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Local Mitigation Strategies for Pandemic Influenza

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Abstract

Local, open-outbreak mitigation strategies for pandemic influenza that target zones of high infectious contact within a community's social network may be very effective. We use a networked agent-based model to instantiate the contact network within a stylized small town and vary the behavior of targeted groups. Simulations show that until sufficient vaccine becomes available, influenza could be halted solely through social distancing whereby children and teenagers stay home while the rest of the population continues normal day-to-day activities. Subsequent vaccinations that start with children and teenagers return the community to normalcy most rapidly, with the least illness, death, and vaccine.

Introduction

The rapid spread of highly pathogenic, H5N1 avian influenza within and among multiple species, both domesticated and wild (*1, 2*), is of great concern (*3*). Because humans have no natural immunity to this strain, if H5N1 evolves the ability to pass from human to human, its infectivity and mortality characteristics may create a pandemic (*4*). Influenza pandemics have occurred many times in the past, the most noted example being the Spanish Influenza of 1918 that killed on the order of 50 million people worldwide (*3*). Recently, RNA sequencing of the deadly 1918 flu virus showed that it was also avian and jumped to humans after only a small number of critical mutations (*5*).

Since the mid 20th century, vaccines have been used to effectively suppress most varieties of influenza. However, at the beginning of a pandemic, an effective vaccine is not expected to be available in sufficient supply (*6*). Anti-viral drugs, while not conferring immunity, may be used to decrease symptom severity and transmission. Unfortunately, antiviral drugs are not fully effective (*7*) and worldwide stores are currently very low (*8*). Behavioral modifications, such as wearing masks, washing hands, disinfecting surfaces, and avoiding close contact with others, can be successful at suppressing influenza in controlled settings (*9*). But, to be effective, such behaviors must be widely adhered to throughout the population, a challenge that is especially difficult for the young. Often thought of as a last resort, quarantine may be enforced to prohibit infectious people within hot zones from carrying the disease to uninfected populations. Widespread quarantine has logistical, economic, and social costs, potentially including civil unrest (*10*).

Computational simulation can be of great use in identifying, evaluating, prioritizing, and coordinating mitigation strategies for pandemic influenza. Recent simulation efforts have focused on containment at the source using vaccines, anti-viral drugs, and quarantine (*11, 12*). Here, we consider the pandemic after the virus has moved beyond the source to threaten communities worldwide. Assuming that vaccines and anti-viral drugs are initially unavailable for the general population, we focus on developing open-outbreak mitigation strategies that target zones of high infectious contact within a community's social network. Towards this end, we develop a simulation model that both instantiates the rich contact network within a structured community, and allows the behavior of specific groups of people targeted by a mitigation strategy to be varied. Simulations for a stylized small town in the United States indicate that until sufficient vaccine becomes available, influenza could be effectively halted solely by implementing a social distancing strategy whereby children and teenagers are kept home while the rest of the population continues to carry on their day-to-day activities. Subsequent vaccinations that start with children and teenagers would return the community to normalcy most rapidly, with the least illness and death, and the least amount of vaccine.

Networked Agent-Based Model

Agent-based models treat entities (individuals, groups) explicitly as *agents*. Individual agents are endowed with behavioral rules for internal states and interaction with other agents or the external environment. Such models been developed and applied in a wide range of fields including economics (*13*), sociology (*14*), and more recently epidemiology (*15*). A number of theoretical studies also show the critical importance of the underlying contact network along which an infectious disease spreads (*16, 17*). Our simulation approach combines both agents and explicit networks (*18*). For the spread of an infectious disease, agents represent individual people and are linked to each other within and among groups to form a contact network reflective of a multiply-overlapping, structured community. Behavioral rules for agents, their interaction, and the performance of network links, are specified to model the spread of influenza.

Contact network:

We constructed our contact network to represent a stylized small town within the United States. The population of 10,000 consists of children (0-11 years of age, 17.7%), teenagers (12-18 years of age, 11.3%), adults (19-64 years of age, 58.5%) and seniors (65+ years of age, 12.5%). All individuals belong to multiple groups, each associated with a sub-network of links reflecting their lives within the community; an example of a typical teenager's groups and contact network is shown in **Figure 1**. Households are composed of families (adults with children/teenagers) or adults and/or seniors without children/teenagers. The makeup of the population and households conforms to the statistics of the 2000 Census (*19*). All individuals within each household are linked to each other (fully connected sub-network topology) with mean link contact frequencies of 6 contacts/day. Every individual also belongs to one multi-age extended family (or neighborhood) group that has a mean membership of 12.5 and is fully connected with mean link contact frequencies of 1 contact/day.

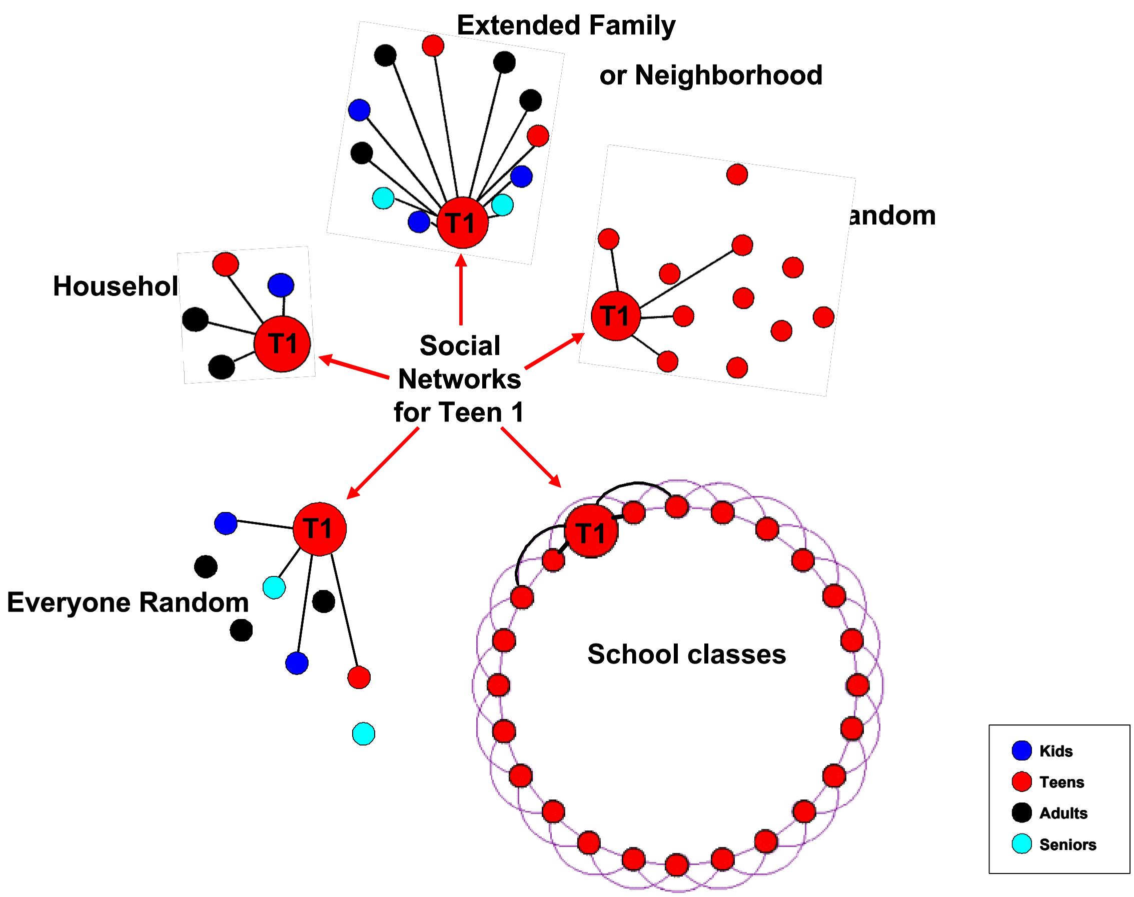


Figure 1: Typical groups and individual-to-individual links for an example teenager. A teen belongs to a household (fully connected network, mean link contact frequency 6/day), an extended family or neighborhood (fully connected network, mean link contact frequency 1/day), and 6 school classes (ring network with connections to 2 other teenagers on each side as shown in black, purple links denote those of other teenagers within the class, mean link contact frequency 1/day). Two random networks are also imposed, one within the age group (teenager random, average of 3 links per teenager, mean link contact frequency of 1/day), and one across all age groups (over-all random, average of 25 links per person (not all shown), mean link contact frequency of 0.04/day).

All children and teenagers go to a pre-school or school; children attend a single class per day while teenagers attend six (all classes of size 20-35). All adults go to work daily where they interact with other adults (size 10 to 50), and all seniors attend senior gatherings (size 5 to 20). For contacts within school classes, work, and senior gatherings, we assume the simplest sub-network topology that imposes local clustering: a ring lattice in which an individual is linked to two (for children/teenager classes and senior gatherings) or three (adult work) neighboring agents on each side along the ring (see **Figure 1**). Mean link contact frequencies for children in a single class are 6 contacts/day while teen classes, adult work, and senior gatherings have mean link contact frequencies of 1 contact/day.

To represent additional within-age-class interactions such as extracurricular activities, playgrounds, bowling leagues, or friends, individuals are linked at random to an average of three other individuals of the same age class (mean link contact frequency of 1 contact/day). Finally, to emulate a somewhat patterned set of random contacts that come from commercial transactions and other ventures into public spaces, we impose a random over-all network across all age classes with a mean of 25 links per person to yield one contact per person per day (mean link contact frequency of 0.04/day). The combination of the ring and random networks add a "small-world" character to the inherently clustered social network. While similar to the idealization of a single ring blended with a single random network introduced by Watts and Strogatz (*20*), our network exhibits the multiply-overlapping quality of a structured community (*21, 22*). Complete group specifications are reported in **SOM Table 1** in the Appendix.

Behavioral rules for influenza:

We model the spread of influenza within the contact network as a series of events. There are two classes of events: the transition of an individual between disease states, and individual-to-individual influenza transmissions. Individual state transitions follow the natural history of influenza (**Figure 2**) proceeding from a *latent* state, to a *pre-symptomatic infectious* state during which the flu can be transmitted before symptoms influence the behavior of the agent. An infected person's state then transitions to either *symptomatic* or to *non-symptomatic* with probability *pS,* or *1- pS,* respectively. Those who develop symptoms either *stay-at-home* with probability *pH*, thus influencing their contacts, or continue to *circulate* with probability *1-pH*. Infected agents who are non-symptomatic continue interacting without behavioral changes. Agents who are symptomatic transition to *dead* or *immune* with probability *pM* or *1- pM*, respectively, while non-symptomatic agents simply transition to immune.

