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Social contact patterns of school-age children in Taiwan: comparison of the term time and holiday periods

S.-C. CHEN[1,2]* AND Z.-S. YOU[1]

[1] *Department of Public Health, Chung Shan Medical University, Taichung, Taiwan, ROC*
[2] *Department of Family and Community Medicine, Chung Shan Medical University Hospital, Taichung, Taiwan, ROC*

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SUMMARY

School closure is one of the most common interventions in the early weeks of an influenza pandemic. Few studies have investigated social contact patterns and compared individual student contact characteristics during the school term and holiday periods in Taiwan. Here, we conducted a well-used questionnaire survey in a junior high school (grades 7–8) in June 2013. All 150 diary-based effective questionnaires covering conversation and skin-to-skin contact behaviour were surveyed. Two questionnaires for each participant were designed to investigate the individual-level difference of contact numbers per day during the two periods. The questionnaire response rate was 44%. The average number of contacts during term time (20·0 contacts per day) and holiday periods (12·6 contacts per day) were significantly different ($P < 0{\cdot}05$). The dominant contact frequencies and duration were everyday contact (89·10%) and contacts lasting less than 5 minutes (37·09%). The greatest differences occurred within the 13–19 years age groups. The result presented in this study provide an indication of the likely reduction in daily contact frequency that might occur if a school closure policy was adopted in the event of an influenza pandemic in Taiwan. Comparing contact patterns during term time and holiday periods, the number of contacts decreased by 40%. This study is the first research to investigate the contact numbers and contact characteristics for school-age children during the school term and a holiday period in Taiwan. With regard to public health, this study could provide the basic contact information and database for modelling influenza epidemics for minimizing the spread of influenza that depends on personal contacts for transmission.

Key words: Behaviour, contact diary, contact patterns, influenza, school closure.

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 [1–3]. The pattern of human interactions has important implications for the spread and management of infectious diseases [4]. Understanding the spread of respiratory pathogens is a public health priority as many of the greatest threats to human health are spread by direct person-to-person contact [3].

Brankston *et al.* [5] identified four main modes of transmission for respiratory infections, each of which defines a contact differently: (*a*) airborne transmission, which involves pathogens expelled from an infectious

* Author for correspondence: Dr S.-C. Chen, Department of Public Health, Chung Shan Medical University, Taichung, Taiwan 40201, ROC.
(Email: scchen@csmu.edu.tw)

host through coughing or sneezing, producing small droplets which become aerosolized; (*b*) droplet transmission, where pathogens are expelled from the host in larger, heavier droplets, quickly settling on surfaces; (*c*) direct transmission, where the secretions of an infected individual are transferred directly to the respiratory tract of a susceptible individual; and (*d*) fomite transmission, where pathogens are deposited by an infected individual onto an inanimate object. With fomites, transfer of infection occurs when an uninfected individual comes into contact with an inanimate object. Because of the tendency of children to make physical contact with their peers, it is reasonable to expect that the social behaviour of school-age children plays a major role in the transmission of influenza within schools and households. Children experience the highest incidence of infection and contribute the most to further spread of infections [2, 6, 7].

School closure is one of the most common interventions in the early weeks of an influenza pandemic. Previous studies have suggested that school closures might be effective for controlling the spread of influenza within a school [3, 8–10]. Miller *et al.* [11] agreed that school closure could reduce student–student contacts but could possibly accelerate spread within a community. Hence, they suggested that student behaviour during a school closure may enhance or detract from the effectiveness of school closure. Eames *et al.* [12] presented the results of a prospective survey designed to provide a detailed comparison of social mixing patterns of schoolchildren during school terms and school holidays. Eames *et al.* [12] suggested that while infections may spread rapidly within schools during term time, in the holiday period there are increased opportunities for transmission to other schools and other age groups. In particular, the patterns of school terms and holidays affect the spread of influenza infections among schoolchildren [3]. Studies focusing on school-age children have confirmed that children make substantially fewer contacts on average during holidays and weekends than when at school [3]. Observational studies have shown that school holidays correlate with reductions in the rate of influenza-like illness within susceptible populations [8].

