
Household Effects of School Closure during Pandemic (H1N1) 2009, Pennsylvania, USA

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To determine the effects of school closure, we surveyed 214 households after a 1-week elementary school closure because of pandemic (H1N1) 2009. Students spent 77% of the closure days at home, 69% of students visited at least 1 other location, and 79% of households reported that adults missed no days of work to watch children.

Some studies have suggested that school-age children are influential in the ongoing transmission of influenza (1,2). Closing schools may potentially reduce the spread of influenza (3,4). In mid-May 2009, an elementary school (kindergarten-4th grade) in a semirural area of Pennsylvania closed for 1 week after an abrupt increase in absenteeism due to influenza-like illness (ILI) and the confirmation of influenza A pandemic (H1N1) 2009 virus infection in 1 student. Other schools in the district remained open. From May 26 through June 2, 2009, investigators from the Pennsylvania Department of Health and the Centers for Disease Control and Prevention surveyed households with students at the school by telephone to assess influenza symptoms, childcare arrangements, movements of affected children during the school closure period, and household demographics and socioeconomic status. This study did not address the transmission effects, but assessed the potential disruption to households resulting from school closure.

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The Investigation

The survey was considered a public health response. School administrators provided contact information for households with children attending the school. Investigators asked to speak to an adult in the household. If an adult was available and consented, the survey was administered. For each day of school closure, respondents were asked for the following information: where the student spent most of the day; whether the student went elsewhere (prompted by specific venues), who watched the student; and whether the person watching the student missed work. Questions were asked regarding the oldest student if multiple children attended the school.

Respondents were also asked, for each household member, whether the person had symptoms of ILI (defined as fever with cough and/or sore throat) between May 1, 2009, and the time of the survey. Children were defined as persons <18 years of age, and those \geq 18 years of age were considered adults. The online Technical Appendix (www.cdc.gov/EID/content/16/8/1315-Techapp.pdf) describes the process followed to calculate variables used in the analysis.

The locations where students spent most of the day and other venues visited were tabulated. Significant differences in venues visited by students with and without ILI were determined by using the Fisher exact test. We computed unadjusted and adjusted odds ratios (ORs) for the following characteristics versus whether the household reported missing \geq 1 workdays: whether the oldest student reported ILI (repeated for whether any adult, any student at the closed school, or any child in the household reported ILI), whether the household had a single child, whether the household had just 1 adult, whether all adults in the household worked outside the home, and whether household income was above the median (online Technical Appendix). Adjusted ORs were computed in a logistic regression model for variables that had unadjusted ORs significant at $p < 0.10$ by the Fisher exact test.

Surveys were completed for 214 (59%) of 364 households (59%), and accounted for 269 (59%) of the 456 students enrolled at the school. Table 1 shows the demographics of surveyed households. Most households had at least 2 adults, at least 2 wage earners, and \geq 2 children. Households with incomes \geq \$60,000 were at or above the median income. Because some of the oldest students spent days in multiple locations during the 5 days of school closure, we calculated the number of student-days at each venue (number of students at each type of venue multiplied by the number of days spent there). Home was the primary location during the school closure for 77% of the

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Table 1. Demographic variables of households affected by school closure during pandemic (H1N1) 2009, Pennsylvania, USA*

Variable	No. (%) households†
No. adults (≥18 y)	
1	25 (11.7)
2	157 (73.4)
>2	32 (15.0)
No. children (<18 y)	
1	44 (20.6)
2	92 (43.0)
3	53 (24.8)
>3	25 (11.7)
Households with ≥1 adult with ILI	34 (15.9)
Households with ≥1 child with ILI	88 (41.1)
Households with the oldest student with ILI	67 (31.3)
Household income (US\$)	
0–29,999	27 (12.6)
30,000–59,999	65 (30.4)
60,000–89,999	51 (23.8)
≥90,000	42 (19.6)
Don't know/refused/missing	29 (13.6)
No. wage earners	
1	64 (29.9)
2	135 (63.1)
≥3	12 (5.6)
Don't know/refused/missing	3(1.4)
Time adult in household missed work to watch oldest student, d	
0	168 (78.5)
1	13 (6.1)
2	7 (3.3)
3	4 (1.9)
4	4 (1.9)
5	18 (8.4)
% Adults in household who work	
33	5 (2.3)
40	1 (0.5)
50	44 (20.6)
67	16 (7.5)
75	3 (1.4)
100	142 (66.4)
Don't know/refused/missing	3 (1.4)

*ILI, influenza-like illness.

†Categories are mutually exclusive and exhaustive, but percentages may not sum to 100% due to rounding.

student-days (online Technical Appendix Figure 1). The next most common location was another family member's home.

Sixty-nine percent of students visited other venues during school closure (online Technical Appendix Figure 2). Those reported as having ILI were more likely to have visited a healthcare provider than those without ILI ($p<0.01$), but no other statistically significant differences were found in terms of venues visited between those with ILI and those without ILI. Seventy-nine percent of households reported zero missed workdays (Table 1); of the remaining households in which work was missed, ≈40% missed work during all 5 days of school closure.