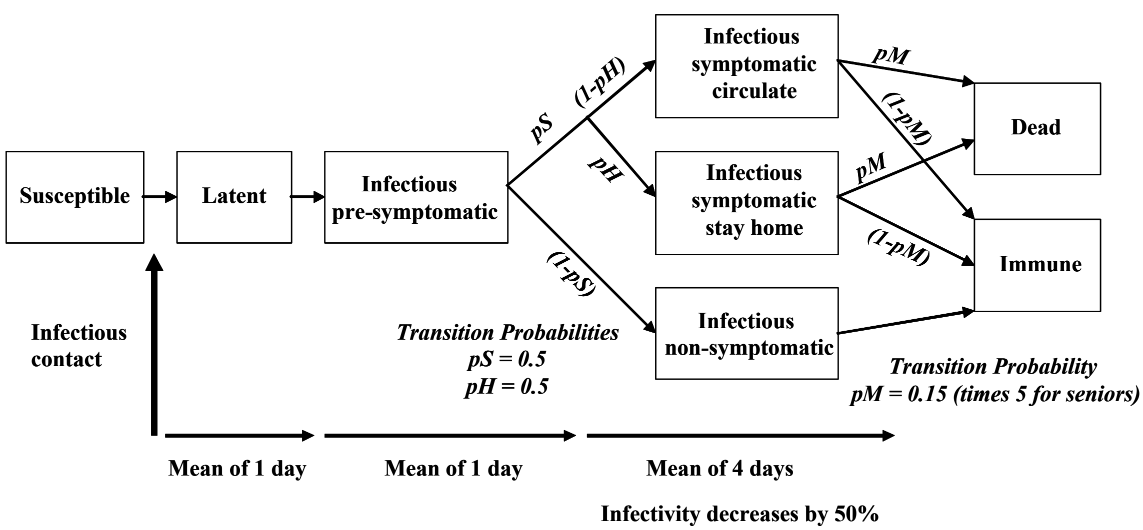


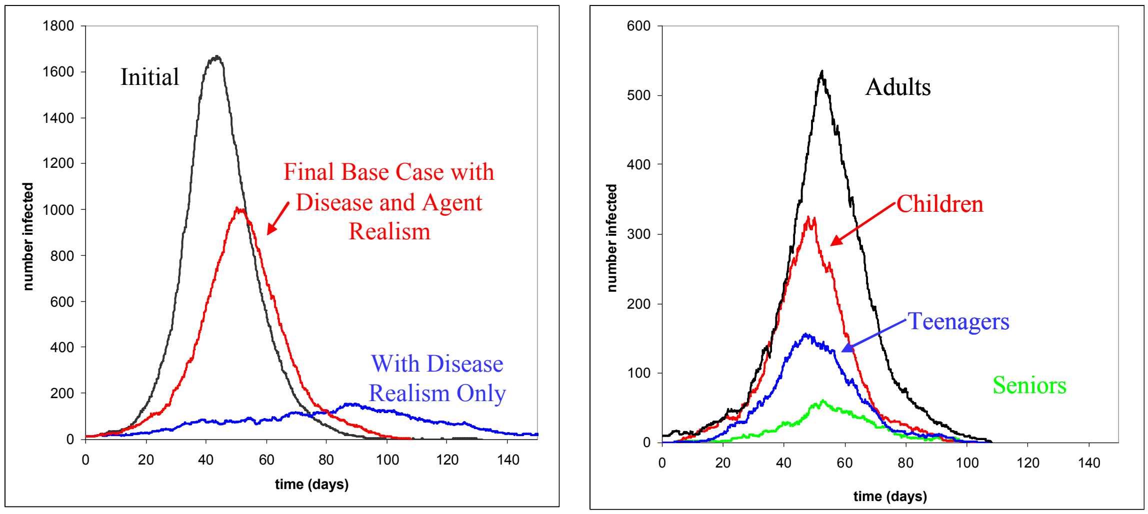
Figure 2: Natural history of influenza as encapsulated within our model. The duration of each state for a given agent is chosen from an exponential distribution with means as noted. Transition probabilities between pre and post symptomatic states are also noted. After the pre-symptomatic infectious stage, we reduce the infectivity of all infected individuals by half. For those that develop symptoms and stay at home, the link frequency within the household is doubled while all other link frequencies are reduced by 99%.

Individual-to-individual transmission events are evaluated at the beginning of each period during which an agent is infectious. Assuming contact events are statistically independent, a transmission time for each of an infectious agent's links within the contact network is chosen from an exponential distribution with the mean of the link's contact frequency scaled by (I_D*I_A*S_P*S_A) where I_D is the infectivity of the disease, S_P is the susceptibility of people to the disease (here taken as 1.0), I_A is the relative infectivity of the agent who is transmitting, and S_A is the relative susceptibility of the agent receiving. If the transmission time is less than the period of time that the agent will be in a particular infectious state, then transmission is scheduled at the chosen time, otherwise transmission along that link does not occur during that particular period. All transmission parameters and contact frequencies may be modified in each of the various states as well as varied among age classes through the use of relative scaling factors.

We have chosen influenza-specific mean state periods (1 day latent, 1 day infectious pre-symptomatic, 4 days infectious symptomatic or non-symptomatic) and transition probabilities for *pS* (0.5) and *pH* (0.5) that are representative of those used in recent pandemic strain simulation studies reported in the literature (*11, 12, 23*). As in the recent study of Ferguson et al. (*12*), we reflect viral shedding data (*24*) by reducing I_D (here by 50%) after the pre-symptomatic period for all states (i.e., symptomatic circulating, symptomatic stay-at-home, or non-symptomatic). We assume that children and teenagers are more infective, as they have closer contact with others (hugging, wrestling, etc.), and are more susceptible, as their immune systems are less developed (*25*). These assumptions are reflected in the values chosen for relative infectivity and relative susceptibility: I_A and S_A are both 1.5 for children, 1.25 for teenagers, 1.0 for adults and 1.0 for seniors. As for normal influenza, we presume seniors are at greatest risk of death after becoming symptomatic, and accordingly increase their probability of dying (*pM)* by a factor of five. We double the frequency of contacts within the family when an individual is in the symptomatic stay-at-home state to reflect an assumed greater contact for care-giving. We choose the remaining two parameters, $I_D = 0.01$ and $pM = 0.15$, to yield total *infected attack rates* of ~50% and *death rates* of ~5%, as might be representative of a highly pathogenic influenza pandemic. Unless otherwise noted, these rates are defined as a percent of the total population. The often reported *illness attack rate* is roughly half of the infected attack rate (the latter we refer to from here on as simply the *attack rate*) and reflects our choice of *pS* (0.5).

Base Case Pandemic Influenza Simulations

With the assumption that adults are first to be infected via business travel or interaction with visitors from outside the community, we begin a simulation by infecting 10 adults at random. In context of our contact network, the influence of increasing disease and agent realism is shown in **Figure 3**. The initial case (with only state periods, I_D, and *pM* specified) is extremely virulent. Differentiating the symptomatic state into three components (see **Figure 2)** and reducing the infectivity in these states by half, dramatically decreases influenza's virulence (blue line). Further differentiating agents by age class (relative values for infectivity, susceptibility, and mortality) reinvigorates influenza (red line). We refer to the final case with full realism as our *base case* for pandemic influenza that yields attack rates of ~50% and death rates of ~5% in our model community. Analysis of the early stage of the base case yields a reproductive number, R_o, defined as the average number of others an infected person will infect, of ~1.6, and a generation time, defined as the average time between becoming infected and infecting others, of ~3.5 days.



a) b)

Figure 3: Example simulations. a) Influence of influenza parameter realism on the number infected (in some stage of the disease) as a function of time. Typical results for a single realization of the community structure and with the identical set of 10 initially infected adults. The initial case (black line) begins with an I_D of 0.01, *pM* of 0.15, and mean state periods. Disease realism is added with a reduction in infectivity after the pre-symptomatic stage to 0.5 and differentiation between symptomatic and non-symptomatic states ($pS = 0.5$), and between circulating and staying at home when symptomatic ($pH = 0.5$) (blue line). We then distinguish each of the four age classes by adding agent specific parameter values for relative infectivity and susceptibility (I_A and S_A 1.5 for children, 1.25 for teenagers, 1.0 for adults and 1.0 for seniors) (red line). This final case with all pandemic influenza parameters forms our *base case* with infectious attack rates of ~50% and death rates of ~5%. b) Breakout of infected by age class (children, red; teenagers, blue; adults, black; seniors, green) for the base case simulation shown in (a. Statistics for peak infected, attack rate, death rate, time to peak, and total time for epidemic from multiple simulations are given in **SOM Tables** in the Appendix; averages for the base case are given in **Table 1**.

The results in **Figure 3** reflect a single realization of the contact network with the same set of 10 initially infected adults. Results vary across multiple realizations and not every realization leads to an epidemic, here defined when the total number infected rises above 1% of the population (**Table 1, SOM Table 2** in the Appendix). The effect of stochastic variability is most clearly observed by increasing the number of initially infected adults, beginning with a single instigator, and counting the number of epidemics that occur. In 100 realizations, a single instigator produced only 35 epidemics, 2 instigators yielded 56, 4 yielded 82, 8 yielded 97, and 10 yielded 98 (as used for our base case). For 16 instigators and above, all simulations yielded epidemics. While timescales for epidemics expectedly shorten as the number of instigators increase (the time to peak infections fell by more than 50%), attack and death rates are remarkably similar (**SOM Table 3** in the Appendix).