Recently, Read *et al.* [1] reviewed several methodologies to measure social mixing behaviour such as the direct observation, contact diaries and proximity sensors. Direct observation by using video cameras has rarely been used to study human social interactions. Contact diaries have commonly been used to record encounters made with other people by face-to-face conversation or physical touch (skin on skin). The proximity sensing method could use radio or Bluetooth communications; however, the interaction between participants with other people can not be quantified. Smieszek *et al.* [13] noted that the preferred technique for measuring epidemiologically relevant information about the frequency and duration of contact between individuals was to use contact diaries. This method has now been applied, from an epidemiological perspective, in a variety of convenience studies, school-based populations, healthcare settings and larger studies of the general public [1].

Many studies have characterized the social contact patterns in different populations and countries, such as school-age children in the UK [12], general population in Vietnam [14], university employees in Switzerland [13], general population in eight European countries [15], and a general population survey in the USA [16]. These contact studies have provided the basic contact numbers per day per participant to model the potential transmission risk. They also describe the different contact networks and contact characteristics.

In Taiwan, few studies have investigated social contact patterns for modelling of respiratory infectious diseases. One such study was reported by Fu *et al.* [17] who collected 1943 contact diaries and recorded a total of 24 265 wide-range, face-to-face interpersonal contacts during a 24-h period. Fu *et al.* [17] found that nearly 70% of contacts occurred outside of respondents' households and the most active age group was schoolchildren (aged 5–14 years), who averaged around 16–18 daily contacts.

The Taiwan Centres for Disease Control (TCDC) has listed school closure as one of the social control measures in their 'Strategy Plan for Executive of Influenza Pandemic Response' to decrease the disease transmission and delay the time of an influenza outbreak (http://flu.cdc.gov.tw). The plan also indicates that during the school closure periods, parents should keep their children at home to avoid contact with infected persons in the community or public environment. However, until now, there have been no reports of the differences in contacts of children during school terms *vs.* holidays for school-age children in Taiwan. Hence, in order to measure the contact rates among school-age students during the regular school term *vs.* the contacts during a holiday from school, the objective of our study was to investigate

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the contact numbers and contact characteristics for schoolchildren during the school term and a holiday period by using social contact diaries. This information could provide the basis for modelling of control measures in the future.

METHODS

Sampling design

In order to measure contact patterns during school term and holiday periods for schoolchildren, this study was conducted in a single junior high school (grades 7–8, age 12–13 years) in Taichung city. The source population comprised the 1052 students enrolled at the school. Students were organized into 36 classes (12 for each grade) with each class comprised of ~30 students. We selected at random three classes in grades 7–8 to take part in our study. The eligible population was comprised of 720 students in grades 7–8. Of that group a total of 169 students gave consent to take part in the study.

The questionnaire used for this study was approved by the Institutional Review Board of the Ethical Committees of Chung Shan Medical University (CSMUH no. CS12211). Questionnaires were completed only after the participants and their parents (or legal guardians) signed a written informed consent form. Parents of students within each of the three selected classes in grades 7–8 were provided with a consent form, asking them to provide permission for their child to take part in the study. Of the 720 students that comprised the eligible population, parental permission was provided for 169 students. Parents were not requested (or required) to provide assistance when students were completing the questionnaire. All questionnaires were completed anonymously.

Three selected classes in grades 7–8 were requested to report their contacts on different days of the week (29 May 2013 to 6 June 2013). Each participant was asked to complete two questionnaires during one randomly assigned term time (weekday) and one randomly assigned day during a holiday (weekend). The participants were told in advance which days they had been assigned and were encouraged to complete the questionnaire before they went to bed. Two questionnaire surveys for each participant were designed to investigate the individual-level difference of contact numbers per day during school term time and during a holiday period.

