Effect of School Closure on the Incidence of Influenza Among School-Age Children in Arizona

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SYNOPSIS

Objective. We assessed the impact of school closures as a viable intervention in the event of an influenza pandemic.

Methods. We evaluated the effect of scheduled, two-week winter break school closures during the 2004–2008 school years on the occurrence of influenza among children aged 5–17 years in Arizona.

Results. We found a consistent pattern of benefit to school-age children during winter school closures when non-school-age children and adults experienced significant increases in influenza incidence, an increase not seen among school-age children. Quantitative analysis showed that school closures may prevent or delay as much as 42% of potential influenza cases among school-age children. In addition, the ratio of illness in school-age children as compared with adults and non-school-age children decreased significantly from before to during the same school closure periods.

Conclusion. This analysis provides evidence to suggest that school-age children may experience a slowing of influenza transmission during winter school closures compared with those not of school age. Federal, state, and local policy makers may consider these findings in their pandemic influenza and public health emergency preparedness planning efforts.

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Pandemic influenza continues to be of great interest in emergency preparedness planning, with discussion increasingly focused on the inclusion of evidence-based guidelines in planning efforts.¹ School closure—a non-pharmaceutical intervention meant to mitigate the effects of pandemic influenza—has been included in the federal guidelines for the Community Strategy for Pandemic Influenza Mitigation² and in 47 of the 50 U.S. states' pandemic influenza plans,³ including Arizona's. During the 1918 Spanish influenza pandemic, and most recently during the 2009 H1N1 influenza outbreak, local authorities across the United States closed schools in an effort to decrease transmission rates.

While there is some historical⁴ and international⁵⁻⁸ evidence of the efficacy of school closures in reducing the incidence of influenza, there is limited quantitative, scientific evidence⁹ to support this influenza mitigation measure, which has profound legal, economic, and social implications.¹⁰ A panel convened by the U.S. Department of Health and Human Services in August 2007, comprising experts in multiple disciplines, deemed school closures likely to be ineffective, infeasible, or unacceptable to the public, especially when there is limited scientific evidence supporting such restrictions.⁹

From a more local perspective, influenza surveillance in Arizona occurs through several different means, with the Arizona Department of Health Services (ADHS) conducting influenza surveillance throughout much of the year. Several components of influenza surveillance are used in most states: sentinel provider reporting of aggregate numbers and percentages of influenza-like illness (ILI) visits, surveillance for influenza-associated pediatric mortality, and subtyping of influenza viruses by the state laboratory. A subset of schools statewide also participates in the Child Health Indicator Program (CHIP), which allows the state and county health departments to obtain de-identified data about student visits to the school nursing offices, including visits for ILI.

Prior analysis of data from CHIP shows a distinct and sudden decrease in the reported cases of ILI during the two weeks of school closure for the winter holidays.^{11,12} Clearly, the mechanism for reporting contributes greatly to the decrease in cases. As school is not in session during this time, there would be no visits to the school nurse during a school's closure period and aggregately many fewer visits statewide during the same time period. However, the data suggest a sustained low number of visits for ILI following the school break. This finding prompts further exploration into what portion, if any, of the short-term reduction in ILI reporting

could represent a reduced number of influenza cases during the period that schools are closed.

In light of this school surveillance data and in an effort to generate a more definitive scientific base to enhance decision-making regarding school closures, we analyzed the effect of the annual two-week closure of schools during the winter holidays on the incidence of influenza among school-age children. We analyzed data from the state of Arizona for four years of influenza surveillance to understand the effects of social distancing provided by school closures during the winter on influenza incidence.

METHODS

Data for this analysis came from two sources: mandatory, statewide laboratory reporting and the hospital discharge database. Data are reported twice yearly, and at the time of publication, inpatient data were available from 2004 through the end of 2007. Hospitalized cases with a primary, secondary, or any diagnosis of International Classification of Diseases, Ninth Revision code 487 (influenza) or any 487 sub-code (influenza with pneumonia or other respiratory manifestations) were included in the study. Both sources of data are part of a passive surveillance system in which people who are ill seek medical attention and medical providers report encounters to ADHS.

