THE SOCIAL AND ECONOMIC EFFECTS OF SCHOOL CLOSURE DURING AN H1N1 INFLUENZA A EPIDEMIC IN THE UNITED STATES

by

Morgan Jesse Rutkowski

BA Human Biology, The University of Virginia, 2004

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This thesis was presented

by

Morgan Jesse Rutkowski

It was defended on

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and approved by

Samuel Stebbins, MD, MPH Associate Professor, Department of Epidemiology, Director, Center for Public Health Preparedness Graduate School of Public Health, University of Pittsburgh

Jeanette Trauth, MS, MPA, PhD, Associate Professor, Behavioral and Community Health Sciences, Graduate School of Public Health, University of Pittsburgh

Thesis Director: Martha Ann Terry, PhD, Assistant Professor, Department of Behavioral and Community Health Sciences, Graduate School of Public Health, University of Pittsburgh

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In the summer of 2009, more than 209 countries officially reported 25,174 deaths from influenza A H1N1 virus infection to the World Health Organization (WHO). As of mid-February 2010, the Centers for Disease Control and Prevention (CDC) estimated that 57 million people in the United States had contracted the H1N1 virus, resulting in approximately 257,000 hospitalizations and 17,160 deaths. In the event of an influenza pandemic, policies are implemented in order to attempt to lessen the spread of the disease. One of these regards school closure, a non-pharmaceutical intervention, often suggested for mitigating influenza pandemic in a population. Proactive school closure is defined as closing schools ahead of a pandemic arriving in an area, whereas reactive school closure occurs simply because many students and staff are sick and the schools feel it is necessary. Health officials making the decision to close schools must weigh the potential health benefits of reducing transmission against high economic and social costs, difficult ethical issues, and the possible disruption of key services such as health care.

This paper examines the public health relevance of school closure as a public health policy in response to an influenza epidemic and shows that school closure as a mitigation strategy will have substantial economic, social, and ethical effects. Seven studies are examined regarding economic costs, social costs, social justice and ethical issues, and effect on the healthcare system, to evaluate the effects of school closure during an H1N1 influenza. Modeling

studies are also discussed. Epidemiology studies and surveys highlight the social effects, ethical issues, and healthcare effects.

Vulnerable populations often suffer disproportionately during an epidemic, therefore the sources of socioeconomic and racial/ethnic disparities during an epidemic are examined. Finally, there is a discussion on communication and implementation of school closure policies and recommendations for improvement of preventative methods as well as specific plans to minimize the disparities.

Overall, closing schools in the United States for an average of four weeks could cost up to $47 billion dollars (0.3% of GDP) and lead to a reduction of 19% in key healthcare workers. School closure also raises a range of ethical and social issues, particularly since families from underprivileged backgrounds are likely to be most affected by the intervention. Some recommendations include simple educational campaigns to be implemented within schools and local businesses to help educate the community about H1N1 influenza. Because it can be extremely difficult for parents to take time off work to get their children vaccinated, doctor offices should offer H1N1 vaccinations during regular check-ups, and schools should try to hold vaccination programs. Finally, due to evidence of existing health care disparities among socially disadvantaged groups, distribution plans of vaccinations may need to include mobile community health centers that can travel to low-income areas and nontraditional sites like soup kitchens and shelters.

TABLE OF CONTENTS

LIST OF TABLES

PREFACE

First and foremost, I would like to express my deepest appreciation to my committee chair, Martha Terry, who has continually encouraged and supported me throughout this entire process. I am extremely grateful for her supervision and critical contributions to this thesis. Without her guidance and comments this thesis would not have been possible. In addition, I would like to thank my committee members, Dr. Sam Stebbins and Dr. Jeanette Trauth, who have offered invaluable help and advice to my success. Finally, thank you to my parents for all of their love and support. They have encouraged me to pursue my passions and inspired me to excel in all areas of my life. I am fortunate to have such wonderful and devoted parents who contribute so much to my happiness.

1.0 INTRODUCTION

In the summer of 2009, more than 209 countries officially reported 40,000 cases and 14,150 deaths from influenza A H1N1 virus infection to the World Health Organization (WHO). These numbers have since increased to over 25,174 deaths in 209 countries worldwide (WHO, 2009). Since the emergence of H1N1 influenza, WHO (2009) raised the influenza pandemic alert level on June 11, 2009, from phase five to phase six, officially declaring a pandemic of moderate severity. This means health officials began to carefully review pandemic protocols and put mitigation strategies in place. As of mid-December 2009, the Centers for Disease Control and Prevention (CDC) estimated that 57 million people in the United States (U.S.) had contracted H1N1 virus, resulting in approximately 257,000 hospitalizations and 17,160 deaths (CDC, 2009) (see Appendix A). The data confirm that people younger than 65 years of age are more likely to become infected by the H1N1 virus compared with seasonal flu relative to people 65 years and older. With seasonal flu, about 90% of flu related deaths occur in people older than 65 years old; however, with the H1N1 flu virus, 88% of the deaths occur in people younger than 65 years old (CDC, 2009).

In the event of an influenza pandemic, policies are implemented to mitigate the spread of the disease. In terms of the H1N1 influenza A virus, children are especially vulnerable; therefore, mitigation strategies that protect the younger population are necessary to protect the community as a whole (CDC, 2009). School closure is a non-pharmaceutical intervention often

suggested for diminishing the influenza pandemic in children as well as the adult population. The rationale for school closures is that children are believed to enable rapid transmission of diseases because they are more infectious and susceptible to many influenza strains than adults. Therefore, high contact rates in schools would increase transmissions. This is a strong argument since 60% of people infected with H1N1 are 18 years old or younger; therefore, officials contend that proactive school closure would lead to less transmission of influenza (Fraser et al., 2009; Team, 2009).

Although some health benefits can be expected from this strategy, there is still a huge debate concerning the risks and benefits of the school closure intervention. Recent studies have highlighted the lack of evidence for the effectiveness of social distancing measures such as school closures. Even if there were benefits, these must be weighed against the potential high economic and social costs of closing schools, as well as the negative effects on households, the workforce, and the healthcare industry (Cauchemez et al., 2008). School closures have the potential to create serious adverse consequences which can disproportionately affect vulnerable populations (Kass, 2001; Childress et al., 2002). For instance, children from families of low socioeconomic status may rely on their schools for particular programs that provide meals (Glass et al., 2006; Inglesby et al., 2006; WHO, 2006). Many parents will likely stay home to care for their children, resulting in a loss of family income; their staying home can also have undesirable effects on businesses.

It is important to use a combination of modeling studies and epidemiological studies to focus on the economic, social, ethical, and public health issues of a school closure policy. This paper examines multiple aspects of school closure and shows that school closure as a mitigation strategy has substantially bad effects economically, socially, and ethically (Ferguson et al., 2006;

Glass et al., 2006; Cauchemez et al., 2008; Cowling et al., 2008). Seven studies are examined regarding economic costs, social costs, social justice and ethical issues, and effect on the healthcare system, to evaluate the effects of school closure during an influenza pandemic. Modeling studies are discussed to investigate the potential economic and social effects of school closure. Epidemiology studies and surveys highlight the social effects, ethical issues, and healthcare effects. Finally, there is a discussion on communication and implementation of school closure policies and recommendations for improvement of preventative methods.

2.0 BACKGROUND

Historically, the world has seen three to four pandemics of influenza per century. One of these was the 1918 influenza pandemic, which killed over 50 million people (Hatchett, 2007; CDC, 2009). For that specific event, various non-pharmaceutical interventions were used in U.S. cities as well as around the world, to help reduce the spread of the influenza A virus. These included school closures and also closing churches, banning mass gatherings, isolating cases, mandating mask wearing, and instituting hygiene measures (Markel et al., 2007). Two studies (Bootsma and Ferguson, 2007; Hatchett, 2007) investigated if the interventions during the 1918 pandemic effectively mitigated the transmission of the influenza virus and whether the timing of implementing the measures played a role in mortality rates. Because school closures occurred in combination with other interventions, it is not possible to estimate the specific effect of the school closure alone; however, the combinations of non-pharmaceutical interventions seemed to have the greatest association with reductions in mortality during this time period (see the graphs for example in the Markel et al. article) (Markel et al., 2007). The studies also showed that the timing of lifting control measures played a major part. After the peak of the pandemic passed, some cities relaxed restrictions and therefore saw a reemergence of infection and had to reintroduce restrictions. Despite the fact that many of these cities imposed non-pharmaceutical interventions, all of the cities experienced significant epidemics because, in the absence of an effective vaccine, the virus continued to spread (Bootsma and Ferguson, 2007; Hatchett, 2007).

The ideal way to contain a potential influenza pandemic is to vaccinate large numbers of people before they are exposed to an influenza strain that can be easily transmitted from person to person (Bootsma and Ferguson, 2007; Hatchett, 2007). Vaccinations are used shortly before the arrival of a outbreak to prevent individuals from becoming sick with the virus and to achieve a certain level of saturation in order to protect the public. Developing such a vaccine in advance however, is difficult because an influenza virus mutates as it replicates, and over time these mutations can alter the virus enough so that older vaccines are no longer effective. Even with current technologies, it takes months to develop a new vaccine after the first cases of outbreak influenza appear (Bootsma and Ferguson, 2007; Hatchett, 2007). In the most recent H1N1 pandemic, the first cases appeared in the spring of 2009, yet the vaccine was not developed and distributed to particular populations until late October of 2009.

Another strategy for decreasing the rate of transmission of an influenza virus is by reducing the social denseness of people in work, community, and school settings, similar to what was done in the 1918 pandemic (Longini et al., 2005). According to researchers, schools are the most socially dense of these settings and homes represent the least socially dense. Public transportation vehicles are another socially dense environment, which more than 33 million passengers in the United States use each week day. Over 54% of these daily excursions are work related and 15% are school related (APTA, 2007).

Another factor to consider in transmission is that children usually shed more of the influenza virus, and they shed for a longer period of time. Children are not skilled in handling their secretions, are in close proximity with many others for most of the day, and therefore are responsible for most secondary transmissions within households. For these reasons, children and schools are targets for mitigation strategies to prevent the spread of the influenza virus (Longini

et al., 2005; Cauchemez et al., 2008). On average, the school closures are about four weeks, however, the closings can range in length from one week to twelve weeks, depending on the severity of the prevalence of the virus (Lempel et al., 2009).

During the 1957 influenza pandemic, studies were completed in France on the effects of school closures as an intervention. A historical review showed that, at the time, public health officials were concerned that school closures might increase anxiety and create a crisis. Therefore, the decision to close a particular school was delayed until 50% to 75% of the children became sick. Due to lack of consistency and lateness of the intervention, the school closures proved to be ineffective (Cauchemez et al., 2008).