Questionnaire survey

A contact was defined as a two-way conversation in which at least three words were spoken by each party [3, 14]. Two types of physical contact were defined: (i) two-way conversations during which at least three words were spoken (conversation only), and (ii) contacts which involved any sort of skin-to-skin contact (physical contact). The form of a contact diary was used to record all contacts during one day. The diary followed the course of the day 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, living at home or in a dormitory, their health status on the sampling day, influenza vaccination in the past 6 months, and the current weather conditions. The scores to express the different levels of health status ranged from 0 to 10, e.g. bad (score = 0), normal (score = 5) and feel good (score = 10). All students were asked to list all contacts they had during the day, as well as the estimated contact age (0–5, 6–12, 13–19, 20–39, 40–59, or $\geqslant$60 years), sex, and the relationship between participants and the person encountered (family, classmate, teacher, other), health status of those contacted (healthy, fever, runny nose, headache, cough, throat ache), whether those contacted were wearing a mask (yes/no), the contact setting (school, home, cram school, other), contact frequency (daily or almost daily, 1–2 times a week, 1–2 times a month, <1 time a month, first time), contact duration (<5 min, 5–15 min, 15 min–1 h, 1–4 h, >4 h), and contact type (conversation or physical contact or both). In this study, the questionnaire survey was designed record up to 35 contacts per day (see Appendix 1, Supplementary material). Hence, if a participant had exactly 40 contacts on a given day this was recorded in the questionnaire as 35.

Statistical analysis and software applications

The frequency of contact stratified by sex, grade, household size, term time/holiday, health status, contact types, and vaccination status were numerically compared. To provide an estimate of the point estimate of the number of contacts compared with a reference group and a 95% confidence interval around that point estimate a negative binomial regression

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approach was used. Here, the outcome variable was number of recorded contacts per participant per day and the explanatory variables were sex, grade, household size, term time/holiday, health status, and vaccination status. Statistical analysis was carried out in SAS v. 9.3 for Windows (SAS Institute Inc., USA).

Individual-level changes in numbers of encounters recorded during term time and during the holiday period were tested using the Wilcoxon signed-rank test ($P<0{\cdot}05$). This non-parametric test was used because of a lack of previous studies indicating the likely distribution of holiday-related changes in individual-level contact behaviour. Finally, frequency histograms of the number of contacts per day were plotted and parametric distributions were fitted to the data using Crystal Ball software v. 2000.2 (Decisioneering Inc., USA). A range of candidate parametric distributions were assessed and the Kolmogorov–Smirnov test used to identify the distribution providing the best fit to the data.

RESULTS

Study population

A total of 338 questionnaires (169 participants) were given to junior high school students, of which 75 were returned by the participants and their parents (or legal guardians) who agreed to complete the assigned questionnaires during term time and the holiday period. The effective sample size was 150 questionnaires with a 44% response rate. The excluded participants included 83 participants who did not agree (49%), 10 missing participants (6%), and one invalid questionnaire (1%).

Participants and contact characteristics

The number of recorded contacts per day and relative number of reported contacts (95% confidence intervals) across all variables is summarized in Table 1. The Wilcoxon signed-rank test and the Kruskal–Wallis test were performed to test the relative number of reported contacts in all categories. We recorded 6675 contacts from 75 participants; 61·3% were female. Results indicate that an average female respondent contacted 16·5 (s.d. = 10·0) persons per day, only slightly more than the average male respondent (mean = 15·8, s.d. = 10·3). Furthermore, the average number of contacts were 15·3 (s.d. = 10·9) and 16·9 (s.d. = 9·6) per day for grades 7 and 8, respectively. The average household size was 4·5. The number of contacts for different grades, participants' sex, and household sizes were not significantly different between term time and holiday period. However, there were no differences in contact numbers between the three score levels (0–4, 5–7, 8–10) of the health status of participants and whether a vaccine was used or not.

Figure 1 shows the frequency distributions and difference analysis of the number of contacts (per day) during term time and holiday periods. Definition of frequency means the number of participants divided by the total number of participants ($n=75$). The results indicate that the highest contact numbers occurred during the intervals of 5–9 per day and 30–35 per day during the holiday and term time, respectively (Fig. 1*a*). We further estimated the individual-based changes in the number of contacts between the two periods (Fig. 1*b, c*). It was defined as the numbers during term time minus the numbers during the holiday period for each specific participant. The change of 0–5 contacts per day produced the highest percentage (41%, 31/75 participants).

