Decision Support for Pandemic Planning for the State of Wisconsin

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1. Introduction

The objective of this project was to develop a decision-analytic framework to support public-health actions that could take place in response to developed pandemic thresholds, based on the guidance contained in the various available Wisconsin, national, and international pandemic plans (World Health Organization, November 2005; U.S. Centers for Disease Control, February 2007; U.S. Department of Health and Human Services, November 2005; U.S. Homeland Security Council, November 2005; U.S. Homeland Security Council, May 2006; Wisconsin Department of Health and Family Services, April 2004).

Even in an average flu season, 40,000-50,000 people die because of influenza (and secondary pneumonia) in the U.S., with more than 100,000 hospitalizations. Normal flu years see a case-fatality rate (CFR) typically in the range of about 0.1%. People infected with influenza are, on average, capable of transmitting the virus on the second and third days, and up to roughly ten days after infection. However, children are distinctly more infectious than adults, and shed virus from just before they develop symptoms until two weeks after infection (Carrat et al. 2006).

By all indications, pandemics caused by the influenza virus have occurred regularly throughout history, and flu experts refer to the times between major outbreaks as "inter-pandemic periods," one of which we are currently experiencing (despite the existing H5N1 pandemic among birds). In particular, influenza viruses periodically undergo significant genetic change or "antigenic shift," creating the possibility of "sudden, pervasive infection in all age groups" (Strikas et al., 2001), often with higher fatality rates than that of seasonal influenza (given the relative lack of immunity among the population to an unfamiliar influenza strain). The influenza virus is notoriously mutable, and there are any number of influenza strains that might be candidates for antigenic shift sufficient to cause high transmission and significant fatalities in a global human outbreak.

The H1N1 pandemic of 1918-1919 is particularly notable, for several reasons. First, the so-called "Spanish flu" is believed to have killed between 50 and 100 million people worldwide–possibly as many as the Black Death (plague) in the 14th century (see for example Knobler et al., 2005). (A pandemic of similar scale today could kill 150-300 million people worldwide.) The 1918 pandemic involved:

- An unusually high *infection rate* for influenza (20-50 percent of the human population is believed to have been infected over the course of two years)
- Unprecedented high values of the *CFR*, averaging two to three percent in the U.S.
- Unusually *low mortality* among adults over 65 (a demographic group that is usually heavily affected by influenza)
- Unusually *severe symptoms* that did not resemble "normal" flu (in many cases, more like a hemorrhagic fever, with massive bleeding and fluid in the lungs and other mucus membranes)
- A *high death rate among young adults* between the ages of 20 and 40 (who represented almost half of the total U.S. deaths, possibly due to a "cytokine storm"

Recently, concerns have been raised about a possible human pandemic of "bird flu" (highly-pathogenic avian influenza, H5N1). H5N1, previously not a threat to human, first became a significant zoonotic disease in 1997, in Hong Kong. That earliest recognized outbreak killed only six people, but had a CFR if approximately 33%, and led to the culling of over a million commercial birds–primarily chickens and geese in Hong Kong's market stalls. Although the outbreak was small, it generated significant concern among global public health officials because H5N1 was a novel strain of human influenza. Larson (1998) noted: "While the outbreak highlighted the success of the surveillance network, it also show how dangerously mutable influenza viruses can be, and that, in their most deadly forms, they can be as deadly as any other disease known to man, more akin to Ebola than to the fevers and aches most people associate with flu."

The current H5N1 strain of avian influenza has so far killed only a little over 200 people worldwide. However, the human variants have produced a CFR comparable to (or even greater than) that of the initial Hong Kong outbreak; H5N1 currently appears to have a CFR of 50-60%. Moreover, with each animal or human exposure to this virus, there is an increasing risk of mutation, or of H5N1 exchanging genetic material with other microorganisms. Fortunately, H5N1 is not yet easily transmitted from person to person. The vast majority of human cases so far have involved bird-to-human transmission, although secondary and tertiary human-to-human transmission clusters have been observed in Sumatra, Indonesia (Reuters, 2007).[1] Of course, H5N1 is also not the only potential candidate for a human influenza pandemic; moreover, non-flu viruses, such as severe acute respiratory syndrome (SARS), could also emerge unexpectedly, and would pose similar challenges. There are too many unknowns to be able to predict exactly how severe a future influenza pandemic might be, how it might evolve, or when it would occur, but enough likelihood of a pandemic that it makes sense to plan accordingly.

Table 1 below illustrates the pandemic severity index developed by the U.S. Centers for Disease Control (CDC, February 2007). Table 2 contrasts the thresholds developed by the World Health Organization (WHO) and the U.S. government. Finally, Table 3 compares the CDC severity indices with the WHO and U.S. thresholds.

[1] Researchers at the Fred Hutchinson Cancer Research Center in Seattle found statistical evidence of second-generation human-to-human transmission in one Sumatra cluster in which eight family members died in 2006. A woman appears to have infected her 10-year-old nephew, who in turn infected his father–all with similar viral DNA and no evidence of animal-to-human transmission except for the original case.

Table 1: CDC Pandemic Severity Index		
Category	**Case-Fatality Ratio**	**Example(s)**
1	less than 0.1%	seasonal flu
2	0.1% to 0.5%	Asian Flu and Hong Kong Flu
3	0.5% to 1%	
4	1% to 2%	
5	2% or higher	Spanish flu

Table 2: WHO Global Pandemic Phases and the Stages for Federal Government Response

WHO Phases		U.S. Response Stages	
Inter-Pandemic Period			
1	No new influenza virus subtypes have been detected in humans. An influenza subtype that has caused human infection may be present in animals. If present in animals, the risk of human disease is considered to be low.	0	New domestic animal outbreak in at-risk country
2	No new influenza virus subtypes have been detected in humans. However, a circulating animal influenza virus subtype poses a substantial risk of human disease.		
Pandemic Alert Period			
3	Human infection(s) with a new subtype, but no human-to-human spread, or at most, rare instances of spread to a close contact.	0	New domestic animal outbreak in at-risk country
		1	Suspected human outbreak overseas
4	Small cluster(s) with limited human-to-human transmission, but spread is highly localized, suggesting that the virus is not well adapted to humans.	2	Confirmed human outbreak overseas
5	Large cluster(s), but human-to-human spread still localized, suggesting that the virus is becoming increasingly better adapted to humans, but may not yet be fully transmissible (substantial pandemic risk).		
Pandemic Period			
6	Pandemic phase: increased and sustained transmission in general population.	3	Widespread human outbreak in multiple locations overseas
		4	First human case in North America
		5	Spread throughout the United States
		6	Recovery and preparation for subsequent waves

Table 3: Triggers for Implementation of Mitigation Strategies by Pandemic Severity Index and U.S. Government Pandemic Stages

Pandemic Severity Index	WHO Phase 6, U.S. Government Stage 3	WHO Phase 6, U.S. Government Stage 4, and first human case in United States	WHO Phase 6, U.S. Government Stage 5, and first laboratory-confirmed cluster in State or region
1	Alert	Standby	Activate
2 and 3	Alert	Standby	Activate
4 and 5	Standby	Standby/Activate	Activate

There is still significant uncertainty about how best to mitigate the health and economic hardships that could be associated with a pandemic, especially given the likely absence or shortfall of medical countermeasures such as effective vaccines and antiviral drugs in the early stages of an outbreak. Ongoing research may lead to effective, mass-produced, and widely available pharmaceutical countermeasures in coming years, but for the time being, the measures most widely available for controlling outbreaks of pandemic influenza disease outbreak measures are likely to be non-pharmaceutical interventions (NPIs). Therefore, many public-health officials believe that, even in an age of widespread air travel, non-pharmaceutical community-containment strategies can substantially slow or mitigate the spread of a pandemic in the absence of sufficient medical interventions.

Recognizing that vaccines and antiviral drugs may be largely unavailable in the early phases of a pandemic, the focus of this study was specifically on the advisability and implementation of various types of NPIs. This focus effectively supplements the expertise that already exists within the Division of Public Health in the Wisconsin Department of Health and Family Services on pharmaceutical and other medical interventions. Thus, this study was not designed to provide support for decisions regarding traditional medical and public-health interventions such as isolation and quarantine, vaccination, distribution of antiviral medications, or allocation of scarce resources such as ventilators. In particular, the scope of the possible public-health actions considered in this project included:

1. Closing schools
2. Closing businesses
    - 2a) entertainment-oriented businesses (including sports venues)
    - 2b) other businesses, including both essential and non-essential businesses
3. Policy options for addressing the needs of the working poor

This focus begins to address at the state level some of the gaps identified by the U.S. Government Accountability Office (2007) at the national level—for example, the fact that "a pandemic could threaten critical infrastructure…by removing essential personnel from the workplace for weeks or months, requiring…actions to protect and sustain critical infrastructure." Similarly, where possible (e.g., in discussing policy options for dealing with the needs of the working poor), we attempt to address for each option "what the strategy will cost, the sources and types of resources…needed, and where resources and investments should be targeted" (U.S. Government Accountability Office, 2007).

2. School Closure

Given the central role of children in influenza transmission, school closures appear to be one policy tool for pandemic response. Our recommendations and observations regarding school closure are based primarily on reviews of the relevant epidemiological and historical literatures. Those reviews are provided in Sections 2.1 and 2.2 below. In addition, members of the study team have participated in tabletop exercises related to school closure and pandemic influenza. The content of the discussions during those exercises has also informed our conclusions, but is not systematically documented here.

2.1 Review of the Epidemiological Literature on School Closure and Other Non-Pharmaceutical Interventions

Published results of epidemiological models written to simulate disease spread and mitigation indicate that school closing may be a reasonable but burdensome public-health action to take in response to a category 4 or 5 pandemic, since school closure may help to limit social contacts among children and teenagers. Models that simulate disease spread are still improving in their predictive ability, and are not yet at the stage where results are fully reliable; however, we have reviewed several different models, using a variety of different assumptions and methods, and find similarities in their results.

Children and teenagers are among the most infectious and susceptible subgroups in a pandemic, and their health and wellbeing are a significant concern to our society. In order for school closing to successfully limit disease progression in a population, however, schools must be closed early in a disease outbreak—for example, the day after the first case is reported in a community, or at least the day after the 10th case of influenza has been reported. In addition, and perhaps even more critical than early closure, children and teenagers must have only limited physical contacts with each other while schools are closed. In particular, the epidemiological literature suggests that these contacts should ideally be limited to members of their immediate family, with high rates of compliance. The details of our review are presented below.

Modeling of disease spread and mitigation

Models are useful in analyzing problems such as disease spread and mitigation, where experimentation would be undesirable, unethical, or extremely costly. Recently, a number of mathematical models have been developed to examine possible mitigation strategies for pandemic influenza. The models are typically based on the available data regarding the epidemiology and biology of influenza, as well as data on contact rates within a population, and the feasibility and likely compliance rates associated with various possible interventions. These models have been used to help predict the course of disease spread over time, and the geographic spread of an outbreak. In addition, models can be used to understand how disease spread is affected by characteristics of social networks, such as the number of contacts and the time spent with each contact.

Several general types of models have been developed and are reviewed in this document. First, some models use deterministic differential equations to represent the susceptible, infectious, and recovered (SIR) portions of the population. These models are generally believed to be best suited to representing the middle phases of a disease outbreak, when large numbers of individuals are affected; such models have also been extended to model the geographic spread of an outbreak. Secondly, some researchers have developed stochastic (i.e., random or probabilistic) models, also based on SIR. These models better capture the uncertainty regarding disease transmission in the initial (seeding) and final (quenching) phases of an outbreak, especially in relatively small communities.

These types of models typically use an assumed disease "reproductive number," R_0, equivalent to the number of new cases resulting from a single existing case of disease in a susceptible population. To illustrate, if the value of R_0 is less than one, a disease outbreak will generally die out on its own, with little need for mitigation; the higher the value of R_0, the larger an outbreak is likely to be, and the more difficult it will be to control or eradicate. For comparison purposes, values of R_0 estimated for the 1918 Spanish flu are 1.8 (Carrat et al., 2006), 1.8 to 2.0 (Glass et al., 2006), and 1.7 to 2.0 (Ferguson et al., 2006). Therefore, it seems reasonable to plan for reproductive numbers in that range. The 1957-58 pandemic of Asian flu is believed to have had a value of R_0 on the order of 1.6 (Glass et al., 2006). In addition, the infectivity of a disease is also important.

More recently, some models have focused on individual contacts made in social networks, in order to better understand disease spread at the person-to-person level, and hence better understand how non-pharmaceutical interventions such as social distancing strategies (including school closure) may be used to slow transmission. In such models, differences in infectivity, susceptibility, and lethality of influenza between different subpopulations can be taken into account. In general, children tend to be both more infective and more susceptible to influenza than healthy adults; however, the 1918 Spanish flu disproportionately affected young healthy adults.

When reporting the results of models of disease spread, it is important to understand the assumptions that are made in their development. Therefore, in this review, we attempt to summarize not only the results and recommendations from the various epidemiological models of pandemic influenza in the scientific literature, but also explain the model assumptions that might affect those results, and identify any gaps or questions that may require further work.

Review of specific epidemiological models

Germann et al. (2006) analyzed three basic types of mitigations: 1) vaccination; 2) targeted prophylaxis with anti-viral drugs; and 3) voluntary and imposed changes in social patterns (including school closures and travel restrictions). Their model is a stochastic, agent-based, discrete-time simulation. While these types of models are more commonly applied at the regional level, this one was expanded to the national level. It combined individual-level descriptions of the dynamics of viral infection and

transmission (for a hypothetical population of 281 million people) with data from the U.S. Department of Transportation on population demographics and mobility. The model addressed the likely spatial and temporal dynamics of a pandemic for this hypothetical population. Major uncertainties in this model include the extent of human-to-human transmissibility of the influenza strain, and the available supply of therapeutic agents. The authors found that the course of the outbreak was sensitive to a number of factors, including both population mobility and population susceptibility.

Germann et al. (2006) found that school closing did reduce mean disease incidence, under the assumption that children and teenagers stayed isolated at home, and did not find alternative social contacts. The study assumed that schools would close no later than seven days after a "pandemic alert" had been issued. Moreover, it was assumed that the closure would apply to all schools in the nation (including regular preschool-age playgroups, preschools, and elementary, middle, and high schools), and would remain in effect for the duration of the pandemic. In addition, it was assumed (perhaps unrealistically) that non-school contacts would not increase.

With an assumed reproductive number of $R_0 = 1.6$, this analysis found a disease incidence of only 3% with implementation of school closure as described above. However, at larger values of R_0, school closure alone was not sufficient to control disease incidence to acceptable levels. For example, the mean disease incidence with school closure was 67% for an R_0 of 1.9, 78% for an R_0 of 2.1, and 86% for an R_0 of 2.3. Therefore, Germann et al. concluded that school closings alone would not significantly reduce disease spread at values of R_0 greater than about 1.9. Recall that this appears to be a realistic value, based on the estimates by Carrat et al. (2006), Glass et al. (2006), and Ferguson et al. (2006).

By comparison, Germann et al. found that social distancing and travel restrictions had smaller effects on mean disease incidence than school closure. In fact, the only interventions resulting in lower mean disease incidence than school closing were vaccination and targeted anti-viral prophylaxis. Moreover, at relatively high transmission rates ($R_0 = 1.9$, 2.1, or 2.3,) even vaccination or targeted anti-viral prophylaxis was not found to be sufficient to mitigate an outbreak.

At these relatively high transmission rates (i.e., values of R_0 greater than about 1.9), the best approach was found to be a combination of intervention strategies. For example, at $R_0 = 2.3$, a child-first vaccination strategy alone yielded a mean disease incidence of 65%, while adding social distancing, travel restrictions, and school closure lowered the mean disease incidence to 14%. Similarly, a combination of targeted anti-viral prophylaxis (20 million courses for the U.S.), school closure, and social distancing achieved a mean disease incidence of 5% at $R_0 = 2.3$

To summarize, Germann et al. (2006) assumed that school closure would be quite effective at limiting contacts among children and teenagers, and thus found it to be a relatively effective mitigation strategy for disease transmission rates R_0 less than 1.9. School closure also appeared to be effective at reducing disease spread for values of R_0

greater than about 1.9, provided that it was combined with other mitigation strategies, such as targeted anti-viral prophylaxis and social distancing.