We retrospectively identified all reported cases of influenza in Arizona comprising 13,798 laboratory reported cases and 13,250 hospital discharge cases from the fall of 2004 to the spring of 2008. Because case definitions and data collection methods are substantially different for the two datasets, they were analyzed separately. We examined the data for three two-week time periods in each year: the two weeks before, during, and after scheduled winter breaks, considered the mode holiday closure period statewide, determined according to the Arizona Department of Education's school district-specific academic calendars. The dates for laboratory data were based on the date each case was reported to ADHS, and hospital data were dated with the date of admission. Dates for the beginning and end of each two-week period were then moved three days later to account for the average 72-hour incubation period of respiratory viruses including influenza.⁶ All diagnoses made during the included dates were used in the study, including weekends and public holidays.

Influenza cases were then stratified by age to reflect those assumed to have been exposed to the social distancing provided by school closure over the winter holidays (with school-age children in this context being

children aged 5–17 years) and those not exposed to such population-wide distancing (e.g., those aged ≤ 4 years and ≥ 18 years at the time of diagnosis). The number of annual cases and the number of cases during the six-week period of interest for each year are shown in Table 1, along with the unadjusted dates used for each of the four years. We excluded cases of unknown age (4.1% of the laboratory data and none of the hospital data).

Although each six-week period of interest fell within the same general time period in each influenza season, from early December of each year to late January of the following year, this six-week period did not fall within the same phase of each year's influenza season. While the first culture-confirmed cases are identified each year in October or November, the peak influenza activity each season varies greatly. Influenza activity in 2004–2005, 2006–2007, and 2007–2008 increased greatly after the time period in question and peaked much later in the season. Therefore, there were relatively few cases around school closures for the holidays. The influenza activity in 2005–2006 in Arizona peaked during the six-week period analyzed for the study, which was much earlier than in other years. The population studied for 2005–2006 included nearly 4,000 influenza cases—more than five times that of any of the other three school years—and comprised 76% of the total laboratory-reported influenza cases for that year. There were no known changes in case definitions or reporting requirements during the four years.

To assess the impact of school closures on school-age children, we compared the rates of influenza diagnoses of school-age children in each time period to the rates of influenza diagnoses for all adults and non-school-age children in the same time period. The incidence of influenza for each group in each year was determined for laboratory-confirmed influenza cases and hospital diagnoses using age-specific annual population denominators from the ADHS Vital Statistics Office.¹³ Rates for each period of interest were obtained by taking daily age-specific cases for the two-week period and calculating the mean age-specific incidence for that period, represented as the mean number of cases per that two-week time period per one million people.

We then compared rates using one-way analysis of variance, followed by pair-wise Tukey post hoc test comparisons between each of the three 14-day periods in each year for each of the two datasets. We made four comparisons for each year—two for laboratory data and two for hospital data—during school closure (“during”) vs. before closure (“before”), and during school closure vs. after school closure (“after”). We also calculated the relative risk and associated 95% confidence intervals

(CIs) comparing the rates of school-age children and others within each time period. We considered a two-tailed value of $p < 0.05$ to be statistically significant. Because we examined the same cohort within and among years, we did not standardize the data for race, gender, or other variables. We conducted statistical analyses with SAS® Enterprise Reporter 9.1.¹⁴

RESULTS

The rates of influenza among school-age children did not significantly increase from the “before” period to the “during” period, as opposed to the non-school-age population, whose rates of influenza diagnosis significantly increased during the same time period (Table 2). These findings remained consistent through all four school years. In the 2007–2008 influenza seasons, for example, adults and non-school-age children saw a significant increase in incidence during the period of school closure for the holidays, from 0.94 to 2.25 cases per one million population (Figure 1). However, there was no significant increase among school-age children during the same time period, whose incidence increased from 0.54 to 1.68 cases per one million population. We found similar patterns of incongruent experience between the two groups in the other three influenza seasons, with school-age children either experiencing a decrease in their incidence of influenza during the school break (2004–2005) or an insignificant increase compared with the significant increase among the non-school-age population.

After the winter break, the incidence of influenza among the school-age population increased significantly across three of the four years, compared with the period during the break, as did the non-school-age population. In the “after” closure period of 2007–2008, both the non-school-age and school-age cohorts showed significant increases from the “during” closure periods, with incidence increasing to 4.13 cases per one million population among the non-school-age group and 5.64 cases per million population among school-age children. The findings suggest that the benefit gained during school closures during the winter holidays is lost when the break ends and school is back in session.