The only household characteristics for which the OR for missing any workdays was significantly different from 1 at $p<0.10$ were single child, all adults work, and household income is greater than or equal to median income (Table 2). When adjusted ORs were calculated, household income greater than or equal to median was significant at $p<0.05$, but because income data were only available for 184 households (vs. 214 for the other factors), the sample on which the adjusted ORs were calculated was somewhat different. All adults in the household working was significantly associated with household income greater than or equal to the median ($p<0.01$).

Conclusions

Estimating the economic effects of school closure can provide useful information to aid in estimating whether it is likely to achieve the intended goals. Households that reported missed work incurred costs, even if those costs were only in terms of lost vacation or sick time.

The data show that most of the oldest students spent the days of school closure at home. However, most students left the home at least once during the closure period to visit routine venues (stores, locations of sports events or practices, restaurants). Few differences were found for reported ILI (with the obvious exception that students with ILI had significantly more visits to healthcare providers). These latter 2 findings are similar to those found in a 2006 study of an influenza B–related school closure in North Carolina, USA (5). This behavior, particularly by students who reported ILI, may increase the risk for onward transmission. A survey of 2 school districts in Kentucky that experienced a seasonal influenza–related school closure also found that students engaged in many activities outside the home (6), as did a survey of households affected by pandemic (H1N1) 2009 school closure in Australia (7).

In our study, only 22% of households reported missing any work to watch the students, fewer than during the

Table 2. Predictors of households reporting days of work missed to watch children during school closure for pandemic (H1N1) 2009, Pennsylvania, USA*†

Variable	OR	Adjusted OR‡
Oldest student with ILI	1.22	
Any student with ILI	1.20	
Any child with ILI	1.16	
Any adult with ILI	1.67	
Single adult	1.50	
Single child	2.02§	2.02§
All adults work	2.35¶	2.08
Household income above median income	2.62¶	2.31¶

*OR, odds ratio; ILI, influenza-like illness.

†When a household had >1 child attending the school that was closed, we asked about time taken from work to watch the oldest child.

‡Adjusted OR estimated by logistic regression.

§ $p<0.10$.¶ $p<0.05$.

closure in Australia (7). However, in $\approx 40\%$ of households in which work was missed, an adult missed work for all 5 days of closure, indicating a relatively large effect on those households (Table 1). A limitation is that the question regarding missed work was narrowly worded (online Technical Appendix) and did not explore whether an adult missed work for other reasons. As shown in Table 2, adult ILI was not significantly associated with missing work. Some adults with ILI may have stayed at home to watch students but determined that they would have stayed home because of their own illness had the school not been closed and answered “no.” In the Kentucky school closure situation, 29% of households had working adults who provided childcare. In 16% of households, adults missed work and lost pay (6). Closures for >1 week may result in more households that report missing work days. The factors “all adults working” and “having a household income equal to or greater than the median” were associated with missed workdays, as were fewer children (other children in the home may have made it possible for some households to avoid having an adult miss work to watch students whose school was closed).

These findings add to the body of literature on the effects of school closure on households. They can be used by decision makers, as well as parents, to assess the potential social disruption of school closure in the context of future influenza outbreaks.

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Technical Appendix

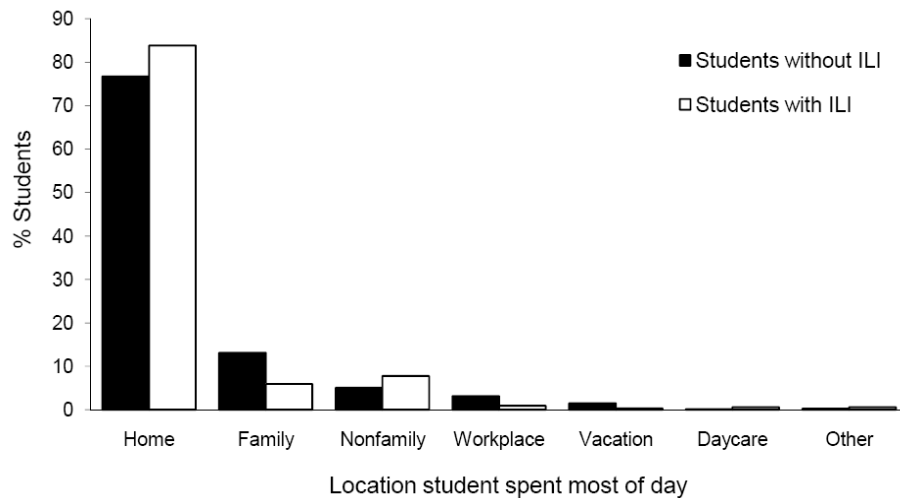
Derivation of Variables Used in Analysis

Respondents were asked questions regarding the childcare arrangements and locations visited outside the home for each of the days the school was closed. To determine who watched the child, the question asked for each day was, “On [given day], who watched [name of oldest child at the school]?” To determine whether the person watching the child had to miss work, the respondents were asked, “Did the person watching [name of oldest child at the school] have to miss work?” To determine where the student spent most of the day, the question was, “On [given day], where did [name of oldest child at the school] spend most of the day?” (online Technical Appendix Figure 1). For the questions concerning child care arrangements, on the second through fifth day of school closure, respondents were asked, “Were the child care arrangements the same as yesterday?”

