



## The Effect of School Closure on Rates of Influenza-Like Illness The 2009 nH1N1 outbreak in New York City

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### Background

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School closure as an NPI strategy in mitigating pandemic influenza has been proposed extensively (Glass et al. 2006)

- May lower contact rates among school-age children
- Lower incident peak
- Delay exponential increase in incidence
- Reduce overall morbidity and mortality

## Background

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### Published literature

- [1918 pandemic](#) (Markel et al. 2007) – Layered containment was found to be more effective than individual interventions.
- [Hong Kong](#) (Cowling et. al. 2008) – Elementary school closure for 2 weeks right after peak incidence.
- [Israel](#) (Heymann et. al 2004) – Comparison of attack rates before and after strike (2 weeks in 1999). Attack rates rebound after strike.
- [France](#) (Cauchemez et. al. 2008) – Normal holiday closure. extrapolated seasonal data to pandemic context.

## Introduction

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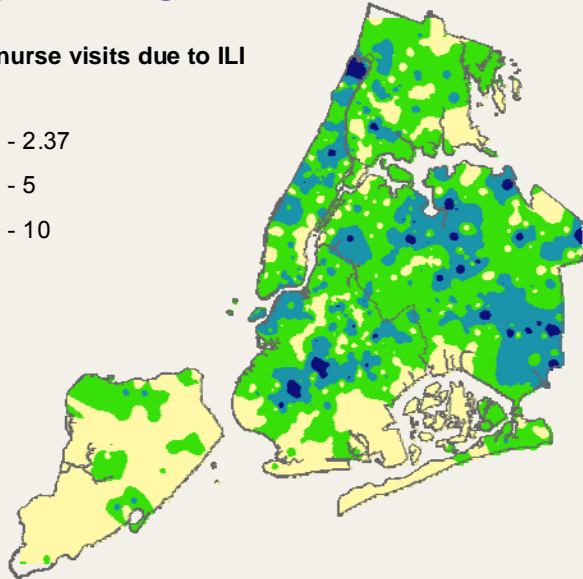
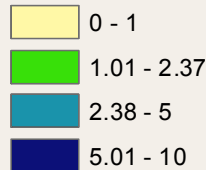


- [April 23<sup>rd</sup> 2009](#) - First confirmed cases of novel H1N1 infection.
- Cases were detected in a private high school – not through syndromic surveillance.
- Clustering of cases in schools appeared heterogeneous.

## Percent ILI by school during nH1N1 outbreak in NYC



### Percent of nurse visits due to ILI



## Introduction



- NYC DOHMH instituted active surveillance to monitor ILI in schools: [May 11 - June 26, 2009](#)
- Schools were asked to report 5 or more cases of ILI  
ILI = 100.4F with cough or sore throat
- Once reaching 5 ILI, DOHMH tracked the schools over time.
- Percent ILI was calculated as: ILI/school enrollment
- Criteria for closure:
  - 2% ILI on a single day
  - 1% ILI for two consecutive days
- This was reactive, ad hoc *class dismissal* to limit school-based transmission.

## Methods



### Data

- 434 schools (K-8) participated in the program.
- Private schools participated but they made their own decisions regarding closure and were excluded.
- 88 public schools met closure criteria.
- 25 special education schools were excluded due to small enrollment.
- 1 school closed before meeting criteria and was excluded.
- 64 schools included in analysis.

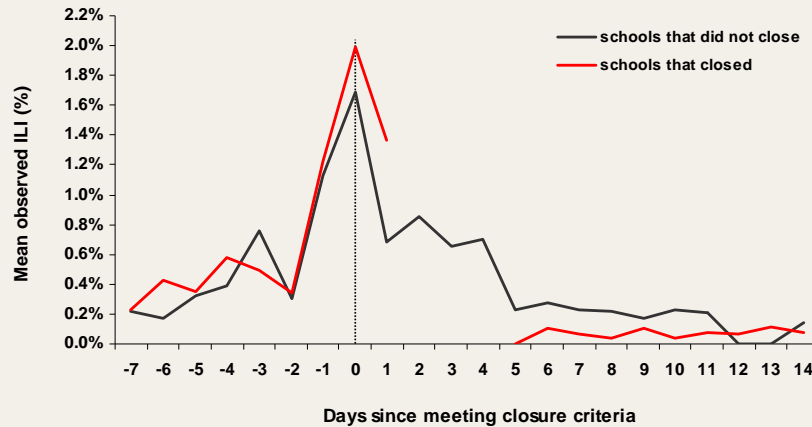
## Methods



Data were by school, by day for 64 schools, N=574.

Closure criteria	Closed ?		Total
	No	Yes	
1.0% ILI (2d)	24	17	41
2.0% ILI (1d)	16	7	23
<b>Total</b>	<b>40</b>	<b>24</b>	<b>64</b>

## Methods



### Closed schools

- ❖ higher rates of ILI before closing.
- ❖ dropped to below those of non-closed schools after re-opening.