Germann et al. concluded that "school closing was likely to be an effective, although burdensome social distancing policy." In other words, school closure as they modeled it would have a high societal cost—both because it would require children and teenagers to strictly limit their non-school contacts during the normal school day, and because it might require a parent or other caregiver to stay home from work. They recommended that in a severe pandemic ($R_0 = 2.5$), mitigation should include both school closure and targeted anti-viral prophylaxis, with the option of omitting one of these measures (but not both) at values of R_0 less than 2.1

Glass et al. (2006) evaluated targeted social distancing as a potential mitigation strategy for reducing the spread of pandemic influenza. Thus, detailed modeling of individual contacts and their associated social networks was critical to the analysis. The study considered contacts within a relatively small community of 10,000 people, and developed a stochastic model for how individuals within the community were linked to each other via an overlapping, stylized social-contact network. The age demographics and household sizes in this hypothetical community were consistent with the results of the 2000 U.S. Census.

The spread of influenza within this network was simulated by means of behavioral rules for persons, the links between people, and the nature of the disease. Pairs of individuals within the same household were assumed to have contact with each other with a mean frequency of six times per day. Similar rules were established for contacts among children or teenagers at school and during extra-curricular activities, as a function of age, and for work and social contacts among adults. In addition, this model took into account relative infectivity as a function of the duration of contact, in both symptomatic and asymptomatic individuals. The model assumed that 50% of the population would remain asymptomatic even once infected, and these individuals were assumed to be significantly less infective to others than symptomatic people.

In the model of Glass et al. (2006), the backbone of the social-contact network by which disease was spread consisted primarily of children and teenagers, with transmission of disease occurring primarily in the household, in the neighborhood, and at school. Thus, Glass et al. found that children and teenagers in their simulated small town constituted only 29% of the population, but were responsible for 59% of the infectious contacts. By contrast, working-age adults were responsible for 38% of all infectious contacts, and older adults only 3% of infectious contacts. They noted that these transmission results are supported by recent field studies showing that children who go to preschool or school are more likely to contact influenza than children who stay at home, and their family members are also more likely to become ill with influenza.

In the base case analyzed by Glass et al. (without any mitigations), on average 78% of children and 71% of teenagers became infected, while only 44% of adults became

infected. Moreover, adults were found to contract influenza mainly from children, teenagers, and other adults in the same family, rather than from work or social contacts.

Glass et al. (2006) assumed that all children and teenagers attended some type of school (including preschool or daycare). Moreover, they assumed that closure of these facilities would occur the day after 10 symptomatic cases had been identified. In examining the impact of closing schools, Glass et al. assumed that if contacts in school classes were removed, those in other categories (e.g., home, neighborhood, friends, and public spaces) would most likely increase. In particular, they assumed that school closing would at least double the rate of household contacts. Moreover, the simulation developed by Glass et al. assumed a strain of flu with an R_0 of about 1.6, similar to the 1957-58 Asian flu.

Under the assumptions described above, if adults continue to go to work, but children and teenagers are assumed to remain at home for the duration of the pandemic (contacting only individuals within their own households) with a 90% compliance rate, then overall disease attack rates were found to be reduced by 93%, compared to the base case with no interventions. However, since a 90% compliance rate with household isolation might be unrealistically high, Glass et al. also considered a compliance rate of 50%, and found that this was still sufficient to reduce the attack rate of the disease by 68% (although reduction in the level of compliance with household isolation also increased the duration of the epidemic).

Both because children tend to be more infective and more susceptible to influenza than teenagers, and because achieving good compliance with social distancing among teens could be more challenging, Glass et al. also considered targeting only children for school closure, and allowing teens to continue to attend school. At 90% compliance with household isolation, this strategy reduced attack rates by only 47%. Thus, achieving good disease control generally seemed to require social distancing for teenagers as well as children. However, at least at relatively low levels of infectivity (similar to that of the 1957-58 Asian flu), Glass et al. found that social distancing of children and teenagers (by closing schools, and keeping children and teens at home) would be sufficient to mitigate a pandemic, and social distancing for adults would not be necessary.

To better reflect the fact that the 1918 Spanish flu disproportionately affected young adults, Glass et al. (2006) then considered a scenario in which children and teenagers experienced a lower attack rate of disease than young adults. In this scenario, it became more important to implement social distancing for adults than for children, at least at relatively low levels of infectivity (substantially less than that of the 1918 Spanish Flu). For more severe pandemics (with higher infectivity, susceptibility, and reproductive rates—similar to the Spanish flu), Glass et al. concluded that effectively mitigating a pandemic would require targeting both young people and adults for social distancing (via school closure, voluntary isolation at home, and either work closure or else social distancing in the workplace). Therefore, given the uncertainty that exists regarding the infectivity and age profile of an eventual pandemic, the exact structure of people's social networks, and the compliance rates with isolation at home, the results of Glass et al.

suggest that it may be prudent to combine school closure with social-distancing strategies that target adults and the work environment.

Haber et al. (2007) used a model similar to that of Glass et al. (2006) to examine interventions for reducing social contacts in the event of a pandemic. However, this model took into account different numbers and durations of contacts on weekdays versus weekend days. Interventions explored were school closure, voluntary confinement of ill persons and their household contacts, and reduction of contact rates at long-term care facilities.

School closure was assumed to be implemented when the prevalence of illness among children exceeded a set threshold (10%, 15%, or 20%) and was assumed to continue for a predetermined period (seven, 14, or 21 days). When school was closed, household and community contacts on weekdays were set to their weekend levels. This assumption generated a substantially larger number of contacts outside of school than that assumed in most other studies.

The findings of this study suggest that school closure by itself would not have a substantial effect on the consequences of a pandemic unless measures were taken to reduce out-of-school contacts. In fact, results suggest that school closing might actually increase the rates of death and illness in some groups with high out-of-school contact rates. (This conclusion is consistent with the observation of some school and public-health personnel that school may be a relatively safe environment during a pandemic, since at least students are supervised, and policies like hand washing can be enforced.)

As expected, Haber et al. found that the effectiveness of school closure decreased with the threshold for disease prevalence at which schools would be closed. For example, when the threshold illness rate required for school closing was 10%, closing school for 14 days had a larger effect on reducing hospitalization rates than closing school for only seven days. Even in this case, the effect of school closings on rates of hospitalization, illness, and death were relatively modest, because children whose schools were closed were assumed to have substantially increased out-of-school contacts. When the threshold disease prevalence for school closure was 20%, however, hospitalization rates were high regardless of the duration of school closure. Therefore, this study supports the general observation that if schools are to be closed, they should be closed relatively early in the course of a pandemic.

Haber et al. also estimate that it might be possible to reduce illness and death rates by as much as 50% by dramatically reducing the contact rates of individuals who are ill. In fact, they conclude that prompt self-isolation is a key to reducing the rates of illness and death in a pandemic. However, achieving this level of effectiveness is estimated to require that 60% of all those with symptoms would withdraw to their homes and confine themselves there, a level of compliance that might be costly, difficult, and unrealistic. In particular, while Haber et al. did not explicitly quantify the economic costs and benefits of their proposed interventions, they did note that during the SARS outbreak in Toronto, some families found it too expensive to comply with a household quarantines longer than

seven days—a period shorter than that found to be desirable for controlling influenza spread.

Ferguson et al. (2006) constructed a simulation of disease spread in the populations of the U.S. and Great Britain that was spatially explicit. Their model explicitly incorporated households, schools, and workplaces, as well as travel (including hotels), both because each of these is known to pose a significant risk of influenza transmission, and because control measures might target each of these locations. It was assumed that all children attended neighborhood schools. The model also included random contacts in the community associated with day-to-day movements and travel. In particular, for adults, 75% of contacts were assumed to be at work, and 25% were picked randomly from the general population in the vicinity of the workplace. The study used detailed data on population density for both the continental U.S. and Great Britain, as well as census data for age and household size.

Because this study used a random mixing model (rather than detailed social networks) for disease transmission, it is not ideally suited for modeling the differential effects of school closure and other forms of social distancing within a single community. Instead, the model compared the aggregate national impacts of school and workplace closures interventions with the impacts of other intervention strategies, such as travel restrictions, vaccination, and quarantine and isolation. Ferguson et al. (2006) assumed a reproductive number for R_0 of 1.7 to 2.0, similar to the first wave of the 1918 pandemic (as determined from city-level mortality data), and then examined how various mitigation options would affect disease transmission in this scenario.

Closure of schools and/or workplaces was assumed to occur the day after diagnosis of a "threshold" case in the school or workplace (with the threshold typically being a single case). This type of reactive closure strategy was assumed to apply to 100% of schools, but typically only 10% of workplaces, and was assumed to remain in effect until three weeks after the last case in the school or workplace. Closure of a school or workplace was assumed to eliminate transmission in that location, but was assumed to increase household and community contact rates by 50% and 25%, respectively, for those individuals who would otherwise have attended the closed facility. The increase in community contact rates was intended to reflect only the use of alternative caregivers other than members of a child's household, not children or teenagers leaving the household to meet with friends. If parents were to provide all needed childcare, with no increase in community contact rates, then household contact rates were estimated to increase by about 70% (instead of 50%). (Note that these assumptions are substantially less conservative than those of Glass et al., who assumed for example that household contacts would double in the event of a school closure.)

Using these assumptions, school closure during the peak of a pandemic was found to reduce the peak attack rate by up to 40%, but had little impact on overall attack rates. While this might have little impact on mortality, it could still be of significant benefit, since even a reduction in peak incidence could mitigate stresses on the healthcare system and absenteeism in critical industries. Closure of 50% of workplaces (rather than 10%)

was found to enhance the impact of school closure, but of course at a significantly higher economic cost. Ferguson et al. also found that isolation and quarantine could have a significant impact, if feasible.

To summarize, in the model of Ferguson et al., school closure had a limited impact on overall attack rates, but enhanced the effectiveness of other types of social distancing. However, this conclusion is highly sensitive to the proportion of disease transmission that is assumed to occur in schools. If contact rates (and transmission rates) in schools were significantly higher than assumed here, then school closure would have a higher impact on reducing transmission than indicated above. Similarly, the impact of school closure on reduced disease transmission is also sensitive to the assumptions made regarding increased contacts outside of schools. Overall, household quarantine of potentially exposed individuals appeared to be the most effective form of social distancing in this study, provided that compliance with the policy was sufficiently high.

Duerr et al. (2007) used a deterministic version of the basic SIR model, with multiple compartments to represent different subpopulations. This study focused on evaluating the effectiveness of anti-viral treatment (where adequate stockpiles are available), but also examined non-pharmaceutical interventions, including quarantine and isolation, closure of daycare centers and schools, canceling of mass gatherings, voluntary self-isolation, and other forms of social distancing. Like the model of Ferguson et al., this one seems more appropriate for large-scale analysis, since it does not use an explicit social-contact network to evaluate the differential effectiveness of particular strategies for social distancing.

Duerr et al. (2007) concluded that a combination of anti-viral treatment, isolation of infected individuals, and social distancing in the general population seems necessary to significantly delay the peak of a possible pandemic by a matter of weeks. In particular, they found that early self-isolation coupled with other forms of social distancing could be highly effective for diseases similar to SARS. However, Duerr et al. also noted that maintaining rigorous social distancing across the entire population would tax the social and economic structure of society, and that people might be unable or unwilling to reduce contacts throughout an entire pandemic wave.

Carrat et al. (2006) simulated the spread of influenza in a community. Their model simulated both the health status of individuals (based on their ages and their treatment and vaccination status), as well as stochastic (i.e., randomly varying) contacts between individuals in the community. The basic SIR structure was used to model the spread of infection, but with a fourth category added to the SIR framework to represent those individuals who had already been exposed to disease, but were not yet infectious. The average reproductive number, R_0, for influenza spread used in the simulations was 2.07.

The study considered closing schools and workplaces when a threshold rate of infection (five per 1000 people) was reached, and then reopening 10 days after the last observed case of infection. School closure combined with isolation of infected individuals was found to be highly effective, limiting the size of outbreaks to 10% of the population.

However, this intervention assumed that parents would stay home with their children, so was associated with large amounts of time off work. This approach might be more feasible in France (where this study was adopted) than in the U.S.

More generally, although the modeling approach adopted by Carrat et al. was substantially different from that of Duerr et al. (2007), the conclusions of the two studies were similar. In particular, both recommended a combination of anti-viral treatment, isolation of infected individuals, and social distancing in the general population.

Wu et al. (2006) reported on results obtained from a slightly more detailed SIR model of influenza transmission within and between households than that used by Carrat et al. (2006). In particular, their model incorporated not only those individuals who were exposed but not yet infectious, but also a separate category for those who were infectious but not yet symptomatic. The distributions of household sizes and average numbers of children were chosen to be representative of the city of Hong Kong. There was no explicit spatial component in the model (which might not be inappropriate for a city with the population density of Hong Kong); however, this suggests that the results might overestimate the speed with which a pandemic might spread in less dense population centers. The value of R_0 assumed in this study was 1.8, consistent with the 1918 outbreak of Spanish influenza.

The interventions modeled by Wu et al. included: (1) quarantine alone; (2) quarantine of exposed individuals combined with isolation of those already infected; (3) quarantine combined with the use of antiviral drugs; (4) quarantine, isolation, and use of antiviral drugs; and (5) quarantine, isolation, anti-viral medication, and contact tracing.

Note that school closure was not explicitly considered. However, some aspects of the findings of Wu et al. may still be relevant to discussions of school closure and other forms of social distancing. In particular, the findings of Wu et al. suggest that even with only moderate levels of compliance with public-health interventions (i.e., 50%), a combination of strategies (household-based voluntary quarantine, isolation of infected individuals in medical facilities outside their homes, and targeted prophylactic treatment of exposed individuals with antiviral drugs) would be feasible and highly effective across a wide range of plausible transmission scenarios. Based on data from the 1918 Spanish flu in New York City, this layered combination of interventions was predicted to reduce the proportion of the population who would become ill in the first year of a pandemic from 49% to 27%.

This study also quantified the numbers of people who would be quarantined and isolated, and the number of doses of antiviral drugs that would be required. These results suggest that use of isolation on such a large scale could be controversial, and might require substantial infrastructure to support it. Therefore, Wu et al. concluded that the marginal additional benefit of isolation might not be justified in regions with large stockpiles of antiviral drugs available. However, the distribution of large amounts of antiviral drugs for prophylactic use in a short period of time could also demand extensive mobilization and high levels of household cooperation (e.g., willingness to come to distribution

centers, even at some risk of infection), making isolation and quarantine a potentially attractive alternative in some regions. Wu et al. also noted that substantial levels of planning would be required to allow quarantined individuals to remain at home by ensuring delivery of food, water, and medicines. Overall, Wu et al. concluded that greater emphasis is needed on methods for reducing transmission rates through household-based interventions, and noted that targeting households for distribution of antiviral medications (where feasible) may reduce the need for some of the mitigation strategies studied by Germann et al. (2006) and Ferguson et al. (2006).

Inglesby et al. (2006) evaluated several intervention options for pandemic influenza, without the use of a formal mathematical model. This paper highlighted a concern that arose in our review of models by other researchers—namely, that the benefits of school closure might be counteracted by increased contacts outside of schools, including at malls, cinemas, fast-food restaurants, churches, and recreation centers. Inglesby et al. also noted that rates of disease transmission in these types of informal social gatherings were difficult to analyze, due to lack of data. For example, the assumption in Ferguson et al. (2006) that contacts outside of home would increase by only 25% when schools are closed may be controversial.

2.2 Review of the Historical Literature on School Closure and Other Non-Pharmaceutical Interventions

Historical evidence appears to support the idea that early intervention to close schools can reduce both the severity of outbreak peaks (the point at which the greatest number of people are sick and dying—critical for reducing the stresses on overstretched response infrastructure) and also the overall morbidity and mortality numbers. However, by its nature, historical evidence is unlikely to provide hard-and-fast guidelines, especially in the face of the numerous variables that must be taken into account by decision makers. The following is an overview of historical lessons learned for a potential future influenza pandemic, focusing on NPIs (especially school closures) as means for reducing the impact of a pandemic outbreak.