Comparison of the contact properties during term time and a holiday period

The properties of contacts during term time and a holiday period are presented in Figure 2. The results revealed that there were 1496 contacts during the term time and obviously the number was higher than those during the holiday period (944 contacts). Several of the stratification variables listed in Table 1, including the sex, contact type, age groups, contact duration, mask used or not, and contact frequency. Most contact characteristics in term time were female (55·28%), conversation type (70%) and the most active age group was 13–19 years. The dominant contact frequencies and duration were everyday contact (89·10%) and contact duration <5 min (37·09%). Regarding the contact setting, 74·13% of contact numbers took place at school during term time and 52·65% contact numbers at home during the holiday period.

Table 2 shows the contact numbers for different age groups and contact levels. The average number of contacts during term time (20·0 contacts per day) and holiday periods (12·6 contacts per day) were significantly different ($P<0{\cdot}05$) based on the Wilcoxon signed-rank test. The median, Q1 and Q3 of contact numbers during term time were 8, 21 and 35, respectively. The median, Q1 and Q3 of contact numbers during holiday periods were 5, 8 and 19, respectively.

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Table 1. *Number of recorded contacts per participant per day by characteristics, and relative number of contacts*

Variable	Covariate	Participants *n* (%)	Mean (s.d.) number of reported contacts	Median (Q1-Q3)	Relative number of reported contacts (95% CI)	*P* value
Sex	Male	29 (38·7)	15·8 (10·3)	14·5 (6·5–22·5)	1·00	
	Female	46 (61·3)	16·5 (10·0)	14 (8·13–23·5)	1·04 (0·76–1·40)	0·3296*
Grade	7	30 (40)	15·3 (10·9)	10·5 (6·5–21·6)	1·00	
	8	45 (60)	16·9 (9·6)	15·5 (9–22·5)	1·11 (0·83–1·50)	0·1190*
Household size	2	1 (1·3)	5·0 (n.a.)	n.a.	1·00	
	3	7 (9·3)	14·6 (11·7)	14·5 (5·25–19·3)	2·91 (0·66–12·92)	
	4	29 (38·7)	14·5 (10·4)	10 (7–20·5)	2·90 (0·69–12·18)	
	5	22 (29·3)	17·5 (9·8)	22·25 (10·6–32·3)	3·51 (0·83–14·81)	
	>5	16 (21·3)	19·1 (9·2)	16·25 (7·86–22·1)	3·82 (0·90–16·23)	0·0613†
Term time	Monday	17 (22·7)	21·9 (11·4)	14·5 (8·5–21·5)	1·00	
	Tuesday	14 (18·7)	21·4 (10·6)	12·5 (9·5–25·9)	0·98 (0·6–1·54)	
	Wednesday	13 (17·3)	20·1 (11·1)	19·5 (9–22·5)	0·91 (0·58–1·46)	
	Thursday	16 (21·3)	17·8 (12·9)	10·75 (6–19·8)	0·81 (0·52–1·26)	
	Friday	15 (20)	18·5 (13·0)	14·5 (6·25–22·3)	0·84 (0·54–1·32)	0·7504†
Holiday	Saturday	39 (52)	14·2 (11·7)	14·5 (7–27)	1·00	
	Sunday	36 (48)	10·9 (9·5)	13·75 (8·75–20·5)	1·30 (0·91–1·87)	0·2062*
Health status (term time)	0–4	5 (6·7)	14·9 (7·34)	17·25 (10·6–20·9)	1·00	
	5–7	34 (45·3)	16·8 (9·8)	14 (8·5–23·5)	1·13 (0·62–2·06)	
	8–10	36 (48)	16·0 (10·8)	14·5 (6·38–22·5)	1·07 (0·59–1·95)	0·7323†
Health status (holiday)	0–4	7 (9·3)	17·6 (7·1)	20·5 (16·3–20·5)	1·00	
	5–7	30 (40)	16·9 (10·0)	13·75 (9·63–13·8)	0·96 (0·57–1·61)	
	8–10	38 (50·7)	15·5 (10·7)	11·25 (6·5–11·3)	0·88 (0·53–1·46)	0·4768†
Vaccine	Yes	13 (17·3)	15·2 (10·9)	13 (8–20·5)	1·00	
	No	62 (82·7)	16·4 (10·0)	14·5 (7·25–22·5)	1·08 (0·74–1·59)	0·2665*

CI, Confidence interval; n.a., not available.
* Wilcoxon signed-rank test.
† Kruskal–Wallis test.