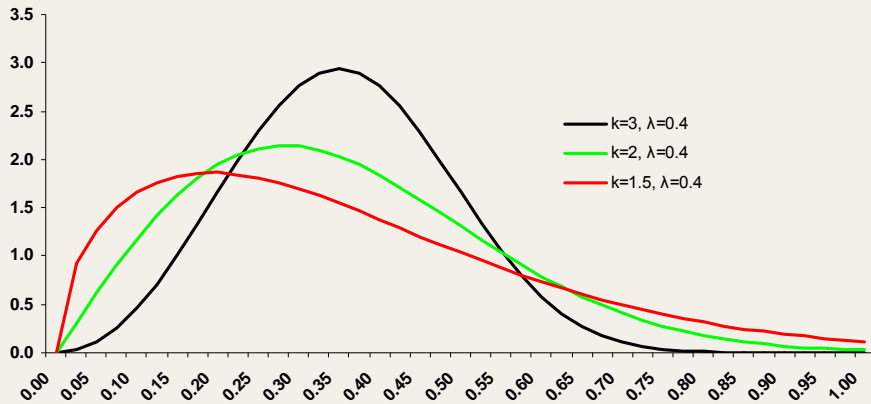
## Methods



- A negative binomial regression model was fit to ILI counts, by school by day.
- Multilevel model, clustering by school –adjusts for repeat measures.
- Intercept was allowed to vary by school (larger schools might report higher ILI than smaller schools).
- Eight potential covariates:
  1. **Daily school attendance**
  2. **City borough**
  3. **School type**
  4. **Whether previous day was a holiday**
  5. **Whether school was closed on previous day**
  6. **Day of week**
  7. **Day of citywide nH1N1 outbreak**
  8. **Days since school met closure criteria**

} Weibull distributed
- Random Weibull shape (k) parameter for day of school outbreak

Probability density function – Weibull distribution



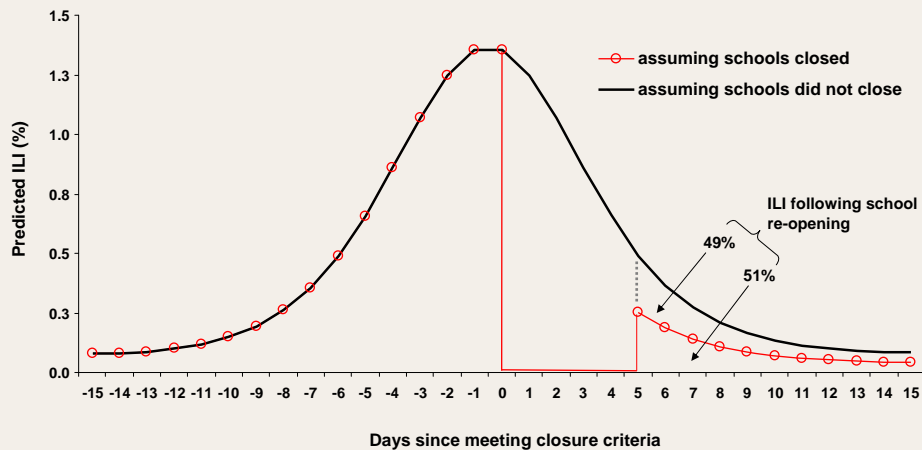
Results – ILI count model



Parameter	Estimate	SE	t	95% CI		p-value
$B_{0j}$	-1.754	0.178	-9.850	-2.109	-1.398	<.0001
$T_0$	0.288	0.097	2.960	0.094	0.482	0.004
Days since meeting crit. (Weibull shape)	3.012	0.150	20.060	2.712	3.312	<.0001
Days since meeting crit. (Weibull scale)	0.414	0.009	44.090	0.396	0.433	<.0001
Flu day (Weibull shape)	1.528	0.173	8.850	1.183	1.873	<.0001
Flu day (Weibull scale)	0.566	0.066	8.580	0.434	0.697	<.0001
Monday	-0.192	0.178	-1.080	-0.548	0.164	0.285
Tuesday	-0.515	0.167	-3.080	-0.849	-0.180	0.003
Wednesday	-0.514	0.168	-3.050	-0.851	-0.178	0.003
Thursday	-0.404	0.178	-2.280	-0.759	-0.050	0.026
Friday	ref	--	--	--	--	--
Prev. close (yes)	-0.666	0.249	-2.670	-1.164	-0.168	<b>0.010</b>
Prev. close (no)	ref	--	--	--	--	--

\*Mean of school-specific intercepts

## Mean linear predictor of percent ILI



## Results



### Summary

- 7.1% average reduction in ILI over the entire outbreak period.
- 48.6% average reduction in ILI once schools reopen.
- Large proportion of ILI occurred before meeting criteria.
- The ILI rate did not increase dramatically after meeting criteria for any school. All returned to baseline or near baseline levels within several days.