Historical lessons learned about community-based disease-mitigation strategies (in the absence of pharmaceutical interventions such as vaccines and antiviral drugs) include the following main elements, all of which have been found to have worked to some degree in various influenza or non-flu situations. However, it must be emphasized that much of the evidence to date remains preliminary and uncertain.

- General social distancing
- Restrictions on public transportation
- International travel restrictions out of affected areas
- Cancellation of group events
- School closures

In this review of the historical literature, we discuss evidence regarding the effectiveness of closure policies for businesses, large public gatherings and schools. We also highlight

some of the practical and ethical issues that could arise either from these policy decisions, or from the overall impact of a pandemic, and might require significant governmental or community response.[2] We begin with a brief review of infection control in the recent SARS outbreak, and then move on to historical reviews of the 1918 pandemic.

Lessons learned from the 2003 SARS outbreak

SARS is viewed by many in public health as a narrow escape from a possible viral pandemic. The entire world was alarmed by the suddenness, novelty, and high mortality rates of the newly emerged pathogen, which proved able to kill even victims who had access to intensive emergency health care (something also true of H5N1 today). Even in Canada, the outbreak had a 10% mortality rate (despite the availability of some of the best medical care in the world), and came close to overwhelming the medical and public-health systems. In the end, however, effective strategies for infection control (possibly combined with good luck) caused the outbreak to disappear before it had reached truly pandemic proportions. For an excellent analysis, see Knobler et al. (2004).

There is some suggestion in studies of the 2003 SARS outbreak, particularly from Hong Kong (Lau et al., 2004), that congregation in public venues did not significantly increase the risk for acquiring SARS. However, the Institute of Medicine (IOM, 2006) concluded that voluntary NPIs (such as wearing face masks, hand washing, and similar hygienic measures by members of the public) may have mitigated the risk of transmission in public venues. Some studies have shown that similar hygiene and health habits can also be moderately effective in minimizing influenza spread.

Other lessons from the SARS epidemic that might be useful for a future influenza pandemic include the utility of "public campaigns to encourage self-recognition of illness, telephone hotlines providing medical advice, and early isolation when potential patients seek health care" (World Health Organization Writing Group, 2006). WHO notes, however, that while quick identification of those sick with SARS, and early isolation and quarantine of their likely contacts, successfully reduced additional cases, the dynamics of "influenza's shorter serial interval and earlier peak infectivity, plus the presence of mild cases and possibility of transmission without symptoms, suggest that these measures would be considerably less successful than they were for SARS." In sum, therefore, transmission of SARS differs in significant ways from that of influenza, so lessons learned from SARS may have limited applicability.

Lessons learned from the 1918 influenza pandemic

Response to any pandemic inevitably involves a complex set of epidemiological, social, behavioral, and resource issues, with many uncertainties. Moreover, there are as yet few definitive studies on many of these factors. However, recent historical studies of the 1918 pandemic have increasingly supported the idea that quick, decisive, yet flexible public-health measures were effective in helping to mitigate the impact of the pandemic in some cities. Among the most important of these measures relate to social distancing.

[2] For a broader discussion of the ethical issues that might surround a pandemic, see Lemon et al. (2007).

With regard to school closures in particular, WHO (1959) observed that "In the Northern hemisphere at least, the opening of schools after the summer holidays seems to have played an important role in initiating the main epidemic phase" of the 1918 pandemic. However, the World Health Organization Writing Group (2006) concluded that "Despite the propensity of influenza epidemics to be amplified in primary schools…, data on the effectiveness of school closures are limited. Apparently no data or analyses exist for recommending illness thresholds or rates of change that should lead to considering closing or reopening schools."

The IOM (2006) reviewed several important aspects of influenza control, prompted by global concerns about the risks of a catastrophic influenza pandemic, and particularly by concerns that there might not be adequate supplies of pharmaceutical countermeasures (vaccines and antiviral drugs). Therefore, the Department of Health and Human Services commissioned the IOM to assess the efficacy of NPIs for pandemic response. One of the main goals of this study was to assess the historical record of community interventions for controlling outbreaks of disease (both pandemic influenza and other diseases), in order to assess whether and how community-wide interventions might have played a role in reducing transmission in such outbreaks, as well as the costs and benefits of such strategies for the communities that implement them.

In particular, the IOM found evidence in favor of the effectiveness of each of the following interventions (among others):

1) "surveillance and case reporting, rapid viral diagnosis, hand hygiene, and respiratory etiquette in reducing pandemic influenza virus transmission"
2) "isolation of sick individuals and…providing social support services to those isolated individuals" (although the IOM also stresses that "…the evidence base [for this conclusion] is scant and primarily based on common sense or from [experience with] other illnesses")
3) "contact tracing (early in the epidemic) to allow for individual action by the contact, voluntary sheltering, and quarantine in reducing pandemic influenza virus transmission"

The IOM noted that: "<u>Historical analyses</u>…suggest useful effects in some communities of implementing a package of community restrictions." However, they cautioned that "The most controversial community restriction involves school closure with or without restrictions of youth going outside the home for any public gathering." In particular, they found that "schools will be naturally depopulated during a pandemic because of influenza-related absences and because parents will keep healthy children home. It is [unclear] whether or not mandatory school closures would have an effect beyond that which would occur naturally." Therefore, the IOM suggested that "Partial closures or other means of increasing the distance between children who remain in the school might also be useful."

Lipsitch et al. (2006) studied the experience of 17 cities with the 1918 pandemic, finding (as summarized by the IOM) that "early interventions were significantly correlated with a

lower peak death rate… Of all the interventions, early school closure was most closely associated with a lower peak. Theater or church closings were also associated with a flatter epidemic curve." In this study, "'Early' interventions were…those interventions implemented below a threshold of 20 cumulative excess deaths per 100,000 people" (IOM, 2006).

Bootsma and Ferguson (2007) also reviewed experiences with NPIs related to social distancing implemented by 23 major U.S. cities during the 1918 pandemic, to explore whether differences in the measures adopted by these cities might statistically explain variations in outbreak patterns and overall death rates. Though only partial data on the timing of interventions was available, Bootsma and Ferguson concluded that earlier introduction of NPIs appeared to correlate with lower overall influenza mortality (not only peak death rates, as found by Lipsitch et al.). Their most important conclusion was that "the timing of public health interventions had a profound influence on the pattern of the autumn wave of the 1918 pandemic." In particular, data analysis for 16 cities (those for which more detailed historical records were available) supported the idea that timely or "early" implementation of interventions in 1918 led to both reduced overall severity and reduced peak levels of the pandemic in particular localities. For instance, San Francisco, St. Louis, Milwaukee, and Kansas City appeared to have 30-50% less overall influenza transmission, in part because their interventions were instituted early and sustained over substantial periods of time. Cities that did not institute mandatory social distancing generally had both higher overall mortality and higher peak mortality per capita. Bootsma and Ferguson cautioned that "Whether the effect in 1918 was caused by people deliberately reducing contacts or by indirect effects (e.g., caring for the sick, absenteeism, or reactive closure of workplaces) cannot be determined," but did attempt to control for such variables to the extent possible.

Hatchett et al. (2007) similarly studied implementation of NPIs in 1918 in 17 U.S. cities. In particular, the study by Hatchett et al.:

> tested the hypothesis that early implementation of multiple interventions was associated with reduced disease transmission. Consistent with this hypothesis, cities in which multiple interventions were implemented at an early phase of the epidemic had peak death rates ≈50% lower than those that did not and had less-steep epidemic curves. Cities in which multiple interventions were implemented at an early phase of the epidemic also showed a trend toward lower cumulative excess mortality, but the difference was smaller (≈20%) and less statistically significant than that for peak death rates.

Note, however, that most of the studies above did not study in detail the dates when particular NPIs were implemented and lifted (in relation to the onset of each municipal outbreak), the total length of time that NPIs were in place, or the detailed effects of combining multiple NPIs. Markel et al. (2007) attempted to address those factors.

Markel et al. (2007) thus far represents the most sophisticated and extensive analysis of historical data. They surveyed the experiences of 43 cities in the continental U.S. during

the 1918 pandemic, and determined that the duration, peak, and overall mortality rates of the pandemic appear to have been reduced in those communities that implemented early, sustained, and hybrid or "layered" strategies for reduction of disease transmission. Their archival research and statistical analysis grouped the main mitigation strategies into three categories: school closure; cancellation of public gatherings; and isolation and quarantine (including not only what today is known as voluntary "social distancing," but also mandatory quarantine as practiced in 1918). In fact, Markel et al. point out that "the U.S. experience with nonpharmaceutical interventions during the 1918-1919 pandemic constitutes one of the largest data sets of its kind ever assembled in the modern, postgerm theory era."

Markel et al. found that all of the 43 cities they surveyed had adopted at least one of the three NPIs (school closure, bans on public gatherings, and isolation and quarantine), but those cities that implemented both school closure and bans on public gathering *early* in the pandemic (and sustained those interventions for long enough) fared best in terms of their experience during the pandemic.

Other observations support the idea that maintaining interventions for an adequate period of time may be as important as initiating them early. In 1918, those communities that lifted use of their NPIs too soon experienced a resurgence of the pandemic. Similarly, miscalculations made in the Toronto SARS outbreak on how soon exposed or infected individuals could be deemed safe to mingle in society again appears to have contributed to a second round of infection there. Therefore, the IOM (2006) cautioned that this may be "a major theoretical reason to explain why NPIs may have little impact on total mortality; that is, unless interventions are kept in place until there is no longer a threat of reintroduction, the interventions may delay when people get infected without having much impact on the total size of the epidemic (the total number of people infected)."

The methodology adopted by Markel et al. has been challenged by some observers. Of course, any one study may have significant methodological or other limitations. Also, as noted by the IOM and others (e.g., Bootsma and Ferguson), the available literature to date does not make it possible to fully distinguish between the effectiveness of *voluntary* versus *mandatory* restrictions. Overall, however, the work by Markel et al. makes a convincing case for a correlation between reduced pandemic severity on the one hand, and specific, timely, well-implemented, and "biologically plausible" NPIs on the other. Moreover, the fact that similar findings have been observed by others, as discussed above, further supports the credibility of their results. Thus, the combined weight of the historical evidence to date now seems to favor the effectiveness of early, sustained, and overlapping NPIs as reducing the impact of pandemic influenza in 1918, suggesting that such measures could have a similar impact in the U.S. today.

2.3 Conclusions and Recommendations Related to School Closure

As noted above, the results of published models by Germann et al. (2006), Ferguson et al. (2006), Glass et al. (2006), and others suggest that NPIs such as school closures, combined with other restrictions on public gatherings, could have a significant influence

on reducing influenza transmission. While the IOM (2006) notes that "models do not take into account the natural behavior of people," this finding is generally also supported by our review of the historical literature.

Therefore, we believe that the results of our epidemiological and historical reviews generally support the recommendations of the U.S. Centers for Disease Control (CDC, February 2007). In particular, the CDC recommendations for school closure are a function of the categories of case-fatality ratios are summarized below, and illustrated in Table 4:

• "No dismissal of students from schools or closure of childcare facilities in a Category 1 pandemic"
• "Short-term (up to 4 weeks) dismissal of students and closure of childcare facilities during a Category 2 or Category 3 pandemic"
• "Prolonged (up to 12 weeks) dismissal of students and closure of childcare facilities during a severe influenza pandemic (Category 4 or Category 5 pandemic)"

Table 4: Community Strategies by Pandemic Flu Severity

	Pandemic Severity Index		
School Interventions (Child Social Distancing)	1	2 and 3	4 and 5
Dismissal of students from schools and school-based activities, and closure of child care programs	Generally not recommended	Consider: ≤ 4 weeks	Recommend: ≤ 12 weeks
Reduce out-of-school contacts and community mixing	Generally not recommended	Consider: ≤ 4 weeks	Recommend: ≤ 12 weeks

Moreover, during periods of school closure, the CDC suggests the use of informal (e.g., home- or neighborhood-based) childcare in small but stable groups: "it is recommended that group sizes be held to a minimum and that mixing between such groups be minimized (e.g., children should not move from group to group or have extended social contacts outside the designated group)." In reaching this recommendation, the CDC appeared to put significant weight on a study indicating that "children in group care with six or more children were 2.2 times as likely to have an upper respiratory tract illness as children reared at home or in small-group care (defined as fewer than six children)"; see National Institute of Child Health and Human Development (2003) for more details. Therefore, if schools are to be closed, it may be appropriate to recommend that families organize such informal care groups, so that parents may continue to work in the event of a school closure. (Schools could also play a role in facilitating establishment of such care groups for families that lack adequate social connections in the community.)

We would also note, based on our literature reviews, that for school closures to be effective, it is particularly helpful if they are initiated early (i.e., after the first few cases of influenza have been identified in a community, rather than in response to high rates of absenteeism in the schools), and if they are supplemented by other non-pharmaceutical interventions (such as cancellation of large public gatherings). Without these additional steps, school closure by itself may not be sufficient to significantly mitigate the course of pandemic influenza experienced by a given community.

While generally supportive of the CDC guidance, however, our analysis of the school-closure decision has identified several significant factors that may argue for decision-maker discretion in how to apply the CDC recommendations. In particular, the CDC guidance on school closure is based primarily on the severity of a pandemic, as measured by the CFR. In practice, it may be desirable to take into account other characteristics of a pandemic as well, such as:

- The speed with which the pandemic appears to be spreading. It is possible that a pandemic influenza virus may be less easily transmissible than standard seasonal influenza. For example, if the strain of influenza involved in a pandemic is not highly infective, and is transmissible mainly through close physical contact (such as between members of the same household), it may be appropriate to treat the pandemic as being of a lesser category than would be indicated by its CFR alone. Thus, in the event of a pandemic that was in category 4 but not highly infective, school closure of up to four weeks rather than 12 weeks might be adequate.
- The age profile of fatalities. If the strain of influenza involved in a pandemic were especially lethal to healthy children or young adults, it may be appropriate to treat it as being of a higher category. Thus, in a pandemic that was in category 3 but was disproportionately lethal to healthy school-aged children, school closure of up to 12 weeks rather than four weeks might be indicated.
- The availability of alternative options for childcare, and the associated potential for unintended consequences of school closure in the absence of suitable childcare options. Such consequences could include greater social and economic burdens on the community (e.g., if parents are unable to work, or children are left in unsafe or unsupervised environments), and possibly even greater risk of disease transmission due to reduced supervision.

In fact, the problem of controlling contacts among children when schools are closed is a significant concern. Haber et al. (2007) noted that school closure by itself might not have a substantial effect on the consequences of a pandemic unless measures were taken to reduce out-of-school contacts, and could actually increase the rates of illness in groups with high out-of-school contact rates. Similarly, Inglesby et al. (2006) conclude that "the impact of school closings on illness rates has been mixed." They report that while some studies of locally severe seasonal influenza outbreaks indicate benefits from school closings, at least one study found that "when schools closed for a winter holiday during the 1918 pandemic in Chicago, 'more influenza cases developed among pupils…than when schools were in session'." Thus, while children do seem to be key vectors for the spread of influenza outbreaks (especially early in the progress of an outbreak), school

closures could in principle simply displace that problem to other community venues (such as malls or neighborhood social groups).

This possibility was pointed out by Osterholm (2000) in the context of a meningitis outbreak in Minnesota. As noted by Osterholm, even though meningitis typically requires intimate contact for transmission (with little or no potential for aerosol transmission), it can be easily spread at commercial shopping malls, parties, and other non-school settings. Thus, Osterholm supports the idea that school closures could in principle have a counterproductive effect:

> This particular father you see here was an individual who was extremely angry, wanted the schools closed. We figured that, as the epidemiology had shown in many other instances, that the transmission of Neisseria meningitis likely was through intimate contact, saliva sharing, and so forth, and that the places where that often occurred was in the shopping malls where they shared pop and sodas, and beer at beer parties, and etcetera, etcetera. And, in fact, ultimately, we could trace most of these students back to a single party that had occurred—the students that were cases. What was amazing is this particular individual right here kept his daughter home that next Monday, along with 14 other daughters, who all went to his house and had a party there all afternoon sharing pop cans. Again, what people may perceive as risk reduction may be risk enhancement, and what you're saying is risk reduction may not be believed. And so you often have to deal with that issue.