After examining containment strategies utilized by U.S. cities during the 1918 pandemic and those used in the 1957 pandemic, researchers (Longini et al., 2005; Cauchemez et al., 2008) found that public health interventions, including school closures, seemed to be correlated with lower mortality rates. However, there are limits when using these and other historical data. Fifty to a hundred years later, the world manifests different social, cultural, and technological characteristics, thus limiting the ability to generalize information based on the 1918 and 1957 pandemics. In addition, it is difficult to use this historical data as definitive proof that school closures would work if a new pandemic influenza strain emerged in the modern world.

More recent studies of influenza school closure strategies prove this point. In March of 2008, elementary schools in Hong Kong were closed for two weeks after two children died from influenza. The schools closed after the peak of the influenza outbreak and the number of cases dropped. However, when an influenza outbreak has just peaked, a reduction in cases is expected even if there is no intervention. In fact, the reduction after the seasonal flu peak in 2008 (when school closure was implemented) was indistinguishable from the seasonal flu data in 2007 (when

the schools remained open). Therefore, researchers detected no significant effect of school closure on the influenza epidemic (Cowling et al., 2008).

Recently, in February of 2007, there was a rare opportunity "to study the impact of school closure on disease transmission as reflected in student absenteeism rates" (Rodriguez et al., 2009, p. 787). In King County, Washington, 12 school districts remained open during a winter break while seven districts took the recess, which inadvertently coincided with the peak of the influenza season. In comparing the schools with and without a break during the peak of influenza season, the study found there was no effect of school closure on the rates of absenteeism. Therefore, the evaluation suggests that there is no evidence to support the benefit of school closures during the peak of an influenza outbreak.

In this review, more studies are examined to study the social and economic costs of school closures during an influenza A H1N1 epidemic. Particular studies focus on various aspects and issues associated with ethical issues such as disproportionately affecting families from underprivileged backgrounds, interrupting the national school food programs, and exposing some families to serious financial problems. Other studies focus on the disruption of health care services like the increased demand of services and absenteeism rates among their workers.

3.0 METHODOLOGY

The focus of this paper is to provide information on the economic and social costs of school closures during the H1N1 influenza epidemic. Literature searches were performed three times between December 15, 2009, and January 10, 2010, on PubMed, GoogleScholar, and Ovid search engines for all literature on the economic and social costs related to H1N1 influenza and influenza. The inclusion and exclusion criteria were as follows: all literature and papers must be written in English; all literature must describe models or studies on H1N1 influenza or influenza, and its relation to the economy, society, and school closures; all simulated models must have been conducted in a U.S. environment due to differences in the economy, workforce, and healthcare system compared to other countries; some of the simulated models and studies could have data on seasonal influenza or other past influenza epidemics other than the recent 2009 H1N1 influenza pandemic; all studies and surveys reviewed must have examined school closures due to H1N1 influenza or influenza outbreaks or epidemics, as opposed to teacher strikes, holidays and breaks, or natural disasters; these studies and surveys could be conducted outside the U.S.; only models and studies conducted from 1990 to the present were accepted due to relevance of the current economy and society. Literature that was not yet published or that could not be accessed at the time was excluded. Newspaper articles, reports, and internet notices and blogs on only incidence rates of H1N1 influenza were also excluded from the studies. Various combinations of the following terms, subject headings, and search parameters were used: “H1N1

influenza," "influenza," "school closure," "social distancing," "economic costs," "social justice," "ethical issues," and "healthcare workforce." Papers were selected for review if they presented data on health, economic, social, ethical, or policy aspects of school closure. The reference lists of selected papers were also screened for papers missed in the original web searches.

The search was limited to program information published in peer-reviewed journals or reported in documents retrieved through the internet from 1990 to 2010. Four thousand three hundred and forty seven articles were identified in PubMed after using the search term "H1N1 influenza." In order to find relevant articles, the term was combined with "school closures," which yielded six articles. Of these articles, two had not been published and were therefore unavailable, and the other four articles were not relevant because they focused on the epidemiology and transmission of H1N1 influenza in school settings. The search terms "H1N1 influenza" and "economic costs" were combined in the PubMed search engine and 21 articles were identified. Two articles were relevant for use in this paper including the Brookings Institution study and the University of Toronto study conducted under Beate Sander. One article was relevant for use in the background and discussion of this paper. The other articles were unrelated. Finally, the search term "H1N1 influenza" was combined with "ethical issues" and 14 articles were generated. Only one article was pertinent for the background and discussion of this paper.

In the Ovid search engine, the term "H1N1 influenza" was combined with "school closures," which generated one appropriate article and one relevant study, which was a survey conducted in Perth, Australia. Each of these terms was also combined with "economic costs," which generated two additional articles to be used in the discussion of this paper. Finally, the term "ethical issues" was combined with "H1N1 influenza," creating two articles for the

discussion sections. In order to produce more results, the term "influenza" was used in combination with "school closures," producing 40 articles. Of these articles, two relevant studies were identified, including a study conducted in North Carolina and a study conducted in Kentucky. Some of the literature generated included information on the U.S. epidemic of 1918 and strategies for mitigating influenza. The term "influenza" was combined with "ethical issues," generating 32 articles. Some of the literature was duplicated or not relevant (it pertained to triage, prison, or rationing of vaccinations). A fifth study in Australia, on the professional duties of the healthcare workforce during an influenza pandemic, was identified for the use in this paper.

The GoogleScholar search engine was used to find more articles and studies on the economic and social costs of school closures during an H1N1 influenza outbreak. The term "H1N1 influenza" was combined with "school closures," generating 483 articles. The term "economic costs" was added, yielding 156 articles. Many of the articles were duplicates or replicated from previous searches. The relevant articles obtained from this search included the sixth and seventh studies reviewed in this paper, a study in King County, Washington, and a national survey completed by the Harvard School of Public Health. Two additional articles on economic models were generated as well. The terms "H1N1 influenza" and "school closures" were combined with the term "ethical issues," generating 53 articles, and the term "healthcare workforce," generating 51 articles. Many of these articles were duplicates and others were irrelevant for this paper. The terms "social distancing" and "social justice" were also combined with the previous terms search for more studies; however, many of the articles were duplicates. The articles that were not duplicated, were identified for the background and discussion sections of this paper.

4.0 RESULTS

In order to evaluate the effects of school closure during an H1N1 influenza epidemic, seven studies concerning past pandemics and influenza epidemics were examined regarding economic costs, social costs and source of income, social justice and ethical issues, and effect on the healthcare system. The Brookings Institution conducted a study estimating the direct economic and healthcare impacts for school closures in two, four, six, and twelve week durations (Lempel et al., 2009). A second study conducted under Beate Sander and colleagues (2008) at the University of Toronto, Canada, uses a transmission model that estimates the effectiveness and cost of 17 various interventions for a pandemic in a community in the United States. In order to discuss social costs, a study conducted in North Carolina by the CDC and North Carolina Department of Health and Human Services used a questionnaire to evaluate the behavior and attitudes of parents and students after a school closure due to an influenza B outbreak (Johnson et al., 2008). The Kentucky Department for Public Health (KDPH) conducted a telephone survey of randomly selected households that had children attending schools closed due to a large seasonal flu outbreak in 2008 (CDC, 2008). A survey administered in Perth, Western Australia, by the CDC used questionnaires to study the social and household effects of school closures during the H1N1 influenza epidemic in 2009 (Effler et al., 2010). The Harvard School of Public Health Project on the Public and Biological Security conducted a national survey to determine the effects of school closures on households and families due to an influenza epidemic (Blendon

et al., 2008). The final study surveyed the Australian public health and health care workforce in 2006, to estimate the impact of school and daycare closures on the staff's ability to work (Dalton et al., 2008). In this chapter these will be discussed as Studies 1 through 7.

4.1 STUDY 1 RESULTS

In 2008, the Brookings Institution applied the results of four surveys to conduct a study that estimates the costs of school closure. A mathematical program measures the impact of school closure in terms of lost income from missed work of employed parents as a consequence of school closure. The method used for valuation of productivity cost is the 'human capital method' (HCM). The HCM estimates the value of potential lost production or income from a financial point of view. The first survey is the Current Population Survey (CPS), a large, U.S. household-based labor force survey. It was used to provide information about the labor force and relationships among other members in the household (Lempel et al., 2009). Adults who stayed in the home to care for the children were surveyed once every month for four months, creating a large sample of observations. The second survey, the 2008 Annual Social and Economic Supplement (ASEC), collected data on workers' total earnings and weeks worked (Lempel et al., 2009). The third survey, the Census's 2004 Survey of Income and Program Participation (SIPP), provided data on the use of informal childcare (Sadique et al., 2008; Lempel et al., 2009). The fourth survey, the Harvard School of Public Health Project on the Public and Biological Security's Pandemic Influenza Survey, provided national data on the ability to work from home (Blendon et al., 2008). In this survey adults with and without children

were questioned on their ability to work from home for multiple week durations during a pandemic, while caring for their children. The cost of absenteeism was estimated as the sum of weekly earnings for all caregivers multiplied by the length of school closure (Lempel et al., 2009).

Using the four surveys, the Brookings Institution produced a report that estimates the economic cost of school closure and its impact on the health care system for school closure durations of two, four, eight and 12 weeks under a range of assumptions. Overall the study finds that 38% of all civilian workers in the U.S. live in households with a child under the age of 16 with no stay-at-home adults. Economic costs are calculated based on low baseline (four week period of school closure), and high cost scenarios and estimates. On average, if schools are closed for four weeks, 52% of civilian workers would miss some work to care for children, and the U.S. economy would lose about 10% of its labor hours. Twenty-five percent of employed people reported they would be able to care for their children while working from home. The lost outputs in these households were multiplied by 0.89, 0.82, 0.77, and 0.62 depending on the percentages of people in the four different income brackets. If many of these workers and households are able to use informal childcare and work from home, only 3% of all labor hours in the U.S. would be lost.

According to the data, on average, females make up 95% of absentees in the workforce. If households chose caretakers without regard to gender, 59% of the caretakers would still be female. This is due to the fact that single mother households are more common in the U.S. than single father households. Results show that households with one adult may have to deal with bringing home no income. Twenty percent of the households contained just one adult and would be left with no income while forced to miss work. Most of these single-parent households are

likely to have low to moderate income, and 43% of these households in the lowest income bracket would lose all of their earnings during a school closure. In the healthcare sector, the study finds that 19% of all healthcare work hours will be lost. Seventy-eight percent of the workers in the healthcare sector are women. Moreover, few healthcare workers can work from home, they cannot make up missed work, and because the system will be overburdened during an epidemic, other workers cannot pick up the slack.