## Conclusions



- Evidence that selective school closure reduced school-based ILI transmission among school attendees.
- Difficult to know about ILI rate in absent students.
- Our estimate of 7.1% reduction in transmission is lower than previously published estimates but is likely conservative:
  1. Unable to estimate days immediately following closure.
  2. Schools that didn't close tended to be later in outbreak.
- Includes a control group of schools that reached criteria but did not close during outbreak - accounts for non-stationarity.

## Conclusions



- The benefits in a mild influenza season are outweighed by the considerable socioeconomic burden of closing schools.
  - ❖ Financial hardship due to lost work
  - ❖ Additional childcare duties
- The NYC Departments of Education and Health have therefore adopted a school open policy for influenza of similar clinical severity.

Thanks to colleagues at NYC DOHMH



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Thank you

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## Limitations



- This was ad hoc, reactive class dismissal and was intended to lower ILI transmission in a particular school. Not for community-wide mitigation.
- Schools tended to close earlier in the outbreak.
- Unable adjust for community-specific factors influencing transmission.
- Assumed outbreak followed Weibull distribution.
- A higher proportion of schools meeting criteria near end of outbreak did not close.

## Outline

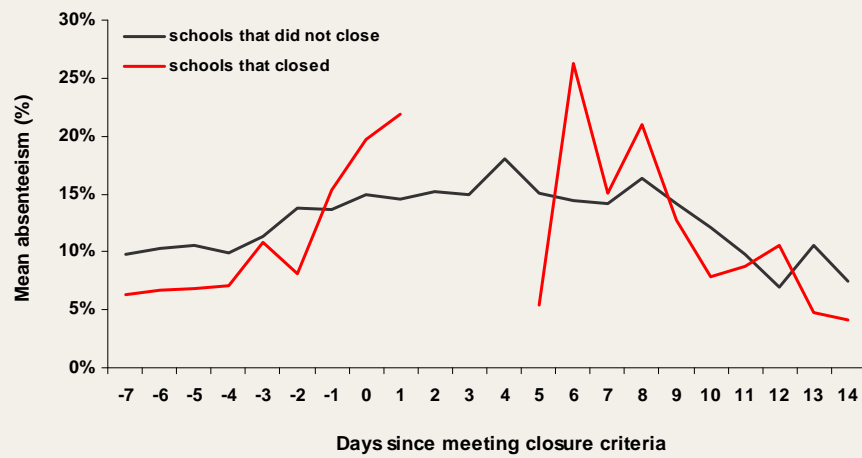


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## Methods



### School absenteeism



## Methods



### School absenteeism

- Similar to ILI model
- Poisson regression of absentee count by school, by day.
- Seven potential covariates:
  1. City borough
  2. School type
  3. Whether previous day was a holiday
  4. Whether school was closed on previous day
  5. Day of week
  6. Day of citywide nH1N1 outbreak
  7. Days since school met closure criteria

## Results – school absenteeism



Parameter	Estimate	SE	t	95% CI		p-value
$B_{0j}$	1.867	0.103	18.170	1.662	2.072	<.0001
$T_0$	0.636	0.124	5.150	0.389	0.883	<.0001
Days since meeting crit. (Weibull shape)	2.367	0.034	69.970	2.299	2.435	<.0001
Days since meeting crit. (Weibull scale)	0.616	0.005	114.410	0.606	0.627	<.0001
Flu day (Weibull shape)	1.313	0.014	92.750	1.285	1.341	<.0001
Flu day (Weibull scale)	0.531	0.012	43.380	0.507	0.556	<.0001
Monday	-0.095	0.017	-5.740	-0.128	-0.062	<.0001
Tuesday	-0.127	0.015	-8.440	-0.157	-0.097	<.0001
Wednesday	-0.259	0.016	-16.460	-0.290	-0.227	<.0001
Thursday	-0.350	0.017	-20.580	-0.383	-0.316	<.0001
Friday	ref	--	--	--	--	--
holiday	0.161	0.026	6.280	0.110	0.213	<.0001
Prev. close (yes)	-0.006	0.023	-0.260	-0.051	0.040	0.795
Prev. close (no)	ref	--	--	--	--	--



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## Background



### Comparison to our study

- Did not control for non-stationary dynamics of transmission.
- These interventions attempted to reduce community transmission.
- Our intent was to reduce school-specific transmission rates.

## Methods



Breakdown of school counts by closing criteria and closure status.

Days closed	Freq.	Percent
0	40	62.5%
3	1	1.6%
5	12	18.8%
6	5	7.8%
7	3	4.7%
8	1	1.6%
10	2	3.1%