Table 1: Summary Results, Averages for Base case and Mitigation Strategies

	Averages for all simulations						Averages for simulations with epidemics (Total Infected > 100)						
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	# of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number Sims	SOM Table
Base Case Pandemic Influenza													
	1007	**5046**	**463**	**45**	**114**	**98**	**1028**	**5154**	**473**	**45**	**116**	**1000**	**2**
SOCIAL DISTANCING STRATEGIES													
Schools closed after 10 symptomatic													
Compliance 99%	218	2760	254	82	207	95	228	2903	267	86	217	100	4
% reduction from base case	78%	45%	45%	-85%	-83%	3%	78%	44%	44%	-89%	-88%		
Schools closed after 10 symptomatic, outside school contacts doubled													
Compliance 99%	1064	5746	552	46	118	98	1085	5863	563	47	120	100	4
% reduction from base case	-6%	-14%	-19%	-4%	-4%	0%	-6%	-14%	-19%	-4%	-3%		
Schools closed after 10 symptomatic, children/teens kept home													
Compliance 99%	30	105	10	12	51	54	37	136	13	13	61	100	5
% reduction from base case	97%	98%	98%	74%	55%	45%	96%	97%	97%	72%	47%		
Schools closed after 80 symptomatic, children/teens kept home													
Compliance 99%	159	636	55	27	82	99	161	643	56	28	83	100	5
% reduction from base case	84%	87%	88%	39%	27%	-1%	84%	88%	88%	39%	28%		
Schools closed after 10 symptomatic, children/teens kept home													
Compliance 80%	40	243	22	23	87	76	46	298	27	27	100	100	6
% reduction from base case	96%	95%	95%	48%	24%	22%	96%	94%	94%	40%	13%		
Schools closed after 10 symptomatic, children/teens kept home													
Compliance 70%	64	719	64	46	147	85	72	835	75	52	166	100	6
% reduction from base case	94%	86%	86%	-2%	-29%	13%	93%	84%	84%	-15%	-43%		
Children's schools closed after 10 symptomatic, children kept home													
Compliance 99%	148	1390	117	58	144	87	168	1590	134	66	161	100	7
% reduction from base case	85%	72%	75%	-31%	-27%	11%	84%	69%	72%	-45%	-39%		
Schools and work closed after 10 symptomatic, children/teens kept home													
Compliance 70%	50	413	36	32	110	84	56	481	42	36	124	100	8
% reduction from base case	95%	92%	92%	29%	3%	14%	95%	91%	91%	22%	-7%		
Adults stay home from work													
Compliance 99%	916	4728	436	46	117	100	916	4728	436	46	117	100	9
% reduction from base case	9%	6%	6%	-4%	-3%	-2%	11%	8%	8%	-2%	-1%		
All sick stay at home													
Compliance 99%	658	3985	357	48	121	92	714	4329	388	51	129	100	9
% reduction from base case	35%	21%	23%	-7%	-6%	6%	31%	16%	18%	-13%	-11%		
VACCINATION SRATEGIES													
Children and teens only													
Coverage 60%	18	76	7	13	52	23	29	178	17	33	101	100	10
% reduction from base case	98%	98%	98%	72%	54%	77%	97%	97%	96%	27%	13%		
All seniors													
Coverage 100%	934	4722	356	45	115	99	944	4770	359	46	116	100	11
% reduction from base case	7%	6%	23%	-2%	-1%	-1%	8%	7%	24%	0%	0%		
Current vaccination rates													
children/teens 26%, adults 30%, seniors, 59%	88	872	69	48	111	55	153	1568	124	84	181	100	11
% reduction from base case	91%	83%	85%	-8%	3%	44%	85%	70%	74%	-85%	-57%		

Analysis of the infectious contact progression shows that influenza must be passed to a child or teenager for an epidemic to occur. Once the virus is within the schools, it affects roughly the same cross-section of the community. On average, 79% of children and 73% of teenagers become infected. Adults, whose attack rate is 42%, receive influenza mainly from children, teenagers, and other adults within the nuclear family. Seniors, who contact children and teenagers only through the extended family/neighborhoods and random over-all network, are relatively isolated with an attack rate of 22%.

The importance of children and teenagers to the spread of influenza is most clearly seen in the infectious contact fractions (given as a percent of the total infectious contacts, **Table 2**). Children and teenagers are responsible for 66% of infectious contacts, while adults are responsible for 32% and seniors for only 2%. Adults receive influenza from children/teenagers with greater frequency (27%) than from other adults (23%), and seniors are equally likely to receive influenza from children/teenagers (3%) as from adults/seniors (3%). Notably, transmissions to children/teenagers are low with only 8% instigated by adults and nearly none by seniors. These transmission results are supported by recent field studies that show children who go to pre-school and school are more likely to contact the flu, and their family members are also more likely to become ill (*26, 27*). In addition, it has been found that an individual is more likely to be infected when exposed to children or teenagers as compared with adults (*26*).

Table 2: Infectious contact fractions between age classes given as a percentages of the total number of infectious contacts.

	To Children	To Teenagers	To Adults	To Seniors	Total From
From Children	21.4	3.0	17.4	1.6	43.4
From Teenagers	2.4	10.4	8.5	0.7	21.9
From Adults	4.6	3.1	22.4	1.8	31.8
From Seniors	0.2	0.1	0.8	1.7	2.8
Total To	28.6	16.6	49.0	5.7	

Given that children and teenagers together are roughly half as abundant as adults, their importance is striking. This importance comes from three characteristics. First, on average, children and teenagers each have 52 contacts per day while adults have 34 and seniors only 24. Secondly, children and teenagers are both more infectious and more susceptible than adults (I_A and S_A are both 1.5 for children, and both 1.25 for teenagers). And thirdly, most of the contacts for children and teenagers are like-to-like with nearly half taking place in school classes. The combination of these factors leads to very different rates of disease spread within age class specific groups. For an I_D of 0.01, transmission from an infectious adult or senior to a susceptible adult or senior occurs an average of once in every 100 contacts (I_A and S_A are both 1.0 for these age classes). If we consider two adults in a work environment, where the average number of contacts is 6 per day, then during the course of one day, an infectious adult will infect another adult at work with a frequency of about 1 in 17. Now consider two children. Because I_A and S_A for children are both 1.5, transmission rates are increased from an average of 1 in 100 contacts to about 1 in 44. In our contact network, a child has an average of 24 contacts per day within the classroom environment, and thus, the frequency per day of transmission from an infectious child to a susceptible child at school is a bit over 1 in 2.

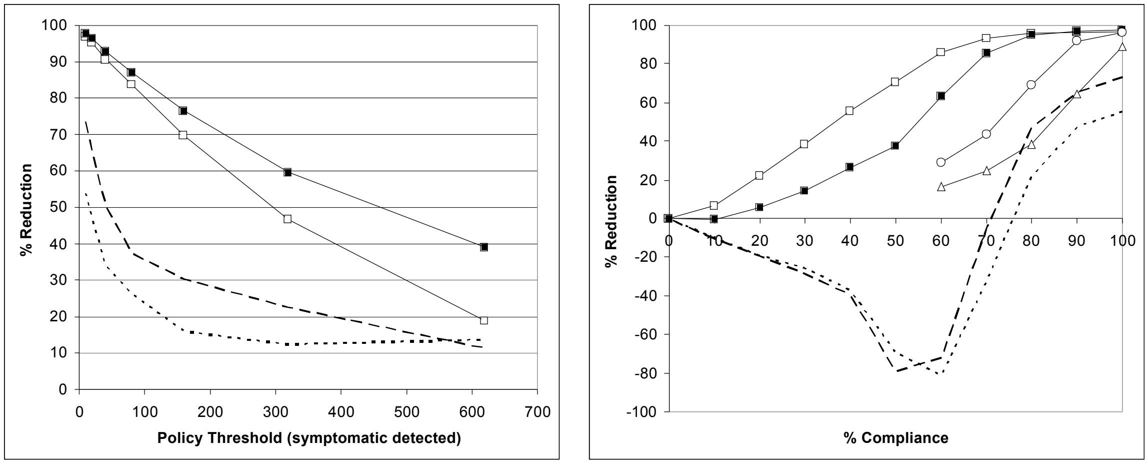
Targeting zones of high infectious contact

In the absence of vaccine or anti-viral treatment, what mitigation strategies afford protection from pandemic influenza carriers arriving from outside? Analysis of the base case presented above shows the critical role of children and teenagers in spreading influenza. The combination of high infectiousness and a high number of contacts, many of which are like-to-like, creates a zone of high infectious contact centered on children and teenagers within the community's social network. Mitigation strategies that target this zone could effectively protect the population at large by lowering the overall infectious contact rate below the epidemic threshold.

As a first strategy, we examine the often implemented social distancing measure of closing schools. We note that, while contacts in classes will be removed, those in all other groups may increase in frequency as children and teenagers now spend more time at home, in their neighborhoods, with their friends, and in public spaces within the community. At a minimum, we assume that school closure doubles household contacts. Closing the schools after 10 symptomatic individuals are detected within the community (by reducing the original contact frequency within classes by 99%), we find a reduction of attack and death rates of 45% as compared with the base case (**Table 1, SOM Table 5** in the Appendix). However, as a possible worst case, if we assume that school closure doubles all the link contact frequencies for children/teenagers within their non-class groups, attack and death rates are actually increased relative to the base case by 14% and 19%, respectively (**Table 1, SOM Table 5**).

In search of a more effective strategy, we send all children and teenagers home on school closure to remain for the duration of the pandemic. Contact frequencies are reduced by 99% for all groups that contain only children or teenagers (classes and their random networks), and doubled, as before, for children/teenagers in households. In the extended family/neighborhood and the random over-all networks, children/teenager contact frequencies are also reduced by 99%. Thus, while children and teenagers are restricted to the home, adults and seniors go about their day-to-day routines as usual except that they avoid children/teenagers who are not family members. Imposition of this strategy after 10 symptomatic individuals are detected reduces attack and death rates by 98% as compared with the base case (**Figure 4a, Table 1, SOM Table 6** in the Appendix). Waiting until 80 individuals are detected (a possible worse case) still reduces attack and death rates by 87%.

To evaluate the trade-off between effectiveness and public compliance with this children and teenager stay-at-home policy, we reduce the percent of the contacts that are reset. At 80% compliance, attack and death rates can be reduced by 95% (**Figure 4b, Table 1, SOM Table 7** in the Appendix). Further relaxation to 70% compliance still reduces influenza severity within the community by above 86% (**Figure 4b, Table 1, SOM Table 7**). Reduction in compliance increases the time scales for the epidemic. Below ~75% compliance, epidemics are lengthened above the base case and reach nearly a factor of two at 60% compliance (**Figure 4b**).



a) b)

Figure 4: Percent reduction from base case due to social distancing of children and teenagers, as a function of a) implementation policy threshold given by the number of symptomatic detected, and b) compliance with the policy. Solid squares are for attack and death rates, open squares for peak infected, long dashed for time to peak infected, and short dashed for total time of epidemic. Results for attack and death rates are also given in b) for two more virulent cases with 25% (open circles) and 50% (open triangles) increases in disease infectivity, each weighted against comparable no social distancing cases. Each point plotted represents the average of 100 simulations. Summary statistics are given in **SOM Tables 5 and 6**.

Other social distancing strategies can be considered. For instance, since there are more children than teenagers, what if only children were distanced while teenagers attended school? While not as effective, simulation results indicate that this strategy still reduces the attack and death rates by 72% at 99% compliance as compared with the base case (**Table 1, SOM Table 8** in the Appendix). Many adults may also wish to be distanced from work; however, distancing all adults has a small effect, whether it is in addition to distancing children/teenagers (92% at 70% compliance) or independently (only 6% decrease at 99% compliance) (**Table 1, SOM Tables 9 and 10** in the Appendix). Finally, as is often suggested, the simplest social distancing policy of all is to require sick individuals to remain at home. Such a policy yields only a 21% reduction in attack rate relative to the base case because just 25% of the infectious are influenced (i.e., $pS*pH$ = 0.25) (**Table 1, SOM Table 10**).

