centers of Disease Control and Prevention (CDC) recommended that healthcare personnel who are in close contact with patients with suspected or confirmed 2009 H1N1 Influenza take respiratory protection measures that are at least as protective as a fit-tested disposable N95 respirator. Most authorities recommended that persons with suspected 2009 H1N1 Influenza who are not severely ill should remain at home

until they are at least 24 h without fever or symptoms of fever to limit further transmissions. However, the production and possible transmission of viral particles is possible 24 h before the first signs occur, and a substantial proportion of seasonal influenza as well as the 2009 H1N1 Influenza is mild or even subclinical and not recognized by the patient [7, 8]. These persons can be infectious for others.

For hospitalized patients, strategies to prevent transmission have been developed and standardized [9]. These include administration of influenza vaccine, implementation of respiratory hygiene and cough etiquette, appropriate management of ill healthcare workers, adherence to infection control precautions for all patient-care activities and aerosol-generating procedures, and implementation of environmental and engineering infection control measures.

However, in the ambulatory setting, it may be difficult to guarantee special waiting rooms for patients with suspected 2009 H1N1 Influenza (or other respiratory pathogens). Furthermore, symptoms may not be obvious, so these people are often placed in a waiting room together with other patients, eventually using the same lavatories and examination rooms. The risk of influenza transmission in public areas (e.g., public trains, busses, and airplanes) has not been defined, and clinical studies and mathematical models show conflicting results [10–12]. Typical airborne pathogens, such as tuberculosis, have been well studied, but to date little is known on the influenza virus where the main transmission route is either directly from person-to-person via droplets, or indirectly via a contaminated surface. On hard surfaces, the influenza virus is infective for up to 24 h; the survival time is much shorter on cloth, paper, and tissues, i.e., 8–12 h; on hands after transfer from environmental sources, the virus survives for only 5 min [13].

Methods

On 1 August 2009, a 19-year-old female patient was admitted to the emergency department of our hospital with complaints of fever (39.2°C), cough, and arthralgia. The symptoms had begun 24 h earlier, just before she stepped onto a long-distance bus in Spain to return to Switzerland after a 1-week holiday. A nasopharyngeal swap was obtained, and 2009 H1N1 Influenza was confirmed by real time rRT-PCR, as previously described [14]. Confirmatory testing and genotyping was performed by the World Health Organization (WHO) collaborating reference center of Influenza (Geneva, Switzerland). The transportation company was contacted, and a complete passenger list of all those on the bus (72 passengers), with seating plan, was obtained. These busses make one round-trip weekly, collecting people from different parts in Spain and bringing them to different parts of Switzerland. During the summer of 2009, the infection rate of 2009 H1N1 Influenza was significantly higher in Spain than in Switzerland. Attempts were made to contact all passengers by telephone. When this was successful, the passengers were asked whether they had symptoms of fever ($\geq$38°C), coughing, and/or arthralgia, and if so, when these symptoms first appeared. A suspected case was defined as the onset of fever ($\geq$38°C) and cough or sore throat [15]. According to the exposure criteria published by the CDC on 1 May 2009, all passengers were included in the survey, as they had "travelled to a community, which has one or more confirmed swine-origin influenza A (H1N1) cases" [15]. Persons without symptoms who did not feel feverish were not asked to take their temperature. The first telephone call was made 6 days after the passengers had returned from Spain. If no fever had occurred by day 6, the persons were contacted a second time on between days 10 and 13.

If no symptoms of influenza had presented by day 10 after the possible contagion during the bus trip, it was considered that no infection had occurred. The bus was double floored, 13.9 m length, with an integrated ventilation system, air inlets on the roof, adjustable nozzles above each passenger and venting in the front of the bus by negative pressure, without air recirculation or HEPA-filters.

The average age of the passengers contacted was 19.7 $\pm$ 7 years, of whom 18 (34.6%) were male.

Results

Data were available for 52/72 (72%) of the bus passengers; the remainder could not be contacted after four attempts. One person became ill on day 3 after the trip, and further investigation revealed the presence of H1N1 virus by rRT-PCR analysis of a nasopharyngeal swap. One other person who also reported having symptoms of influenza in Spain, even prior to boarding the bus, also tested positive for H1N1. Genotyping of the two persons who were ill during the bus trip could not identify a common source. Unfortunately, the amount of the nucleic acid amplified from the secondary case was too small to allow genotyping, so transmission could not be confirmed by genotyping. One other person complained of cough without fever that had begun on day 3 after the return home from Spain but which was still present on day 13. As fever was not present on days 3 and 13, the case definition for suspected influenza was not fulfilled and we postulated an unspecific viral upper respiratory tract infection; however, no nasopharyngeal swab was obtained from this individual. Six of the individuals contacted complained of fever during the

holiday in Spain, but no further investigation was made as their symptoms had resolved at the time of the first telephone call. Four of these six individuals also complained of concomitant cough and arthralgia, while two of the six reported fever and only cough.

