Comparison of the social contact patterns among school-age children in specific seasons, locations, and times

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ABSTRACT

Social contact patterns among school-age children play an important role in the epidemiology of infectious disease. This study explored how people interact in specific seasons (flu season and non-flu season), environmental settings (city and county), and times (weekend and weekday). We conducted a survey of junior high school students (grades 7–8) using an established questionnaire during May–June 2013 and December 2013. The sample size with pair-wise comparisons for the times (weekday/weekend) and stratification by location and seasons were 75, 87, 105 and 106, respectively. The sample size with pair-wise comparisons for the seasons (flu/non-flu) and stratification by location were 54 and 83, respectively. Conversation and skin-to-skin contact behaviors were surveyed through diary-based questionnaires, of which 665 valid questionnaires were returned. There was no difference in the number of contacts during the flu and non-flu seasons, with averages of 16.3 (S.D. = 12.9) and 14.6 (S.D. = 9.5) people, respectively. However, statistical analysis showed that the average number of contacts in Taichung City and Yilan County were significantly different ($p < 0.001$). Weekdays were associated with 23–28% more contacts than weekend days during both the non-flu and flu seasons ($p < 0.001$) (Wilcoxon signed-rank test). Our work has important implications for the dynamic modeling of infectious diseases and performance analysis of human contact numbers and contact characteristics for schoolchildren in specific seasons, places, and times.

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1. Introduction

Social contact is thought to be a major factor in the transmission process for many important infections, including SARS, influenza, smallpox, measles, pertussis and tuberculosis (Read et al., 2012; Eames et al., 2012; Wallinga et al., 2006). Since many of the greatest threats to human health are spread by direct person-to-person contact, understanding the spread of respiratory pathogens and patterns of human interactions are public health priorities (Read et al., 2012; Eames et al., 2012). The social mixing of schoolchildren is considerable, and favors the spread of infectious diseases in school environments. Such environments are thus an important source of infection into households, from which infections can spread further (McLean et al., 2010; Miller et al., 2010a,b).

Empirical studies of social mixing specifically targeted at understanding the spread of respiratory infections have been performed in the UK (Eames et al., 2011), Switzerland (Smieszek et al., 2012), Italy (Fournet and Barrat, 2014) and other European countries (Mossong et al., 2008), as well as the USA (Destefano et al., 2011) and Vietnam (Horby et al., 2011). Contact studies such as these provide the contact number per day per participant, model the potential transmission risk, and describe the different contact networks and contact characteristics. However, few studies have investigated if seasonal and environmental differences have an impact on contact patterns. In other words, there is a tendency to investigate the role of human contact behavior in the influenza seasons. Consequently, we decided to study how mixing is driven by seasonal variation (specifically, flu season and non-flu season), variation by location (city and county), and variation in time (weekend and weekday).

The seasonality of influenza is governed by numerous factors, and calls for the efforts of researchers from multiple disciplines. The effects of weather on viral survival (Shaman and Kohn, 2009) and host susceptibility (Dowell, 2011) as well as the effects of social contacts on transmission (Cauchemez et al., 2008) favor the spread of influenza during the winter months (Lipsitch and Viound, 2009).

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Furthermore, Willem et al. (2012) provided information on the relationships between weather conditions and those social contact patterns relevant to influenza transmission. They pointed out that while weather conditions are believed to affect the efficiency of transmission and host immunity, seasonality may also be driven by a tendency of people to congregate indoors during periods of bad weather. With regards to this hypothesis, they combined data from a social contact survey in Belgium with local weather data, and found the number of contacts at school increased in conditions of high temperature and low precipitation.

Recently, Read et al. (2014) conducted a study of human contact patterns in Guangzhou, China, which focused on the social mixing patterns in rural and urban areas. They contrasted the contact patterns by age and community urbanization, finding little difference in the number and duration of contacts or the age-mixing patterns between these populations. While animal densities are generally higher in rural areas, urban locations tend to serve as hubs for global spread. The difference between urban and rural populations may be particularly important for the initial spread of zoonotic pathogens (Hufnagel et al., 2004).