While it appears that social distancing strategies can be quite effectively designed, implementation is challenging. The strategies must be imposed for the duration of the local pandemic and possibly for the entire period of the global pandemic if infected individuals continue to enter the community. To return to normalcy, vaccination is required. As vaccine becomes available, who should be vaccinated first? Knowledge of the heterogeneous structure of infectious contact within social networks enables us to define a vaccination strategy that can most quickly and effectively protect the community. Vaccinating children and teenagers first shows that at 60% coverage and above (assuming 100% vaccine effectiveness), attack and death rates are decreased by 98% or greater (**Figure 5**, **Table 1, SOM Table 11** in the Appendix). Similar to that found for compliance in **Figure 4b**, epidemic time scales lengthen as vaccination coverage is decreased.

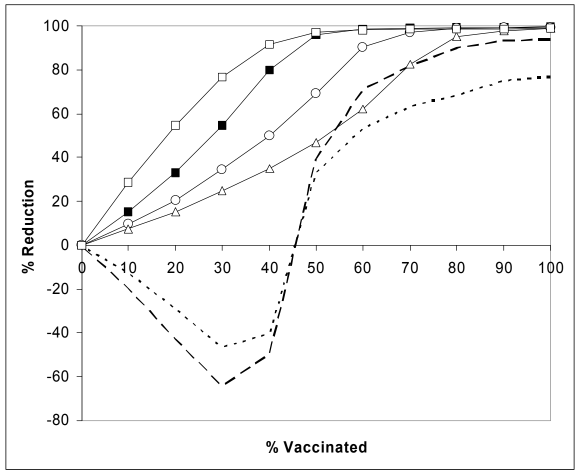


Figure 5: Average percent reduction from base case due to priority vaccination of children and teenagers, as a function of the percentage vaccinated. Solid squares are for attack and death rates, open squares for peak infected, long dashed for time to peak infected, and short dashed for total time of epidemic. Results for attack and death rates are also given for two more virulent cases with 25% (open circles) and 50% (open triangles) increases in disease infectivity, each weighted against comparable no vaccination cases. Each point plotted represents the average of 100 simulations. Summary statistics are given in **SOM Table 10**.

A vaccination strategy that targets seniors first (based on their higher mortality) is less effective, cutting the death rate by only 23% and the attack rate by a mere 6% (**Table 1, SOM Table 12** in the Appendix). Implementing a typical influenza vaccination demographic (26% vaccination in children and teenagers, 30% in adults, and 59% in seniors) not only requires a large supply of vaccine, it is also less effective than a children and teenagers first policy, with an 83% decrease in attack and 85% decrease in death rates (**Table 1, SOM Table 12**). The effectiveness of vaccinating children and teenagers has also been advocated by Longini and coworkers (*28*) with support from both mathematical modeling using a non-network approach (*29, 30*) and from field data (*31-33*).

We probed the robustness of our targeted mitigation strategies in three ways. First, the disease infectivity, I_D, was increased by 25% and 50% to reflect more virulent strains (note that increasing infectivity to 50% yields an average $R_o \sim 2.4$). Increasing influenza infectivity decreases the effectiveness of both the children and teenagers targeted social distancing and vaccination strategies, thus requiring higher compliance or vaccination rates to achieve the same benefit (**Figures 4b and 5, SOM Tables 13 and 14** in the Appendix). Second, we removed the increased infectivity and susceptibility of children and teenagers as this may not be the case for the influenza strain that erupts. Third, we considered a single perturbation to the given contact networks by increasing the frequency of random connections by a factor of 10 within the population at large (from one random contact to 10 per day). Taken independently or together these last two perturbations did not significantly change results, thus emphasizing the critical controlling influence of the underlying structured contact network.

Discussion

Results for our stylized small town, suggest significant value in targeting zones of high infectious contact within a community, to both stop the progression of pandemic influenza when no vaccine or antiviral drugs are available, and to immunize the community most effectively once vaccine arrives. Effective strategies can be designed at the community level but they must draw on insights that do not currently inform public policies (*34*). For social distancing, we must not just close the schools, we must maintain reduced contact among children and teenagers to be most effective. When vaccine becomes available, a focus on children and teens rather than on individuals with presumed highest mortality would return the community to normalcy most rapidly, with the least illness, death, and vaccine.

While our results are dependent on the underlying social contact network and influenza strain characteristics, we have chosen both such as to give a reasonable "worst case" for the design and testing of mitigation strategies during the open-outbreak phase of an influenza pandemic. Results for both targeted social distancing and vaccination of children and teenagers are robust both to reasonable increases in random contacts (e.g., shopping malls) and to the removal of age-class specific differences in infectivity and susceptibility for children and teenagers. Increases in disease infectivity require higher compliance and vaccination coverage for the same benefit; the virulence of a pandemic virus will not be known until it erupts.

As has been pointed out by a number of researchers (*35-37*), results from epidemiological models must be interpreted with their assumptions in mind. The classical modeling approach considers a population as continuous and shows that the reproductive number, R_o (the average number of people an infected person will infect), critically controls whether or not an outbreak develops into an epidemic (*38*). If R_o is above 1, an epidemic forms; if below, it does not. While conceptually powerful, R_o is an effective parameter at the population scale that must be estimated empirically, post hoc. It subsumes both the properties of the disease-host interaction and the contact network along which the disease has spread. It therefore depends on the initial conditions within the population (susceptibility), and the operable mixing processes within the local culture (contact network), both of which vary from place to place and will change during the worldwide progression of a pandemic. More importantly, as demonstrated in our analyses, averaging over a highly heterogeneous contact network can hide critical features that could be exploited to design effective mitigation strategies.

Our networked agent-based model is a bottom-up, discrete process approach that explicitly implements both the disease-host interaction and the contact network. The full system behavior is built from appropriate "unit" processes. In principle, experiments can be defined to estimate parameters for both the contact network and the viral-spreading rules between individuals. Measuring contact networks within communities for the spread of infectious diseases requires focused research that combines sociology and epidemiology. Such networks will likely differ between urban and rural communities, and possibly vary with community size. In our current study the contact network has been created to represent a stylized small town in the United States. With the aid of detailed demographic data, expert elicitation, behavioral surveys, and experiments, it can be expanded or adjusted for communities of interest and for other parts of the world. Configurations that explicitly consider college campuses might be of great importance in light of the fact that the highest death rate of any group in the 1918 Spanish Influenza pandemic were young adults (*39*).

The spread of infectious diseases is a critical problem in the densely populated and well-connected world of the 21st century. Fears of a massive pandemic akin to that of the 1918 Spanish Influenza have heightened with the H5N1strain of avian influenza as a potential candidate. When such a pandemic begins, will we be prepared? We believe our results, based on networked agent-based simulations, compel exploration of the "how to" of effective social distancing strategies. For such strategies to be used effectively in a time of crisis, their value must be understood, and their implementation must be clear, well prepared for, and supported by all of society.

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Appendix: Supporting Online Material

Base Case:
SOM Table 1: Community structure
SOM Table 2: Increasing Influenza realism. Results for 100 simulations each.
SOM Table 3: Summary statistics for influence of number of instigators. Results for 100 simulations each.

Social Distancing Strategies:
SOM Table 4: Social Distancing: Closing Schools, Threshold 10 symptomatic, Compliance 99%, with contact displacement. Results for 100 simulations each.
SOM Table 5: Social Distancing: Closing Schools and Children-Teenagers stay at home, Threshold variation, Compliance 99%. Results for 100 simulations each.
SOM Table 6: Social Distancing: Closing Schools and Children-Teenagers stay at home, Threshold 10 symptomatic, Compliance variation. Results for 100 simulations each.
SOM Table 7: Social Distancing: Only Children's Schools are Closed and stay at home, Threshold 10 symptomatic, Compliance variation. Results for 100 simulations each.
SOM Table 8: Social Distancing: Closing Schools and Work, only Children-Teenagers stay at home, Threshold 10 symptomatic, Compliance variation. Results for 100 simulations each.
SOM Table 9: Adults only avoid work, Threshold 10 symptomatic, 99% compliance; and All who become symptomatic always Stay At Home when sick. Results for 100 simulations each.

Vaccination Strategies:
SOM Table 10: Vaccination Strategy: Percent Coverage of Children and Teens. Results for 100 simulations each.
SOM Table 11: Vaccination Strategies: Seniors Only and Current Vaccination Practice. Results for 100 simulations each.

SOM Table 1: Community structure

Group (and number of groups in Community)	Membership	Average # of links per member	Network type and parameters	Average Frequency of contact per link
Non-Senior Households (2730)	1-2 adults 0-4 children 0-4 teens Mean size 3.13	2.13	Fully connected	6 times a day
Senior Households (742)	1-2 seniors Mean size 1.75	0.75	Fully connected	6 times a day
Extended families or Neighborhoods (800)	0-2 seniors 0-8 adults 0-8 teens 0-8 children Mean size 12.5	11.5	Fully connected	once a day
Child classes (69)	1 class per child, 20-35 children in each class	4	Ring network with radius 2	6 times a day
Child random (1)	All children	3	Random network link density 3/1769	once a day
Teen classes (264)	six classes per teen, 20-35 teens in each class	4	Ring network with radius 2	once a day
Teen random (1)	All teens	3	Random network link density of 3/1129	once a day
Adult work (351)	1 work group per adult, 10-50 adults in each	6	Ring network with radius 3	once a day
Adult random (1)	All adults	3	Random network link density of 3/5849	once a day
Senior gathering (156)	1 gathering per senior, 5-20 seniors in each	4	Ring network with radius 2	once a day
Senior random (1)	All seniors	3	Random network link density of 3/1249	once a day
Over-all random (1)	All age classes	25	Random network link density of 25/9999	1/25 a day

SOM Table 2: Increasing Influenza realism. Results for 100 simulations each.