The persons contacted spent their holiday at three different locations in six, one, and five different hotels, respectively.

The six persons reporting fever during the holiday were staying at four different hotels and two different places, with one cluster of three persons in the same hotel and in close contact.

The passenger with the first signs of infection on day 3 after his return and proven 2009 H1N1 Influenza was probably infected during the bus trip. He did share the hotel with the cluster of persons with fever during their stay in Spain but had no other contact. He did not share the hotel with the two persons with proven 2009 H1N1 Influenza. The other person who complained of cough and arthralgia, but without fever, did not fall into the case definition. Therefore, transmission of the 2009 H1N1 Influenza virus may have occurred in only 1/51 persons, with two proven index cases with fever and coughing during the bus trip. This person did not sit in close proximity to the two infected persons (see Fig. 1). The index person sat at the opposite window and three rows behind, the other infected person at the same window seat but eight rows in front of the patient becoming ill 3 days later. We calculated the risk of transmission for laboratory confirmed symptomatic cases as 1.96% (95% confidence interval 0–5.76%).

Discussion

Since April 2009, when the first cases of the 2009 H1N1 Influenza infections were identified, the pandemic has spread throughout the world. Early studies reported a high hospitalization rate, but with growing experience in dealing with this new virus, it has become clear that the disease has a relatively mild course in the majority of patients, with most not requiring hospitalization [16]. However, in contrast to seasonal forms of Influenza A, young people are more affected, and pregnant women are especially at risk of developing severe disease. Consequently, rapid antiviral treatment is recommended.