Another concern is that young children are especially likely to spread influenza and other diseases to others around them—in part due to poor hygiene habits. Therefore, there might be arguments for closing only elementary schools and childcare centers, as considered by Glass et al. (2006), under the assumption that older children and teenagers can be more effectively educated on proper infection control in the schools.

There may also be legitimate reasons for different decisions on school closure from one community to another, even within the same state. For example, our review of the epidemiological literature indicated that in order for school closure to be effective, it is important for children and teenagers to have only limited physical contact during the period of time when schools are closed, with a high rate of compliance. Achieving this may be more difficult in urban areas, where shopping malls, restaurants, and other venues for children or teenagers to gather are readily accessible. The World Health Organization Writing Group (2006) noted that "School closure might be less effective in some urban areas than in rural areas because urban children can more easily meet elsewhere: in 1918, more influenza cases developed among pupils in a Chicago school after a holiday than when schools were in session." The WHO Writing Group went on to observe that "In Connecticut, the 3 largest cities (Bridgeport, Hartford, and New Haven) kept schools open under 'close medical supervision,' and their death rates were reportedly lower than those in some Connecticut cities…that closed their schools." While modeling has not significantly addressed such differences between rural versus urban environments, further

anecdotal evidence from 1918 suggests that rural areas and small towns may be more able to implement and maintain some types of social distancing than large urban areas.[3]

The CDC guidance of relying on informal small-group childcare may likewise not be equally feasible or desirable for all children, or in all neighborhoods. For example, the feasibility of limiting social contacts among children in a given community may depend on factors such as the percentage of families without a stay-at-home parent. Similarly, some families (including in some cases families of critical employees such as nurses or police officers) may have few social connections in the community, and hence be unable to arrange informal childcare. Some children may have such severe disabilities or behavioral problems that they cannot receive adequate care from untrained caregivers (such as other parents in the same neighborhood), and may require the greater level of supervision that only their parents or other trained caregivers (such as school personnel) would be able to provide. In some communities (e.g., neighborhoods with high rates of violent crime and drug use), available options for informal childcare in the community may not always even be safe for children. For reasons such as these, we envision that there may be a legitimate need for decision-maker discretion on issues related to school closure from one community to another.

Despite recent historic and epidemiological results that encourage an overlapping suite of NPIs that include early and sustained school closures, any careful policy should account for the law of unintended consequences, particularly in modern settings that may deviate significantly from those existing in 1918. As noted by Markel et al. (2007), "There exist numerous well-documented and vast differences between U.S. society and public health during the 1918 pandemic compared with the present."

The evidence as of now suggests: 1) that children are disproportionately responsible for the spread of seasonal influenza in the community; 2) that schools and childcare centers may be central loci for disease transmission; and 3) that early and sustained closure of schools (in combination with other NPIs) appeared to yield significant disease mitigation in 1918. All of these considerations would seem to argue in favor of school closure, and in support of the current CDC recommendations. However, care should be taken, since the literature to date is not sufficient to reliably distinguish the effects of school closure from those of other community-based NPIs (such as closure of public gatherings), and in particular suggests that school closure may not be effective in the absence of other NPIs.

Moreover, both the available literature and experience with tabletop exercises raise a number of provocative questions: Will closing schools and other community gatherings cause too much social disruption if continued for eight weeks or more (as presently envisioned by the CDC for a severe pandemic)? Would closing schools make it difficult for children in low-income homes to obtain adequate food? How could the roughly 60 million workers in the U.S. who don't have sick leave care for their children when

[3] During the 1918 pandemic, some small rural towns actually maintained armed cordons preventing entrance into their communities and in some cases were successful in preventing significant disease impact by this means. In other towns however, even the mailman may have brought influenza through otherwise well-maintained barriers, according to Crosby (1989).

schools are closed? Is it fair or ethical for certain segments of society to bear an unfair share of the burden of disease mitigation? These issues are explored to varying degrees in the remainder of this report.

2.4 Alternative Uses of School Resources When Schools Are Closed

One issue that was addressed by the CDC (February 2007), and also emerged in tabletop exercises related to school closure, was the option of using schools to provide services other than instruction when schools are closed. For example, Inglesby et al. (2006) noted that poor children could be adversely affected by school closure due to inability to access the National School Lunch Program, and working parents could be without childcare if children were out of school. Therefore, the CDC (February 2007) suggested that "If students are dismissed from school but schools remain open, school- and education-related assets, including school buildings, school kitchens, school buses, and staff, may continue to remain operational and potentially be of value to the community in many other ways."

In particular, one option that seems especially promising is the idea of schools as "safe havens" to provide emergency childcare (but not instruction). Thus, when schools are closed for instructional purposes, parents could be encouraged to keep their children at home or arrange for informal small-group childcare, but a limited number of classrooms could remain open to provide safe and supervised childcare for families unable to make other arrangements. Of course, the feasibility of implementing this idea would need to be explored in much greater detail than we were able to do in this brief study, and might depend on factors such as the specific terms of teacher contracts in each school district.

School buildings could also be used as distribution sites for emergency food supplies. This might involve simply distributing food that would otherwise have been used for school breakfast and lunch (if school had been in session) to families in need. However, available school buildings could also be used as distribution sites for food from other sources, such as food donated by local stores and restaurants, or even meals ready-to-eat distributed by the National Guard. Finally, the use of school buildings as sites for influenza clinics, distribution of antiviral medication, and vaccination clinics has already been extensively explored within the fields of public health and emergency planning.

3. Business Closure

Business closure is another important consideration in determining the appropriate public-health response to a pandemic. First, some types of businesses (especially large entertainment venues) may actually be closed by order of public health (or at least encouraged to close voluntarily by public-health authorities), as a non-pharmaceutical method for controlling the spread of disease. An equally important challenge for emergency preparedness is to make sure that other types of businesses (especially those that constitute portions of society's critical infrastructure) remain open and operational even in the midst of a severe pandemic.

Businesses that fall between those two ends of the spectrum may pose a variety of challenges. On the one hand, some businesses might be candidates for possible closure if a pandemic turns out to be unusually severe, and closure of businesses in that particular industry sector is unlikely to be damaging to the economy. On the other hand, businesses may also seek various types of state support or assistance in order to remain open and operational during a pandemic.

3.1 Criteria for Possible Closure of Entertainment-Oriented Businesses

In considering possible closure of sporting events, theaters, and other entertainment venues, it is important to ensure that the criteria for determining which venues to close are well understood, so that a thoughtful decision would be made. It would obviously be highly undesirable for government authorities to cancel a highly publicized sporting event, only to find out that several other events involving similar numbers of attendees were taking place at the same time frame, and posed a comparable risk of infection.

In order to obtain a reasonably comprehensive list of entertainment-oriented businesses, a systematic and data-driven approach was used. In particular, we began by reviewing the arts, entertainment, and recreation sectors of the North American Industry Classification System (NAICS), which replaced the Standard Industrial Classification. NAICS is currently used by the U.S., Canada, and Mexico. Within the arts, entertainment, and recreation sectors, we excluded those businesses that were likely to be occupied primarily by employees (e.g., movie-production companies), without large numbers of the general public in attendance. This process ensured a reasonably complete listing of relevant businesses. Community events (parades, festivals, and carnivals) were added to the list to enhance the usefulness of the resulting tool, even though not included in NAICS. Some additional caveats to the completeness of the resulting list will be discussed later, at the conclusion of this section.

Then, we identified five criteria that may be important to public-health authorities in determining which venues should be closed. Those include:

1) Number of people likely to be present—with larger venues presumably posing a greater risk of disease transmission

2) Density of people present—with more densely populated facilities (such as theaters) presumably posing a greater risk than less densely populated facilities (such as ice rinks or bowling alleys)

3) Likely means of disease transmission—for example, if the density of people is low enough that coughing is unlikely to be a highly effective means of disease transmission, disease might also be spread by touching shared objects (such as door handles, bowling balls, or rented ice skates), but maybe less effectively

4) Whether the facility is indoors or outdoors—with indoor facilities presumably posing a greater risk than outdoor facilities, for a given density of people

5) The typical age range of people present at the facility—with facilities catering to children or a mixed audience presumably posing a greater risk of disease transmission than those catering primarily to adults

Given the large number and wide variety of entertainment-related businesses in the state of Wisconsin, we were not able to evaluate particular types of businesses on the above characteristics. However, the tables in Appendix 1 should serve as useful decision tools for public-health authorities wishing to ensure that they have undertaken a systematic review of entertainment-oriented businesses for possible closure. An Excel version of these tables is available from the lead author of this report electronically on request.

We do not anticipate that public-health authorities will wish to close all entertainment-venues listed in Appendix 1, or even a majority of them. For example, based on the criteria identified above (and others that public-health authorities may wish to consider), some types of entertainment-oriented businesses (such as wildlife sanctuaries) may never need to be closed, even in an extremely severe pandemic. Other entertainment venues may be subject to possible closure, depending on the characteristics and severity of the pandemic (e.g., its case-fatality ratio, infectivity, and age profile of fatalities).

As mentioned earlier, there are some types of entertainment-oriented venues that were not included in the NAICS arts, entertainment, and recreation sectors. Thus, Appendix 1 includes skiing facilities without accommodations but not those with accommodations, and free-standing casinos but not casino hotels. Thus, care should be given to consider other similar facilities that may include accommodations. For example, given the importance of water parks to the tourism industry of Wisconsin, it would not make much sense to close free-standing water parks, but not water-park hotels.

Similarly, Appendix 1 includes arts festivals with facilities, but not those arts festivals that do not have their own permanent facilities. This is addressed to some extent by the inclusion of transitory community events (parades, festivals, and carnivals) as their own category at the end of the table; however, care should be taken to ensure a complete listing of such events—for example, by reviewing the types of businesses listed under NAICS code 711310 ("promoters of performing arts, sports, and similar events with facilities") to ensure that comparable events without facilities are also considered.

Finally, while not falling strictly within the category of entertainment, it is also of course important to consider possible closure or cancellation of conventions and other large

public gatherings. Thus, for example, college graduations might be one category of event to consider for possible cancellation.

3.2 Critical Infrastructure

Homeland Security Presidential Directive 7 identified a number of areas of critical infrastructure in the U.S. (http://www.whitehouse.gov/news/releases/2003/12/20031217-5.html). Subsequently, Homeland Security Presidential Directive 9 added food and agriculture to the list of critical infrastructure, in light of their critical importance to the nation (http://www.whitehouse.gov/news/releases/2004/02/20040203-2.html). The listing of critical infrastructure in these directives was taken as the starting point for determining which businesses might be truly critical for survival and social stability in the event of a pandemic.

Of course, not all elements of any given infrastructure are equally important. For example, within the energy infrastructure, electricity generation is obviously critical, while production of kerosene might not be. To obtain more detail on which elements of each infrastructure should be considered critical, we consulted a series of studies published by the Los Alamos National Laboratory in 2004, as part of a project to develop a decision-support system (DSS) for use in critical-infrastructure protection (CIP). In particular, those studies are as follows:

Metropolitan CIP/DSS Key Resources Sector Model
Metropolitan CIP/DSS Energy Sector Model
Metropolitan CIP/DSS Postal Sector Model
Metropolitan CIP/DSS Transportation Sector Model
Metropolitan CIP/DSS Government Sector Model
Metropolitan CIP/DSS Telecommunications Sector Model
Metropolitan CIP/DSS Public Health Sector Model
Metropolitan CIP/DSS Emergency Services Sector Model
Metropolitan CIP/DSS Potable Water Sector Model
Metropolitan CIP/DSS Food Sector Model
Initial Stability and Sensitivity Studies of the CIP/DSS Agricultural Sector Models

Table 5 summarizes the key elements of critical-infrastructure sectors, based largely on the above studies.

Table 5: Critical Infrastructure

Potable Water
Reservoirs
Rivers
Groundwater
Pipelines
Metropolitan water treatment process
Post-treatment potable storage tanks
Damage repair and decontamination for water and sewage systems
Distribution of water
End-user demand (residential, commercial, industrial, public health, emergency services, etc.)
Sewage treatment

Postal
Trucks (freight, long haul)
Light vehicles such as vans and small trucks
Independent contractors/long-haul carriers
Rail
Air
Collection/distribution centers
Pickup/delivery points
Public mail drop box points
Mail and parcel delivery
Home mailboxes
Commercial mail drop-off points
Within-facility mail delivery
Exports
Imports

Government (other than emergency services)
Conduct monitoring
Make decisions on behalf of pubic safety
Observe key variables from other sectors
Alert the public and other sectors to any problems
Call up federal resources, or resources from other jurisdictions
Provided needed financial or other support to other sectors
Collect tax revenue and other sources of government revenue

Transportation

Roadways: passenger cars, buses, cargo trucks
Railways: subways, local light rail systems
Waterways: barges, ferries
Airports: international hubs, local airports
Bridges
Bus stations/stops
Parking lots
Freeways
Entry ramps
Local streets
Truck loading zones

Key Resources

National monuments
Nuclear power plants
Dams
Government facilities
Key commercial assets

Energy (and chemicals)

Electricity generation
Electricity transmission and distribution (buses, overhead and underground lines, transformers)
Natural gas—production, storage, and distribution (by pipeline)
Chemical and petrochemical plants
Petroleum, oil, lubricants, and other chemicals—storage and distribution (by tanker trucks)

Information and Communications

Telecommunications (voice communications, including wire lines, wireless, and long distance)
Data network (the Internet, corporate networks, and SCADA networks)
Broadcast (television and radio systems, the emergency broadcast system)
Repair (network repair, handling call overloads)

Emergency Services

Fire services (fire response and suppression, rescue operations, support when there is a risk of fire)
Emergency medical services (rapid response to medical emergencies)
Law enforcement (investigation of crimes, crime prevention, traffic and crowd control, incarceration and control of criminal suspects)
Support services (for example, Salvation Army, Red Cross)

Public Health

Hospitals
Emergency rooms
Public and private clinics
Special care facilities
Pharmaceutical supply
Long-term healthcare facilities
Mental-health institutions

Food and Agriculture

Agriculture in support of food production
Conversion of raw agricultural products to food products
Subsequent distribution of the food products to consumers
Retail outlets
Storage facilities
Businesses (restaurants, food service at facilities such as hospitals)
Industrial consumers (including the military)

Note that under extreme circumstances, some businesses in the above sectors may have a legitimate call on state resources. For example, if needed for critical infrastructure to remain operational, the National Guard could be used to provide site security in the event of public disorder, and/or to provide transportation and logistics services if the ordinary distribution system is not functioning effectively.

Even if no physical assistance is needed for businesses to remain operational, some limited form of state financial assistance may sometimes also be required to ensure the stability and viability of critical businesses. For example, government loan guarantees could make it possible for critical businesses such as hospitals or electric utilities to obtain needed debt financing and continue normal operations, even if their ordinary sources of revenue were catastrophically affected by a pandemic.

3.3 Impact of Business Closures on the Economy and Employment

The vast majority of businesses in the state of Wisconsin will undoubtedly fall in between the two categories discussed above (large entertainment venues that may need to be closed for reasons of public health, and critical infrastructure that should not be closed to preserve the ordinary functioning of society). For the most part, businesses in this middle category will presumably be left to their own devices to determine how best to manage the challenges associated with a pandemic. However, several questions regarding such businesses are likely to come to the attention of government authorities.

On the one hand, some businesses may appeal for state resources to remain open on the grounds that they are critical to the state's economy, even if not formally designated as critical infrastructure. While there may not be resources available to assist any such businesses, it might be helpful to have some basis to assess which claims of economic

importance are most valid, and hence which businesses might have a legitimate claim on state resources by virtue of their importance to the state.