	Statistics for all 100 simulations including those without epidemics						Statistics for simulations with epidemics (total infected > 100)				
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)
Initial						100					
Average	1527.2	7207.2	1082.6	43.1	111.1		1527.2	7207.2	1082.6	43.1	111.1
Max	1703	7404	1171	56.0	141.5		1703	7404	1171	56.0	141.5
Min	1368	6911	954	33.8	88.9		1368	6911	954	33.8	88.9
STD	74.7	93.0	37.8	4.4	10.7		74.7	93.0	37.8	4.4	10.7
Reduction from *base case*	-51.7%	-42.8%	-134.0%	3.2%	2.3%		-48.5%	-39.8%	-129.1%	5.2%	4.0%
ID reduced by 50% after pre-symptomatic period						83					
Average	184.4	2253.3	338.6	81.1	194.5		219.4	2705.3	406.7	95.8	225.9
Max	391	3626	549	201.9	403.6		391	3626	549	201.9	403.6
Min	10	18	0	0.1	13.4		20	101	10	12.6	51.2
STD	101.1	1164.9	176.3	44.6	90.1		71.1	649.3	99.5	32.9	61.8
Reduction from *base case*	81.7%	55.3%	26.8%	-82.1%	-71.1%		78.7%	47.5%	13.9%	-110.7%	-95.3%
Probability of Symptomatic (*pS* = 0.5)						87					
Average	193.6	2366.2	179.0	86.9	199.0		220.4	2714.8	205.4	99.5	224.5
Max	376	3353	282	235.7	430.6		376	3353	282	235.7	430.6
Min	11	14	1	1.1	11.7		25	122	5	4.5	49.7
STD	92.3	1053.5	80.4	47.6	83.8		64.7	576.1	44.9	37.3	55.1
Reduction from *base case*	80.8%	53.1%	61.3%	-95.3%	-75.1%		78.6%	47.3%	56.5%	-118.8%	-94.1%
Probability of Stay At Home (*pS* = 0.5)						71					
Average	78.2	1055.3	78.7	71.0	164.5		103.5	1468.0	109.5	97.2	217.1
Max	222	2496	202	232.9	436.7		222	2496	202	232.9	436.7
Min	10	20	0	0.1	15.6		18	106	5	3.2	71.2
STD	54.9	841.1	64.0	56.4	99.8		44.7	636.2	49.9	45.4	66.1
Reduction from *base case*	92.2%	79.1%	83.0%	-59.3%	-44.8%		89.9%	71.5%	76.8%	-113.9%	-87.7%
Relative Infectivity of Children (1.5) and Teenagers (1.25)						91					
Average	428.9	3581.8	271.0	66.9	157.2		470.1	3933.2	297.6	73.3	170.1
Max	650	4373	367	149.9	273.7		650	4373	367	149.9	273.7

Min	10	15	0	0.1	13.5		314	3422	248	49.2	129.9
STD	149.5	1139.8	88.4	25.8	48.0		74.4	203.7	26.0	16.3	25.4
Reduction from *base case*	57.4%	29.0%	41.4%	-50.2%	-38.3%		54.3%	23.7%	37.0%	-61.3%	-47.1%
Relative Susceptibility of Children (1.5) and Teenagers (1.25)						99					
Average	1012.5	5103.7	384.3	45.6	116.6		1022.6	5155.1	388.2	46.1	117.6
Max	1210	5477	440	68.6	182.7		1210	5477	440	68.6	182.7
Min	12	18	1	1.9	22.6		833	4759	338	34.3	86.7
STD	124.6	529.6	44.3	7.8	19.1		73.3	129.4	21.6	6.4	16.7
Reduction from *base case*	-0.6%	-1.1%	16.9%	-2.4%	-2.6%		0.5%	0.0%	17.9%	-1.3%	-1.6%
Relative mortality of Seniors increased by factor of 5 (base case)						97					
Average	994.0	4974.6	452.5	43.0	111.2		1024.4	5127.8	466.5	44.3	114.1
Max	1185	5432	554	62.0	144.3		1185	5432	554	62.0	144.3
Min	10	12	0	0.1	8.5		813	4709	400	33.5	90.0
STD	186.9	885.9	84.1	9.3	21.0		70.3	137.4	27.1	5.6	12.8
Reduction from *base case*	1.3%	1.4%	2.2%	3.4%	2.2%		0.4%	0.5%	1.3%	2.5%	1.4%
Base case, 1000 simulations						979					
Average	1006.7	5046.3	462.7	44.5	113.7		1028.1	5154.2	472.6	45.5	115.7
Max	1295	5592	552	99.4	195.5		1295	5592	552	99.4	195.5
Min	10	11	0	0.1	9.6		796	4780	386	32.2	85.3
STD	163.8	746.4	71.5	9.8	19.3		75.5	122.9	23.7	7.6	13.7

SOM Table 3: Summary statistics for influence of number of instigators. Results for 100 simulations each.

	Statistics for all 100 simulations including those without epidemics						Statistics for simulations with epidemics (total infected > 100)				
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)
1 Instigator						35					
Average	357.0	1792.1	166.5	21.4	50.3		1016.7	5115.3	475.2	57.4	130.0
Max	1208	5573	522	86.5	158.0		1208	5573	522	86.5	158.0

Min	1	1	0	0.1	0.8		793	4724	415	37.2	101.0
STD	489.4	2453.1	228.2	27.6	59.6		90.91	177.2	25.3	11.6	13.7
Reduction from *base case*	64.5%	64.5%	64.0%	51.9%	55.7%		1.1%	0.8%	-0.6%	-26.4%	-12.4%
2 Instigators						56					
Average	564.8	2869.4	264.7	31.2	74.3		1006.2	5120.3	472.5	53.4	123.5
Max	1190	5401	523	83.1	190.2		1190	5401	523	83.1	190.2
Min	2	2	0	0.1	2.5		852	4700	421	35.3	100.8
STD	503.9	2554.1	236.4	26.4	57.9		79.7	134.6	26.2	10.1	19.2
Reduction from *base case*	43.9%	43.1%	42.8%	30.0%	34.6%		2.1%	0.7%	0.0%	-17.4%	-6.8%
4 Instigators						82					
Average	847.2	4231.7	388.3	43.3	102.5		1031.8	5158.3	473.3	51.8	121.4
Max	1184	5518	531	91.6	174.4		1184	5518	531	91.6	174.4
Min	4	4	0	0.1	3.5		891	4811	422	36.3	96.5
STD	400.2	1990.9	183.7	20.5	42.8		63.9	123.1	23.8	10.0	14.1
Reduction from *base case*	15.8%	16.1%	16.1%	2.7%	9.8%		-0.4%	-0.1%	-0.2%	-14.0%	-5.0%
8 Instigators						97					
Average	991.3	4996.3	456.5	46.7	116.4		1021.6	5150.3	470.6	48.1	119.4
Max	1219	5408	517	83.1	154.3		1219	5408	517	83.1	154.3
Min	8	11	0	0.1	10.9		816	4693	419	33.9	93.2
STD	192.6	888.8	82.8	11.8	21.9		85.4	124.9	19.7	8.9	13.5
Reduction from *base case*	1.5%	1.0%	1.4%	-4.9%	-2.4%		0.6%	0.1%	0.4%	-5.8%	-3.2%
16 Instigators						100					
Average	1031.5	5158.5	474.6	41.9	113.5		1031.5	5158.5	474.6	41.9	113.5
Max	1188	5463	527	65.7	150.7		1188	5463	527	65.7	150.7
Min	835	4846	418	31.3	85.0		835	4846	418	31.3	85.0
STD	67.3	120.8	22.2	5.9	14.0		67.3	120.8	22.2	5.9	14.0

Reduction from *base case*	-2.5%	-2.2%	-2.6%	6.0%	0.1%		-0.3%	-0.1%	-0.4%	7.9%	1.9%
32 Instigators						100					
Average	1057.0	5196.6	476.2	35.1	105.3		1057.0	5196.6	476.2	35.1	105.3
Max	1301	5528	544	45.4	146.8		1301	5528	544	45.4	146.8
Min	865	4915	398	26.1	82.1		865	4915	398	26.1	82.1
STD	80.4	117.8	24.2	3.6	12.5		80.4	117.8	24.2	3.6	12.5
Reduction from *base case*	-5.0%	-3.0%	-2.9%	21.1%	7.3%		-2.8%	-0.8%	-0.7%	22.7%	8.9%
62 Instigators						100					
Average	1068.8	5227.2	479.5	30.7	99.7		1068.8	5227.2	479.5	30.7	99.7
Max	1307	5560	532	38.0	140.5		1307	5560	532	38.0	140.5
Min	923	4989	403	24.9	76.9		923	4989	403	24.9	76.9
STD	70.3	123.2	24.5	2.6	12.3		70.3	123.2	24.5	2.6	12.3
Reduction from *base case*	-6.2%	-3.6%	-3.6%	31.0%	12.2%		-4.0%	-1.4%	-1.5%	32.5%	13.8%
128 Instigators						100					
Average	1102.4	5287.3	485.5	25.5	96.0		1102.4	5287.3	485.5	25.5	96.0
Max	1259	5636	532	30.4	131.9		1259	5636	532	30.4	131.9
Min	917	4946	441	21.6	76.7		917	4946	441	21.6	76.7
STD	74.7	120.2	22.0	2.1	10.8		74.7	120.2	22.0	2.1	10.8
Reduction from *base case*	-9.5%	-4.8%	-4.9%	42.6%	15.5%		-7.2%	-2.6%	-2.7%	43.8%	17.0%
256 Instigators						100					
Average	1183.7	5432.4	495.0	20.6	87.8		1183.7	5432.4	495.0	20.6	87.8
Max	1379	5735	548	25.5	130.8		1379	5735	548	25.5	130.8
Min	985	5146	442	17.3	68.8		985	5146	442	17.3	68.8
STD	75.7	134.1	25.1	1.7	9.4		75.7	134.1	25.1	1.7	9.4
Reduction from *base case*	-17.6%	-7.7%	-7.0%	53.7%	22.8%		-15.1%	-5.4%	-4.7%	54.6%	24.1%
Base case, 1000 simulations						979					

Average	1006.7	5046.3	462.7	44.5	113.7		1028.1	5154.2	472.6	45.5	115.7
Max	1295	5592	552	99.4	195.5		1295	5592	552	99.4	195.5
Min	10	11	0	0.1	9.6		796	4780	386	32.2	85.3
STD	163.8	746.4	71.5	9.8	19.3		75.5	122.9	23.7	7.6	13.7

SOM Table 4: Social Distancing: Closing Schools, Threshold 10 symptomatic, Compliance 99%, with contact displacement. Results for 100 simulations each.

	Statistics for all 100 simulations including those without epidemics						Statistics for simulations with epidemics (total infected > 100)				
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)
just schools + double in Houshold						95					
Average	217.6	2759.7	253.5	82.2	207.5		228.3	2903.0	266.6	86.1	217.0
Max	440	3546	341	208.7	402.6		440	3546	341	208.7	402.6
Min	12	17	2	1.3	11.4		37	269	23	15.2	94.0
STD	81.4	795.9	74.1	37.3	65.6		68.3	501.9	48.1	34.0	52.0
Reduction from *base case*	78.4%	45.3%	45.2%	-84.7%	-82.5%		77.8%	43.7%	43.6%	-89.4%	-87.6%
just schools + double in all groups						98					
Average	1063.5	5746.1	552.0	46.4	117.8		1085.0	5862.8	563.2	47.3	119.7
Max	1339	6184	625	64.3	162.2		1339	6184	625	64.3	162.2
Min	10	19	1	0.1	20.2		946	5545	512	36.4	94.1
STD	169.9	831.3	82.2	9.0	19.1		78.5	132.8	23.7	6.5	13.6
Reduction from *base case*	-5.6%	-13.9%	-19.3%	-4.3%	-3.6%		-5.5%	-13.7%	-19.2%	-4.1%	-3.5%
Base case, 1000 simulations				979							
Average	1006.7	5046.3	462.7	44.5	113.7		1028.1	5154.2	472.6	45.5	115.7
Max	1295	5592	552	99.4	195.5		1295	5592	552	99.4	195.5
Min	10	11	0	0.1	9.6		796	4780	386	32.2	85.3
STD	163.8	746.4	71.5	9.8	19.3		75.5	122.9	23.7	7.6	13.7

SOM Table 5: Social Distancing: Closing Schools and Children-Teenagers stay at home, Threshold variation, Compliance 99%. Results for 100 simulations each.