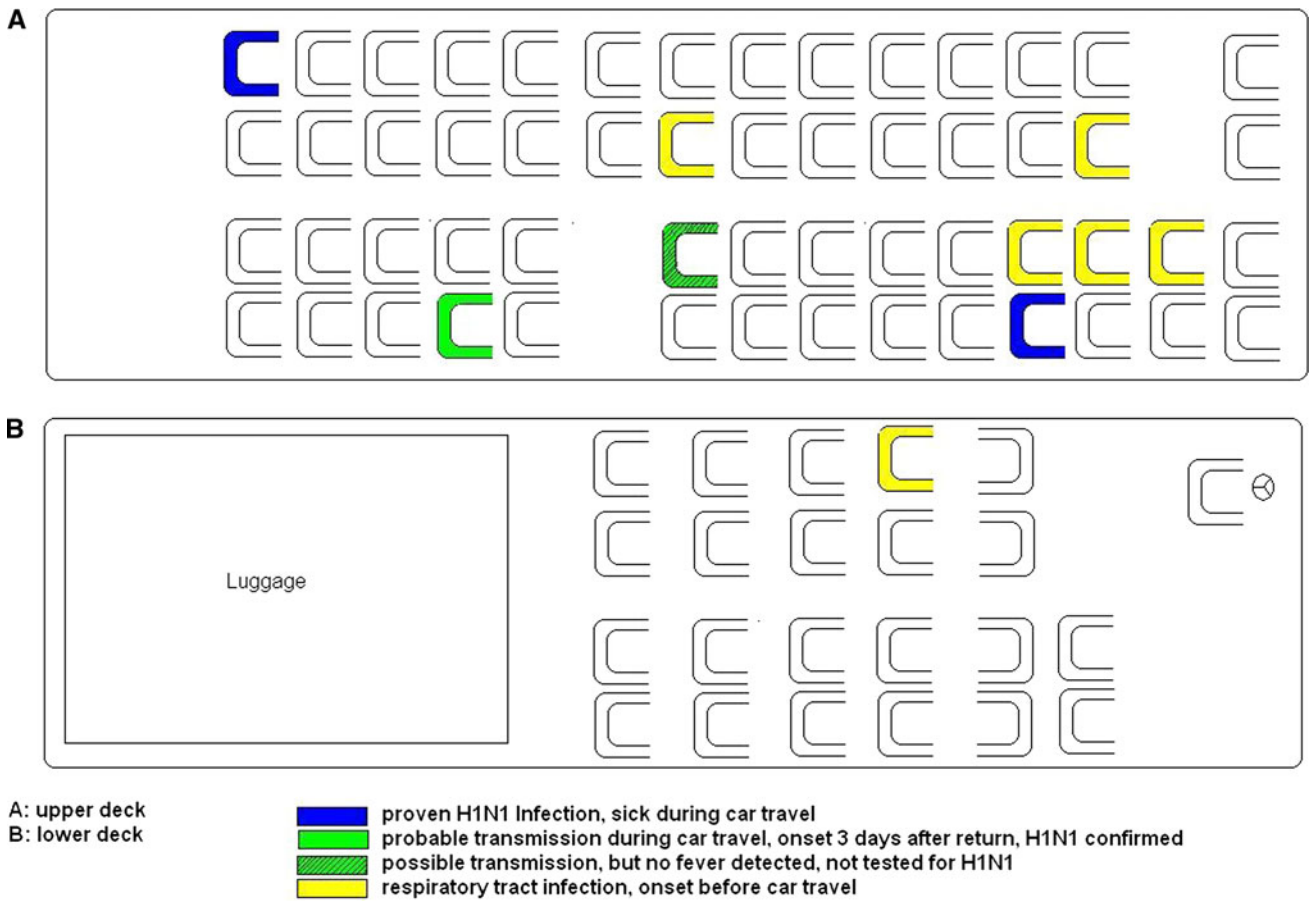

Fig. 1 Seating arrangements of passengers on the long distance bus

The transmission rate of the 2009 H1N1 virus seems to be higher than that of seasonal influenza [16], explaining its rapid spread throughout the world. Health authorities have warned that many segments of public life could be affected (e.g., transportation, education, healthcare systems). For hospitalized patients, guidelines are in place for dealing with those individuals harboring the 2009 H1N1 virus, but outside of hospitals or even in the ambulatory care setting, it has often proven difficult to establish strict guidelines.

It is believed that most transmissions of influenza virus occur via person-to-person or via droplets falling upon hard surfaces where the virus can survive up to 48 h. However, airborne transmission cannot be ruled out completely, and small droplet nuclei containing influenza virus have been found in waiting rooms in an emergency department [17]. The individuals investigated in this study were on the same bus for more than 12 h, and at least two persons had symptomatic documented 2009 H1N1 Influenza. Only one other person developed H1N1 Influenza, resulting in a transmission rate of 1.96%. The average age of our population was 19.7 $\pm$ 7 years. Younger people are, in contrast to seasonal influenza, more vulnerable to the 2009 H1N1 virus [18, 19]. Consequently, our data emphasize that airborne transmission may not be the main route of the spread of the 2009 H1N1 Influenza virus. However, several authors propose that in special situations, airborne transmission of influenza virus may be underestimated [20]. Other pathogens that are usually transmitted by direct contact can, under certain conditions, spread through the air [21]. A significant increase in the dispersal as well as transmission to patients and even outbreaks in hospital wards have been demonstrated for *Staphylococcus aureus* and linked to concomitant upper respiratory tract infection in otherwise healthy nasal carriers [22–24]. This phenomenon is called "cloud adult" and was also proposed for "supersreaders" in the severe acute respiratory syndrome (SARS) epidemic [25].

We believe that the situation of this long-distance bus trip with a relatively low transmission rate cannot be transferred directly to other public transport modes. It was a night bus with just a few stops, and the passengers were sleeping most of the time. Consequently, the movement of passengers in the bus as well as boarding events were much less frequent than those on a city bus or in a public train. As the movements of passengers may facilitate the dispersion of droplets to surfaces as well as person-to person contacts, we postulate that the transmission rate on public transport systems may be higher. However, in an outbreak of 2009 H1N1 Influenza in two school classes in the UK, there was no evidence of transmissions on a school bus where the children were exposed for more than 50 min to a symptomatic case [26].

This investigation has its limitations. Some people contract only mild or even asymptomatic 2009 H1N1 Influenza [27]. We contacted the passengers by telephone only and did not investigate any further if the passenger considered him/herself not to be ill. Thus, the real transmission rate could have been higher. We postulate that one person was infected during the bus trip, but transmission even before boarding or shortly after the bus trip cannot be completely ruled out.

Acknowledgments We are grateful to Dr. Y. Thomas from the National Reference Centre for Influenza, University Hospital of Geneva for genotyping the isolates and performing the primary analysis of the two cases and to Dr. A. Dumoulin from the Molecular Diagnostics Laboratory, Institute for Medical Microbiology, University of Basel for performing the primary analysis of the index case.

Conflict of interest None.