A significant difference (7·36 per day) was shown during term time and holiday periods for all contacts. The major difference between holiday period and term time took place in the 13–19 years age group, i.e. it was most common for junior high-school students to decrease contacts with their classmates during holiday periods. Finally, Figure 3(*a, b*) shows the distribution of the number of contacts per day during term time and the holiday period, respectively. Superimposed on each plot are lognormal distributions which provided the best fit to the data.

DISCUSSION

The contact numbers and contact characteristics for schoolchildren during the school term and holiday period in Taiwan were quantified in this study and were evaluated by statistical tests. We now discuss further the definition of contact, and contact numbers for term time and the holiday period compared to other published researches, and the limitations of our study.

Based on previous studies, we found that the definition of contact types (conversation or face-to-face conversation) given in thecontact diaries were different. Smieszek *et al.* [13] defined conversation as 'a conversation held at <2 m distance and >10 words'. Horby *et al.* [14] defined it as 'two-way conversation with $\geqslant$3 words', and 'a face to face conversation lasting >1 min' [16]. In this study, we defined 'contact' as a two-way conversation in which at least three words were spoken by each party [3, 14]. A definition based on understanding or not would influence the recorded numbers. A simple definition might be more likely to record all of the people the students met during the investigation periods.

The average contact numbers of this study were 20·0 (s.d. = 11·7) and 12·6 (s.d. = 10·7) for term time and holiday period, respectively. With an upper cut-off at 35, our result is close to those in England [12]

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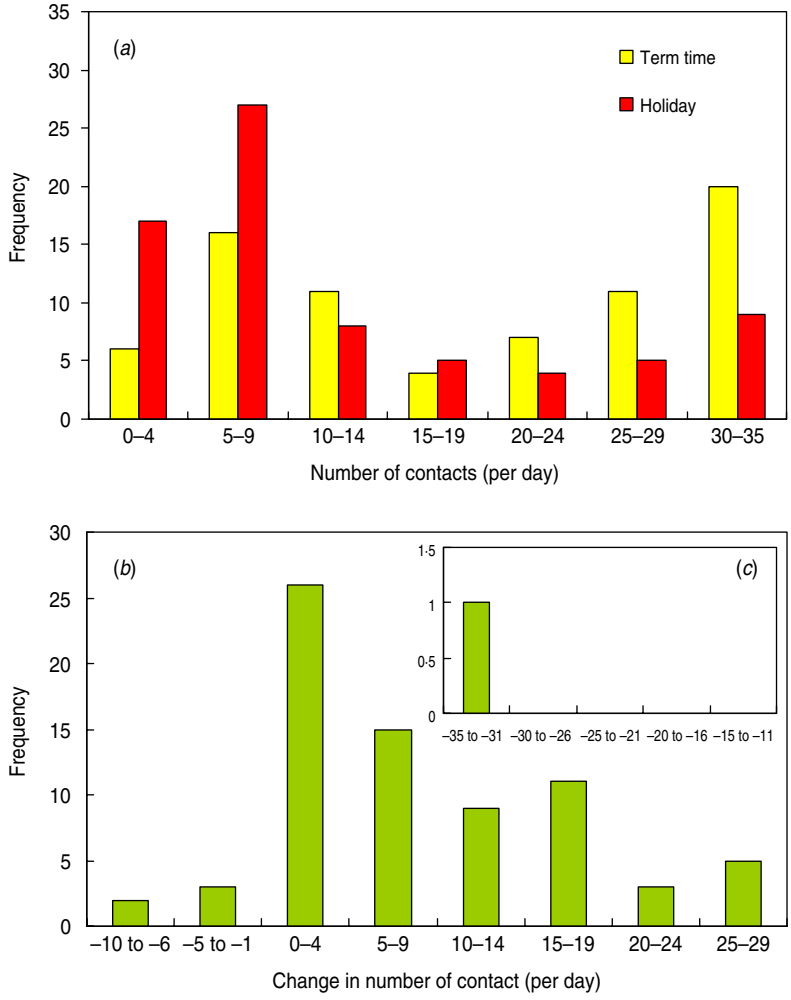