The study finds that closing all schools in the U.S. for four weeks could cost between $10 and $47 billion dollars (0.1-0.3% of GDP) and lead to a reduction of 6% to 19% in key health care personnel. The lower estimate of $10 billion dollars takes into account most adults working from home and using informal childcare; the high estimate of $47 billion dollars is due to households distributing caretaking responsibilities without regard to gender (see Appendix B). Estimates of the "per student weekly cost" of closing schools is calculated as well. The weekly economic cost of closing schools in the U.S. is divided by the total number of students in the U.S. in order to estimate the costs. The study finds that closing schools for four weeks could cost between $140 and $630 per student (Lempel et al., 2009).

4.2 STUDY 2 RESULTS

The University of Toronto, Canada, developed a model to simulate an influenza pandemic in the community (Sander et al., 2008). The transmission parameters and predictions are similar to other published models. The probability that an infected individual will be symptomatic is 0.67. An asymptomatic infection is assumed to be 50% infectious as a symptomatic infection. The study uses 17 different strategies to demonstrate the effectiveness of the strategies and economic

impact of an influenza pandemic. The following table describes each of the 17 strategies in detail.

Table 1 Description of Strategies for Study 2

Strategy	Description
No intervention	No prevaccination, prophylaxis or treatment with antivirals
HTAP25	Household targeted antiviral prophylaxis, stockpile for 25% of population
HTAP50	Household targeted antiviral prophylaxis, stockpile for 50% of population
HTAP	Household targeted antiviral prophylaxis, stockpile unlimited
FTAP25	Full targeted antiviral prophylaxis (household contacts and 60% of work/school contacts), stockpile for 25% of population
FTAP50	Full targeted antiviral prophylaxis (household contacts and 60% of work/school contacts), stockpile for 50% of population
FTAP	Full targeted antiviral prophylaxis (household contacts and 60% of work/school contacts), stockpile unlimited
Prevaccination	Prevaccinating 70% of population with low-efficacy vaccine
School closure	Closing all schools for 26 weeks
HTAP25 + school closure	Household targeted antiviral prophylaxis, stockpile for 25% of population, plus closing all schools for 26 weeks
HTAP50 + school closure	Household targeted antiviral prophylaxis, stockpile for 50% of population, plus closing all schools for 26 weeks
HTAP + school closure	Household targeted antiviral prophylaxis, stockpile unlimited, plus closing all schools for 26 weeks
FTAP25 + school closure	Full targeted antiviral prophylaxis (household contacts and 60% of work/school contacts), stockpile for 25% of population, plus closing all schools for 26 weeks
FTAP50 + school closure	Full targeted antiviral prophylaxis (household contacts and 60% of work/school contacts), stockpile for 50% of population, plus closing all schools for 26 weeks
FTAP + school closure	Full targeted antiviral prophylaxis (household contacts and 60% of work/school contacts), stockpile unlimited, plus closing all schools for 26 weeks
Prevaccination + school closure	Prevaccinating 70% of population with low-efficacy vaccine, plus closing all schools for 26 weeks
Treatment only	Treating all cases with antivirals

TAP is carried out treating identified index cases and offering post exposure prophylaxsis to contacts of these index cases. It is assumed that 60% of index cases have noticeable symptoms. Prevaccination assumes that 70% of the population is successfully vaccinated with a low-efficacy vaccine (no efficacy percentage is stated) before the pandemic outbreak. In order to

estimate costs of resources and work loss, data are obtained from published journals and surveys. It is assumed 2.5 days of work is lost per week in each household with children under 12 years old. Five days of work is lost per week for teachers and other professionals in the school arena. Unit medical cost estimates are based on U.S. fee and price schedules and hospitalization costs are derived from Diagnosis Related Group (DRG) codes (Sander et al., 2008).

With no intervention for a pandemic outbreak in the simulated model (Sander et al., 2008), an illness attack rate is projected at 50%, resulting in 13 deaths per 1000 in the population. All other 16 interventions reduce the illness attack rate, thus decreasing morbidity and mortality. The most effective single strategy is FTAP, reducing the attack rate by 54%. It is also the least costly intervention. Prevaccination of 70% of the population, if available and administered before the pandemic, is the second least costly intervention and is expected to reduce the number of cases by 48%. The expected illness attack rate is lowest if the FTAP strategy is combined with school closure (6%) or 70% of the population is prevaccinated and schools are closed (4%). However, school closure is extremely costly to society ($2.72 million per 1000 population); therefore, in combination with these other strategies, the interventions become 14 to 21 times as costly as single interventions with antivirals or prevaccination. The following table shows the results for all interventions (Sander et al., 2008).

Table 2 Base-case results

Intervention	Illness attack rate (%)	Deaths per 1000	Total cost in million $ per 1000
No intervention	50	13	0.19
FTAP25	48	12	0.18
FTAP50	45	11	0.18
HTAP25	48	11	0.19
School closure	39	10	2.72
HTAP50	42	8	0.17
Treatment only	49	8	0.19
HTAP	41	7	0.17
Prevaccination	26	6	0.14
HTAP25 and school closure	31	7	2.70
FTAP25 and school closure	23	6	2.66
FTAP50 and school closure	22	5	2.66
HTAP50 and school closure	27	5	2.68
HTAP and school closure	24	4	2.67
FTAP	23	5	0.12
FTAP and school closure	6	1	2.61
Prevaccination + school closure	4	1	2.62

HTAP, household targeted antiviral prophylaxis; FTAP, full targeted antiviral prophylaxis.

4.3 STUDY 3 RESULTS

In Yancey County, North Carolina, schools were closed from November 2 to November 12, 2006, in response to an influenza B epidemic (Johnson et al., 2008). A total of 1,750 households had children enrolled in the public schools. A questionnaire was administered by telephone to random households from November 16 to November 18, 2006. Parents and legal guardians in the households were asked to provide demographic information on the household, answer questions about how school closure affected their employment and daily routines, and how other

adults in the household were affected. They were asked to provide information about arrangements for childcare, activities during the school closure, and attitudes toward the school closures (Johnson et al., 2008).

During a period of three days, interviewers administered over 200 questionnaires, in which 438 adults and 355 school-age children were interviewed. A total of 424 (97%) adults completed the survey and 14 (3%) adults refused. One hundred seventy four (41%) of the 424 adult responses reported their children receiving free or reduced-cost lunches at school through the National School Lunch Program. One hundred thirty (37%) of the 355 surveyed children were ill for more than one day of the period of October 23 to November 15, 2006. A total of 78 (22%) children received the influenza vaccine for the current November flu season, and 63 (81%) of these children received the vaccine after schools closed.

Participating in activities and visiting public locations during the school closure was very common, with 316 (89%) of 355 children visiting at least one public place. Older children were more likely to go out to restaurants and parties, while younger children were more likely to go grocery shopping with parents or travel outside the county to visit family members.

A total of 315 (72%) of the adults surveyed were employed outside the household. The 438 adults surveyed made up 212 households. Of the 212 households, 118 (54%) had all adults living in the home, working full-time outside the home. Of 218 adults living in these 118 households, only 39 (18%) had occupations that allowed them to work from home. Seventy-six (24%) of the 315 employed adults missed more than one day of work during the school closure because of their own illness (47%), to take care of sick family members (24%), or because of school closure (18%).

Overall, 167 (76%) households reported that someone was available to provide childcare during the day. Due to school closure, 22 (10%) indicated they had to make special arrangements for childcare. Only seven (3%) had to make accommodations for their child to stay overnight and outside the home while they worked. A total of 201 (91%) households felt the school closures were appropriate. Eighty-two of the households, or 41%, thought the reason to close schools was to protect the health of the community (Johnson et al., 2008).

4.4 STUDY 4 RESULTS

To assess the impact of school closures on families in the community in southeastern Kentucky, the Kentucky Department of Public Health (KDPH) conducted a telephone survey (CDC, 2008) with randomly sampled households whose children attended any of the 14 schools in two school districts that were closed due to an outbreak of seasonal influenza in February 2008. Three weeks after school closures, the surveys were conducted. Interviewers asked about household demographics, if children participated in the school meal programs, and whether children participated in other activities during the school closure. Adults were questioned about their employment and whether they could provide or easily obtain childcare. Respondents were also asked about their opinions on the school closure and if they knew ways to lower their risk for acquiring influenza (CDC, 2008).

From February 27 to March 3, 2008, interviewers obtained a random sample of 602 households (CDC 2008). Three hundred twenty households were successfully contacted by telephone and a total of 261 (81.9%) surveys were completed on a total of 480 children who lived in the households. In 112 (42.9%) households, there was at least one child in the school's

National School Breakfast and Lunch Programs. In 11 (10%) households surveyed, the school closure caused difficulty for the family because of the loss of these meals. The survey also asked respondents what activities children participated in during the school closures and what places they visited. Children were most likely to go to malls or Wal-Mart (43.3%), visit family (42.9%), go grocery shopping (38.7%), and out to eat (32.6%). Parents expressed their concern about athletic practices, games, and events still being held while schools were closed.

In only 39 (14.9%) of the households surveyed, did adults have the option to work from their homes. One hundred fifty seven (60.1%) households had to make other arrangements for childcare, while 104 (39.8%) households had a "non-working adult" member who was able to stay home. In 76 (29.1%) households, a "working adult" provided care and in 41 (15.7%) households, at least one adult missed work and lost pay.

When asked about influenza, 233 (89.3%) respondents stated they knew ways to reduce their risk. A total of 171 (65.5%) knew the proper hand-washing etiquette. When asked about the decision to close schools, a total of 252 (96.6%) respondents agreed with the decision. Two hundred thirty seven (90.8%) households believed it was extremely important to disinfect schools while they were closed (CDC, 2008).

4.5 STUDY 5 RESULTS

The CDC conducted a survey on the H1N1 influenza A 2009 epidemic in Perth, Australia, in three schools during the period of June 22 to July 3, 2009 (Effler et al., 2010). A student with results positive for influenza A (H1N1) 2009 virus was defined as a case-patient. Any student who had been in a classroom or in close proximity with a case-patient was defined as a contact.

Students affected by the closure but not meeting these definition criteria were referred to as school peers. Parents of those students who had attended any of the three schools that were closed for the week of June 8 to 14, 2009, because of the H1N1 influenza epidemic were asked to complete a written questionnaire. The survey asked questions about their children and whether the school closure affected them.

The CDC sent out 402 surveys to parents in Perth, Australia, of which 233 (58%) were returned. Respondents were asked about activities their children participated in during the closure and childcare arrangements. Parents were also asked about the appropriateness of the school closure (Effler et al., 2010). The median age of the students affected was 11 years old with a range from five to 13 years old. Of the 233 surveys, 12 (5%) were from households with case-patients who had the H1N1 2009 infection and led to the school closure. One hundred forty-three of the 233 (61%) were from households with contacts of the case-patients and 78 (34%) were from households with peers. Thus the total of contacts and peers was 221 (95%) of 233. During the week of school closure, 19 (9%) of the total of contacts and peers (221) reported onset of respiratory symptoms.