A more in-depth look at the percentage changes from one period to the next between the two groups sheds light on the potential influenza cases among school-age children prevented through school closure. In the 2006–2007 influenza seasons, for example, the rate of laboratory-diagnosed influenza among school-age children increased 10.5% during the two weeks of the scheduled winter break, while the non-school-age population's rate of influenza increased 176.5% during

Table 1. Influenza cases in Arizona by year and data source

Flu season		Before school closure	During school closure	After school closure	Beginning of peak week of flu activity	Laboratory-confirmed cases included in analysis			Hospital cases included in analysis		
						Total annual laboratory-confirmed cases	School-age children N (percentage of total laboratory-confirmed cases)	Adults and non-school-age children N (percentage of total laboratory-confirmed cases)	Total annual hospital cases	School-age children N (percentage of total hospital cases)	Adults and non-school-age children N (percentage of total hospital cases)
2004–2005		12/5/04 to 12/18/04	12/19/04 to 1/1/05	1/2/05 to 1/15/05	2/18/05	1,675	10 (0.6)	109 (6.5)	3,654	42 (1.1)	273 (7.5)
2005–2006		12/4/05 to 12/17/05	12/18/05 to 1/1/06	1/2/06 to 1/15/06	12/31/05	5,238	580 (11.1)	3,216 (61.4)	6,435	733 (11.4)	3,812 (59.2)
2006–2007		12/10/06 to 12/23/06	12/24/06 to 1/6/07	1/7/07 to 1/20/07	2/31/07	1,665	112 (6.7)	174 (10.5)	2,668	110 (4.1)	427 (16.0)
2007–2008		12/9/07 to 12/22/07	12/23/07 to 1/5/08	1/6/08 to 1/19/08	2/23/08	5,217	131 (2.5)	537 (10.3)	NA	NA	NA

NA = not available

Table 2. Mean daily incidence of influenza per 1,000,000 population in Arizona, 2004–2008

2004–2005			
	<i>Incidence before school closure</i>	<i>Incidence during school closure (percent change over immediately prior period)</i>	<i>Incidence after school closure (percent change over immediately prior period)</i>
Laboratory-reported cases			
School-age children	0.13	0.06 (–53.8)	0.45 (650.0)
Adults and non-school-age children	0.20	0.62 (210.0) ^a	0.83 (33.9) ^a
Hospital-reported cases			
School-age children	0.45	0.70 (55.6)	1.53 (118.6) ^a
Adults	0.70	1.80 (157.1) ^a	1.64 (–8.9)
2005–2006			
	<i>Before</i>	<i>During</i>	<i>After</i>
Laboratory-reported cases			
School-age children	15.38	16.99 (10.5)	3.46 (–79.6) ^a
Adults and non-school-age children	13.53	26.56 (96.3) ^a	6.90 (–74.0) ^a
Hospital-reported cases			
School-age children	11.55	24.03 (108.1) ^a	9.70 (–59.6) ^a
Adults and non-school-age children	18.72	31.02 (65.7) ^a	5.96 (–80.1) ^a
2006–2007			
	<i>Before</i>	<i>During</i>	<i>After</i>
Laboratory-reported cases			
School-age children	1.36	1.50 (10.5)	5.14 (242.7) ^a
Adults and non-school-age children	0.34	0.94 (176.5) ^a	1.19 (26.6)
Hospital-reported cases			
School-age children	1.35	2.24 (65.9)	2.89 (29.0)
Adults and non-school-age children	1.25	1.85 (48.0)	2.97 (60.5) ^a
2007–2008 ^b			
	<i>Before</i>	<i>During</i>	<i>After</i>
Laboratory-reported cases			
School-age children	0.54	1.68 (210.9)	5.64 (235.7) ^a
Adults and non-school-age children	0.94	2.25 (139.3) ^a	4.13 (83.6) ^a

^aStatistically significant difference^bHospital discharge data for 2007–2008 were not available at the time of the study.