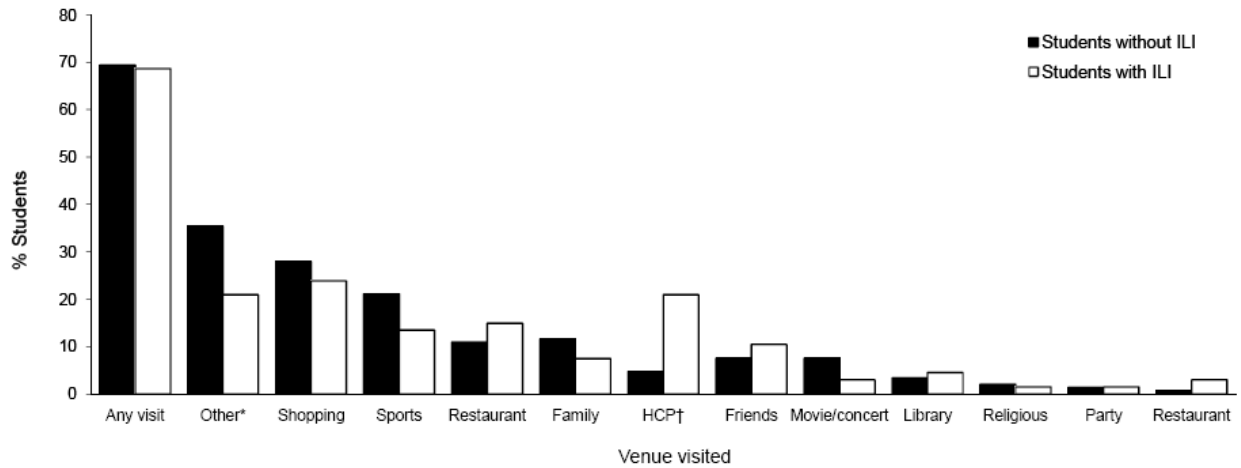
To assess what other venues the student may have visited, respondents were asked, “In addition to where [name of oldest child at the school] spent most of the day, did they go anyplace else?” Respondents were provided with the following list for each day: library, sports practice or game, mall or other shopping site, restaurant (except drive-through), drive-through restaurant, party, hang out with friends (other than a party), church function or services, movie, or other. For respondents who indicated an “other” venue, survey takers wrote in the answer provided, which was then entered in the database as a text field. When responses were aggregated, a large number of health care provider visits and visits to family members were noted; these were identified as additional venues (online Technical Appendix Figure 2). Also, some of the “other” venues included visits to concerts, which were aggregated with movies (online Technical Appendix Figure 2).

The daily data were summed for the variables on number of missed workdays and venues visited used in the analyses. For example, if the respondent indicated that an adult missed work to watch the oldest student on the first and third days of school closure, the number of missed workdays for that household would be 2 (Table 1). If, on any given day, the respondent indicated that, “the child care arrangements were the same as yesterday,” the previous day was examined to see the details for the child care arrangements; this process continued until the details could be ascertained. The same process was followed to determine the number of days the oldest students spent at each location. The number of times during the period of school closure that each of the outside venues was visited was determined by adding the number of days for which a given venue was identified.

The percentage of adults in the household whose work was calculated by dividing the number of wage earners by the number of adults. This number was truncated at 100 (in some cases, persons in the household <18 years of age could have been wage earners, and the result could have led to a percentage >100%). Household median income was assessed by determining the median category for household income based on the responses to the household income question. Single adults and single children were determined by identifying households that only indicated 1 person \geq 18 years of age or 1 person <18 years of age, respectively.



Technical Appendix Figure 1. Location where oldest students spent most of the day on days when school was closed for pandemic (H1N1) 2009, Pennsylvania, USA. ILI, influenza-like illness; family, someone else’s home (family); nonfamily, someone else’s home (nonfamily); workplace, parent/guardian workplace.



Technical Appendix Figure 2. Other venues visited by the oldest students on days when school was closed for pandemic (H1N1) 2009, Pennsylvania, USA. ILI, influenza-like illness; sports, sports practice or game; family, visiting family; HCP, visiting health care provider; friends, hanging out with friends; religious, religious function or service; party, attending a party; restaurant, drive-through restaurant. * $p < 0.05$. † $p < 0.01$.