Parents reported that a total of 172 (74%) students participated in activities outside the home. On average, students had a mean of 3.7 activities outside the home per week. The most common activities included sporting events, shopping, outdoor recreation, and parties.

A total of 91 (45%) parents of asymptomatic students had to take one to five days off work to care for their child during the school closures. Seventy one (35%) of the parents had to make special arrangements for childcare. During the closure period, 20 (10%) students cared for themselves at home.

When asked about the appropriateness of the school closure, 110 (47%) parents agreed with the closures, 76 (33%) thought it was inappropriate, and 47 (20%) were unsure. Parents who thought the school closure was inappropriate thought the H1N1 influenza was mild and their children spent much of the time outside the home participating in activities during the school closure. The main reason parents believed the school closure was appropriate was to "protect the community." Overall, 90% of parents reported that school closure caused minimal anxiety for their child, but 55% parents felt that the school closure caused disruption to the family routine (Effler et al., 2010).

4.6 STUDY 6 RESULTS

A survey was conducted by the Harvard School of Public Health Project on the Public and Biological Security from September 28 to October 5, 2006 (Blendon et al., 2008). A national sample of 1,697 adults was used to help public officials understand the public's response to community mitigation interventions for an influenza outbreak. People were asked questions about their familiarity with influenza, their ability to stay home, and whether they could make arrangements for childcare. Adults were also asked about school closings and their ability to stay home from work (Blendon et al., 2008).

The representative sample of 1,697 people included adults living with children (Blendon et al., 2008). The survey asked respondents how familiar they were with "pandemic influenza"; some 41% said they knew what it meant, 33% said they had heard the term but did not know the meaning, and 25% had never heard the term. When respondents were asked if they would stay home, away from others for seven to ten days if they had influenza, 94% said they would comply

with this recommendation. Eighty five percent of the respondents said all members of the household would stay home if a member of the household were sick. Yet, 76% believed they would get sick caring for a sick household member. Of the adults surveyed, 73% said they would have someone to take care of them if they became sick; however, 24% said they would not have someone available to take care of them. About 36% of low income, 34% African Americans, 33% disabled, and 32% chronically ill adults said they would not have anyone to take care of them. A large percentage of these adults (71%) believed they would likely experience financial problems if they had to stay home for seven to ten days in order to avoid others.

A total of 39% respondents reported having children under the age of 18 living in their household. If schools were closed for one month, 93% of adults thought they could arrange care for their children. However, only 86% of adults thought they would probably be able to make arrangements for one month in order to provide childcare. Of these, 50% would receive help from family, 34% would use outside agencies, and 11% would use friends or neighbors.

In 60% of the households, at least one employed adult would have to stay home to care for their children. If schools were closed for one month, 25% adults said they would be able to work from home and take care of their children. If schools were closed for three months, 95% of the adults believed they could give school lessons at home, yet 47% of these respondents said they would need a lot of help while 53% believed they would need little help to teach.

In terms of the National Food Programs at school, 25% of the respondents said their children receive free breakfast and lunch in daycare and school. If schools were closed for three months, 34% of these respondents said that not receiving these meals would be a problem.

When the survey was distributed, 63% of the adult sample was employed. Many of the employed adults (74%) said they could miss seven to ten days of work without serious financial problems; however, 25% believed they would suffer financial problems. This number increased to 57% if they were to miss one month of work and jumped to 76% adults believing they would have serious financial problems if they stayed home from work for three months. Only 29% of employed adults reported they could work from home for one month due to a serious influenza pandemic. Of the employed respondents, 42% believed they would not get paid if they stayed home from work, while 35% thought they would still get paid. Adults from households that make less than $25,000 per year were less likely to get paid staying home from work than adults who make more than $50,000 per year (Blendon et al., 2008).

4.7 STUDY 7 RESULTS

The Queensland Health Group in Australia designed a Health Survey that was distributed to healthcare workers of the Hunter New England Population Health Unit (Dalton et al., 2008). The survey was conducted in July 2006 with the 120 full-time staff members who make up the clinical and public health workforce, who may be called upon to provide support in an influenza pandemic. The survey asked staff and healthcare workers how school and daycare facility closures affect their lives. They were asked questions about their ability to work from home and if they had any concerns about working from home. The staff were also asked about their access to the Internet for communication (Dalton et al., 2008).

A total of 87 of the 120 (72%) staff completed the survey. Thirty eight percent (33 of 72) staff reported they would be absent from work due to school closure and childcare issues. Yet

73% (24 of 33) of these staff stated they would be able to work from home. Of the 24 members working from home, 87% had access to the Internet and stated they could estimate working from home for six to 40 hours per week. Among the 87 respondents, 18 reported concerns: six adults stated potential exposure to influenza or the need for personal protection, four respondents reported a requirement to have training in a pandemic, three adults said availability of technology and equipment to work from home, and three respondents reported workers compensation for getting sick from caring for ill patients or sick leave during a pandemic (Dalton et al., 2008).

5.0 DISCUSSION

5.1.1 Economic Effects of School Closure

The economic costs associated with school closures for an H1N1 influenza epidemic can outweigh the epidemiological benefits. Lempel and colleagues (2009) estimated the potential economic effect of school closure in the U.S. They found that 38% of all U.S. workers live in households with a child under the age of 16 and no stay-at-home-adults. The main cost of school closure was because of absenteeism of working parents who stayed home to take care of their children. Because 52% of these workers would miss work to care for their children, an average of 10% of all labor hours in the U.S. economy would be lost during the school closure period. These estimates suggested that closing schools for four weeks would reduce the U.S. GDP by about $43 billion dollars.

The costs would be even greater ($47 billion dollars) if households decided to distribute childcare responsibilities without regard to gender. These estimates amounted to around 0.3% of GDP for school closure (Lempel et al., 2009). Of course, these estimates were dependent on a number of assumptions and were subject to uncertainty. First, the number of individuals who may be able to access informal childcare can be a critical determinant of the cost of school closures. Yet, one should also consider that the use of informal care over long periods of time may be difficult to arrange, and in fact decrease the benefits of school closure, if the children are

kept in large informal groups or daycares. In fact, children might mix more in their households and neighborhoods during these extended periods of school closures (Sadique et al., 2008). Second, one may assume that all workers who are at home with their children are unable to work, yet the Harvard School of Public Health Project Study found that 29% of workers would be able to do some work from home. It would be difficult, however, to estimate the level of productivity from these arrangements.

Sander and colleagues (2008) used a microsimulation transmission model to estimate the economic costs of pandemic mitigation strategies in the U.S. The strategies included the economic impact of no intervention with 16 single and combination strategies (including full targeted antiviral prophylaxsis, prevaccination, and school closure). For the model, particular assumptions were made including that 63% of the adults were working adults and that for school closure, 2.5 days per week would be the time lost for affected households. The illness attack rate of 50% was used as well. Thus, reviewing the overall results shows that illness attack rates and death numbers were much higher with no intervention or single strategies. However, when estimating the economic costs, school closure as a single strategy or in combination with another strategy incurred high costs on society ($2.61-$2.7 million per 1000 population). The strategies involving school closure were between 14 and 21 times as costly as interventions with antiviral drugs or prevaccination alone. Clearly, this model demonstrated that FTAP was the most effective and least costly strategy for an influenza epidemic (Sander et al., 2008).

5.1.2 Social Costs and Sources of Income

Major factors in evaluating economic costs of school closures for an H1N1 influenza epidemic were income and parental jobs. Two critical financial concerns arose for parents if schools

closed due to an influenza outbreak and they had to stay at home to care for their children. First, parents were concerned about job security, and second, they were concerned about maintaining their source of income. The American Legal system lacks the ability to protect those who deal with job or income loss due to quarantine or simply workers caring for their children during a school closure. Even if there were laws in place to allow parents to return to their jobs after a long time spent caring for their children, many families may still struggle without a regular source of income (Rothstein and Talbott, 2007). If severe enough, absenteeism in the workplace could affect employers as well as contribute to the closing of workplaces (temporarily or permanently). Depending on who is affected, this could result in a lack of essential goods and services, interrupt businesses, and possibly threaten sustainability of critical infrastructure. Absenteeism in the workplace and the lack of income would test the sustainability of families, especially vulnerable populations (Rothstein and Talbott, 2007; Blendon et al., 2008).

In the study completed in North Carolina, schools were closed for 10 days during an influenza B epidemic (Johnson et al., 2008). The survey assessed how families responded to the school closure and found that because more than 50% of the households had at least one adult who did not work outside the home, only 10% of the households had to make special childcare arrangements. Only 8% of adults reported missing work to stay home with a sick family member. Of course, these outcomes would likely be different if the proportion of working parents were as high as it is in many urban settings. Residents of Yancey County were accustomed to dealing with frequent school closures due to snowstorms and bad weather, and many had extended family in the area to provide childcare for such occasions. Also, the average age of children in this study was 12 years old, making it easier for parents to work out childcare arrangements. Results of the study might also have been different if the school closure had

extended beyond ten days. There would certainly be differences in how parents respond to school closures lasting one to two weeks versus two to three months (Johnson et al., 2008).

Although the study in North Carolina found that closing schools had a positive effect on decreasing influenza and did not adversely affect households or society, other research has not seen the same results. In fact, some researchers have proposed that school closures in urban areas might have the opposite effect. Children in urban areas can more easily congregate and in very close settings (Johnson et al., 2008). In Chicago during the 1918 pandemic, the rates of influenza among children increased during the school closure period (WHO, 2006). In three cities in Connecticut, schools remained opened during the same 1918 influenza pandemic, and they experienced mortality rates lower than the two cities of comparable size nearby that closed schools (WHO, 2006).

More recently, studies in Kentucky (CDC, 2008) and Australia (Effler et al., 2010) demonstrated how school closures allowed for children to congregate and increase the spread of influenza. In Kentucky, 43% of the children visited malls, Wal-Mart, family members, and friends. High percentages of children also attended religious services, sports activities, and other public events like concerts and festivals (CDC, 2008). In Australia, 74% of the students reported leaving the home for similar activities. The community might have followed the recommendations of the CDC to practice social distancing by closing schools, but chose not to stay away from one another and people in fact congregated more. Willingness to adhere to community mitigation strategies became a serious issue when children and teenagers were released from the confines of school hours and allowed to participate in any activities they wanted outside the home and school (Effler et al., 2010). This indicates that despite parental

concerns about reducing the spread of influenza among their children, parents' and children's perceptions about how to prevent the spread of influenza were unclear and inaccurate.