	Statistics for all 100 simulations including those without epidemics						Statistics for simulations with epidemics (total infected > 100)				
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)
Threshold 10 symptomatic detected						54					
Average	30.4	105.0	9.7	11.5	51.4		36.9	135.9	13.0	12.6	60.9
Max	64	208	23	24.3	106.6		64	208	23	23.1	106.6
Min	11	18	1	1.0	18.5		20	101	5	5.9	32.8
STD	10.6	42.9	5.1	4.8	17.4		9.09	29.7	4.3	4.3	13.6
Reduction from *base case*	97.0%	97.9%	97.9%	74.1%	54.8%		96.4%	97.4%	97.2%	72.2%	47.3%
Threshold 20 symptomatic detected						81					
Average	47.9	178.4	15.7	15.1	59.0		53.6	203.9	17.8	16.2	64.4
Max	104	398	42	64.4	130.5		104	398	42	64.4	130.5
Min	13	15	0	1.8	7.4		24	103	8	8.8	31.4
STD	20.5	79.1	7.7	6.9	20.5		18.3	64.5	7.0	6.6	18.4
Reduction from *base case*	95.2%	96.5%	96.6%	66.0%	48.1%		94.8%	96.0%	96.2%	64.3%	44.3%
Threshold 40 symptomatic detected						100					
Average	93.7	361.2	32.2	21.6	73.5		93.7	361.2	32.2	21.6	73.5
Max	173	680	66	38.6	136.2		173	680	66	38.6	136.2
Min	34	185	11	12.8	44.1		34	185	11	12.8	44.1
STD	25.9	91.4	10.6	5.5	19.9		25.9	91.4	10.6	5.5	19.9

Reduction from *base case*	90.7%	92.8%	93.0%	51.5%	35.3%		90.9%	93.0%	93.2%	52.5%	36.5%
Threshold 80 symptomatic detected						99					
Average	159.5	636.5	55.2	27.3	82.5		161.0	642.7	55.8	27.6	82.9
Max	268	923	89	58.9	115.6		268	923	89	58.9	115.6
Min	10	24	1	0.1	36.1		75	329	26	16.0	54.4
STD	44.8	151.1	14.6	8.3	14.4		42.4	138.6	13.6	7.8	13.7
Reduction from *base case*	84.2%	87.4%	88.1%	38.7%	27.4%		84.3%	87.5%	88.2%	39.3%	28.3%
Threshold 160 symptomatic detected						99					
Average	297.9	1163.3	103.4	30.3	93.7		300.7	1174.5	104.4	30.6	94.2
Max	409	1593	148	54.0	160.3		409	1593	148	54.0	160.3
Min	21	48	4	6.9	46.1		174	720	70	18.8	62.6
STD	57.9	201.7	19.4	7.0	17.3		50.9	168.1	16.7	6.6	16.7
Reduction from *base case*	70.4%	76.9%	77.6%	31.9%	17.6%		70.7%	77.2%	77.9%	32.7%	18.6%
Threshold 320 symptomatic detected						99					
Average	525.6	1994.2	176.7	33.7	97.4		530.7	2014.0	178.5	34.0	98.1
Max	663	2456	229	57.9	156.1		663	2456	229	57.9	156.1
Min	14	30	2	2.3	24.6		347	1491	122	22.6	70.0
STD	85.2	273.9	27.0	7.1	16.7		68.0	189.8	20.5	6.4	15.0
Reduction from *base case*	47.8%	60.5%	61.8%	24.4%	14.3%		48.4%	60.9%	62.2%	25.2%	15.1%
Threshold 640 symptomatic detected						98					
Average	799.3	3012.3	267.8	38.6	96.0		815.4	3073.2	273.2	39.3	97.6
Max	985	3550	337	55.8	126.1		985	3550	337	55.8	126.1
Min	13	16	2	3.1	10.9		619	2699	223	29.0	76.2

STD	137.3	460.1	44.4	7.3	15.5		79.1	168.4	23.0	5.5	10.6
Reduction from *base case*	20.6%	40.3%	42.1%	13.3%	15.5%		20.7%	40.4%	42.2%	13.6%	15.6%
Threshold 1280 symptomatic detected						99					
Average	1003.2	4166.0	380.4	44.4	100.0		1013.2	4207.7	384.2	44.9	100.7
Max	1175	4414	442	65.2	138.3		1175	4414	442	65.2	138.3
Min	10	33	4	0.1	30.6		874	3981	343	34.8	81.4
STD	122.3	430.9	44.1	7.9	13.1		70.3	107.1	22.4	6.5	11.1
Reduction from *base case*	0.4%	17.4%	17.8%	0.2%	12.0%		1.4%	18.4%	18.7%	1.2%	13.0%
Threshold 10000 symptomatic detected						96					
Average	986.2	4944.6	456.1	43.5	111.5		1026.8	5149.7	475.0	45.2	115.2
Max	1167	5474	526	65.8	159.8		1167	5474	526	65.8	159.8
Min	10	16	1	0.1	16.3		864	4891	420	32.9	92.5
STD	210.2	1018.5	95.8	10.8	23.4		66.5	137.3	23.1	6.9	14.6
Reduction from *base case*	2.0%	2.0%	1.4%	2.2%	1.9%		0.1%	0.1%	-0.5%	0.5%	0.4%
Base case, 1000 simulations						979					
Average	1006.7	5046.3	462.7	44.5	113.7		1028.1	5154.2	472.6	45.5	115.7
Max	1295	5592	552	99.4	195.5		1295	5592	552	99.4	195.5
Min	10	11	0	0.1	9.6		796	4780	386	32.2	85.3
STD	163.8	746.4	71.5	9.8	19.3		75.5	122.9	23.7	7.6	13.7

SOM Table 6: Social Distancing: Closing Schools and Children-Teenagers stay at home, Threshold 10 symptomatic, Compliance variation. Results for 100 simulations each.

	Statistics for all 100 simulations including those without epidemics						Satistics for simulations with epidemics (total infected > 100)				
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)
99% Compliance						51					
Average	32.9	112.4	9.2	11.7	49.8		41.6	152.8	12.3	14.2	59.9
Max	67	300	22	33.2	97.1		67	300	22	33.2	97.1
Min	11	26	1	1.7	17.4		23	101	3	5.5	31.2
STD	13.1	55.4	4.9	5.8	17.0		11.9	47.6	4.5	5.5	15.5
Reduction from *base case*	96.7%	97.8%	98.0%	73.7%	56.2%		96.0%	97.0%	97.4%	68.8%	48.2%
90% Compliance						61					
Average	36.1	146.4	12.9	15.0	58.7		45.6	194.9	16.8	16.7	67.7
Max	76	476	43	54.2	125.0		76	476	43	54.2	125.0
Min	10	22	1	0.1	20.0		18	103	5	8.1	28.8
STD	16.8	89.8	8.5	8.4	21.6		14.4	83.1	8.6	8.8	22.1
Reduction from *base case*	96.4%	97.1%	97.2%	66.3%	48.3%		95.6%	96.2%	96.4%	63.2%	41.5%
80% Compliance						76					
Average	39.5	243.0	22.0	23.0	86.5		45.6	298.4	27.0	27.1	100.1
Max	88	938	91	136.3	270.4		88	938	91	136.3	270.4
Min	11	15	1	0.7	10.4		22	104	8	5.3	38.6
STD	17.8	177.1	17.0	21.6	45.6		15.9	167.9	16.4	23.0	43.5
Reduction from *base case*	96.1%	95.2%	95.2%	48.4%	23.9%		95.6%	94.2%	94.3%	40.3%	13.5%
70% Compliance						85					
Average	63.8	718.6	64.2	45.5	146.9		71.8	834.9	74.5	52.1	165.7
Max	152	1902	191	196.2	390.5		152	1902	191	196.2	390.5

Min	10	21	1	0.1	13.6		16	101	8	1.9	51.2
STD	35.6	538.9	48.3	37.7	74.9		32.5	500.9	45.0	37.1	64.7
Reduction from *base case*	93.7%	85.8%	86.1%	-2.2%	-29.2%		93.0%	83.8%	84.2%	-14.5%	-43.3%
60% Compliance						94					
Average	140.2	1825.6	161.4	74.9	201.6		148.0	1938.5	171.4	79.3	212.1
Max	299	3069	276	206.5	344.2		299	3069	276	206.5	344.2
Min	10	17	1	0.1	19.3		24	128	11	10.2	50.0
STD	65.6	807.0	72.4	41.3	74.4		59.6	691.6	62.5	38.6	63.5
Reduction from *base case*	86.1%	63.8%	65.1%	-68.2%	-77.4%		85.6%	62.4%	63.7%	-74.4%	-83.4%
50% Compliance						97					
Average	291.3	3091.5	273.3	77.8	188.3		299.8	3185.5	281.6	79.8	193.0
Max	499	3681	360	208.1	336.9		499	3681	360	208.1	336.9
Min	13	22	2	2.2	18.7		138	2608	206	34.9	134.5
STD	79.8	591.9	54.3	31.8	46.5		64.5	252.3	26.7	30.1	38.0
Reduction from *base case*	71.1%	38.7%	40.9%	-74.8%	-65.6%		70.8%	38.2%	40.4%	-75.5%	-66.9%
40% Compliance						95					
Average	436.8	3640.0	325.7	60.7	152.7		459.0	3829.7	342.6	63.6	159.4
Max	650	4293	411	112.0	221.8		650	4293	411	112.0	221.8
Min	11	17	1	0.4	17.0		23	106	13	12.1	46.2
STD	127.0	938.6	84.5	18.3	38.5		83.6	447.9	41.4	13.2	25.3
Reduction from *base case*	56.6%	27.9%	29.6%	-36.2%	-34.3%		55.3%	25.7%	27.5%	-40.0%	-37.8%
30% Compliance						97					
Average	606.4	4219.5	383.6	55.9	140.2		624.8	4349.0	395.4	57.6	143.8

