Objective

To estimate the effect of H1N1 vaccination in reducing H1N1 cases, hospitalizations, and deaths in Ohio during the 2009-2010 H1N1 influenza outbreak.

Methods

Estimating the Number of Actual H1N1 Cases, Hospitalizations, and Deaths

The CDC methodology[1] developed to estimate the number of H1N1 cases, hospitalizations, and death was based on a model which corrects for under-ascertainment and under-reporting, developed by researchers from the CDC and Harvard School of Public Health[2]. These methods have been used to estimate the national burden of Pandemic H1N1 from April 2009-April 2010[3]. CDC investigators involved in this study have indicated to us that the data used to generate the national estimates is too sparse to apply directly to the state level. Also, the national methods should not be applied to state-collected data such as the number of H1N1 confirmed hospitalizations in Ohio. The CDC recommendation for applying these methods to Ohio was to apply the age-specific rate estimates from the national study to the Ohio population. The national methodology provides estimated rates for cases, hospitalizations, and deaths for each of the age ranges 0-17, 18-64, and 65+. The CDC methodology generated a range of 3 rates for each estimate based on the distribution of rates observed in their surveillance data. These rates are referred to as the midrange, low, and high rates.

Table 1. Estimated Age-Specific Rates for H1N1 Cases, Hospitalizations, and Deaths[3]

Age Range	Attack Rate (cases per 100): midrange (low, high)	Hospitalization (per 100,000 cases)	Deaths (per 100,000 cases)
0-17	26.1 (18.5, 38.3)	445.2	6.6
18-64	18.4 (13.1, 27.0)	452.7	27.1
65+	15.0 (10.7, 22.1)	458.7	27.2

Estimating the Impact of H1N1 Vaccination

Through discussions with the CDC, it became apparent that the simulation software *CommunityFlu*[4] should not be used in the manner originally suggested to estimate the H1N1 burden under the scenario that no vaccinations were administered. The original plan was to use the baseline simulation without incorporating the intervention (vaccination) part of the module. Instead, the recommended usage was to "calibrate" the model parameters under the intervention scenario. By modifying the transmission probabilities and vaccine effectiveness (cases averted/total cases if no vaccination), the results can be made to match the expected values, which are the estimates derived above (26.1% attack rate for 0-17 year olds, etc.). The *CommunityFlu*[4] simulation model only functions under the scenario in which all vaccinations are administered before the start of the outbreak, but the actual vaccinations were not administered until after the outbreak had begun. Therefore it was necessary to enter the "equivalent vaccine effectiveness" into the simulation. The equivalent vaccine effectiveness is the effectiveness of a vaccine administered before the outbreak that would yield the same results as the true effectiveness

(unknown) administered when the vaccinations actually took place (after the outbreak). For example, if the true vaccine effectiveness is 50% or 60% and the vaccination occurs during the outbreak, there is a corresponding (lower) vaccine effectiveness that would result in the same number of cases if these vaccinations all occurred before the outbreak. A 12% vaccine effectiveness administered at baseline may result in the same number of total cases as a 60% vaccine effectiveness administered at the peak of the outbreak.

Using *CommunityFlu*, the outcomes were able to be calibrated to our expected results under a wide range of parameter entries. With higher transmission probabilities the simulation could be calibrated with equivalent vaccine effectiveness above 90%. Likewise, with lower transmission probabilities the calibration could be achieved with equivalent vaccine effectiveness less than 5%. At this point there was insufficient basis by which to determine which equivalent effectiveness should be preferred, other than avoiding the upper ranges of 60%+.

The CDC has been working on such a model for the nationwide estimated, and reported that a 12% equivalent effectiveness is currently their best estimate, and that an equivalent effectiveness above 20% would be unreasonable given the timing of the actual vaccinations. Therefore, the table below reports the vaccine impact using 12% equivalent effectiveness, and also using 20% as an upper limit. Applying these equivalent effectiveness values and the rates of hospitalizations and deaths per 100,000 cases yielded estimates for cases, hospitalizations, and deaths averted by vaccination.

Results

Table 2. Estimates of Cases, Hospitalizations and Deaths due to H1N1 in Ohio (April 12, 2009 to April 10, 2010)

	Estimate: Midrange (Low Range - High Range)
Cases	
0-17 years	709,074 (504,295 - 1,041,025)
18-64 years	1,326,076 (943,108 - 1,946,874)
65+ years	241,131 (171,493 - 354,016)
TOTAL	**2,276,281 (1,618,896 - 3,341,915)**
Hospitalizations	
0-17 years	3,157 (2,245 - 4,634)
18-64 years	6,003 (4,270 - 8,814)
65+ years	1,106 (787 - 1,624)
TOTAL	**10,266 (7,301 - 15,072)**
Deaths	
0-17 years	47 (33 - 68)
18-64 years	358 (255 - 526)
65+ years	66 (47 - 97)
TOTAL	**471 (335 - 691)**

Table 3. Estimated Cases, Hospitalizations, and Deaths Averted by H1N1 Vaccination in Ohio (April 12, 2009 – April 10, 2010)

	Estimate: Midrange (Low Range - High Range)	
	12% Equivalent Vaccine Effectiveness	**20% Equivalent Vaccine Effectiveness**
Cases		
0-17 years	96,692 (68,768 - 141,958)	177,269 (126,074 - 260,256)
18-64 years	180,829 (128,606 - 265,483)	331,519 (235,777 - 486,719)
65+ years	32,882 (23,385 - 48,275)	60,283 (42,873 - 88,504)
TOTAL	**310,402 (220,758 - 455,716)**	**569,070 (404,724 - 835,479)**
Hospitalizations		
0-17 years	430 (306 - 632)	789 (561 - 1,159)
18-64 years	819 (582 - 1,202)	1,501 (1,067 - 2,203)
65+ years	151 (107 - 221)	277 (197 - 406)
TOTAL	**1,400 (996 - 2,055)**	**2,566 (1,825 - 3,768)**
Deaths		
0-17 years	6 (5 - 9)	12 (8 - 17)
18-64 years	49 (35 - 72)	90 (64 - 132)
65+ years	9 (6 - 13)	16 (12 - 24)
TOTAL	**64 (46 - 94)**	**118 (84 - 173)**

References

1. 2009 H1N1-Related Deaths, Hospitalizations and Cases: Details of Extrapolations and Ranges: United States, Emerging Infections Program (EIP) Data. *Centers for Disease Control and Prevention*. 14 May 2010. Retrieved from http://www.cdc.gov/h1n1flu/pdf/Exact%20Numbers_AprilN.pdf on 22 December 2010.

2. Reed C, Angulo FJ, Swerdlow DL, Lipsitch M, Meltzer MI, Jernigan D, and Finelli L. (2009). Estimates of the Prevalence of Pandemic (H1N1) 2009, United States, April-July 2009. *Emerging Infectious Diseases*. 15(12): 2004-2007.

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4. Community Flu 1.0. *Centers for Disease Control and Prevention*. 25 August 2009. Downloaded from http://www.cdc.gov/flu/tools/communityflu/ in October 2010.