the same time period. Should the school-age population in the state have experienced the same increase in influenza diagnosis as others not of school age during this year, their daily incidence would have been 3.76 cases per one million population rather than 1.50 cases per one million population. Total case count for school-age children during those two weeks would have been 63 cases instead of the actual count of 25. Arguably, school closures for two weeks during the 2006–2007 school seasons had the potential of having prevented 38 cases (or 60%) of the potential influenza cases among school-age children. Similar analyses for other

years result in a mean 42% reduction (95% CI –15, 99) in potential laboratory-diagnosed influenza cases among school-age children during the three years from 2004 to 2007 during the two weeks of school closure. Although the findings are not statistically significant, this is due in large part to the limited number of years included in the analysis.

Analysis of variance in hospital discharge data had less consistent, but still supportive findings of the previously evidenced benefit to school-age children during school closures. Results from 2004–2005 mirrored those of laboratory-reported cases, with significant increases

Figure 1. Incidence of laboratory-reported influenza cases by two-week period relative to school closure, Arizona, 2004–2008

*Significant change vs. period immediately prior

in the rate of hospitalization for influenza among adults and non-school-age children during the school break, with no corresponding significant increase among school-age children. However, in 2006–2007, neither group saw significant increases in hospitalizations for influenza during the break from schools, and in 2005–2006, both the school and non-school groups showed significant increases in hospitalization for influenza during the closure period. As hospital discharge data may reflect the severity of cases more than overall incidence, such variations from laboratory-reported data may not be totally unexpected.

Relative risk analysis gave some perspective on the differing experiences of the school and non-school groups within the same time period, as reflected in Figure 2. With adults and non-school-age children as the reference group, the bars in the graph represent school-age children's relative risk of having a positive laboratory report of influenza relative to adults and non-school-age children across each of the four years.

While each year has varying significance from period to period, data show a consistent pattern of decreased relative risk among the school-age children during the two-week period of school closure compared with the period before break. In the 2006–2007 influenza season, for example, the relative risk of influenza for

school-age children dropped from 3.3 (95% CI 1.8, 6.0) before the winter break to 1.3 (95% CI 0.8, 2.2) during the break, rising again to 3.6 (95% CI 2.6, 4.9) when school resumed. In other words, the risk of school-age children having a positive laboratory report during the period before break was significantly higher than for the other age groups, approached the rate of the other group during break, and then increased again after the school break. The same lower rates can be seen across all four years of laboratory data, with school-age children at consistently lower relative risk when schools are closed.

DISCUSSION

In comparing the change in incidence from before, during, and after school closures during the winter holidays, we found surprisingly consistent results from year to year. While the general population was significantly more likely to be diagnosed with influenza during the two-week holiday break than in the two weeks before the break, school-age children whose interaction at school was eliminated during this time period saw no such increase. This finding lends some quantitative evidence to the social-distancing theories that predict fewer children contract the influenza virus when not congregated in a classroom setting or other large group

Figure 2. Relative risk of contracting flu: school-age children vs. adults and non-school-age children, by flu season and period relative to school: Arizona, 2004–2008

*Significant difference vs. adults and non-school-age children

activity. Conversely, when schools were back in session, the experience of school-age children became more similar to the rest of the general population.

As stated previously, these findings were consistent in all four years of laboratory-reported influenza data, including the 2005–2006 higher incidence year. The only shift in the overall incidence pattern occurred in this peak activity year, in which incidence overall dropped in the “after” school closure period for both groups, while increasing among both age groups in the other three years. This finding is reflective of the phase in which the period of interest fell during this year. Influenza activity peaked during the six weeks included in this study for 2005–2006, so during the last two-week period, incidence fell for both groups following the peak in influenza activity. Nevertheless, as seen in other years, influenza cases among school-age children were prevented even during this peak activity year, as reflected in the insignificant increase in cases during the 2005–2006 school break.