References

1. Bundesamt für Gesundheit Schweiz. Pandemische Grippe (H1N1) 2009. Situationsbericht des Bundesamtes für Gesundheit. BAG Bull. 2009;09:600–3.
2. Loudon RG, Roberts RM. Droplet expulsion from the respiratory tract. Am Rev Respir Dis. 1967;95:435–42.
3. Tellier R. Aerosol transmission of influenza A virus: a review of new studies. J R Soc Interface. 2009;6:S783–90.
4. Brankston G, Gitterman L, Hirji Z, Lemieux C, Gardam M. Transmission of influenza A in human beings. Lancet Infect Dis. 2007;7:257–65.
5. Loeb M, Dafoe N, Mahony J, John M, Sarabia A, Glavin V, et al. Surgical mask vs N95 respirator for preventing influenza among health care workers: a randomized trial. JAMA 2009;302:1865–71.
6. Beggs CB, Shepherd SJ, Kerr KG. Potential for airborne transmission of infection in the waiting areas of healthcare premises: stochastic analysis using a Monte Carlo model. BMC Infect Dis. 2010;10:247.
7. Elder AG, O'Donnell B, McCruden EA, Symington IS, Carman WF. Incidence and recall of influenza in a cohort of Glasgow healthcare workers during the 1993–4 epidemic: results of serum testing and questionnaire. Br Med J. 1996;313:1241–2.
8. Bridges CB, Kuehnert MJ, Hall CB. Transmission of influenza: implications for control in health care settings. Clin Infect Dis. 2003;37:1094–101.
9. Guidelines and recommendations: prevention strategies for seasonal influenza in healthcare settings. 2010. Available at: http://www.cdc.gov/flu/professionals/infectioncontrol/healthcaresettings.htm.
10. Wagner BG, Coburn BJ, Blower S. Calculating the potential for within-flight transmission of influenza A (H1N1). BMC Med. 2009;7:81.
11. Baker MG, Thornley CN, Mills C, Roberts S, Perera S, Peters J, et al. Transmission of pandemic A/H1N1 2009 influenza on passenger aircraft: retrospective cohort study. Br Med J 2010;340:c2424.

12. Moser MR, Bender TR, Margolis HS, Noble GR, Kendal AP, Ritter DG. An outbreak of influenza aboard a commercial airliner. Am J Epidemiol. 1979;110:1–6.
13. Bean B, Moore BM, Sterner B, Peterson LR, Gerding DN, Balfour HH Jr. Survival of influenza viruses on environmental surfaces. J Infect Dis. 1982;146:47–51.
14. Dumoulin A, Widmer AF, Hirsch HH. Comprehensive diagnostics for respiratory virus infections after transplantation or after potential exposure to swine flu A/H1N1: what else is out there? Transpl Infect Dis. 2009;11:287–9.
15. Centers for Disease Control and Prevention (CDC). Update: infections with a swine-origin influenza A (H1N1) virus—United States and other countries, April 28, 2009. MMWR Morb Mortal Wkly Rep. 2009;58:431–3.
16. Michaelis M, Doerr HW, Cinatl J Jr. An influenza A H1N1 virus revival–pandemic H1N1/09 virus. Infection. 2009;37:381–9.
17. Blachere FM, Lindsley WG, Pearce TA, Anderson SE, Fisher M, Khakoo R, et al. Measurement of airborne influenza virus in a hospital emergency department. Clin Infect Dis. 2009;48:438–40.
18. Bansal S, Pourbohloul B, Grenfell B, Meyers LA. The shifting demographic landscape of influenza. PLoS Curr. Influenza 2009;RRN1047.
19. Scalera NM, Mossad SB. The first pandemic of the 21st century: a review of the 2009 pandemic variant influenza A (H1N1) virus. Postgrad Med. 2009;121:43–7.
20. Tellier R. Review of aerosol transmission of influenza A virus. Emerg Infect Dis. 2006;12:1657–62.
21. Sherertz RJ, Bassetti S, Bassetti-Wyss B. "Cloud" health-care workers. Emerg Infect Dis. 2001;7:241–4.
22. Mortimer EA Jr, Wolinsky E, Gonzaga AJ, Rammelkamp CH Jr. Role of airborne transmission in staphylococcal infections. Br Med J. 1966;1:319–22.
23. Belani A, Sherertz RJ, Sullivan ML, Russell BA, Reumen PD. Outbreak of staphylococcal infection in two hospital nurseries traced to a single nasal carrier. Infect Control. 1986;7:487–90.
24. Bassetti S, Bischoff WE, Walter M, Bassetti-Wyss BA, Mason L, Reboussin BA, et al. Dispersal of *Staphylococcus aureus* into the air associated with a rhinovirus infection. Infect Control Hosp Epidemiol. 2005;26:196–203.
25. Bassetti S, Bischoff WE, Sherertz RJ. Are SARS superspreaders cloud adults? Emerg Infect Dis. 2005;11:637–8.
26. Kar-Purkayastha I, Ingram C, Maguire H, Roche A. The importance of school and social activities in the transmission of influenza A(H1N1)v: England, April–June 2009. Euro Surveill. 2009;14(33)pii=19311. Available at: http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19311
27. Yang J, Yang F, Huang F, Wang J, Jin Q. Subclinical infection with the novel influenza A (H1N1) virus. Clin Infect Dis. 2009;49:1622–3.