We could hypothesize that during extended periods of school closure, teenage crime might increase, along with teen pregnancy and STDs. The Wallace Foundation and Public Agenda (WFPA) is a project that explored how young people spent time when they were not in school. Well over half of the students surveyed (57%) said they participated in some kind of out-of-school activity or program every day or almost every day (Duffett and Johnson, 2004). Still, nearly three in ten said they were home alone after school at least three days a week. The majority of students (77%) also admitted to being bored often and said that when they got together with friends they typically would hang out without anything special planned. Usually this resulted in teenagers getting into trouble, especially when they had nothing to do. Most teenagers (71%) agreed that it was a lack of motivation, not lack of alternatives that explained why teenagers did not participate in organized activities (Duffett and Johnson, 2004).

One could speculate that with school closures due to an H1N1 influenza epidemic, other sports, clubs, and after-school activities would be cancelled as well, resulting in even more children without anything specifically planned. This could increase the numbers of children and teenagers unsupervised and getting into trouble. The WFPA found that over half the young people admitted that drugs and alcohol were easy for them to obtain, and sexual activity was becoming more common as an accepted activity among teenagers (Duffett and Johnson, 2004). One could speculate that these risky and illegal behaviors would increase during the school closure period, especially since many of these teenagers would be unsupervised.

Even more so, the Internet has become the source of social networking for these young people, possibly leading to overuse, cyber-bullying, and communicating with strangers and

sexual predators when parents are at work. We have become a sedentary nation, thus the time usually spent in school, could instead be spent watching television, playing video games, and searching on the internet all day. If many areas throughout the country decided to close schools at the same time due to an H1N1 influenza outbreak, the Internet could in fact crash.

When comparing the various studies in terms of parental employment and ability of parents to obtain care for their children, there were major differences. In the Kentucky study (CDC, 2008), only 15% of the working adults had the option of working from home and 60% of the households had to make alternative arrangements for childcare. In about 30% of the households, a working adult provided care to the children during the school closure, and around 16% of the households had an adult who missed work and lost income (CDC, 2008). In the Australian study (Effler et al., 2010), about 45% of the parents took more than a day off work to care for their children and 35% of the adults had to make special arrangements for their children (Effler et al., 2010). Compared to the study in North Carolina (Johnson et al., 2008), many more households in Kentucky and Australia were affected by the school closures, causing parents to lose work hours, lose income, and make other childcare arrangements (CDC, 2008; Johnson et al., 2008; Effler et al., 2010).

Based on these studies, it appears that the numbers of adults having to arrange for childcare and those who had the ability to work from home varied greatly across areas of the U.S. and other countries. One could speculate that demographics and culture play an important role in the percentage of parents that stays home, loses work hours, and loses income. Those who live with other adult family members or grandparents may find it easier to make childcare arrangements. On the other hand, wealthier families may find it easier to pay for childcare or may be more likely to have jobs that allow them to work from home.

Type of work in specific areas of the country may also contribute to the difference in the studies. For example, if hospitality and service industries are the leading careers in a particular area, adults will not be able to stay home from work or work from home. One could also speculate that the population that completed the surveys and studies may not have accurately represented the communities. More research may need to be collected on the households in these areas, predominant businesses and careers, and average family incomes.

Although there were significant differences between the studies on job security, family income, and ability to obtain childcare, there were some similarities in acceptance or appropriateness of school closure. In the North Carolina study (Johnson et al., 2008), 91% of parents thought the school closure was appropriate, and in the Kentucky study (CDC, 2008), about 97% agreed with the school closures (CDC, 2008; Johnson et al., 2008). In the Australian study, however, only 47% of the parents believed the school closure was appropriate (Effler et al., 2010). A key finding in this survey was that parental opinions about the appropriateness of the school closures were correlated with the large number of activities their child participated in outside the home. With so many children going outside the home, parents believed the closures were unnecessary. Across all the studies discussed, the main reasons given for why parents believed the schools closed were to keep the "school community healthy" and " to disinfect the schools." These statistics indicated that parents' perceptions of the reasons for school closure were probably unclear; public health departments should reinforce the reasons for closures and recommend measures to reduce the spread of influenza during the school closures (CDC, 2008; Johnson et al., 2008; Effler et al., 2010).

5.1.3 Social Justice and Ethical Issues

Policies to close schools for an H1N1 influenza epidemic may seem very effective and straightforward but actually have the potential to cause adverse social consequences and raise numerous ethical issues. Unintended nutritional, safety, and educational effects could potentially result from prolonged school closures. Although these can affect the entire community, low-income and vulnerable populations are those most affected, thus raising serious social justice concerns (Kass, 2001; Childress et al., 2002; Gostin and Powers, 2006).

In the U.S., social programs targeting underprivileged children rely heavily on school facilities. The NSLP and the SBP enable schools to deliver meals to students during the school day. In 2004, over 29 million children participated in the NSLP and over nine million children participated in the SBP (Oliviera, 2006; NSLP, 2007). If schools are closed due to an influenza outbreak, the children who participate in these programs may be compromised, leaving large numbers without daily meals and vital sources of nutrients. In Study 3 (Johnson et al., 2008), 41% of the children in the households reported receiving free or reduced cost lunches through the NSLP (CDC, 2008; Johnson, et al., 2008), and in Study 4 (CDC, 2008), about 43% of the children participated in the NSLP and SBP (CDC, 2008). In each of the studies, about 10% of the households reported that school closures caused difficulty for their family due to the absence of these meals. Similar results were found in the Harvard Survey (Blendon et al., 2008), in which about 25% of the children surveyed received free meals through the school programs, and 34% of these children would have a difficult time getting food during a school closure (Blendon et al., 2008).

Safety becomes a critical issue with long periods of school closure in response to influenza. Working parents may rely on self-care, defined as leaving a child in his or her own

care or in the care of a sibling younger than 13 years old. Although it may be appropriate in some situations, many studies have associated self-care with risky behaviors, including giving in to peer pressure, underage drinking, and using drugs. Often from low-income families, children who are left to care for themselves suffer more from behavioral and social problems (Casper and Smith, 2004). The Urban Institute Study of 2002 found that

> self-care exposes children to elevated risks: the risk of poor physical, social, and intellectual development because of the poor choices of activities when in self-care; the risk of suffering emotional or psychological harm; and the risk of injury (Capizzano et al., 2002, p. 376).

Furthermore, the study suggested that parents overestimated their child's ability to self-care. Children were ill-equipped to take care of themselves, even failing to remember basic safety and emergency procedures. Thus many of these children will remain uneducated about necessary self-care skills. (Kerrebrock and Lewit, 1999).

Closing schools for prolonged periods of time will likely affect the learning development of children, as well as have significant educational costs. Studies of education performance show that declines after the long summer breaks are largest for children from poor and minority backgrounds (Entwisle and Alexander, 1992; Downey et al., 2004). If schools were closed due to an influenza epidemic, this same type of social disparity should be expected. In Study 6, the Harvard Survey (Blendon et al., 2008) found that 95% of the respondents thought they would be able to give lessons to their children at home during a prolonged school closure, which could average from two to twelve weeks. However, 47% of the parents agreed they would need "a lot of help." In these situations, it can be expected that children from high-income homes would be less disadvantaged than those from low-income households (Blendon et al., 2008). In particular, lack of access to computers could be a significant barrier for many low-income families.

Obviously, the longer the duration of school closure, the more costly the consequences as working parents either have to take time off work to supervise their children or pay for someone else to care for them. If a large number of school days is lost, school districts might consider extending the school year, which would accrue additional costs, although the circumstances of extended school days or school year length would be expected to vary greatly between school districts. These increased costs would have to be weighed against the limited predicted effectiveness of the intervention (Entwisle and Alexander, 1992).

Finally, low-income households and minority groups in particular are exposed to financial problems if schools are closed for a period of time. In Study 6, Blendon and colleagues (Blendon et al., 2008) found that 84% of low-income Americans (households that make less than $25,000/year) would have serious financial problems if they had to stay home for one month due to school closures, as opposed to 37% for high-income Americans (households that make $75,000/year or more). These proportions increased with longer periods of time, which primarily affected low-income populations. Clearly, school closures raised distributive justice concerns (Kass, 2001; Childress et al., 2002). This ethical principle requires that the risks, benefits, and burdens of public health action be fairly distributed. As such, the principle requires that officials act to limit the extent to which the burden of disease falls unfairly upon the least advantaged and to ensure that the burden of interventions themselves are distributed equitably. Thus, if school closures are to be ethically employed, implementation must include strategies to minimize these potential effects, so as not to disproportionately burden particularly vulnerable populations.

5.1.4 Effect on Healthcare System and Workforce

For many areas in the U.S., school closures could be particularly disruptive to the workforce, especially healthcare systems. This is due to the fact that women represent a high proportion of the healthcare workforce, and working from home is likely to be virtually impossible for much of the staff. In a U.K. study, Sadique and colleagues (2008) found that 33% of the healthcare staff were likely to be the main caregiver in the home to children under 16 years of age. During an influenza epidemic, the study concluded that absenteeism in the healthcare workforce could be as high as 45%, 30% due to school closure, 10% due to sickness in staff, and 5% for other reasons. The benefits of school closures may be undermined by healthcare worker absenteeism, if workers have to stay home from work to take care of their children. In Study 1, Lempel and colleagues (2009) found similar results and estimated that 19% of the healthcare labor hours would be lost in the event of schools closing. In Study 7, Dalton and colleagues (2008) found that 38% of the healthcare workforce might be absent from work if schools closed during an epidemic. Clearly, this could result in an inadequate supply of healthcare workers when they are needed most.

According to a survey (Knebel and Phillips, 2008) of healthcare workers in 47 healthcare facilities in New York, the workers' ability and willingness to report to duty varied considerably depending on the type of disaster or epidemic. The healthcare workers were most willing to report during a snowstorm (80%) or environmental disaster (84%) and least willing during an epidemic (48%) or chemical event (60%). The basic reason behind the lack of willingness to show up to work was fear, and usually the concern was for the safety of their families and themselves (Knebel and Phillips, 2008). For healthcare systems that are run with very high levels of bed occupancy in a typical winter, understaffing might have immediate and deleterious

effects. With high levels of absenteeism and the increased demand for health services, the remainder of the healthcare workforce becomes severely strained (Dalton et al., 2008).