Fig. 1. (*a*) Frequency distribution of the number of contacts (per day) in term time (yellow) and holiday periods (red). (*b, c*) Frequency distribution of the change in number of contacts (per day) by 75 participants. The compared numbers of contacts were defined as the numbers during term time minus the numbers during holiday periods for each specific participant.

for term time (mean = 19·0, S.D. = 8·9) and a holiday period (mean = 9·4, S.D. = 6·0). In European countries, German and Italians participants reported the average daily numbers of contacts were 7·95 (S.D. = 6·26) and 19·77 (S.D. = 12·27), respectively [15]. Those contacts were much higher than in Vietnam (mean = 7·7, S.D. = 3·9) [14]. Fu *et al.* [17] also collected contact diaries in Taiwan from a national sample, they showed that the average number of contacts in the 24-h diaries was 12·5 (S.D. = 9·3). The above studies indicate that our results were reasonable in the contact number investigation. Besides the Vietnamese research, the lower contacts numbers may be because the studied community is rural, or may reflect recall bias [14].

Read *et al.* [1] reviewed the methods of measuring social mixing behaviour and cited Brankston *et al.* [5] who indentified the four main modes of transmission for respiratory infections. These modes of transmission include airborne, droplet, direct, and fomite transmission. However, the method of the questionnaire survey only captured the potential droplet (conversation) and direct (physical contact) transmissions. As with most other surveys [2, 6, 15, 18, 19], conversations were also a primary measure of social contacts.

Our results indicate that the change in the number of encounters reported for all contact numbers during term time minus the number during the holiday period was highly significant ($P < 0{\cdot}0001$). Comparing contact patterns during term time and holiday periods, the number of contacts decreased by 40%. Most term time contacts were made between individuals of similar ages, but during a holiday period a small number of contacts were with adults. Eames *et al.* [12] stated that infections spread predominantly within school during

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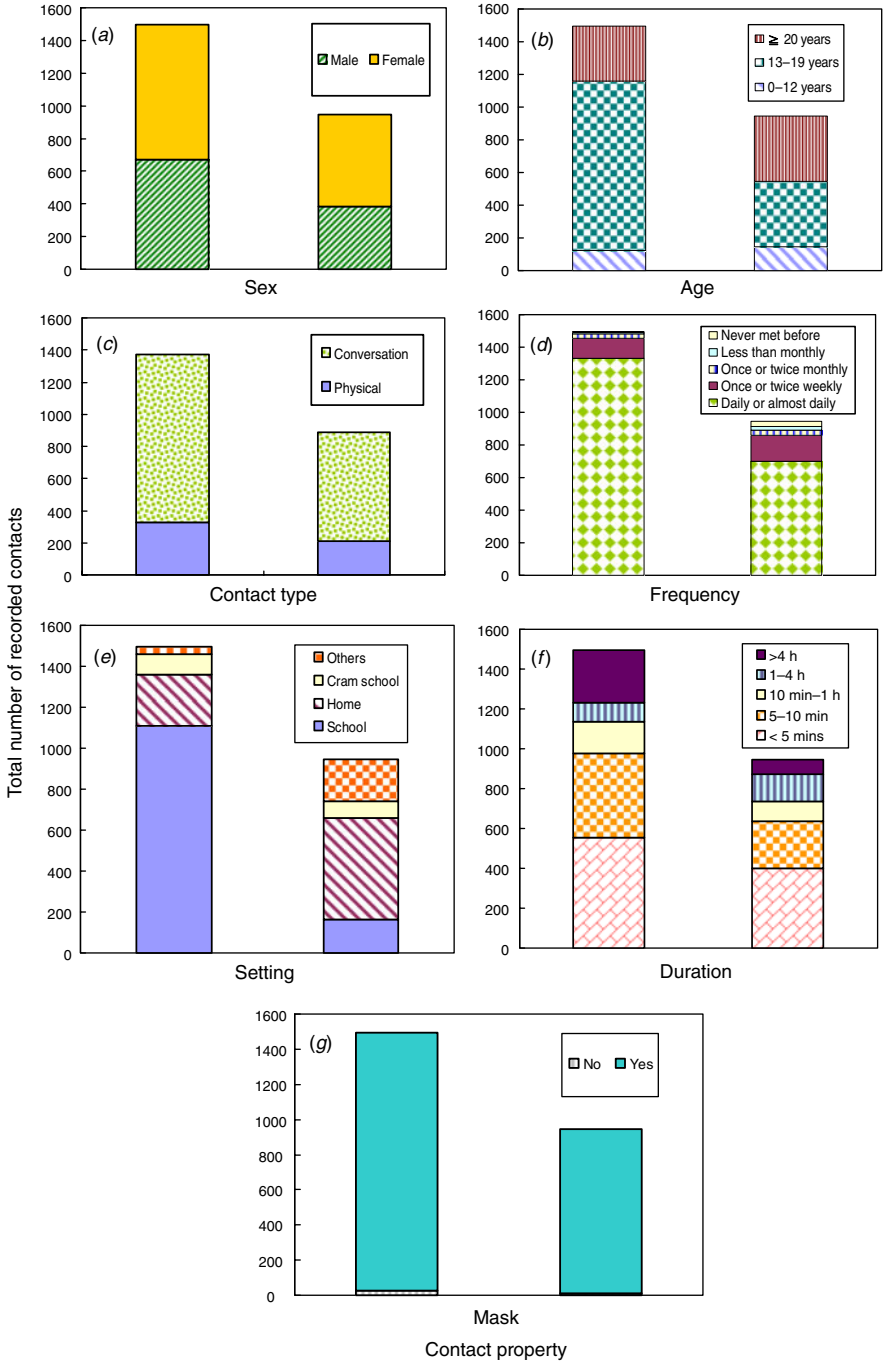