On the other hand, if a pandemic appears to be particularly severe, there may be an interest in closing particular workplaces above and beyond entertainment venues (or at least recommending that they close). After all, most workplaces provide opportunities for the transmission of disease, either among employees, or between employees and customers or suppliers. Thus, for example, one can imagine encouraging temporary closure of large employers in a particular community that has been especially hard hit by a pandemic, or of workplaces that have a high rate of absenteeism due to influenza. In determining which such workplaces should be closed, it would be desirable to consider not only the potential public-health benefits of closure, but also any economic impacts of closure.

Thus, the answers to both types of questions—which workplaces should receive priority to stay open, and which are the best candidates for (mandatory or voluntary) closure—should ideally be informed by a sense of how important each type of industry is to the overall economy of the state. After all, one would not want to close a workplace for public-health reasons only to discover that the closure had severe unanticipated economic consequences. Among the types of consequences that should ideally be taken into account are:

(1) Consequences of reduced supply (e.g., the business provides raw material to other industry sectors that are important contributors to the Wisconsin economy);
(2) Consequences of reduced demand (e.g., the business being considered for closure is an important customer for raw materials produced in Wisconsin);
(3) Consequences for employment (e.g., effects on customers or suppliers will result in large numbers of people in other industry sectors becoming unemployed); and
(4) Consequences for the working poor (e.g., any resulting unemployment would fall disproportionately on those at risk of becoming a burden on state resources).

For example, one can easily envision that a temporary cessation of construction activities might have spillover effects for industry sectors that are stimulated by new construction (such as real estate, or retail furniture), as well as for suppliers of construction materials (e.g., plumbing suppliers).

Given limits of time and budget in this project, we were unable to perform a definitive analysis of these issues. However, such an economic analysis should be reasonably straightforward to do at a statewide level, given modern software for economic input-output analysis (such as IMPLAN). Such an analysis could provide, for two- or three-digit industry sectors (e.g., not only "Agriculture" but "Oilseed farming," not only "Manufacturing" but "Envelope manufacturing"), information on supply and demand effects on employment and gross domestic product (GDP) for the state of Wisconsin. Depending on the software and data sources available for the analysis, the same type of analysis could in principle also estimate distributional impact (e.g., what fraction of the resulting unemployment would affect each income level). Considering the potential

usefulness of this type of analysis for decision support, we highly recommend that this analysis be undertaken.

It is also important, of course, to examine the extent of the authority vested in public-health officials under current state law to order business closures. In particular, In particular, Section 252.02, Wis. Statutes, reads in part:

> (3) The department may close schools and forbid public gatherings in schools, churches, and other places to control outbreaks and epidemics.
> (4) The department may promulgate and enforce rules or issue orders for guarding against the introduction of any communicable disease into the state, for the control and suppression of communicable diseases, for the quarantine and disinfection of persons, localities and things infected or suspected of being infected by a communicable disease and for the sanitary care of jails, state prisons, mental health institutions, schools, hotels and public buildings and connected premises. Any rule or order may be made applicable to the whole or any specified part of the state, or to any vessel or other conveyance. The department may issue orders for any city, village or county by service upon the local health officer. Rules that are promulgated and orders that are issued under this subsection supersede conflicting or less stringent local regulations, orders or ordinances.

Similarly, Section 252.03(2) states: "Local health officers may do what is reasonable and necessary for the prevention and suppression of disease; may forbid public gatherings when deemed necessary to control outbreaks or epidemics and shall advise the department of measures taken."

However, this wording is extremely general. Thus, it is unclear, for example, whether rules issued by the Department of Health and Family Services would allow for closure of private businesses such as malls, if not due to specific and identifiable shortcomings (such as failure of the mall owner to provide for proper sanitation). At the time Section 252.03 was drafted, malls were not yet a major source of concern, and mall owners or other similar business interests would undoubtedly argue that a retail establishment does not constitute a public gathering. Therefore, it might be desirable to explore the scope of public-health authority under existing legislation, and possibly issue new regulations to clarify those powers if needed. An alternative strategy would be to propose a model local-health regulation that would clarify for local health officers some of the substantive and procedural issues that could form the basis for challenging local public-health orders.

4. Needs of the Working Poor

4.1 The Macroeconomic Impact of a Pandemic on the Working Poor

In non-pandemic (normal) years, influenza costs over $10 billion per year in the U.S. alone. During the current outbreak of H5N1 ("bird flu"), a large fraction of the economic losses worldwide were caused by infection control measures, particularly within the poultry industry. By mid-2005 alone, an estimated 140 million domestic birds had died or been destroyed for the sake of infection control in Asia, Africa, the Middle East, and Europe, at a cost of well over $10 billion, resulting in devastating losses to the poultry industry in those regions—particularly among poorer nations (World Bank, 2007).

During the 2003 SARS outbreak, the broad, unprecedented WHO alert urged curtailed travel in affected areas, and led to significant economic losses to tourism- and commerce-dependent regions, as well as heightened global public fears. Nevertheless, the WHO was later applauded for its quick action. In the end, according to Knobler et al. (2004), one model estimated short-term losses from curtailed economic activity and trade worldwide at $80 billion, while total costs (including medium- to long-term losses) were undoubtedly greater.

Numerous analyses of the economic impacts of a pandemic have been conducted. For example, Brahmbhatt (November 2005) suggested, based on experience with losses in Hong Kong and Toronto during the SARS outbreaks there, that global GDP could be expected to decline by two percent during even a moderate flu pandemic. Similarly, Burns et al. (2006) estimates GDP losses worldwide of 0.7-4.8%, depending on the severity of a pandemic, with worldwide losses potentially reaching into the trillions, and the World Bank (November 2005) projected that economic losses from a relatively severe pandemic could reach $550 billion for the high-income nations alone. An interesting critique of some of the assumptions in these types of studies is available on the web at http://www.bmonesbittburns.com/economics/reports/20060313/report.pdf.

Among the various available studies, we found the one by Trust for America's Health (March 2007) to be especially useful, since it estimated economic losses from a pandemic by state, based in part on data and estimates from the Congressional Budget Office (July 2006). Overall, Trust for America's Health estimates that Wisconsin would see a 2% loss in annual GDP from a pandemic. However, since most of the impact of a pandemic is estimated to occur over a period of roughly three months, that actually corresponds to roughly an 8% loss of GDP during the time period most affected by the pandemic.

Table 6 highlights some of the key results of that report for the state of Wisconsin. The second column of this table shows what percentage of the total GDP of each sector is estimated to be lost as the result of a pandemic. For example, roughly 17% of Wisconsin GDP in the transportation and logistics sector is expected to be lost; similarly, the report projects 20% losses in arts, entertainment, food, and accommodations (i.e., 80% losses in demand during the peak of a severe pandemic, which is anticipated to last for one quarter of the year). The third column of Table 6 shows how much of the 2% annual GDP loss

for the state would come from each sector. Thus, both the transportation and logistics sector and the food and accommodations sector are expected to contribute substantially to the loss of GDP in Wisconsin, since they are large sectors, and would be hard hit. By contrast, the arts and entertainment sector would be hard hit, but does not contribute as much to the Wisconsin economy, so the losses there would not have a large impact on the state GDP. Manufacturing is not expected to be particularly hard hit by a pandemic, but contributes so much to the Wisconsin economy that even a modest reduction in the manufacturing sector would make up a large fraction of the state's total GDP loss due to a pandemic. Finally, health care is expected to see an upsurge in demand for services, and an upsurge in hours worked. Of course, whether this can be considered an economic benefit is debatable, since there may be severe staffing shortages, and in any case the increase in GDP in that sector would involve significant human cost.

Table 6: Recessionary Impacts of a Pandemic in the State of Wisconsin

Industry	% of industry GDP	% of GDP loss
Agriculture	**2.5**	**2**
Mining	**2.5**	**0**
Construction	**2.5**	**6**
Manufacturing	**2.5**	**25**
Wholesale trade	**2.5**	**7**
Retail trade	**2.5**	**8**
Transportation and warehousing	**17**	**27**
Finance and insurance	**2.5**	**9**
Educational services	**2.5**	**1**
Health care and social assistance	**-4**	**-15**
Arts, entertainment, and recreation	**20**	**7**
Accommodation and food services	**20**	**22**
Utilities; Information; Real estate; Professional and technical services; Management; Administrative services; Government; Other services	**<1**	**<1**

Note that Table 6 captures primarily the direct loss in gross domestic product due to loss of demand and/or loss of productivity in each sector. The direct effects of a pandemic would be primarily on the labor force (e.g., due to deaths and illnesses, as well as "lost productivity due to people who stay home as caregivers or out of fear"—Trust for America's Health, March 2007), as well as a loss of demand to particular sectors (most especially the entertainment and hospitality industries). However, the estimates given above do not address the secondary effects of losses in one sector on other sectors (e.g., the fact that workers who become unemployed due to losses in the manufacturing sector would spend less on retail purchases, etc.). A preliminary economic analysis graciously undertaken by Adam Rose and Bumsoo Lee of the University of Southern California estimates that total losses could easily be roughly double the direct losses.

Moreover, some of the estimates developed by Trust for America's Health are subject to debate. For example, they predict negligible losses in the real-estate industry. However, it seems likely that in a pandemic, few people will choose to purchase homes; those that do may be more likely to trade down to a less costly home (due to job losses or business downturns) than to purchase a more expensive home. Finally, there may be foreclosures or rental evictions due to inability to make mortgage or rent payments. Thus, we believe that the results shown above can fairly be described as a conservative estimate of GDP losses in the state of Wisconsin due to a severe pandemic—especially since some pandemics may be more severe than the assumptions used by Trust for America's Health.

Even a brief perusal of Table 6 indicates that some of the sectors that will be hardest hit (food and accommodations, and arts and entertainment) are ones that typically pay low wages. Workers in these industries may have few financial resources on which to fall back if they lose their jobs due to a pandemic. Presumably, those who are receiving government welfare benefits prior to a pandemic will continue to receive those benefits during the pandemic (barring a complete breakdown of government function). However, families that are living paycheck to paycheck prior to a pandemic may quickly become dependent on state resources in the event of job losses, even if they had previously been self-sufficient financially. It is important to anticipate such needs, not only to avoid or mitigate the associated human suffering, but also to adequately plan and prepare for the demands on government services.

In order to make the consequences of a pandemic more tangible, and highlight the significant geographical disparities that could result from differing concentrations of industries between regions, we extended the analysis done by Trust for America's Health to the county level. In doing this, we were greatly aided by the Wisconsin Department for Workforce Development, which graciously made available data for each county on average employment, average annual wages, and total wages by industry sector and sub-sector. Applying the percentage losses of GDP provided by Trust for America's Health to these data, we were able to estimate percentage losses of both wages and jobs in each county, as well as computing the average annual wages of the lost jobs. This analysis thus provides a reasonably complete picture of economic hardship as it might affect Wisconsinites due to a pandemic.

Some assumptions were needed in working with the data provided by the Department of Workforce Development. First of all, for some counties, not all data were available at the county level, due to reasons of confidentiality (for example, if there was only a single employer in a given industry sector or sub-sector in that county). In this case, the missing data was imputed or estimated, based on counties for which the data was available. In Table 7, we show the counties and sectors for which data was approximated in this way. In general, this approximation is not expected to have a large effect on the accuracy of the results, since most such cases involved either small sub-sectors, or sectors that are not expected to be hard hit in a pandemic. However, in principle, this type of imputation could affect the accuracy of the results in some cases—for example, if a county had a single extremely large employer in an important sector.

Table 7: Wisconsin Counties with Approximate Data

	County	Agriculture	Construction	Manufacturing	Trade	Transportation	Finance and Insurance	Educational Services	Health Care	Entertainment and Hospitality	Other Services
1	Adams					A		A	A		
2	Ashland										
3	Barron										
4	Bayfield										
5	Brown										
6	Buffalo					A					
7	Burnett										
8	Calumet										
9	Chippewa										
10	Clark					A					
11	Columbia										
12	Crawford										
13	Dane										
14	Dodge										
15	Door										
16	Douglas										
17	Dunn										
18	Eau Claire					A					
19	Florence	A	A		A	A	A				A
20	Fond du Lac										
21	Forest				A	A					
22	Grant										
23	Green										A
24	Green Lake										
25	Iowa					A					
26	Iron							A	A		A
27	Jackson										
28	Jefferson										
29	Juneau					A					
30	Kenosha										
31	Kewaunee										

	County	Agriculture	Construction	Manufacturing	Trade	Transportation	Finance and Insurance	Educational Services	Health Care	Entertainment and Hospitality	Other Services
32	La Crosse										
33	Lafayette				A						
34	Langlade										
35	Lincoln										
36	Manitowoc										
37	Marathon										
38	Marinette										
39	Marquette										
40	Menominee		A	A	A	A	A				A
41	Milwaukee										
42	Monroe										
43	Oconto										
44	Oneida										
45	Outagamie										
46	Ozaukee										
47	Pepin										
48	Pierce										
49	Polk										
50	Portage										
51	Price										
52	Racine										
53	Richland										
54	Rock										
55	Rusk					A					
56	Sauk										
57	Sawyer					A					
58	Shawano										
59	Sheboygan										
60	St. Croix										
61	Taylor										
62	Trempealeau					A					
63	Vernon					A					
64	Vilas										

	County	Agriculture	Construction	Manufacturing	Trade	Transportation	Finance and Insurance	Educational Services	Health Care	Entertainment and Hospitality	Other Services
65	Walworth										
66	Washburn					A					
67	Washington										
68	Waukesha										
69	Waupaca										
70	Waushara										
71	Winnebago										
72	Wood										

Some caveats regarding the interpretation of the data are in order. In particular, the data provided by the Department of Workforce Development concerns jobs, not employees or households. Thus, loss of one job may not be devastating if an individual had previously been working two jobs (especially if the lost job represented only part-time employment), or if other members of the household are gainfully employed. This is important, since in some industries that are predicted to be hard hit by a pandemic (such as entertainment and hospitality), part-time and/or seasonal work might be quite common.

Maps illustrating the results of our analysis were graciously prepared by Matthew Kures of the Center for Community and Economic Development at the University of Wisconsin Extension. Those maps are shown in Figures 1 through 5 below. Figure 1 and Figure 2 show the county losses in annual payroll and jobs as percentages of the corresponding total state payroll and jobs, respectively. As can be seen from these figures, the impacts of the various counties on state payroll and employment are quite similar, as we might expect. In particular, only a few counties contribute substantially to state losses—especially the Milwaukee area, and Dane and Brown counties (reflecting the economic importance of Madison and Green Bay in the state economy).

However, while these few geographic areas may be responsible for a large share of the statewide losses from a pandemic, other counties would actually be harder it from a local perspective—i.e., losing a larger fraction of local jobs and payroll. This is important, since some types of social services are highly localized, so county and municipal officials may need to plan and prepare ahead of time if large impacts are anticipated. Figure 3 and Figure 4 show the county losses in payroll and jobs as percentages of the corresponding county totals (rather than state totals), and present a dramatically different picture.