More research is necessary to determine the structure and response of the healthcare workforce during an influenza epidemic. Some healthcare workers might be easy to replace during school closures, yet the absence of other workers might degrade the healthcare system. If rates of absenteeism due to school closure are evenly distributed throughout the healthcare system, then the workforce might be able to adapt. Nurses and doctors may be able to work extended shifts for a couple of days, and some medical or surgical procedures could be postponed. However, if all the nurses or doctors, for example, are unavailable for a period of days or weeks, then treatment in hospitals might be severely affected. The U.S. Department of Health and Human Services (DHHS) estimates that a severe influenza epidemic could cause 90 million Americans to become infected and 9.9 million to be hospitalized (DHHS, 2005). There are only a million hospital beds in the U.S. so such an event would quickly overwhelm hospital capacity, as well as decrease hospital profits. Elective surgical procedures are more profitable than treatment for influenza, and hospitals would face an increase in uncompensated costs, because of surge in the number of insured patients (Schull et al., 2006). Overall, the impact of a severe influenza epidemic can have a harmful effect on the healthcare workforce as well as a negative financial impact on the hospitals.

5.1.5 Vulnerable Populations

Low-income and disadvantaged people often suffer disproportionately during natural disasters and influenza epidemics. Transmission can be expected to occur in various settings, including homes, healthcare facilities, schools, places of work, public transportation, and other settings at

which people gather for social, commercial, or entertainment purposes. Higher exposure risk among particular population groups as a result of factors such as crowding and occupation could contribute to health disparities among socioeconomic and racial/ethnic groups during an influenza pandemic.

Crowding, an established risk factor for many infectious diseases, can increase the likelihood of pathogen transmission. In the U.S., urban poverty and Hispanic and Asian ethnicity are correlated with domestic crowding. Even at higher income levels, Hispanic and Asian households are relatively more crowded than white and African-American households (Sydenstricker, 2006). In addition, low-income persons, African Americans, and nonwhite Hispanics are more likely than persons in other groups to obtain regular medical care at emergency departments and publicly funded clinics (AHRQ, 2004), where airborne transmission of infectious agents, especially influenza is prevalent. Because these locations typically do not isolate sick from well patients and are becoming increasingly crowded (Trzeciak, and Rivers, 2003), patients waiting for care in these settings are likely to have greater exposure to influenza viruses and other respiratory pathogens.

Another source of increased exposure to infected persons is public transportation, on which persons from low-income and minority households account for 63% of users (Pucher and Renne, 2003). Over 33 million trips occur each day on public transportation. Minorities, including African Americans and Hispanics, are eight times as likely as whites to use public transportation, thus leading the vulnerable populations to come in contact with influenza illnesses more often (Pucher and Renne, 2003).

Low-income occupations are likely to lead to differences in risk to exposure during an influenza pandemic, particularly in terms of adherence to strategies that aim to limit the contact

of sick patients with others (CDC, 2007). Their jobs are necessary because they provide essential goods and services. Staying home may not be economically feasible for persons in lower wage occupations. These people are less able to afford losing income as a result of missed work and often lack the job flexibility that would permit them to work at home. For such reasons, parents in lower wage and lower status occupations may be more likely to keep their children in communal childcare settings or in groups with other children in neighboring households where exposure risks are relatively high during an influenza pandemic, placing everyone in the family at greater risk for exposure.

Given overwhelming evidence that low-income persons are generally more susceptible to infectious diseases, it is reasonable to plan on the basis of well-documented annual epidemic patterns, which show that influenza disease development is influenced by factors that are differentially distributed across socioeconomic and racial/ethnic groups. These patterns, as well as those of many other diseases, indicate that socially disadvantaged groups are likely to be at higher risk for influenza, particularly the severe form of the disease.

The inability to predict which influenza virus will cause a future pandemic, together with the very limited national and global capacity to produce influenza vaccine in massive quantities in a short time, almost ensures that an effective vaccine will be unavailable for most or all of the population during the early stages of a pandemic and in very short supply thereafter. African American children and children from lower income families, who are at higher risk of contracting influenza (Erhart et al., 2000) in this country, are less likely to be up-to-date with other routine immunizations (Santoli et al., 2004). It is possible that, in the context of an influenza epidemic, vaccine-seeking and acceptance behavior and resultant coverage patterns may differ from those observed during routine vaccination efforts; however, the weight of

available evidence indicates that social disparities in vaccine coverage are likely to occur in the absence of careful planning to prevent them, leaving the most vulnerable populations at highest risk for infection.

In the United States, the likelihood of substantial disparities in access to timely and appropriate care under influenza pandemic conditions is high, given long-standing and persistent disparities in access to medical care. For example, persons with low income are about two times as likely as those with higher incomes to lack a usual source of health care (AHRQ, 2004). Similarly, non-Hispanic black and Hispanic persons are significantly less likely than non-Hispanic white persons to report having a usual primary care provider (AHRQ, 2004). Among persons who do report having a usual source of care, those who are poor or near poor and those who are non-Hispanic black or Hispanic are 2.5 to four times as likely as their relatively higher income and white counterparts to rely on a hospital-based source of primary care (AHRQ, 2004).

Language and cultural barriers to seeking and receiving medical care also may contribute to disparities. In emergency departments, for example, interpreters are frequently unavailable or underused, which has potentially adverse implications for patients' understanding of their disease or treatment and for clinical decision making and quality of care (Baker et al., 1996). In addition, the large numbers of persons who lack health insurance, as well as those who lack documentation of US citizenship, often delay seeking care because they are concerned about paying for the care or encountering legal difficulties.

Reasons for concern about disparities in the timeliness and appropriateness of the care received by influenza patients who might benefit from in-hospital care are similar. Given the predicted insufficient supply of hospital beds and staff during a epidemic (Schull et al., 2006), a person's access to potentially lifesaving therapies such as respiratory support and treatment of

secondary bacterial pneumonias in an inpatient setting is likely to depend on factors that include usual source of care, citizenship status, and ability to speak English. Disparities may also occur in the quality of care received by persons who are hospitalized, especially if those hospitalized are uninsured.

5.1.6 Communication and Implementation of Mitigation Strategies

Although reducing or eliminating socioeconomic and racial/ethnic disparities in health is a priority, particular pandemic mitigation strategies can be used to minimize economic and social costs as well. Mitigation strategies include voluntary case isolation, voluntary quarantine of members in households with sick people, antiviral treatment, social distancing, and infection control measure including hand hygiene and cough etiquette (Ferguson et al., 2006; CDC, 2009).

If an H1N1 influenza epidemic became severe enough, the timing of interventions to prevent further spread of the virus would be of crucial importance. Most likely, public health authorities would recommend that ill persons remain at home. Isolation and treatment with influenza antiviral medications of all people with influenza could prevent further spread within the community. However, resiliency of sick people would depend on their preparedness for an influenza epidemic. Previous studies have indicated that many Americans have made no preparations for such a public health emergency. In fact, these studies indicated that people were concerned about having sufficient supplies including food and medicine in their home if they had to stay there for a prolonged period of time. Respondents also reported that they were concerned about getting sick themselves if they had to care for a member in their household who is sick with the H1N1 flu. Public health workers and agencies must educate the public on how to

protect themselves from influenza and how they can be prepared for a pandemic (Blendon et al., 2008).

The use of vaccines, especially in young children, has proven to be extremely effective in reducing the rates of influenza, as well as saving money from a societal perspective. A study completed in Virginia by the Advisory Committee for Immunization Practices of the CDC (Nettleman et al., 2001) found that vaccine acceptance among parents for influenza was very high and closely linked with the amount of absenteeism caused by influenza in the previous year. The more days of school a child missed due to influenza, the more likely the parent would be to accept getting their child vaccinated. Parents who had to miss work to care for their sick child were even more accepting of the vaccine (Nettleman et al., 2001). A similar study completed by the same group of researchers focused on the economic impact of routine vaccination of preschool children. Two settings were examined in which vaccination was available only during usual work hours. A net cost savings resulted in both settings, leading to the conclusion that vaccinating preschool children was economically cost-effective. The largest problem with vaccines was that they needed to be readily manufactured and available for distribution before the influenza hit its peak attack rate (Cohen and Nettleman, 2000).

Due to the unpredictability of influenza attack rates and which populations would be at highest risk, severe measures may have to be put in place, especially if the strain of influenza has a high mortality rate. If closures of schools become necessary, timing and implementation become extremely important. Detection of high rates of influenza among school populations can lead to school closures; however, local surveillance might be lacking in sensitivity, meaning schools may be closed too late to have an effect on illness rates.

The trigger for closures is also crucial. If schools close due to absenteeism rates, this might lead to closures occurring too late into the epidemic, limiting the effect on the spread. Some closures might occur due to other closings in local areas and districts, which can have a substantial effect on the economy, and little effect on preventing further spread of influenza. For example, in November of 2006, schools were closed in Yancey County, NC, in response to an outbreak of influenza B virus. High incidence rates among students and staff, and inadequate numbers of substitute teachers prompted local school board and health officials to close schools for ten days. Initial reactions were mixed as to the timing and effect of countywide school closures. The state epidemiologist suggested that health officials should not generally recommend closure because it was not proven to be an effective control measure. The school closure occurred too late due to high absenteeism (Johnson et al., 2008), and it was very restrictive to society and inconsistent with the state department of health's policy of using the least restrictive measures necessary. The head of the State Public Health Surveillance Team agreed but thought these were local decisions to make.

The local decision to close schools in Yancey County prompted similar action in adjacent Mitchell County. The Mitchell County School Superintendent explained that the decision to close schools was a precautionary measure in response to 46 confirmed cases and the outbreak in Yancey County (Newsome and Neal, 2006). While local officials were able to contain the spread of disease in Yancey County, disagreements among state and local government officials as to the efficacy of school closures as a control measure illustrate the potential for delays or resistance to efficient statewide school closures in response to pandemic influenza. Furthermore, the decision to reopen schools might be equally challenging. The effect of social distancing

measures stops as soon as the intervention is relaxed. In the 1918 influenza pandemic, several U.S. cities had a second peak of influenza as soon as interventions were lifted.

Another important factor in planning for an influenza epidemic is that individuals are likely to change their behaviors as the epidemic proceeds. In the beginning of a pandemic, people may closely follow recommendations of the CDC and other health agencies, and may reduce their contacts if mortality rates are high. However, as time progresses, people may become more lax, especially if the severity of illness in their community is relatively undetectable. In addition, the public can be affected by the perceived effectiveness of the government and agencies in dealing with the influenza pandemic. For example, people may have high confidence in their government to deal with an epidemic so people relax their own vigilance, thinking the government will take care of it. On the other hand, if vaccinations and resources are perceived to be scarce during an influenza epidemic, the community may become more outraged and fearful of not receiving these resources. Planning and public health preparedness are important to enhancing adherence to recommendations and reducing fear in the public during an influenza pandemic (Blendon et al., 2008).