Analysis of the relative risk of influenza diagnosis among school-age children as compared with adults and non-school-age children from laboratory-reported data supports our previous findings from CHIP school-based data. School-age children had significantly lower rates of laboratory-diagnosed influenza than others during school closures in 2004–2005 and 2005–2006. In 2006–2007 and 2007–2008, school-age children had relatively higher rates of influenza while school

was in session and not when school was on break. In the peak year of 2005–2006, the relative risk of school-age children during school closures was lower than in both 2006–2007 and 2007–2008, with school-age children 36% less likely to have a positive influenza test reported during that peak incidence period than adults and non-school-age children. The results from the 2005–2006 analysis may represent the effect that might be expected from an intervention implemented during the peak of an influenza pandemic, while results from the other three years may better represent the effect of a social-distancing intervention implemented early in a pandemic. The risk analysis shows strong trends in decreasing relative risk of influenza for school-age children during school holiday breaks, supporting our previous evidence that both early in and during the peak of an influenza pandemic, school closures may decrease the incidence of influenza among school-age children.

Besides the benefit to school-age children suggested in this article, there may be residual benefits to the general population that may warrant further study. Research has shown that school-age children are critically important for influenza transmission in the general population,^{7,15,16} and a decrease in the incidence of influenza among school-age children because of school closures may have a positive secondary effect on others with whom they come into contact.^{17–19}

Research also suggests that children show earlier

evidence of influenza.²⁰ Tracking reports of ILI, especially when there may be evidence of the beginnings of a pandemic elsewhere, may allow for early action to decrease the social contact provided at school. As discussed previously, such distancing may not only have benefits evidenced quantitatively in this study, but also have secondary benefits for the general population.

State and local governments that struggle with the difficult decisions of how and when to trigger social-distancing measures face major social, legal, and economic implications for their decision to close schools.²¹ When schools are closed, the availability of alternative sites for children's care may have implications for parents' employment.²² During a pandemic, some health-care providers and others in critical infrastructure positions who are parents of school-age children may be adversely affected by school closure.²³ Many children who rely on free or reduced meals provided through the schools may not be able to maintain their nutritional status if schools are closed. A strong body of quantitative evidence, including the findings of this study, will provide those in emergency management and public health preparedness planning some of the evidence necessary to justify the implementation of social-distancing measures such as school closures.

It is interesting to note that the rates between the two data sources were remarkably similar, when one might expect there to be many more laboratory-confirmed influenza cases in the population than were hospitalized for influenza. This finding may represent a combination of factors: underreporting of laboratory-confirmed cases, the fact that many people with influenza do not seek health care or are not tested for influenza if they do, and differences in case definitions used in the two data sources. While laboratory reports include only laboratory-confirmed cases, a hospital diagnosis of influenza may not necessarily include laboratory confirmation.

Limitations

This study had several limitations. First, there was no information on the behaviors of influenza cases. Not able to control for the social networking of school-age children during the closure period, we assumed that other congregating behaviors remained constant for school-age children. There were also no data on the specific school attended by each school-age case to identify with certainty individual school closure periods. However, there was only a slight variation in the closure periods for different school districts across the state, with the standard deviation of winter breaks among the 1,500 school districts and independent schools in Arizona only 1.2, 2.9, 2.7, and 1.6 days from

2004–2005 to 2007–2008, respectively. It was assumed that these small deviations in closure periods have resulted in nondifferential misclassification of influenza cases and, consequently, our results are most likely an underestimate of the true effects of school closure. Lastly, the holiday break generally occurs early in the influenza season, so future studies may consider doing similar analyses on extended school closures taken later in the year.

CONCLUSION

This study provides some quantitative evidence to suggest that community-wide school closures during an influenza pandemic may significantly reduce the incidence of influenza among school-age children. This finding corroborates earlier findings from school-based data suggesting that winter holiday school closures mimic the social-distancing methods discussed in the context of pandemic influenza planning. Confirmation of these suggestions warrants further studies exploring the value and larger implications of school-based disease surveillance programs. Policy makers and community emergency planners may consider the continued inclusion of policies to close schools during an influenza pandemic with this growing body of evidence to support such social-distancing interventions.

