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The environmental deposition of influenza virus from patients infected with influenza A(H1N1)pdm09: Implications for infection prevention and control☆

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☆ This work was conducted over two years. Preliminary data (from the first year only) has been published previously in an HTA report: http://www.ncbi.nlm.nih.gov/pubmed/20923613.

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Summary In a multi-center, prospective, observational study over two influenza seasons, we sought to quantify and correlate the amount of virus recovered from the nares of infected subjects with that recovered from their immediate environment in community and hospital settings. We recorded the symptoms of adults and children with A(H1N1)pdm09 infection, took nasal swabs, and sampled touched surfaces and room air. Forty-two infected subjects were followed up. The mean duration of virus shedding was 6.2 days by PCR (Polymerase Chain Reaction) and 4.2 days by culture. Surface swabs were collected from 39 settings; 16 (41%) subject locations were contaminated with virus. Overall, 33 of the 671 (4.9%) surface swabs were PCR positive for influenza, of which two (0.3%) yielded viable virus. On illness Day 3, subjects yielding positive surface samples had significantly higher nasal viral loads (geometric mean ratio 25.7; 95% CI 1.75, 376.0, $p = 0.021$) and a positive correlation ($r = 0.47$, $p = 0.006$) was observed between subject nasal viral loads and viral loads recovered from the surfaces around them. Room air was sampled in the vicinity of 12 subjects, and PCR positive samples were obtained for five (42%) samples. Influenza virus shed by infected subjects did not detectably contaminate the vast majority of surfaces sampled. We question the relative importance of the indirect contact transmission of influenza via surfaces, though our data support the existence of super-spreaders via this route. The air sampling results add to the accumulating evidence that supports the potential for droplet nuclei (aerosol) transmission of influenza.

Introduction

Little is definitively known about the modes of influenza transmission and their relative importance, and important health policy and infection control issues remain unresolved. The World Health Organization, the Centers for Disease Control and Prevention (CDC), the European Centre for Disease Prevention and Control and the U.S. Institute of Medicine have each prioritized improving the understanding of influenza transmission as a critical component for pandemic preparedness and response [1—3].

Influenza transmission begins with the production of virus containing particles by actions such as coughing and sneezing, which generate an 'expiratory spray' containing particles varying in size from <1 to 1000 μm. The majority are small and have a geometric mean diameter of 13.5 μm during coughing [4]. Large droplets (typical size >20 μm) deposit on mucous surfaces of the upper respiratory tract (URT), such as the mouth and nose; they can be inhaled, but are too large to reach the lungs. Droplet nuclei (frequently called aerosols; typically ≤5 μm) are inhaled and can reach the lower respiratory tract (LRT) [5]. Contact transmission involves the transfer of particles to the mucous membranes either directly, e.g., via kissing, or indirectly via hands or fomites.

Laboratory studies have confirmed the ability of human influenza virus to survive in these environments [6—8], but few studies have attempted to investigate its presence, quantity and viability around infected patients. In previous research, viral shedding has mostly been determined by the measurement of the virus that is recoverable from the nasopharynx, i.e., via a deliberately performed invasive technique. Such 'viral shedding' studies in fact measure the virus shed from infected cells into the nasopharynx but do not actually measure the amount of virus deposited into the environment (on surfaces or in the air); therefore, they imply but do not define environmental contamination and the actual hazard posed to others. In this study, we describe viral shedding and its relationship to symptom duration, illness severity and the amount of virus recovered from the immediate environment.

Methods

We conducted a multi-center, prospective, observational cohort study over two influenza seasons, comprising the second and third waves of the 2009/10 pandemic in England [September 2009—January 2010 (Year 1) & December 2010—January 2011 (Year 2)]. An accredited UK Research Ethics Committee approved the study.