Max	800	4766	462	103.1	199.2		800	4766	462	103.1	199.2
Min	11	25	0	0.4	15.2		472	3708	322	36.7	107.6
STD	125.8	762.9	73.1	16.0	27.5		70.4	189.4	28.9	13.0	18.7
Reduction from *base case*	39.8%	16.4%	17.1%	-25.6%	-23.4%		39.2%	15.6%	16.3%	-26.7%	-24.3%
20% Compliance						100					
Average	765.5	4667.7	424.9	52.0	132.6		765.5	4667.7	424.9	52.0	132.6
Max	917	5220	493	78.1	186.5		917	5220	493	78.1	186.5
Min	580	4320	368	36.3	102.0		580	4320	368	36.3	102.0
STD	70.6	155.4	25.5	8.2	16.7		70.6	155.4	25.5	8.2	16.7
Reduction from *base case*	24.0%	7.5%	8.2%	-16.7%	-16.7%		25.5%	9.4%	10.1%	-14.3%	-14.6%
10% Compliance						100					
Average	919.8	4961.6	458.8	48.0	122.4		919.8	4961.6	458.8	48.0	122.4
Max	1107	5336	513	66.6	166.1		1107	5336	513	66.6	166.1
Min	775	4709	386	33.2	95.1		775	4709	386	33.2	95.1
STD	69.8	124.1	24.0	7.3	14.2		69.8	124.1	24.0	7.3	14.2
Reduction from *base case*	8.6%	1.7%	0.9%	-7.8%	-7.7%		10.5%	3.7%	2.9%	-5.6%	-5.8%
0% Compliance						96					
Average	986.2	4944.6	456.1	43.5	111.5		1026.8	5149.7	475.0	45.2	115.2
Max	1167	5474	526	65.8	159.8		1167	5474	526	65.8	159.8
Min	10	16	1	0.1	16.3		864	4891	420	32.9	92.5
STD	210.2	1018.5	95.8	10.8	23.4		66.5	137.3	23.1	6.9	14.6
Reduction from *base case*	2.0%	2.0%	1.4%	2.2%	1.9%		0.1%	0.1%	-0.5%	0.5%	0.4%
Base case, 1000 simulations						979.00					

Average	1006.7	5046.3	462.7	44.5	113.7		1028.1	5154.2	472.6	45.5	115.7
Max	1295.00	5592.00	552.00	99.4	195.5		1295.00	5592.00	552.00	99.4	195.5
Min	10.00	11.00	0.00	0.1	9.6		796.00	4780.00	386.00	32.2	85.3
STD	163.8	746.4	71.5	9.8	19.3		75.5	122.9	23.7	7.6	13.7

SOM Table 7: Social Distancing: Only Children's Schools are Closed and stay at home, Threshold 10 symptomatic, Compliance variation. Results for 100 simulations each.

	Statistics for all 100 simulations including those without epidemics						Satistics for simulations with epidemics (total infected > 100)				
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)
99% Compliance						87					
Average	148.1	1389.5	116.8	58.4	144.3		167.7	1589.6	133.6	65.8	160.9
Max	300	2233	202	176.9	262.1		300	2233	202	176.9	262.1
Min	11	11	1	0.9	12.2		22	123	12	7.0	40.1
STD	79.3	703.2	58.8	33.4	59.0		65.2	507.5	42.3	29.2	42.9
Reduction from *base case*	85.3%	72.5%	74.8%	-31.1%	-27.0%		83.7%	69.2%	71.7%	-44.7%	-39.1%
90% Compliance						88					
Average	179.0	1718.5	147.3	64.7	152.6		201.4	1947.0	166.8	72.6	168.7
Max	371	2581	227	200.7	267.6		371	2581	227	200.7	267.6
Min	10	18	0	0.1	16.4		28	111	7	9.3	44.0
STD	92.9	833.0	72.8	38.7	59.9		74.7	590.9	53.0	34.3	43.2
Reduction from *base case*	82.2%	65.9%	68.2%	-45.4%	-34.3%		80.4%	62.2%	64.7%	-59.7%	-45.9%
80% Compliance						94					
Average	257.9	2349.5	202.7	62.6	160.2		273.4	2496.6	215.4	66.2	168.1
Max	442	3135	284	140.0	281.2		442	3135	284	140.0	281.2
Min	12	21	1	1.1	16.4		20	106	3	20.7	48.7
STD	97.1	757.5	66.6	23.8	51.0		77.4	496.2	44.6	19.6	41.3

Reduction from *base case*	74.4%	53.4%	56.2%	-40.6%	-41.0%		73.4%	51.6%	54.4%	-45.6%	-45.3%
70% Compliance						91					
Average	324.7	2782.8	244.5	60.7	155.3		355.4	3053.8	268.3	65.9	167.0
Max	590	3643	335	116.4	237.1		590	3643	335	116.4	237.1
Min	10	19	1	0.1	17.4		194	2395	192	38.1	116.9
STD	117.3	902.5	80.6	23.2	44.7		67.5	266.6	27.6	16.9	25.2
Reduction from *base case*	67.7%	44.9%	47.2%	-36.4%	-36.6%		65.4%	40.8%	43.2%	-44.9%	-44.4%
60% Compliance						96					
Average	446.9	3455.0	305.0	59.4	149.6		465.0	3597.7	317.6	61.7	154.4
Max	658	4125	380	109.4	216.0		658	4125	380	109.4	216.0
Min	10	15	1	0.1	13.3		30	153	15	30.4	50.1
STD	125.1	814.8	73.3	17.6	34.6		89.6	421.1	39.7	13.6	25.6
Reduction from *base case*	55.6%	31.5%	34.1%	-33.3%	-31.6%		54.8%	30.2%	32.8%	-35.8%	-33.5%
0% Compliance						98					
Average	1008.7	5044.2	462.0	44.2	112.4		1029.1	5146.6	471.4	45.0	114.3
Max	1180	5509	526	60.3	148.6		1180	5509	526	60.3	148.6
Min	10	21	1	0.1	16.5		867	4813	418	33.2	88.7
STD	161.1	734.2	71.1	8.8	18.1		74.4	141.0	26.6	6.5	12.1
Reduction from *base case*	-0.2%	0.0%	0.1%	0.7%	1.1%		-0.1%	0.1%	0.3%	0.9%	1.1%
Base case, 1000 simulations						979.00					
Average	1006.7	5046.3	462.7	44.5	113.7		1028.1	5154.2	472.6	45.5	115.7
Max	1295.00	5592.00	552.00	99.4	195.5		1295.00	5592.00	552.00	99.4	195.5
Min	10.00	11.00	0.00	0.1	9.6		796.00	4780.00	386.00	32.2	85.3
STD	163.8	746.4	71.5	9.8	19.3		75.5	122.9	23.7	7.6	13.7

SOM Table 8: Social Distancing: Closing Schools and Work, only Children-Teenagers stay at home, Threshold 10 symptomatic, Compliance variation. Results for 100 simulations each.

	Statistics for all 100 simulations including those without epidemics						Satistics for simulations with epidemics (total infected > 100)				
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)
99% Compliance						36					
Average	32.4	89.4	8.1	10.2	40.4		46.6	133.5	11.4	11.7	48.0
Max	78	228	23	19.7	76.9		78	228	23	19.2	76.9
Min	12	20	0	1.3	13.0		30	102	4	6.0	33.6
STD	13.6	41.0	4.2	3.8	11.8		10.8	28.7	4.0	2.9	9.5
Reduction from *base case*	96.8%	98.2%	98.3%	77.1%	64.5%		95.5%	97.4%	97.6%	74.3%	58.5%
90% Compliance						55					
Average	32.7	113.2	10.0	12.1	49.8		41.6	153.4	13.5	13.5	60.7
Max	95	417	42	31.1	99.3		95	417	42	23.0	99.3
Min	11	21	0	0.5	16.9		20	101	3	5.9	30.1
STD	15.4	63.8	6.3	4.9	17.2		14.8	58.8	6.2	4.1	14.5
Reduction from *base case*	96.8%	97.8%	97.8%	72.9%	56.2%		96.0%	97.0%	97.1%	70.3%	47.5%
80% Compliance						79					
Average	38.7	174.2	15.0	15.3	65.4		43.6	204.2	17.6	17.3	72.1
Max	96	488	39	56.6	142.2		96	488	39	56.6	142.2
Min	10	14	0	0.1	22.4		16	101	6	5.3	33.3
STD	17.5	101.0	8.9	8.7	24.2		16.3	92.3	8.3	8.6	22.0
Reduction from *base case*	96.2%	96.5%	96.8%	65.6%	42.5%		95.8%	96.0%	96.3%	62.0%	37.6%
70% Compliance						84					
Average	50.1	413.2	36.1	31.5	110.0		56.0	480.6	41.9	35.6	123.7
Max	152	1471	129	133.5	262.9		152	1471	129	133.5	262.9
Min	12	17	2	1.2	13.6		20	101	6	5.2	32.9
STD	28.1	336.3	29.4	24.3	57.8		26.7	325.6	28.6	24.3	52.6
Reduction from *base case*	95.0%	91.8%	92.2%	29.2%	3.2%		94.6%	90.7%	91.1%	21.7%	-7.0%
60% Compliance						90					
Average	97.6	1199.9	104.1	67.5	180.6		106.5	1328.0	115.3	74.3	197.1
Max	216	2514	238	185.0	390.7		216	2514	238	185.0	390.7

Min	10	12	1	0.1	11.9		17	150	11	8.6	50.8
STD	51.2	677.2	59.5	43.1	80.6		45.9	586.6	51.8	40.1	66.6
Reduction from *base case*	90.3%	76.2%	77.5%	-51.6%	-58.9%		89.6%	74.2%	75.6%	-63.4%	-70.4%
0% Compliance						98					
Average	1010.6	5044.4	466.6	43.6	114.3		1031.1	5147.1	476.1	44.5	116.4
Max	1208	5518	536	79.6	178.1		1208	5518	536	79.6	178.1
Min	10	11	0	0.1	11.2		846	4815	401	33.8	91.6
STD	161.5	735.8	71.2	9.7	20.9		74.6	140.7	24.9	7.4	15.0
Reduction from *base case*	-0.4%	0.0%	-0.8%	2.1%	-0.6%		-0.3%	0.1%	-0.7%	2.1%	-0.7%
Base case, 1000 simulations						979.00					
Average	1006.7	5046.3	462.7	44.5	113.7		1028.1	5154.2	472.6	45.5	115.7
Max	1295.00	5592.00	552.00	99.4	195.5		1295.00	5592.00	552.00	99.4	195.5
Min	10.00	11.00	0.00	0.1	9.6		796.00	4780.00	386.00	32.2	85.3
STD	163.8	746.4	71.5	9.8	19.3		75.5	122.9	23.7	7.6	13.7

SOM Table 9: Adults only avoid work, Threshold 10 symptomatic, 99% compliance; and All who become symptomatic always Stay At Home when sick. Results for 100 simulations each.