Figure 1: County Loss in Annual Payroll as a Percentage of State Annual Payroll

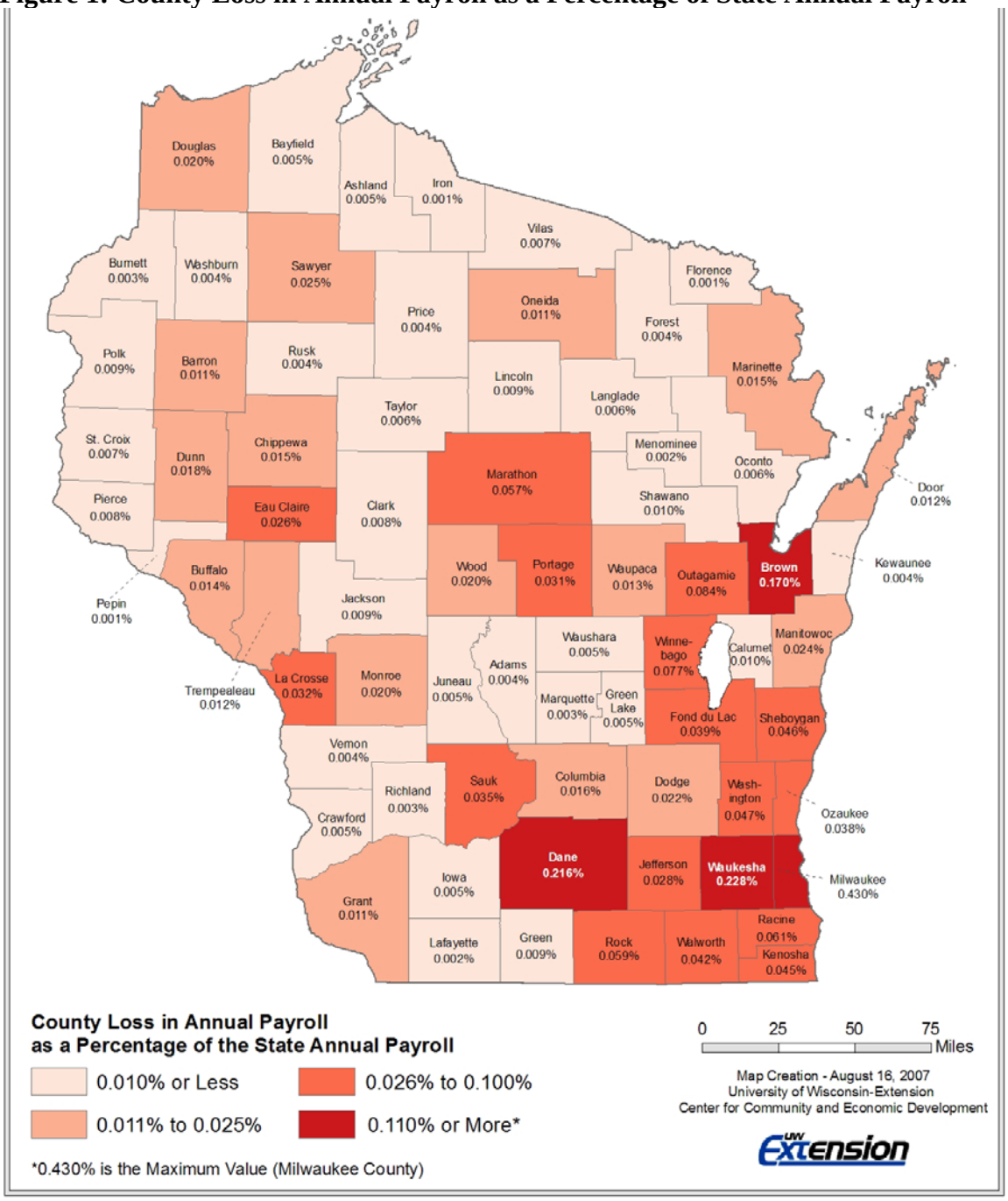


Figure 2: County Loss in Employment as a Percentage of Total State Employment

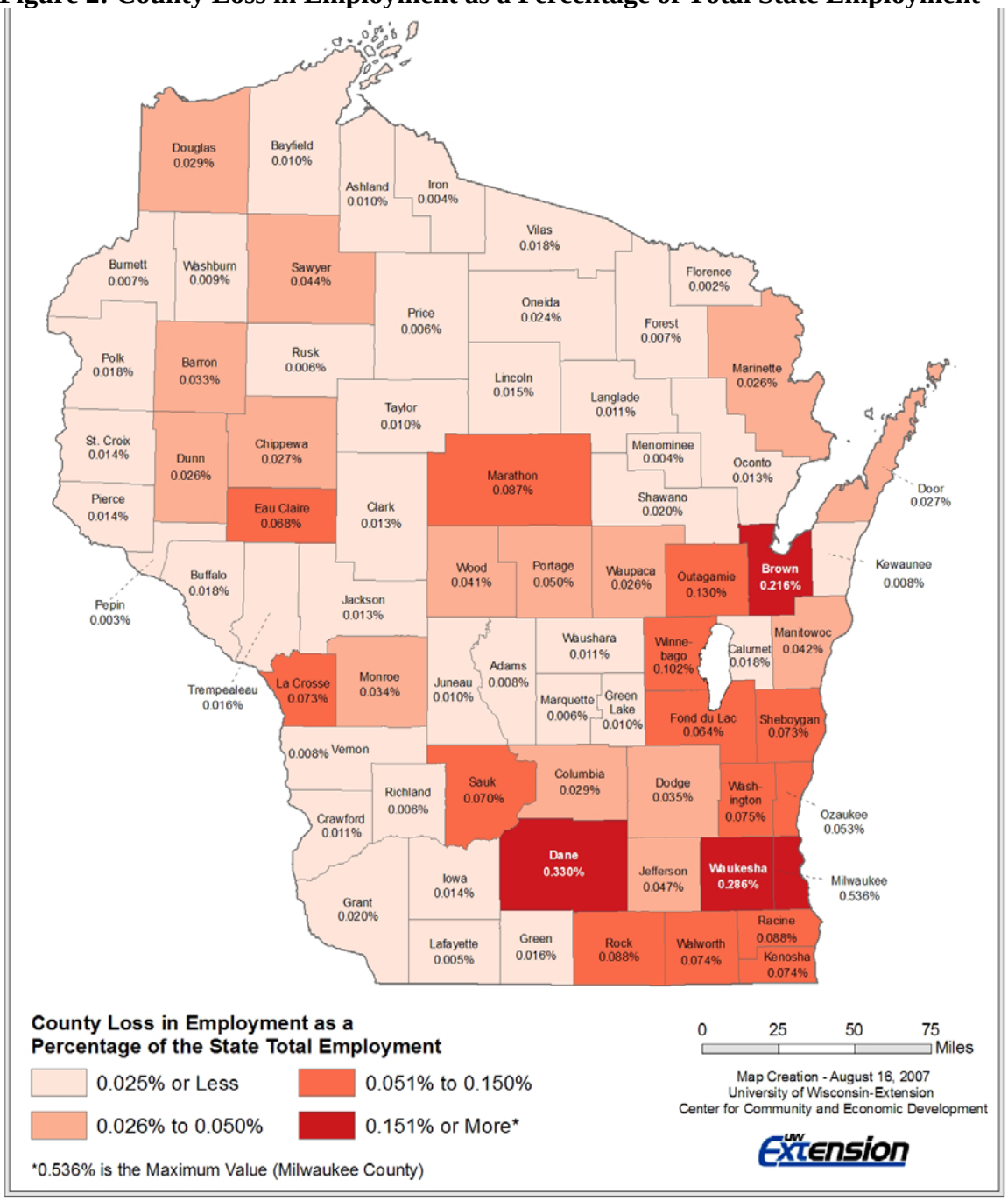


Figure 3: County Loss in Annual Payroll as a Percentage of County Annual Payroll

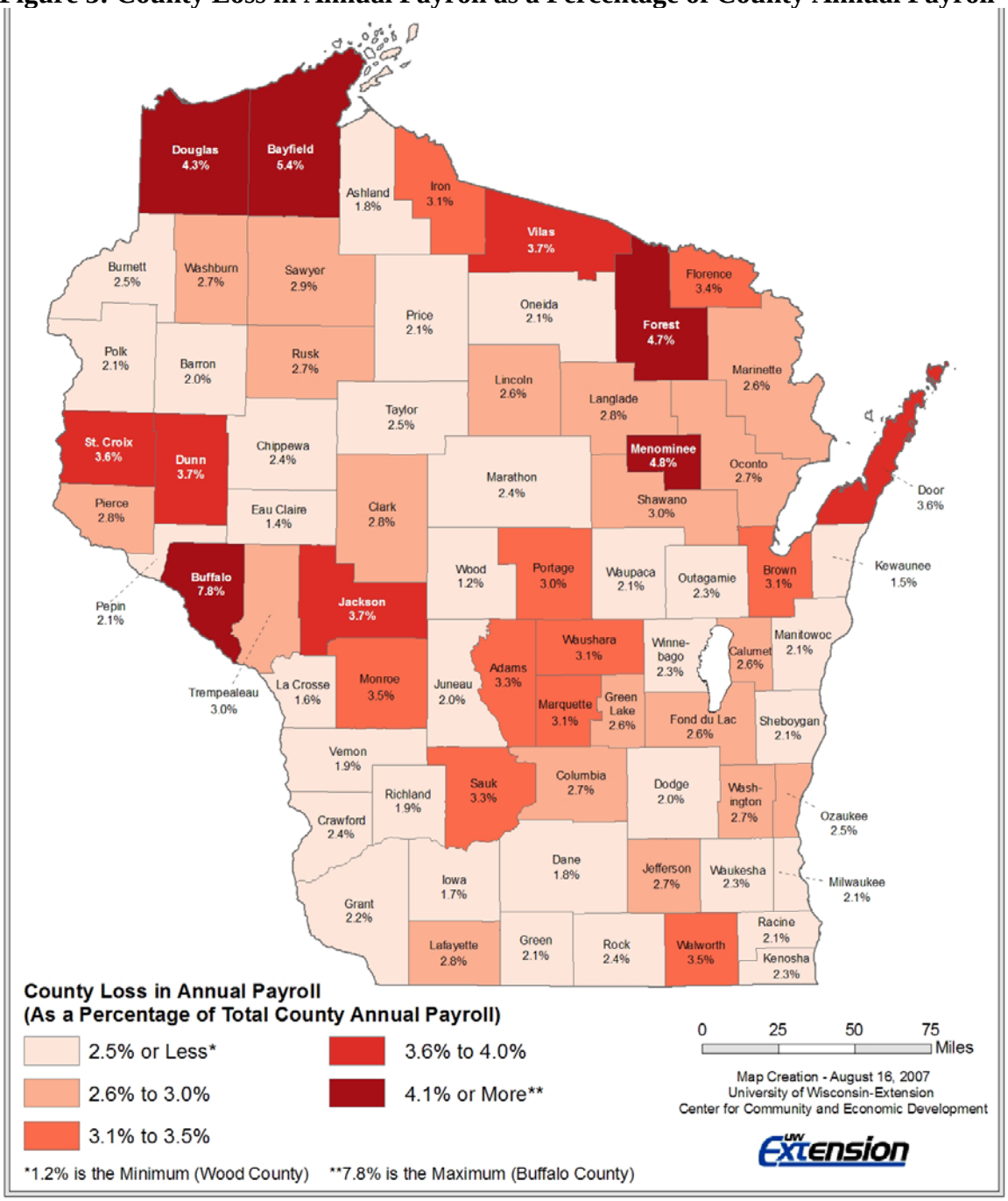


Figure 4: County Loss in Employment as a Percentage of Total County Employment

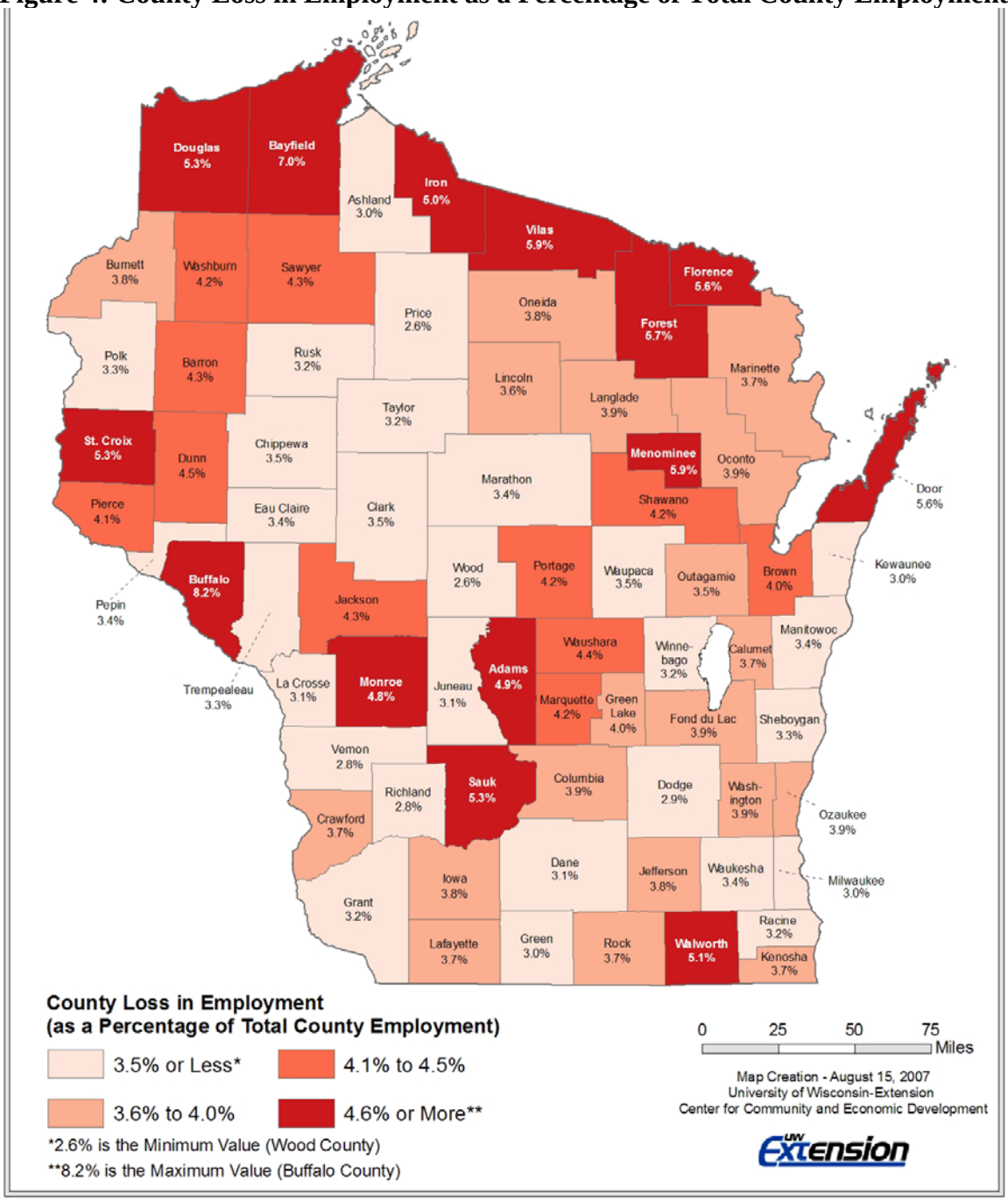
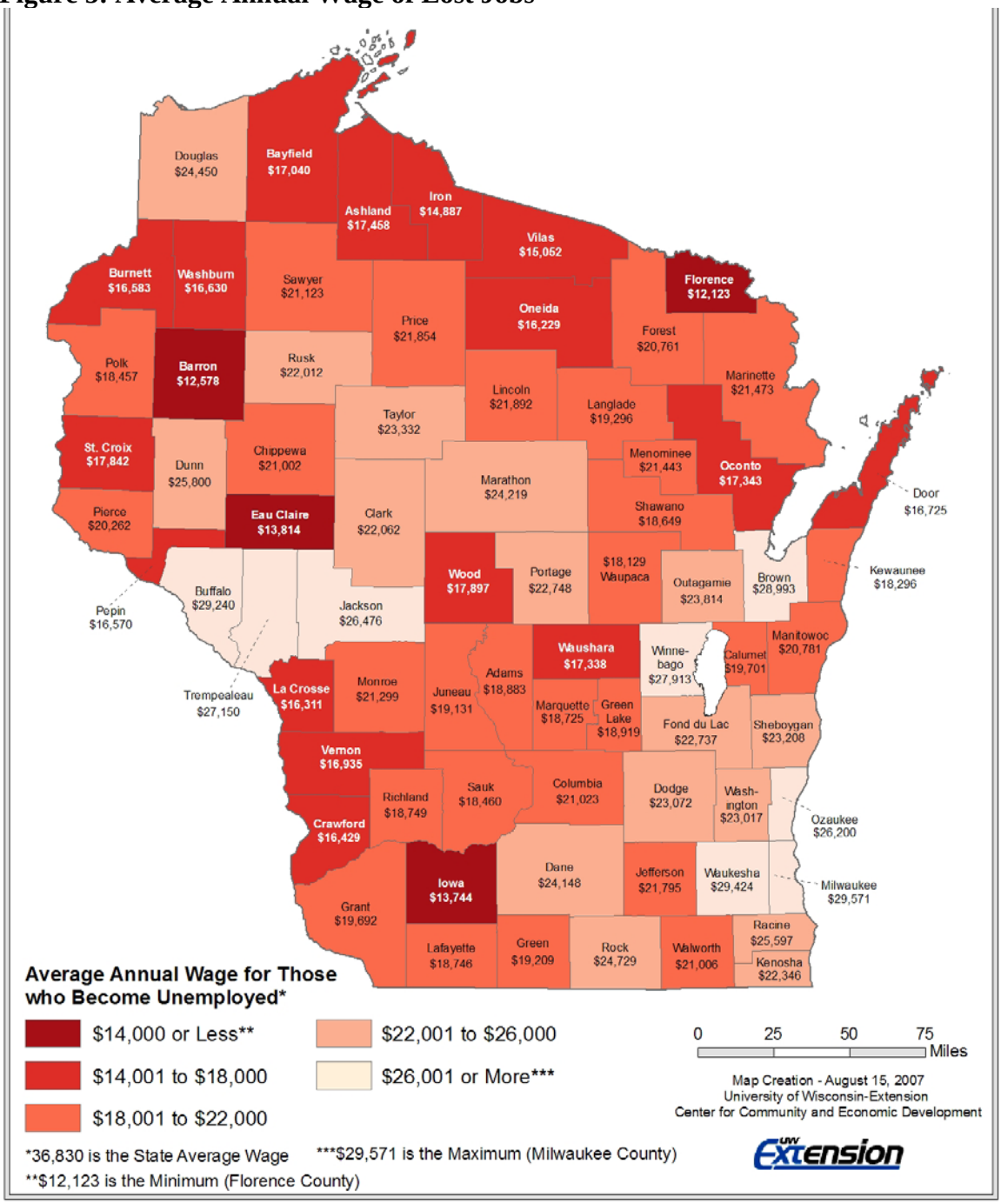