6.0 CONCLUSION

More than 209 countries officially reported 14,150 deaths from influenza A H1N1 virus infection to the World Health Organization (WHO), in the summer of 2009. As of mid-December 2009, the Centers for Disease and Prevention (CDC) estimated that 55 million people in the United States had contracted the H1N1 virus, resulting in approximately 11,160 deaths. In the event of the H1N1 influenza pandemic, policies were implemented in order to attempt to lessen the spread of the disease. One of these was school closure, a non-pharmaceutical intervention, often suggested for mitigating influenza pandemic in children. This paper examined multiple aspects of school closure as a public health policy in response to an influenza epidemic and showed that school closure as a mitigation strategy had substantial effects economically, socially, and ethically (Ferguson et al., 2006; Glass et al., 2006; Cauchemez et al., 2008; Cowling et al., 2008). The data confirmed that people younger than 65 years of age were more severely affected by the H1N1 virus compared with seasonal flu relative to people 65 years and older. With seasonal flu, about 90% of flu related deaths occurred in people older than 65 years old; however, with the H1N1 flu virus, 88% of the deaths occurred in people younger than 65 years old (CDC, 2009).

Although some health benefits could be expected from the school closure strategy, there is still a huge debate about if this policy should be used in the future. Recent studies have highlighted the lack of evidence for the effectiveness of social distancing measures such as

school closures. Even if there were benefits, these were weighed against the potential high economic and social costs of closing schools, as well as the negative effects on households, the workforce, and the healthcare industry (Cauchemez et al., 2008). School closures have the potential to create serious adverse consequences, which can disproportionately affect vulnerable populations (Kass, 2001; Childress et al., 2002). Children from families of low socioeconomic status may rely on their schools for particular programs that provide meals (Glass et al., 2006; Inglesby et al., 2006; WHO, 2006). Many parents will likely stay home to care for their children, resulting in a loss of family income; their staying home can also have undesirable effects on businesses.

In this review, various studies focused on the economic and social costs of school closure during an H1N1 influenza epidemic. The studies concluded that school closures could severely affect the U.S. economy, services and businesses, households, and social programs. That said, this paper has some limitations. First, it would be impossible to review all studies that discussed seasonal influenza and H1N1 influenza epidemics. Therefore, this review focused on only a few selected studies from the extensive literature research because not all of the past studies were relevant to the current economic and social costs of school closure during an H1N1 influenza epidemic. Second, each strain of influenza is different, with various symptoms and target populations, yet seasonal influenza is quite comparable to the H1N1 influenza, as well as other influenza strains. This becomes a limitation when particular influenza strains impact children more than adults and thus school closures might have an increased effect in reducing the spread. Third, the studies and surveys used in this review were from several areas of the U.S. and multiple countries. All of these areas had similar circumstances, with comparable influenza epidemics; however, these areas differ socially and culturally. Therefore, the responses obtained

from particular areas in the U.S. or from other countries may not be generalizable to other communities and cultures. Finally, because the recent H1N1 influenza pandemic of 2009 in the U.S. and other countries is fairly new, many studies and reports are only beginning to be published on the subject, and therefore, the literature at the time of this paper being constructed is limited. When more studies are completed on the school closures that took place during the most recent H1N1 influenza epidemic in the U.S., a more extensive review can be conducted on its economic and social effects.

In terms of the specific studies, the surveys conducted may have had certain bias. Possible sources of non-sampling error included non-response bias, as well as question wording and ordering effects. Non-response in telephone surveys produced some known biases in survey-derived estimates because participation tended to vary for different subgroups of the population. Other techniques, including random-digit dialing, replicate sub-samples, and systematic respondent selection within households, were used to ensure that the sample was representative. If surveys were completed retrospectively, recall bias might have reduced the response accuracy as well.

On the basis of this paper, communities should consider several recommendations before closing schools due to an H1N1 influenza outbreak. First, simple educational campaigns can be implemented within schools and local businesses to help educate the community about H1N1 influenza and how it can protect itself. Very simple steps can be taken to help prevent the spread of influenza in schools. Teachers, faculty, and staff can educate and encourage children and students to cover their nose and mouth with a tissue when they cough or sneeze and to throw the tissue away after they use it; to wash their hands often with soap and water, especially after they

cough or sneeze and if water is not near; to use an alcohol-based hand cleaner; and remind them to not to touch their eyes, nose, or mouth since germs are often spread this way (CDC, 2009).

Broader community-wide steps can also be effective. Businesses can use simple interventions to help control the spread of germs. They can post signs in the workplace and encourage people to use sanitizers, clean desktops and computer stations, and to wash their hands (Glass et al., 2006). Second, encouraging parents and children to get seasonal influenza and H1N1 influenza vaccinations can help to prevent the spread of these viruses. Because it can be extremely difficult for parents to take time off work to get their children vaccinated, doctors' offices should offer these vaccinations during regular check-ups, and schools should try to hold vaccination programs through the schools. If parents were able to sign release forms in the beginning of the school year, vaccinations could be taken care of through school nurses and vaccination programs, so parents would not have to take off work to get their children vaccinated (Rodriguez et al., 2009; Nettleman et al., 2001).

Given the current limitations of our public health infrastructure and the disparities in health care, a pandemic influenza outbreak in the United States is likely to disproportionately affect persons from socially disadvantaged groups. These disparities can be minimized through careful planning that considers and proactively addresses vulnerability at each level: exposure to disease, susceptibility to disease if exposed, and treatment of disease. Public officials should systematically consider additional barriers faced by socially disadvantaged groups at each of these levels and then actively seek ways to address those barriers. Local service providers, leaders of community-based organizations and other organizations working with socially vulnerable groups, and leaders of labor unions representing low-wage service workers are likely to have valuable insights and should be included in the planning process.

Third, if school closures become absolutely necessary during an influenza pandemic, policies need to be addressed to protect vulnerable populations and still carry out the school lunch and breakfast programs. Policies need to be put in place so that children could still receive these meals, even if schools were closed due to an influenza epidemic (Oliviera, 2006). Besides the children, parents should be protected. If parents have to stay home from work in order to care for their children during an influenza epidemic and school closure, they should not be penalized. Businesses need to have policies in place so that these parents can use "sick days" or "school closure days" to stay home and still be able to receive their income. Outreach to providers, community leaders, and organizations, particularly in disadvantaged communities, will be an important component of any strategy for addressing disparities during a pandemic.

Although CDC advocates flexible work arrangements, income replacement, and job security to minimize the negative effects of social-distancing measures, they pay inadequate attention to those whose jobs will not accommodate these interventions. More specific solutions should be outlined in pandemic preparedness plans to address the economic effects of quarantine on low-income persons, who by staying home may be at risk of wage loss, job termination, or both. Job security and income replacement are key components to limiting the effects of potential quarantine measures on disadvantaged persons (Rothstein and Talbott, 2007) and should be extended to all people, regardless of their type of work.

Well-documented evidence of existing healthcare disparities suggests that during a pandemic, shortage of influenza vaccine, antiviral drugs, inpatient services, and healthcare staff will disproportionately affect persons in socially disadvantaged groups. To limit the crowding that might occur at hospitals and clinics, plans for the release of stockpiles of vaccines, medications, or both could include distribution from private pharmacies or doctors' offices.

However, because private pharmacies and private practitioners are less likely to be located in lower income neighborhoods, plans to make access to potentially lifesaving vaccines and drugs speedier and more equitable might, in fact, exacerbate disparities (AHRQ, 2004). Distribution plans may need to include mobile community health centers (staffed by nurses and nurse practitioners) that can travel to low-income areas, along with a variety of community medical and other service providers and nontraditional sites like soup kitchens and shelters, which have become popular places for administering yearly influenza vaccine (Nettleman et al., 2001). Other factors, such as the availability of transportation to a hospital, might also become more important during a pandemic.

Finally, it is important to remind students, faculty, staff, families, and communities about the importance of ensuring the continuity of learning in the event of student or school dismissals. In order to help schools maintain the continuity of learning for individual or small groups of students who are out of school for extended periods, and large groups of students disrupted by school dismissals or large numbers of faculty absences, plans can be established to provide continuous learning ranging from take home assignments to online learning capabilities (Rothstein and Talbott, 2007; Blendon et al., 2008).

This paper reviews the economic and social impacts of school closure as a public health policy in an H1N1 influenza pandemic. This intervention has a high economic cost, with an estimate of up to 6% of the U.S. GDP (Lempel et al., 2009). The U.S. might be prepared to pay these high economic costs to benefit from the potential reduction in influenza cases, but we should consider the effect the intervention might have on the workforce, households, education, and on crisis management capacity. School closure might lead to important reductions in the peak incidence of cases, thus reducing the burden on the healthcare system. Yet, this should be

weighed against the potential impact on households and the increased absenteeism in the workforce.

School closure also raises a range of ethical and social issues, particularly since families from underprivileged backgrounds are likely to be most affected by the intervention. Officials should act to limit the extent to which the burden of disease falls unfairly upon the least advantaged and ensure that the burden of interventions themselves, are distributed equally. Thus, if school closures are to be ethically instituted, implementation must include strategies to mitigate or minimize these potential effects, so as not to adversely affect vulnerable populations. Balancing benefits and costs is particularly important in the event of an influenza pandemic, where the stress and fear caused by an immediate threat of widespread mortality can lead to poor decisions. The best way to protect health and maintain functioning communities during a pandemic is to promote public health measures and a coordinated response within and between communities.

APPENDIX A

CDC Estimates of 2009 H1N1 Cases and Related Hospitalizations and Deaths from April-December 2009, By Age Group

2009 H1N1	Mid-Level Range*	Estimated Range *
Cases		
0-17 years	~18 million	~12 to ~26 million
18-64 years	~32 million	~23 to ~47 million
65 years and older	~5 million	~4 to ~7 million
Cases Total	~55 million	~39 to ~80 million
Hospitalizations		
0-17 years	~78,000	~55,000 to ~115,000
18-64 years	~145,000	~102,000 to ~213,000
65 years and older	~23,000	~16,000 to ~34,000
Hospitalizations Total	~246,000	~173,000 to ~362,000
Deaths		
0-17 years	~1,180	~830 to ~1,730
18-64 years	~8,620	~6,090 to ~12, 720
65 years and older	~1,360	~960 to ~2,010
Deaths Total	~11,160	~7,880 to ~16,460

Deaths have been rounded to the nearest ten. Hospitalizations have been rounded to the nearest thousand and cases have been rounded to the nearest million.

APPENDIX B

ECONOMIC COSTS OF ABSENTEEISM DUE TO SCHOOL CLOSURE IN THE U.S.