	Statistics for all 100 simulations including those without epidemics						Statistics for simulations with epidemics (total infected > 100)				
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)
99% of adults avoid work						100					
Average	915.6	4727.8	435.7	46.4	117.2		915.6	4727.8	435.7	46.4	117.2
Max	1116	5034	477	81.9	186.2		1116	5034	477	81.9	186.2
Min	690	4399	393	33.4	93.8		690	4399	393	33.4	93.8
STD	80.7	126.9	20.8	8.3	15.3		80.7	126.9	20.8	8.3	15.3
Reduction from base case	9.1%	6.3%	5.8%	-4.2%	-3.1%		10.9%	8.3%	7.8%	-2.1%	-1.3%
All who become symptomatic stay at home						92					
Average	657.9	3985.0	356.9	47.6	120.7		713.9	4328.5	387.6	51.4	128.7

Max	889.00	4690.00	449.00	94.6	187.3		889.00	4690.00	449.00	94.6	187.3
Min	10.00	14.00	1.00	0.1	15.7		542.00	3953.00	335.00	37.1	96.3
STD	205.7	1180.1	106.8	15.7	31.6		80.2	153.5	22.3	9.1	16.1
Reduction from base case	0.35	0.21	0.23	-0.07	-0.06		0.31	0.16	0.18	-0.13	-0.11
Base case, 1000 simulations						979					
Average	1006.7	5046.3	462.7	44.5	113.7		1028.1	5154.2	472.6	45.5	115.7
Max	1295	5592	552	99.4	195.5		1295	5592	552	99.4	195.5
Min	10	11	0	0.1	9.6		796	4780	386	32.2	85.3
STD	163.8	746.4	71.5	9.8	19.3		75.5	122.9	23.7	7.6	13.7

SOM Table 10: Vaccination Strategy: Percent Coverage of Children and Teens. Results for 100 simulations each.

	Statistics for all 100 simulations including those without epidemics						Satistics for simulations with epidemics (total infected > 100)				
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)
100% Coverage						0					
Average	12.8	25.5	2.2	2.7	26.6		NA	NA	NA	NA	NA
Max	22	59	8	13.4	100.6		NA	NA	NA	NA	NA
Min	10	10	0	0.1	6.9		NA	NA	NA	NA	NA
STD	2.2	10.2	1.9	2.5	13.5		NA	NA	NA	NA	NA
Reduction from *base case*	98.7%	99.5%	99.5%	94.0%	76.6%		NA	NA	NA	NA	NA
90% Coverage						0		NA	NA	NA	NA
Average	13.5	28.4	2.6	2.9	28.3		NA	NA	NA	NA	NA
Max	25	80	10	19.8	64.5		NA	NA	NA	NA	NA
Min	10	12	0	0.1	10.2		NA	NA	NA	NA	NA
STD	3.0	12.2	2.1	2.9	11.2		NA	NA	NA	NA	NA
Reduction from *base case*	98.7%	99.4%	99.4%	93.4%	75.1%		NA	NA	NA	NA	NA
80% Coverage						2					
Average	14.4	37.6	3.7	4.3	35.6		29.0	133.0	8.5	31.1	102.3

Max	36	142	14	49.3	121.7		36	142	10	49.3	121.7
Min	10	12	0	0.1	7.6		22	124	7	12.9	82.9
STD	4.3	22.9	2.6	6.3	18.6		9.9	12.7	2.1	25.7	27.4
Reduction from *base case*	98.6%	99.3%	99.2%	90.2%	68.7%		97.2%	97.4%	98.2%	31.6%	11.6%
70% Coverage						12					
Average	15.7	51.2	5.2	8.0	41.4		22.3	123.1	12.3	24.1	79.4
Max	33	186	22	69.2	115.0		33	186	22	69.2	115.0
Min	10	11	0	0.1	10.4		16	102	8	4.9	41.4
STD	4.7	35.1	4.1	11.1	24.2		5.9	25.4	4.6	18.7	24.4
Reduction from *base case*	98.4%	99.0%	98.9%	82.1%	63.6%		97.8%	97.6%	97.4%	47.0%	31.4%
60% Coverage						23					
Average	18.4	75.8	7.3	12.7	52.5		28.7	178.4	17.4	33.3	100.6
Max	48	332	45	121.7	176.3		48	332	45	121.7	176.3
Min	10	12	0	0.1	11.1		18	102	6	5.9	43.2
STD	7.6	68.7	7.4	18.9	34.9		7.7	70.5	8.9	28.5	33.7
Reduction from *base case*	98.2%	98.5%	98.4%	71.5%	53.8%		97.2%	96.5%	96.3%	26.7%	13.0%
50% Coverage						47					
Average	29.2	205.1	18.9	26.3	75.1		44.9	382.7	35.2	46.8	116.9
Max	110	1115	117	138.4	203.6		110	1115	117	138.4	203.6
Min	10	10	0	0.1	7.8		14	104	6	7.7	43.3
STD	22.1	251.7	24.3	31.3	51.8		23.6	273.6	27.3	34.9	46.5
Reduction from *base case*	97.1%	95.9%	95.9%	41.0%	33.9%		95.6%	92.6%	92.6%	-2.9%	-1.1%
40% Coverage						75					
Average	86.7	1022.7	96.6	65.2	158.2		110.4	1348.0	127.4	84.5	198.1
Max	217	2309	238	259.1	352.0		217	2309	238	259.1	352.0
Min	10	10	0	0.1	12.9		18	101	10	3.1	56.4
STD	58.2	768.9	73.9	52.2	90.8		47.3	601.6	58.8	46.0	66.7
Reduction from *base case*	91.4%	79.7%	79.1%	-46.4%	-39.2%		89.3%	73.8%	73.1%	-85.8%	-71.2%
30% Coverage						87					
Average	237.7	2294.9	212.8	71.6	165.6		271.3	2632.3	244.1	81.5	184.9
Max	414	3301	321	156.3	297.7		414	3301	321	156.3	297.7

Min	11	18	1	0.3	14.1		30	106	11	14.6	47.2
STD	106.7	938.5	88.4	34.4	59.5		66.1	357.6	36.8	24.1	33.3
Reduction from *base case*	76.4%	54.5%	54.0%	-60.7%	-45.7%		73.6%	48.9%	48.4%	-79.4%	-59.9%
20% Coverage						95					
Average	461.1	3383.5	312.3	62.1	145.4		484.7	3559.7	328.6	64.8	151.5
Max	623	3968	375	109.3	231.9		623	3968	375	109.3	231.9
Min	10	13	1	0.1	14.1		331	3068	274	36.7	117.1
STD	122.7	795.4	74.7	18.8	34.6		67.8	195.6	23.2	14.6	22.2
Reduction from *base case*	54.2%	33.0%	32.5%	-39.5%	-27.9%		52.9%	30.9%	30.5%	-42.6%	-31.0%
10% Coverage						98					
Average	723.3	4300.7	400.9	52.0	126.7		737.8	4387.8	409.0	53.0	128.7
Max	933	4673	461	88.6	187.2		933	4673	461	88.6	187.2
Min	11	23	2	0.6	14.6		571	4013	347	35.7	102.7
STD	125.9	627.7	61.8	12.1	21.3		74.3	137.5	23.6	9.9	16.3
Reduction from *base case*	28.2%	14.8%	13.4%	-16.8%	-11.5%		28.2%	14.9%	13.5%	-16.7%	-11.2%
0% Coverage						98					
Average	1015.3	5063.7	465.4	43.6	112.9		1035.8	5166.6	474.8	44.5	114.8
Max	1211	5464	540	73.6	147.0		1211	5464	540	73.6	147.0
Min	10	16	1	0.1	17.8		854	4880	397	32.8	87.7
STD	162.8	734.4	72.4	9.5	17.9		76.2	122.2	28.6	7.3	12.0
Reduction from *base case*	-0.8%	-0.3%	-0.6%	2.0%	0.7%		-0.7%	-0.2%	-0.5%	2.1%	0.8%
Base case, 1000 simulations						979.00					
Average	1006.7	5046.3	462.7	44.5	113.7		1028.1	5154.2	472.6	45.5	115.7
Max	1295.00	5592.00	552.00	99.4	195.5		1295.00	5592.00	552.00	99.4	195.5
Min	10.00	11.00	0.00	0.1	9.6		796.00	4780.00	386.00	32.2	85.3
STD	163.8	746.4	71.5	9.8	19.3		75.5	122.9	23.7	7.6	13.7

SOM Table 11: Vaccination Strategies: Seniors Only and Current Vaccination Practice. Results for 100 simulations each.

	Statistics for all 100 simulations including those without epidemics						Statistics for simulations with epidemics (total infected > 100)				
	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)	Number of Epidemics	Peak Infected	Total Infected	Dead	Time to Peak (days)	Total Time (days)
Vaccination of all seniors						99					
Average	934.4	4722.5	355.5	45.2	114.8		943.7	4770.0	359.1	45.7	115.7
Max	1135	5043	409	71.3	152.3		1135	5043	409	71.3	152.3
Min	11	19	2	0.7	18.5		757	4461	309	33.0	85.4
STD	118.3	487.4	41.3	8.2	15.8		73.2	109.5	20.9	6.9	12.5
Reduction from base case	7.2%	6.4%	23.2%	-1.5%	-1.0%		8.2%	7.5%	24.0%	-0.5%	-0.1%
Current Policy (26% children and teenagers, 30% adults, 59% seniors)						55					
Average	88.4	872.3	69.1	48.2	110.6		153.1	1568.3	124.4	84.1	181.4
Max	303	2040	174	154.5	323.6		303	2040	174	154.5	323.6
Min	4	4	0	0.1	5.4		30	125	12	22.0	61.5
STD	81.0	806.0	64.1	45.4	86.1		50.6	306.9	25.2	28.6	45.8
Reduction from base case	91.2%	82.7%	85.1%	-8.2%	2.7%		85.1%	69.6%	73.7%	-85.1%	-56.8%
No Vaccination (100 simulations)						98					
Average	1015.3	5063.7	465.4	43.6	112.9		1035.8	5166.6	474.8	44.5	114.8
Max	1211	5464	540	73.6	147.0		1211	5464	540	73.6	147.0
Min	10	16	1	0.1	17.8		854	4880	397	32.8	87.7
STD	162.8	734.4	72.4	9.5	17.9		76.2	122.2	28.6	7.3	12.0
Reduction from base case	-0.8%	-0.3%	-0.6%	2.0%	0.7%		-0.7%	-0.2%	-0.5%	2.1%	0.8%
Base case, 1000 simulations						979					
Average	1006.7	5046.3	462.7	44.5	113.7		1028.1	5154.2	472.6	45.5	115.7
Max	1295	5592	552	99.4	195.5		1295	5592	552	99.4	195.5
Min	10	11	0	0.1	9.6		796	4780	386	32.2	85.3
STD	163.8	746.4	71.5	9.8	19.3		75.5	122.9	23.7	7.6	13.7