Figure 5: Average Annual Wage of Lost Jobs



In particular, the Madison and Milwaukee areas are not anticipated to be especially hard hit by a pandemic (although their disproportionate economic importance means that even modest losses in those counties would still be important to the overall state economy). However, significant fractions of the state are expected to experience job and payroll losses greater than 3.5% of county jobs and payroll. Note also that the job and payroll loss is anticipated to occur primarily within a single quarter. Thus, the results in Figure 4 are more accurately viewed as "person-years of jobs lost"; the actual fraction of people losing jobs would be roughly four times higher, even though the job losses would typically be brief. Thus, even though a 2% loss of annual GDP statewide might be considered manageable, some counties would experience much more severe recessions, with as many as 15-20% or more of jobs being lost in some counties during the peak of the pandemic.

Visual review of Figures 3 and 4 shows that many of the counties that are predicted to be hardest hit are in areas heavily dependent on tourism, such as Douglas, Bayfield, and Door counties. TThis is not universally true. For example, Buffalo County is expected to suffer losses of seven to eight percent annually (roughly 30% during the quarter of the pandemic—the highest losses in the state), due largely to the high concentration of transportation and logistics activity in that county. However, the losses to Buffalo County may not be as great as estimated here, if transportation losses turn out to be are concentrated primarily in passenger transportation (e.g., air, rail, and public transit), and do not severely affect the trucking and warehousing industries that form a large part of the economy in Buffalo County.

Care should be taken in interpreting the above figures, since the data from the Department of Workforce Development tracks jobs by county of employment, not by the county of the employee's residence. Therefore, lightly shaded counties that are near or adjacent to heavily hit counties will not necessarily escape severe impacts from a pandemic. For example, Ashland County is shown as losing only a small percentage of total jobs in the county, but significant numbers of Ashland residents may commute to nearby Bayfield County for work in the tourism industry. Thus, county and municipal officials in Ashland County, and other counties that are similarly situated, may still find it prudent to prepare for large impacts from a possible pandemic.

Finally, Figure 5 shows the average annual wages of the jobs that are estimated to be lost due to a pandemic, by county. As noted above, care needs to be taken in interpreting this data, since the average annual wages computed in our analysis are annual wages per job, not per employee or per household, so may tend to overstate the level of economic hardship currently being experienced by employees in low-wage sectors. Therefore, the results presented below should not be considered definitive. Still, we believe that our analysis gives a reasonable first-order approximation of the economic hardship that a pandemic might cause, and are thus useful for alerting state, county, and local officials to the economic problems that may arise in a pandemic.

In particular, the jobs anticipated to be lost due to a pandemic are in general quite low-wage. In most counties, the average wages of the lost jobs would be less than $26,000

per year, and in some counties, well under $14,000 per year. Admittedly, some of these may represent part-time or seasonal work by employees who have other sources of household income. However, it is important to recognize first that these numbers are averages. For example, in Florence County, with an average of $12,123 in annual wages per lost job (the lowest in the state), a sizable fraction of the lost jobs undoubtedly paid well under $12,000 per year. Second, even if many low-wage workers (e.g., waitresses) may work multiple jobs or have employed household members, some are undoubtedly trying to survive on a single income, and barely making it even while working.

As noted above, households that are subsisting on low-wage employment may be self-sufficient as long as those jobs are maintained, but may be only a hair's breadth away from becoming dependent on government assistance with job loss. In addition, low-wage workers are unlikely to have more than a few days worth of food and other necessities at home, and may also lack sick leave or other protections that would allow them time off to recover from a serious illness. Therefore, they are unlikely to be able to follow many public-health recommendations for preventing the spread of pandemic flu, such as voluntary self-isolation.

Thus, the analysis above, although preliminary, supports the importance of investigating policy options for addressing the needs of the working poor. In the remainder of this chapter, we first review some key economic and legal characteristics of the working poor, and existing compensation programs for addressing their economic needs. Next, we identify a range of policy options that could be considered in order to extend existing compensation options to help meet the challenges posed by a pandemic.

4.2 Characteristics of the Working Poor—Economic and Legal Concerns

Any analysis of the impact of a pandemic on the working poor raises several kinds of questions. For example, the situation of a specific family could be affected by factors such as:

Does the family have health insurance?

Does the family have the economic capacity to practice isolation or quarantine? For example, would voluntary (or mandated) isolation or quarantine result in untenable consequences to the family—such as loss of a job?

Does the family have sufficient financial resources to pay for basic expenses in the event of job loss (whether due to isolation, or simply due to the recessionary effects of a pandemic)?

Does the family have the social skills and resources to understand and observe the precautions advised during a pandemic?

We discuss each of these issues below, and then propose a range of policy options consistent with what is known about the economic and legal status of the working poor.

Health insurance

The epidemiological studies cited above concerning diagnosis, treatment, and compliance with quarantines and treatment distinguish between symptomatic and non-symptomatic people, and between the infected and the non-infected. A poor person may have limited resources for ascertaining whether he or she is infected or symptomatic.

In the U.S., the absence of universal health care means those who are uninsured often defer seeing a doctor to obtain an initial diagnosis of any medical conditions. In 2006, Cohen and Martinez (June 2007) noted the results of a survey indicating that 43.6 million persons of all ages (14.8%) were uninsured at the time they were surveyed, 54.5 million (18.6%) had been uninsured for at least part of the prior year, and 30.7 million (10.5%) had been uninsured for more than a year at the time of the survey. The percentage of children under the age of 18 years who were uninsured at the time of the survey was 9.3%. Moreover, according to Cohen and Martinez, almost 58% of unemployed adults and nearly 23% of employed adults aged 18-64 had been uninsured for at least part of the previous year at the time they were surveyed; more than 33% of unemployed adults and nearly 14% of employed adults had been uninsured for more than a year.

Conversations with officials at the Trust for America's Health suggest that the White House intends to support a bill offering emergency medical care for the uninsured during a pandemic. If such a bill is passed early in the pandemic and the availability of medical care is widely publicized, then the financial disincentive to seek medical care for those without health insurance would be eliminated. This solution, however, will not address the financial concerns of those people with private insurance who have policies with large co-payments. Thus, one possible consequence of being poor may be reluctance or inability to seek medical care at the appropriate time. (Note that this consequence may also affect other groups, such as illegal aliens residing within the U.S., or the members of language minorities).

Economic capacity to practice isolation or quarantine

Even if suitable medical diagnosis and healthcare services are available to the working poor, the working poor may not have the economic capacity to participate in some types of social distancing. Sadique et al. (2007) surveyed respondents in five European countries and three Asian regions on their willingness to take precautionary actions in the event of an influenza pandemic. They found: "The only individual-level variable that appeared to affect many of the precautionary actions was employment status. Fewer employed respondents reported being likely to avoid public transportation, entertainment venues, and work, and less likely to stay at home than those not employed full-time." Sadique et al. therefore suggested that homemakers, retirees, and students may have limited economic reasons to leave home, and a correspondingly greater willingness to comply with strategies of social distancing such as isolation and quarantine.

Among working people who have been asked about their ability to stay home from work, money to pay bills is a significant source of anxiety. A 2006 national survey conducted by the Harvard School of Public Health found that when faced with a serious outbreak of pandemic flu, a large majority of Americans would be willing to make major changes in their lives in order to cooperate with the recommendations of public-health officials (http://www.hsph.harvard.edu/news/press-releases/2006-releases/press10262006.html). However, the survey also found that a substantial share of Americans would have no one to care for them if they became ill, or would face serious financial problems if they had to stay home from work for a week or more.

The Harvard survey asked employed Americans about the problems they might encounter if they were asked to stay out of work for seven to ten days, a month, or three months because of an outbreak of pandemic flu in their community. The longer people were hypothesized to be out of work, the more people indicated that they would face financial problems. While most employed people that were surveyed (74%) believed that they could miss seven to ten days of work without serious financial problems, one in four (25%) said they would face such problems. We assume that those 25% represent the working poor. However, limits in financial liquidity and total assets quickly affect even individuals not classified as working poor, as the period they are hypothesized to be out of work approaches one month. In fact, a majority (57%) of those surveyed thought they would have serious financial problems if they had to miss work for one month, and three-fourths (76%) thought they would have such problems if they were away from work for three months. Only about three in ten individuals surveyed (29%) said that they would be able to work from home if they had to stay away from their workplaces for one month.

The economic inability to stay home for extended periods of time could be problematic. . The authority for a local public-health department to enforce quarantine is found in Wis. Statutes, Section 252.06(1), which reads: "The department or the local health officer acting on behalf of the department may require isolation of a patient or of an individual under s. 252.041 (1) (b), quarantine of contacts, concurrent and terminal disinfection, or modified forms of these procedures as may be necessary and as are determined by the department by rule." However, Section 252.06(10)(a) provides that "Expenses for necessary medical care, food and other articles needed for the care of the infected person shall be charged against the person or whoever is liable for the person's support." Similar policies have been found to be problematic in other jurisdictions.

For example, the Canadian government conducted an extensive study after their experiences with the SARS outbreak, including an analysis of quarantine policies. That study (SARS Commission, December 2006, Volume 1) noted one problem affecting compliance with social distancing: "The failure to blueprint compensation for those who really need it, such as those quarantined, medical workers deprived of their livelihood and those whose jobs are disrupted." Discussing failures in compliance with quarantine orders, DiGiovanni et al. (2004) observed that:

> Fear of loss of income was of paramount importance. It was especially significant, according to our interviews, focus groups, and Healthcare Workers

> Survey, for people who were unconvinced that their quarantine was necessary. This fear was the most common reason given to us for noncompliance or non-self-quarantine among people who were advised that they met quarantine criteria. And the fear was justified. Although some employers assured their employees at the outset that their pay would continue while they were in quarantine, others said it would not. The situation was even more disconcerting for those whose income came from part-time work, casual work, or self-employment.

Finally, the SARS Commission (December 2006, Volume 5) observed that, "Despite criticism that it took too long to bring forward an appropriate SARS compensation package, some observers suggest that the compensation system once in place was largely responsible for the success of the voluntary quarantine programme." Dr. James Young was quoted by the SARS Commission as saying:

> During SARS, we were using quarantine for the first time in 50 years. One of the important things in using quarantine was getting people to abide by it. One of the important ways of getting people to abide by it was by offering financial compensation so they would in fact abide by it and stay in quarantine if and when they were ordered by the medical officer of health. We got approval from the Ontario government to institute a quarantine program and to pay people for that. That resulted in us being able to manage the quarantine in an effective manner.

Therefore, the SARS Commission (December 2006, Volume 5) concluded that "advance planning for health emergency compensation is vital. It is impossible to predict in advance the precise form and amount of compensation necessary and affordable for every conceivable emergency. It is possible to require by legislation that every government emergency plan include a basic blueprint for the most predictable type of compensation packages." The purpose of the rest of this chapter is to identify some of those types of compensation that may be needed.

Personal resources—savings and liquidity

Ability to comply with strategies such as isolation and compliance depends more on assets than on income. Therefore, it is important to review studies of family assets. Haveman and Wolff (April 2001) report that, "Based on 1998 figures, one-fourth of households in the United States have insufficient net worth to enable them to get by for 3 months at a poverty-line level of living, and nearly one-half have liquid assets of less than $5,000." They also provide data indicating elevated rates of asset poverty among particular subgroups, including minority households, renters, and families in which the heads of household were young, relatively uneducated, or female with children:

Blacks/Hispanics	61%
Head aged less than 25 years	75%
Head aged 25-34 years	60%
Head with less than a high school degree	59%
Renters	63%
Young female heads with children	64%

One particular risk to renters from a pandemic is eviction. The number of days one has to move (upon receipt of an order from one's landlord) varies with the length of lease. However, it is important to note that the procedure for starting an eviction may involve an extremely short grace period of 28 days, or even less (for instance, in the case of a tenant without a written lease, who pays rent twice a month). If a tenant does not move upon receiving a landlord's notice, the landlord must obtain a court order. This requires a trial if the tenant objects. However, in general, renters can more quickly be removed for nonpayment than can homeowners who default on mortgages. Moreover, the data given above suggest that renters are much more likely to be in precarious financial positions than homeowners (with an asset poverty rate of 63%, versus less than 10% for homeowners). This finding is supported by Apgar and Di (2005), who found that among all households headed by individuals less than 65 years of age, homeowners had median wealth holdings of $154,100 (in 2001), while renters had wealth holdings of only $4,500. Moreover, the average assets of homeowners had grown by roughly 37% since 1992, while those of renters had grown by barely over two percent.

Loss of employment

Whether individuals are able to stay home from work in a pandemic depends not only on their financial resources, but also on their legal and contractual rights as employees. Employment law, and more specifically the rights and obligations of employees and employers, not only affects the financial resources of employees, but can also present difficulties other than merely the financial inability to comply with social distancing. For example, the actions that individuals must take to adjust to school closings or participate in voluntary isolation may endanger their ability to keep their jobs.

Table 8 below examines some of the different circumstances under which an employee might be required to, or choose to, stay home during a pandemic, and illustrates some of the possible economic and legal consequences of doing so under current employment law. Three variables are of particular significance:

- Will the employee have a right to return to work?
- Will the employee continue to be paid while staying home?
- Will the employee's employer-provided health insurance and any associated premiums be affected?

Unemployment compensation (UC) did not exist during the 1918 pandemic. However, unemployment law today specifies that if an employee cannot work because the workplace has closed, the employee is considered unemployed in determining eligibility for financial compensation. Moreover, employees who have been laid off due to lack of work are also considered unemployed. Thus, UC may offer a partial solution to the compensation problem, but only when the employee's business or workplace has been closed by the health department, or the employer has chosen to lay off the employee or close the business. For example, some employers may choose to lay people off if business demand or availability of raw materials is reduced (as might occur in a pandemic).