Economic Costs of Absenteeism Due to School Closure in the United States
(Billions of 2008 US dollars and Percent of 2008 GDP)

Closure Length	Low Cost Estimate[1]	Base Estimate[2]	High Cost Estimate[3]
2 weeks	$5.2 (<0.1%)	$21.3 (0.1%)	$23.6 (0.2%)
4 weeks	$10.6 (0.1%)	$42.6 (0.3%)	$47.1 (0.3%)
6 weeks	$15.6 (0.1%)	$ 63.9 (0.4%)	$70.7 (0.5%)
12 weeks	$31.3 (0.2%)	$127.8 (0.9%)	$141.3 (1.0%)

Sources: 2007 and 2008 CPS Outgoing Rotation Groups; 2008 CPS March Supplement; Child Care Module of the 2004 SIPP; Sadique et. al.; Harvard School of Public Health Project on the Public and Biological Security's *Pandemic Influenza Survey*.

[1] Allows for use of informal care and work-from-home and assumes the elasticity of output with respect to hours worked is 0.8. If a male and female are equally closely related to a child, the female misses work.

[2] Assumes that an adult must miss work in each household with at least one child and the elasticity of output with respect to hours worked is 1. If a male and female are equally closely related to a child, the female misses work.

[3] Assumes that an adult must miss work in each household with at least one child and the elasticity of output with respect to hours worked is 1. Assumes that households randomly choose whether males or females care for children.

BIBLIOGRAPHY

AHRQ, Agency for Healthcare Research and Quality. *National healthcare disparities report.* 2004. Rockville (MD): US Department of Health and Human Services. 2004.

APTA, American Public Transportation Association. *National Service and Operating Data.* 2007.

Baker, DW, Parker, RM, Williams, MV, Coates, WC, Pitkin, K. *Use and effectiveness of interpreters in an emergency department*. JAMA. 1996. **275**: p.783–788. Medline

Blendon, R., Koonin, LM, Benson, JM, Cetron, MS, Pollard, WE, Mitchell, EW, Weldon, KJ, Herrmann, MJ, *Public Response to Community Mitigation Measures for Pandemic Influenza.* Emerging Infectious Diseases, 2008. **14**(5).

Bootsma, M. and Ferguson, N., *The Effect of Public Health Measures on the 1918 Influenza Pandemic in US Cities.* NIH, 2007.

Capizzano, J., Adelman, S., and Stagner, M., *What Happens When the School Year Is Over? The Use and Costs of Child Care for School-Age Children During the Summer Months The Urban Institute.* Occasional Paper Number 58, 2002.

Casper, L. and Smith, K., *Self-care: Why Do Parents Leave Their Children Unsupervised?* Demography, 2004. **41**(2): p. 285-301.

Cauchemez, S., Valleron AJ, Boelle, PY, Flahault, A, Ferguson, N, *Estimating the Impact of School Closure on Influenza Transmission from Sentinel Data.* Nature, 2008. **452**: p. 750-754.

CDC, *Impact of Seasonal Influenza-related School Closures on Families-Southeastern Kentucky.* MMWR, 2008. **58**(50).

CDC, *Estimates of the Prevalence of Pandemic (H1N1) 2009.* JAMA, 2009.

Childress, J., Faden, R., and Gaare, RD, *Public Health Ethics: Mapping the Terrain.* Journal of Law, Medicine, and Ethics, 2002. **30**(2): p. 170-181.

Cohen, G. and Nettleman M., *Economic Impact of Influenza Vaccination in Preschool Children.* Pediatrics, 2000. **106**(5): p. 973-976.

Cowling, B., Lau, E., and Lam, C., *Effects of School Closures, 2008 Winter Influenza Season, Hong Kong.* Emerging Infectious Diseases, 2008. **14**(1660-1662).

Dalton, C., Durrheim, D., and Conroy, M., *Likely Impact of School and Childcare Closures on Public Health Workforce During an Influenza Pandemic: A Survey.* Communication Disease Intelligence, 2008. **32**(2): p. 261-262.

DHHS, *Pandemic Influenza Plan*. US Department of Health and Human Services, 2005.

Downey, DB, Von Hippel, PT, and Broh, BA, *Are Schools the Great Equalizer? Cognitive Inequality During the Summer Months and the School Year*. American Social Review, 2004. **69**(5): p. 613-635.

Duffett, A. and Johnson, J., *All Work and No Play? Listening to What Kids and Parents Really Want from Out-of-School Time.* The Wallace Foundation and Public Agenda, 2004.

Effler, P., Carcione, D, Giele, C, Dowse, GK, Goggin, L, Mak, DB, *Household Responses to Pandemic (H1N1) 2009-related School Closures, Perth, Western Australia.* Emerging Infectious Diseases, 2010.

Entwisle, D. and Alexander, K., *Summer Setback: Race, Poverty, School Composition, and Mathematics Acheivement in the First Two Years of School.* American Social Review, 1992. **57**(1): p. 72-84.

Erhart, L.M., Rangel, M.C., Lu, P.J., Singleton, J.A. *Prevalence and characteristics of children at increased risk for complications from influenza, United States, 2000*. J Pediatrics. 2004. **144**: p.191–195. Medline

Ferguson, N., Cummings, DAT, Fraser, C., Cajka, JC, Cooley, PC, Burke, DS, *Strategies for Mitigating an Influenza Pandemic.* Nature, 2006. **442**: p. 448-452.

Fraser, C., Donnelly, C., and Cauchemez, S., *Pandemic Potential of A Strain of Influenza A (H1N1): Early Findings.* Science, 2009. **324**: p. 1557-1561.

Glass, R., Glass, LM, Beyeler, WE, Min, HJ, *Targeted Social Distancing Design for Pandemic Influenza.* Emerging Infectious Diseases, 2006. **12**: p. 1671-1681.

Gostin, L. and Powers, M., *What Does Social Justice Require for the Public's Health?: Public Health Ethics and Policy Imperatives.* Health Affairs, 2006. **25**: p. 1053-1060.

Hatchett, R., *Public Health Interventions and Epidemic Intensity during the 1918 Influenza Pandemic*. NIH, 2007.

Inglesby, T., Nuzzo, JB, O'Toole, T, Henderson, DA, *Disease Mitigation Measures in the Control of Pandemic Influenza.* Biosecurity Bioterrorism, 2006. **4**: p. 366-375.

Institute of Medicine. *Unequal treatment: what healthcare providers need to know about racial and ethnic disparities in healthcare.* Washington (DC): The Institute. 2002.

Johnson, A., Moore, ZS, Edelson, PJ, Kinnane,L, Davies, M, Shay, DK, Balish, A, McCarron, M, Blanton, L, Finelli, L, Averhoff, F, Bresee, J, Engel, J, Fiore, A, *Household Responses to School Closure Resulting from Outbreak of Influenza B, North Carolina.* Emerging Infectious Diseases, 2008. **14**(7).

Kass, N., *An Ethics Framework for Public Health.* American Journal of Public Health, 2001. **91**(11): p. 1776-1782.

Kahn, I., *Pandemic Influenza School Closure Policies.* Emerging Infectious Diseases, 2007. **13**: p. 344-345.

Kerrebrock, N. and Lewit, E., *Children In Self-Care.* Future Child, 1999. **9**(2): p. 151-160.

Knebel, A. and Phillips, SJ, Agency for Healthcare Research and Quality. *Home Health Care During an Influenza Pandemic: Issues and Resources.* AHRQ. Rockville, MD: Agency for Healthcare Research and Quality. 2008.

Lempel, H., Hammond, R., and Epstein, J., *Economic Cost and Health Care Workforce Effects of School Closures in the U.S.* Center on Social and Economic Dynamics Working Paper, 2009. **55**.

Longini, I.M., Koopman, JS , Haber, M, Cotsonis, GA, *Statistical Inference for Infectious Diseases. Risk-specific Household and Community Transmission Parameters.* American Journal of Epidemiology, 1988. **128**(4): p. 845-859.

Longini, I.M., Nizam, A , Xu, S, Ungchusak, K, Hanshaoworakul, W, Cummings, DA, *Containing Pandemic Influenza at the Source.* Science, 2005. **309**(5737): p. 1083-1087.

Markel, H., Lipman, H., and Navarro, J., *Nonpharmaceutical Interventions Implemented by US Cities during the 1918-1919 Influenza Pandemic.* JAMA, 2007. **298**: p. 644-654.

Nettleman, M., White, T, Lavoie, S, Chafin, C, *School Absenteeism, Parental Work Loss, and Acceptance of Childhood Influenza Vaccination.* The American Journal of Medical Sciences, 2001. **321**(3): p. 178-180.

Newsome, A. and Neal, D., *School Closures Do Little To Stop Flu.* Asheville Citizen Times, 2006.

NSLP, *US Department of Agriculture Food and Nutrition Service.* School Lunch Program Fact Sheet, 2007.

Oliviera, V., *US Department of Agriculture Economic Research Service. Food Assistance Landscape.* In: Economic Information Bulletin 6-2, 2006.

Rodriguez, C., Rietberg, K, Baer, A, Kwan-Gett, T, Duchin, J, *Association Between School Closure and Subsequent Absenteeism During a Seasonal Influenza Epidemic.* Epidemiology, 2009. **20**(6): p. 787-792.

Rothstein, M. and Talbott, M., *Encouraging Compliance with Quarantine: A Proposal to Provide Job Security and Income Replacement.* American Journal of Public Health, 2007. **97**(1): p. 49-56.

Sadique, M., Adams, E., and Edmunds, W., *Estimating the Costs of School Closure for Mitigating an Influenza Pandemic.* BMC Public Health, 2008. **8**(135).

Sander, B., Nizam, A, Garrison, LP, Potsma, MJ, Halloran, ME, Longini, IM, *Economic Evaluation of Influenza Pandemic Mitigation Strategies in the United States Using A Stochastic Microsimulation Transmission Model.* ISPOR, 2008. **12**(2).

Santoli, JM, Huet, NJ, Smith, PJ, Barker, LE, Rodewald, LE, Inkelas, M. *Insurance status and vaccination coverage among US preschool children*. Pediatrics. 2004. **113**(6): p.1959–1964. Medline

Schull, MJ, Stukel, TA, Vermeulen, MJ, Guttmann, A, Zwarenstein, M. *Surge capacity associated with restrictions on nonurgent hospital utilization and expected admissions during an influenza pandemic: lessons from the Toronto severe acute respiratory syndrome outbreak.* Academy Emergency Medicine. 2006. **13**: p.1228–1231.

Sydenstricker, E., *The incidence of influenza among persons of different economic status during the epidemic of 1918. 1931*. Public Health Rep. 2006. **121**(1): p.191–204. Medline

Team, N.S., Novel Swine-origin Influenza A virus Investigation, *Emergence of a Novel Swine-origin Influenza A (H1N1) virus in Humans.* New England Journal of Medicine, 2009. **360**: p. 2605-2615.

WHO, *Nonpharmaceutical Interventions for Pandemic Influenza, National, and Community Measures.* Emerging Infectious Diseases, 2006. **12**: p. 88-94.

WHO, G., *Influenza A (H1N1).* World Health Organization, 2009.