Previous studies have suggested that school closures might be effective for controlling the spread of influenza within a school (Eames et al., 2012; Cauchemez et al., 2008; Eames, 2014; Xue et al., 2012; Cowling et al., 2008; Glass et al., 2006). A systematic review of epidemiological studies to assess the effect of school closures on the transmission of influenza has also been reported (Jackson et al., 2013). Miller et al. (2010a,b) agreed that school closure can reduce student–student contacts but may also accelerate spread within a community. Hence, they suggested that the student behavior during a school closure may enhance or detract from the effectiveness of the closure. Eames et al. (2011) presented the results of a prospective survey designed to provide a detailed comparison of social mixing patterns of schoolchildren both during school terms and during school holidays. Eames et al. (2011) also suggested that while infections may spread rapidly within schools during the term, in the holiday period there are increased opportunities for transmission to other schools and other age groups. Hence, a precise quantification of human contacts can help in the identification of possible contagion pathways, and in the design and evaluation of containment strategies such as targeted vaccination, social distancing, and school closures.

This study used social contact diaries to compare the number of contacts per day per participant across different seasons, locations, and times of the week. We also present contact properties such as sex, age, masking, setting, frequency, duration, and contact types among school-age children. This information could provide the basis for investigations into social contact patterns in Taiwan and for the modeling of control measures in the future.

2. Material and methods

2.1. Study population

The study populations were chosen from Taichung City and Yilan County. Taichung City is located in western Taiwan, and has a population of just over 2.7 million people as of April 2014, making it the third largest city in Taiwan. Taichung has a warm, humid subtropical climate with an average annual temperature of 23.3 °C. The highest temperature of the year occurs in July and August, while the lowest temperature occurs in January and February. The average annual rainfall is just above 1700 mm and the average humidity is 75.6%. Yilan is a county in northeastern Taiwan with a population of 458,000. The average annual temperature is 22.5 °C with the highest temperature of the year occurring in July and August and the lowest temperature occurring in January and February. The average annual rainfall is just above 2837 mm and the average humidity is 82%.

Our study was conducted using a questionnaire survey in Chung-Lun and Shun-An junior high schools (grades 7–8, age 13–15 years) in Taichung City and Yilan County, respectively. In Chung-Lun Junior High School, the population was 1052 students in 36 classes, and each grade had 12 classes. In Shun-An Junior High school the population consisted of 313 students in 12 classes, and each grade had 4 classes. Each class had an average of 30 and 27 students in the Chung-Lun and Shun-An junior high schools, respectively. We selected 3 classes in each grade for our analysis. The eligible population was 720 students in Grades 7–8. The study population (selected schools) in Taichung City and Yilan County were chosen with the convenience sampling. However, the grades 7–8 were chosen because the better comprehension to the definition of "contact" in our questionnaire. Besides, those classes were selected with random sampling.

2.2. Study design

Fig. 1 shows the design and framework for this study. We investigated the social contact patterns in specific seasons (flu and non-flu season), locations (Taichung and Yilan), and times (weekday and weekend). During the non-flu season (NS), each participant in the Chung-Lun (T) and Shun-An (Y) junior high schools was asked to fill out two questionnaires during one randomly assigned weekday (denoted NSTa and NSYa) and one randomly assigned weekend (NSTb, NSYb), respectively. Each participant from each school was additionally requested filled out two questionnaires in the same way (FSTa, FSYa and FSTb, FSYb for a random weekday and weekend, respectively) during the flu season (FS).

Time-paired sample sizes were defined by the number of participants who correctly completed the questionnaires during the weekday and weekend, while season-paired sample sizes were defined by the number of participants in the same school who correctly completed questionnaires during flu/non-flu seasons and during the weekday and weekend.

2.3. Questionnaire survey and contact variables

This questionnaire survey was approved by the Institutional Review Board of the Ethical Committee of Chung Shan Medical University (CSMUH No: CS13100). Questionnaires were completed only after the participants and their parents (or legal guardians) signed an informed consent form. Parents signed the consent form but did not participate in this study or assist children when they were completing a questionnaire. The participants were told in advance which days they had been assigned and encouraged to fill out the questionnaire before they went to bed.

A contact was defined as a two-way conversation in which at least 3 words were spoken by each party. Two types of physical contact were defined: (i) two-way conversations during which at least three words were spoken (conversation only), and (ii) contacts that involved any sort of skin-to-skin contact (physical contact) (Horby et al., 2011). A contact diary was used to record all contacts during one day. The diary followed the course of the day, which was broken down by activities, starting with activities in the morning after waking, on the way to school, playing during breaks, and other activities after school until going to bed.

At the beginning of the questionnaire, participants were asked to provide information regarding sex, age, household size, their living situation (at home or in a dormitory), their health status on the day of sampling, their influenza vaccination history of the past six months, and the weather conditions that day. The scores to express the different levels of health status ranged from 0 to 10, e.g., feeling