Fig. 2. Properties of encounter in term time (left bars) and holiday period (right bars). (*a*) Sex (male, female) and contact type (conversation, physical). (*b*) Age groups (0–12, 13–19, ⩾20 years) and contact duration (<5 min, 5–15 min, 15 min–1 h, 1–4 h, >4 h), and (*c*) mask (used or not), contact frequency (every day, 1–2 times a week, 1–2 times a month, <1 time a month, first time), and setting (school, home, cram school, other).

term time but that holiday periods offer increased opportunities for transmission to other schools and to other age groups. However, the participants' siblings who attended other schools were not investigated in our study. However, the strength of our analysis was that the difference in contact numbers in two periods was individual-based. That is to say, the contact numbers during term and holiday periods had a relatively positive correlation ($R^2 = 0{\cdot}39$).

The limitations of our study included a relatively low response rate, 44%. This low response rate may have been related to disagreement between parents

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Table 2. *Mean number (s.d.) of reported encounters by different contact type. Number of encounters reported during term time and holiday period compared*

Contact levels	Age (years)	Term time	Holiday	Difference	*P* value†
All contact	Total	20·0 (11·7)	12·6 (10·7)	7·36 (9·78)	<0·0001*
	0–5	0·33 (1·5)	0·67 (3·1)	−0·33 (3·2)	0·3211
	6–12	1·29 (3·3)	1·6 (3·8)	−0·30 (3·3)	0·2721
	13–19	13·8 (9·9)	5·0 (7·0)	8·84 (8·3)	<0·0001*
	20–39	2·14 (2·5)	1·9 (2·4)	0·21 (2·3)	0·2948
	40–59	2·1 (2·3)	3·0 (3·8)	−0·88 (3·2)	0·0962
	⩾60	0·3 (0·7)	0·4 (1·2)	−0·17 (1·1)	0·0171*
Physical contact	Total	4·4 (5·8)	2·8 (4·16)	1·5 (5·46)	0·1422
	0–5	0·2 (1·4)	0·08 (0·3)	0·12 (1·44)	0·40
	6–12	0·2 (0·9)	0·7 (2·1)	−0·41 (2·20)	0·34
	13–19	3·52 (5·2)	1·2 (2·6)	2·36 (5·50)	0·41
	20–39	0·12 (0·6)	0·21 (0·6)	−0·09 (0·90)	0·43
	40–59	0·27 (0·6)	0·62 (1·1)	−0·36 (1·15)	0·07
	⩾60	0·02 (0·2)	0·10 (0·4)	−0·08 (0·43)	1·00

† Wilcoxon signed-rank test.
* $P<0·05$.