REFERENCES

1. Pandemic and All-Hazards Preparedness Act; Pub. L. No. 109-417, 101 et seq. (2006).
2. Department of Health and Human Services (US). Community strategy for pandemic influenza mitigation. February 2007 [cited 2008 Aug 25]. Available from: URL: <http://www.pandemicflu.gov/plan/community/commitigation.html>
3. Hodge JG Jr, Bhattacharya D, Gray J. Legal preparedness for school closures in response to pandemic influenza and other emergencies. Baltimore: The Center for Law and the Public's Health at Georgetown and Johns Hopkins Universities; April 2008. Also available from: URL: <http://www.pandemicflu.gov/plan/school/schoolclosures.pdf> [cited 2008 Aug 25].
4. Markel H, Lipman HB, Navarro JA, Sloan A, Michalsen JR, Stern AM, et al. Nonpharmaceutical interventions implemented by US cities during the 1918–1919 influenza pandemic. *JAMA* 2007;298:644–54.
5. Ferguson NM, Cummings DA, Cauchemez S, Fraser C, Riley S, Meeyai A, et al. Strategies for containing an emerging influenza pandemic in Southeast Asia. *Nature* 2005;437:209–14.
6. Heymann A, Chodick G, Reichman B, Kokia E, Laufer J. Influence of school closure on the incidence of viral respiratory diseases among children and on health care utilization. *Pediatr Infect Dis J* 2004;23:675–7.
7. Glass RJ, Glass LM, Beyeler WE, Min HJ. Targeted social distancing design for pandemic influenza. *Emerg Infect Dis* 2006;12:1671–81.
8. Cauchemez S, Valleron AJ, Boelle PY, Flahault A, Ferguson NM. Estimating the impact of school closure on influenza transmission from sentinel data. *Nature* 2008;452:750–4.
9. Aledort JE, Lurie N, Wasserman J, Bozzette SA. Non-pharmaceutical public health interventions for pandemic influenza: an evaluation of the evidence base. *BMC Public Health* 2007;7:208.

10. Ammon CE. The 1918 Spanish flu epidemic in Geneva, Switzerland. *Intl Congress Series* 2001;1219:163-8.
11. Arizona Department of Health Services. Arizona weekly influenza summary [cited 2008 Aug 28]. Available from: URL: http://www.azdhs.gov/phs/oids/epi/flu/pdf/az_fluweb_21_0708.pdf
12. Trujillo L, Qiu Y, Komatsu K, Erhart L. Arizona's near real time school-based syndromic surveillance program. *Adv Dis Surveill* 2007;4:19.
13. Arizona Department of Health Services. Arizona vital statistics: population denominators for 2007 [cited 2008 Aug 10]. Available from: URL: <http://www.azdhs.gov/plan/menu/info/pop/pop07/pd07.htm>
14. SAS Institute, Inc. SAS®: Version 9.1. Cary (NC): SAS Institute, Inc.; 2003.
15. Principi N, Esposito S, Gasparini R, Marchisio P, Crovari P. Burden of influenza in healthy children and their households. *Arch Dis Child* 2004;89:1002-7.
16. Viboud C, Boelle PY, Cauchemez S, Lavenue A, Valleron AJ, Flahault A, et al. Risk factors of influenza transmission in households. *Br J Gen Pract* 2004;54:684-9.
17. Noble GR. Epidemiological and clinical aspects of influenza. In: Beare AS, editor. *Basic and applied influenza research*. Boca Raton (FL): CRC Press; 1982. p. 1277-82.
18. Taber LH, Paredes A, Glezen WP, Couch RB. Infection with influenza A/Victoria virus in Houston families, 1976. *J Hyg (Lond)* 1981;86:303-13.
19. Arden NH. The epidemiology of influenza in children. *Pediatr Ann* 2000;29:678-82.
20. Couch RB, Kasel JA, Glezen WP, Cate TR, Six HR, Taber LH, et al. Influenza: its control in persons and populations. *J Infect Dis* 1986;153:431-40.
21. Sadique MZ, Adams EJ, Edmunds WJ. Estimating the costs of school closure for mitigating an influenza pandemic. *BMC Public Health* 2008;8:135.
22. Johnson AJ, Moore ZS, Edelson PJ, Kinnane L, Davies M, Shay DK, et al. Household responses to school closure resulting from outbreak of influenza B, North Carolina. *Emerg Infect Dis* 2008;14:1024-30.
23. Dalton CB, Durrheim DN, Conroy MA. Likely impact of school and childcare closures on public health workforce during an influenza pandemic: a survey. *Commun Dis Intell* 2008;32:261-2.