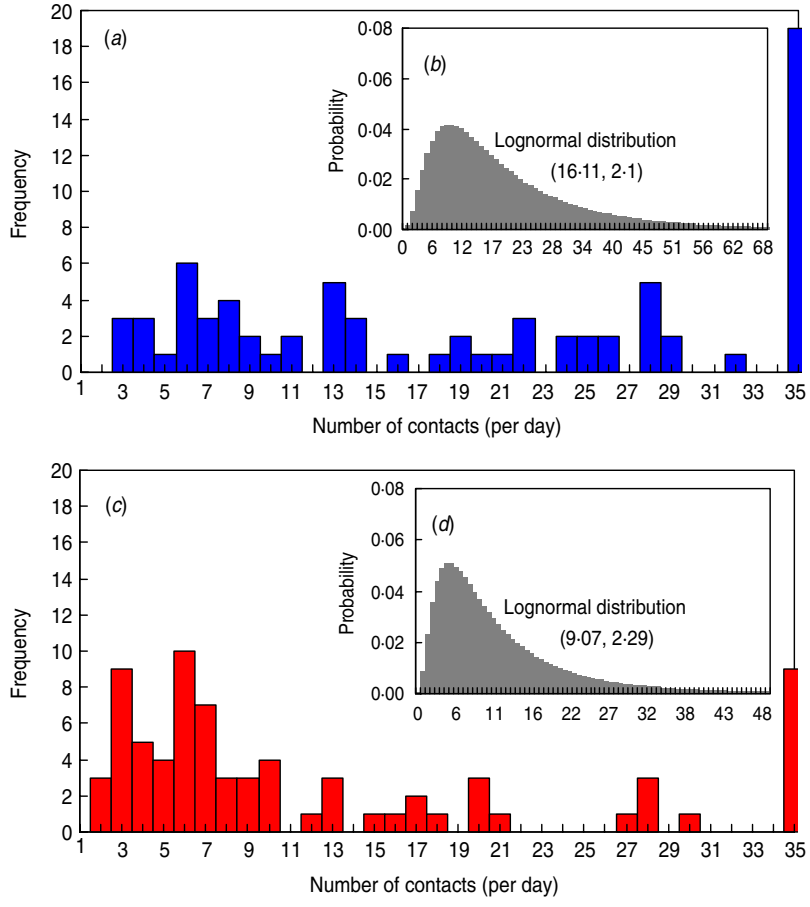

Fig. 3. Histograms of frequency distribution of contact numbers per day in (*a*) term time and (*c*) holiday period, respectively. The grey area presented the best-fit lognormal distribution with geometric mean and geometric standard deviation in (*b*) term time and (*d*) holiday period, respectively.

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or legal guardians. However, only a small percentage (2%) of parents stated that they refused their children's participation because of a disagreement. Rubin *et al.* [20] reported a 7% response rate for a UK general population telephone survey. Eames *et al.* [12] reported that 11% of distributed surveys were correctly completed and returned. Our results imply that some participants either did not pay attention to the purpose of the questionnaire or did not have an understanding of the importance of disease transmission. Second, as with most other surveys, it is difficult to quantify potential biases in participant recall and reporting. Smieszek *et al.* [13] investigated errors and biases in contact diaries used to collect close-contact social mixing data. They found that problems recalling contacts occurred more often in the case of short encounters than in the case of long-lasting interactions. More than one third of all reported contacts were only reported by one participant [13].

In conclusion, this study is the first research to investigate the contact numbers and contact characteristics for schoolchildren during the school term and a holiday period in Taiwan. Although the term time and holiday periods only focused on the weekday and weekend, respectively, we believe that this framework could provide the basic contact information and could be incorporated into population dynamics for modelling of control measures.

SUPPLEMENTARY MATERIAL

For supplementary material accompanying this paper visit http://dx.doi.org/10.1017/S0950268814001915.

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DECLARATION OF INTEREST

None.

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