However, an unemployed person's eligibility for the financial benefits of UC depends on whether the employee is "covered" (which is based in part on having worked enough hours in the past four quarters). In the state of Wisconsin, this determination is made by the Department of Workforce Development, using data on the employee's duration of employment with the current employer and recent prior work history. For those deemed eligible for UC, Wisconsin benefits approximate 50% of the average weekly wage for the preceding three-month period, up to a maximum of $355 per week; benefits last for up to 26 weeks, unless extended. UC benefits also require that the recipients look for a job (although this could be done via correspondence or by telephone during a pandemic). Employees who have not worked for a long enough period of time, or who are considered self-employed (such as some cleaning contractors, for example), would generally not be eligible for UC. (Disaster Unemployment Assistance is a federal program that extends UC benefits to such individuals if they become unemployed as the result of a natural disaster.)

Table 9 indicates the level of unemployment benefits that fully vested employees in Bayfield County would receive if they were eligible for the Wisconsin UC. These benefits are likely to fall beneath the fixed cost of living for many of the unemployed. Although discretionary consumer expenditures can be expected to fall (and even expenditures for essential items, such as new clothing or home maintenance, can be deferred), many of the hardest hit employees identified in this study may have little discretionary income in the first place.

The U.S. Department of Labor has confirmed that it intends to interpret the Disaster Unemployment Assistance program to apply during a federally declared pandemic. This program provides financial assistance to individuals whose employment (or self-employment) has been lost or interrupted as a direct result of a major disaster declared by the President of the U.S. The program is administered by the states, as agents of the federal government. Before an individual can be determined eligible for Disaster Unemployment Assistance, it must first be established that the individual is <u>not</u> eligible for regular UC benefits under state or federal law. Eligibility for Disaster Unemployment Assistance includes people who cannot work as a direct result of the disaster, and also families where the primary breadwinner has died. However, under the current eligibility criteria, Disaster Unemployment Assistance does not extend to people who are caring for ill family members, or who are quarantined (people who are also not eligible for ordinary UC benefits). The Department of Labor has not yet indicated whether or how it intends to modify the program to address the needs of such persons.

Table 8: Coping with Isolation/Quarantine/Childcare Needs

Method of achieving social isolation	Workplace closed by health department, or due to lack of business	Parent stays home because school is closed	Family member caring for flu victim	Flu victim is employee, and stays home while ill	Employee voluntarily stays home–but cannot work at home	Employee voluntarily stays home–and works at home
Legal status	May be eligible for unemployment, but would have to look for work	Employment status may continue, at employer's option	Employment status continues for at least two weeks, if covered by FMLA	Employment status continues, if covered by sick leave or FMLA (up to two weeks)	Employment status may continue, at employer's option	Employment status continues
Income available through UC?	May be eligible for UC	Ineligible for UC	Ineligible for UC	Ineligible for UC	Ineligible for UC	UC not needed
Available income sources	UC income	Paid vacation time, if available	Paid sick leave if available; accrued vacation if covered by WFMLA, or with employer's approval	Paid sick leave if available; accrued vacation if covered by WFMLA, or with employer's approval	Paid vacation time, if available	Full or prorated salary
Right to return to job?	Considered unemployed, must look for work	No, if fired for cause	May be fired for cause, if not covered by FMLA	May be fired for cause, if not covered by FMLA	No, if fired for cause	Employment status continues
Does existing health Insurance continue?	Yes, but must elect COBRA and pay premium	May be negotiated if employee keeps job; else, COBRA possible	Yes, if FMLA coverage; may be negotiated if employee takes voluntary leave; else, COBRA possible	Yes, if FMLA coverage; may be negotiated if employee takes voluntary leave; else, COBRA possible	May be negotiated if employee keeps job; else, COBRA possible	Yes, employer share of premium continues

Table 9: UC Benefits for Bayfield County

Sector	Number of Jobs Lost	Average Wage of Lost Jobs	Assumed Highest Quarterly Wage[1]	Weekly Wage before Taxes[2]	Weekly UC Benefit	Shortfall	Annual Wage Rate with UC (before taxes)[3]
Agriculture, forestry, fishing, and hunting and mining	0.975	20404	5101	392	204	-188	10608
Construction	5.65	26062	6515	501	261	-240	13572
Manufacturing	4.375	25915	6479	498	259	-239	13468
Wholesale and retail trade	14.25	18707	4676	360	187	-173	9724
Transportation and warehousing	21.672	30670	7667	589	307	283	15964
Finance and insurance	2.375	38326	9581	737	355[4]	-382	18460
Educational services	19.025	24872	6218	478	249	-229	12948
Health care and social assistance	-13.984	19533	NO JOBS LOST				
Art, entertainments, recreation, accommodation and food services	220.6	14409	3602	277	144	-133	7488
Other services, except government	0.858	21112	5270	406	211	-195	10972
Total	**275.796**	**17040**					

Note 1: Unemployment benefits are calculated using the employee's recent wage history. Benefits are calculated using the highest paid quarter during the previous year. Although wages fluctuate from quarter to quarter (for reasons such as seasonality and job mobility), this chart assumes that the annual wage is equal in all four quarters.
Note 2: Weekly wage is computed assuming equal pay in all weeks of the year. In seasonal industries (such as summer tourism), this assumption may understate the highest quarterly wage. In addition, no adjustment for withholding has been made. The weekly wage is thus overstated by the amount withheld from the employee's paycheck.
Note 3: Tax withholding is required for wages. Although UC payments are taxed, withholding is not required. The computed weekly benefit represents gross payments.
Note 4: For Bayfield County (where wages are relatively low), the UC benefit is roughly one half of wages. However, the UC benefit is capped at a maximum of $355 per week for workers earning annual wages in excess of $35,500. Therefore, the UC benefit will represent a decreasing percentage of the former weekly wage for workers with higher previous wages (such as in the finance and insurance industry).

Benefits from UC are not intended to replace all of a lost wage or salary. In fact, as shown in Table 9, UC benefits will at best approximate one half of the employee's recent highest earnings, up to a maximum of $355 per week. For comparison purposes, Table 10 shows the current federal poverty level (FPL) as a function of household size. If a worker represented in the Bayfield County analysis is the sole paid employee in a two-person household and earned the average income reported for that sector in Bayfield County, unemployment compensation levels would exceed the FPL for a household of that size only in the transportation ($15,964) and financial ($18,460) sectors.

Table 10: Federal Poverty Guidelines (Effective February 2007)

Group Size	Annual FPL	100% Monthly FPL
1	$10,210	$850.83
2	$13,690	$1,140.83
3	$17,170	$1,430.83
4	$20,650	$1,720.83
5	$24,130	$2,010.83
6	$27,610	$2,300.83
7	$31,090	$2,590.83
8	$34,570	$2,880.83
9	$38,050	$3,170.83
10	$41,530	$3,460.83
Each Additional Person	$3,480	$290.00

Canada and other countries affected by SARS concluded that the need for continuing income and job security would affect individuals' compliance with quarantines and social distancing. Based on this review of how unemployment compensation and sick leave operate, one can conclude that the combination of paid sick leave and unemployment compensation is unlikely to be adequate to achieve high rates of compliance with quarantines and social distancing among the working poor.

Job security is limited in Wisconsin, since with regard to employment law, Wisconsin (like many other states) is considered an "at will" state. This means that in the absence of some other legal or contractual obligation, an employer may fire an employee at virtually any time, and for no particular reason. For example, employees who do not attend work during their established work schedules may be fired at the option of the employer.

Exceptions to this rule include policies such as sick leave. Sick leave grants employees the right not to attend work, and may be either paid or unpaid:

- Unpaid sick leave means that the employer has no obligation to pay the employee while taking sick leave.

- Paid sick leave is purely at the discretion of the employer (or by contract between the employer and the employee).

When paid sick leave is available, it typically amounts to roughly five days of paid leave per year for non-unionized, private-sector employees. Some large corporate and governmental employees do allow unused paid sick leave to carry over from year to year; in that case, employees may have substantial amounts of time that can be compensated as paid sick leave. However, using recent data from the U.S. Bureau of Labor Statistics, Lovell (2004) revealed that nearly half of all private-sector U.S. workers (47%) are not provided *any* paid sick time. For employees who receive paid vacation benefits, whether they can use paid vacation time while taking unpaid sick leave is also at the discretion of their employers. (However, if the employee quits, the usual practice is to pay the employee any accrued vacation time.)

Sick leave can occur either because the employer voluntarily offers that right, or because the law forbids employers from firing employees who take time off for reasons of illness, or to care for family members. The primary federal law designed to protect workers from job termination when ill or caring for ill family members is the Family Medical Leave Act (FMLA). The Wisconsin Family Medical Leave Act (WFMLA) has somewhat more flexibility with regard to eligibility criteria, and offers employees the option to take accrued leave. Both require employers with 50 or more employees to offer two weeks of unpaid sick leave for employees who are ill, as well as two weeks of unpaid sick leave for employees caring for ill family members. (Additional time is available for parents of newborns and newly adopted children.) Thus, these laws may provide for some job security, if the employer is subject to them, the employee is eligible, and the employee's reason for staying home qualifies.

Employers with more than 25 but fewer than 50 employees must post their sick-leave policies under the WFMLA (employers with fewer employees have no statutory obligation to state a sick-leave policy). Note, however, that the provisions of the WFMLA that are applicable to employers of 25 to 50 employees do not require any sick leave to be offered. A sick-leave policy must state whether employees are eligible for paid sick leave, and what proof of illness, if any, must be submitted to the employer.

Employees contemplating staying home to care for children whose school has closed, or to care for an ill family member, are therefore well advised to determine whether their employers grant sick leave, whether this policy includes caring for sick family members, and whether it includes providing childcare for a child who does not appear to be ill, but whose school has been closed by order of public health. If the policy does not allow employee absences in any of these situations, or if an employee fails to comply with the

policy's requirements to notify the employer or obtain permission, not attending work could result in discharge.

Employers that do not choose to grant sick leave and are not subject to FMLA/WFMLA requirements with regard to sick leave may fire employees for taking time off without permission. Thus, many employees who become ill, who choose to comply with quarantine or isolation, or who stay home to care for a child or an ill family member generally would not have job security. Moreover, there is considerable fear among the working poor of being fired for nonattendance.

Continued compensation for employees who are on sick leave is not required even under the FMLA, unless the employer offers has chosen to offer paid sick leave, or the employee is authorized (and able) to continue working from home. (The WFM LA supplements the federal law for employers of more than 50 employees, allowing employees to substitute accrued paid or unpaid leave of any other type provided by employer.) In many instances, however, the current state of workplace law and the extent of employer discretion will seriously threaten an employee's job security and compensation. As a result, many employees may be unwilling to risk staying home from work in a pandemic. In fact, if an employee has no paid sick time or accrued vacation time available, that employee may actually find it financially advantageous to be fired. This is discussed below, where unemployment insurance is described.

Health insurance may be continued in the event of job loss. In particular, a terminated employee with group health insurance would generally be eligible to elect continuation of coverage under a law known as COBRA. However, continuation of insurance coverage under COBRA usually requires the former employee to pay higher premiums. Moreover, a cooperative employer who agrees to an employee taking a leave of absence might also expect the employee to pay her full insurance premium (including the employer's share) during the voluntary leave.

4.3 Addressing the Needs of the Working Poor during a Pandemic

The potential for job loss and general hardship during a pandemic already provides a humanitarian reason for addressing the needs of the working poor in such situations. However, providing for the needs of the working poor and planning ahead for any possible disruptions that might occur can also help in achieving reduced disease transmission. As noted above, people potentially exposed to or at risk of contracting pandemic influenza may resist staying home in the early phases of the pandemic—not only due to lack of familiarity with pandemics, but also due to an economic need to continue working. Employees in many industries typically continue to go to work while ill, even in industries (such as the hospitality industry) where doing so could directly jeopardize others. As noted above, the primary reasons for this are typically economic. While lack of familiarity with the risks of a pandemic can be addressed through public-health education, economic need can also be addressed through a coordinated series of policies and programs.

The policy options that follow are consistent with recommendations of the SARS Commission (December 2006) that compensation mechanisms should be integrated into policies for social distancing during a pandemic. They are also consistent with remarks by Wu et al. (2006) about the importance of planning ahead for the social disruption that could occur during a pandemic:

> Reducing the first-wave [disease] attack rate should be the primary goal of influenza preparedness planning. When complete transmission control is not achieved, this necessarily implies a longer epidemic. If the mortality rate of the pandemic strain is considered to be low in the local context, it is likely that some governments will place a greater priority on reducing the duration of the outbreak than on reducing the number of infections. We suggest that designing policy for a longer period of societal disruption may be justified not only by reduced mortality but also by reduced peak stresses on the society as a whole.

A number of options exist for reducing the burdens on those who are not able to work in a pandemic.

Facilitate liquidity

Although credit cards provide a convenient form of liquidity for many people, this can become prohibitively expensive for people who do not routinely pay their balances in full. Moreover, even those individuals who currently do not maintain substantial debt on their credit cards may begin to do so if affected by job loss during a pandemic. Therefore, other forms of liquidity might be desirable. Many people have 401(k) plans, but limited immediate cash liquidity. While some employers might approve a loan from an employee's 401(k) plan during a pandemic as an "emergency" measure, federal law gives no clear authority for borrowing from these plans for living expenses. Although not a matter of state law, Wisconsin legislators might wish to explore amending the federal law to facilitate borrowing from 401(k) plans for medical emergencies.

Modify existing programs to assist with liquidity shortfalls

For workers who are not eligible for UC and do not have paid sick leave, the traditional methods of filling any financial gaps caused by illness or job loss include programs such as food stamps, school and elderly nutritional programs, and Badger Care (health insurance). These programs offer financial assistance only after the financial hardship has already been incurred. Moreover, aid under these programs is conditioned upon income history and, sometimes, asset level.

While each of these programs is actively preparing its own pandemic plan, many people considering staying home may be unaware of these programs and the factors determining their eligibility for aid. The speed with which eligibility can be determined, and the stigmatization of these programs as "poverty programs," may also limit their usefulness in providing support for social distancing. Therefore, it may be prudent to determine what options are available to expedite determination of eligibility and/or waive asset

eligibility criteria in the event of a pandemic. Moreover, while not a matter of Wisconsin law, thought should be given to making federal Disaster Unemployment Assistance (or perhaps a similar state program) available to individuals not eligible for traditional UC during public-health emergencies, as well as during natural disasters; see discussion in Section 4.2 above.

Compensation for those quarantined or participating in isolation

As discussed above, current employment law does not necessarily provide for continued compensation in the event of quarantine or isolation. The U.S. CDC (2003) notes, however, in its morbidity and mortality reports related to SARS, that in China, some employers paid salaries to employees under quarantine. Similarly, in Taiwan, individuals who completed quarantine received the equivalent of $147, and could request other social services from the government. Thus, a direct income-replacement program could pay the working poor to stay home when they are ill, exposed, or caring for someone who is ill.

One model for funding such a program is California's Short Term Disability Insurance (SDI) program, funded by a small tax (under one percent) paid by employees on their wages.[4] In particular, California's SDI program provides coverage for parents tending ill children. At present, it does not cover parents staying home from work to tend children whose schools have been closed by a directive of public health during a public-health emergency. However, it does provide benefits for those subject to quarantine, and provides up to 52 weeks of benefits to those who are ill or subject to quarantine. (Administrators of the program were unaware of any effort to modify the program to pay for parents tending children whose schools have closed under a public-health emergency order, or plans to modify the requirement for a "written order from a…health officer.") The law provides that eligible California employees are entitled to six weeks of leave in a 12-month period, paid at up to 55% of their weekly salary, to take care of a "seriously ill child, spouse, parent, domestic partner." Appendix 2 (reproduced from the 2006 Annual Statistical Supplement prepared by the Office of Policy in the U.S. Social Security Administration) provides information on temporary disability programs in several jurisdictions of the U.S., including California.

By contrast, Canada adopted a more limited aid program during SARS. In particular, Canada enacted a compensation program that paid $400 per week to people who were employed full time; or $200 per week for part-time employees (SARS Commission, December 2006, Volume 5). This compensation was limited to a maximum of $6000 (15 weeks), and served only medical and non-medical employees of recognized healthcare facilities who, during their work, either suffered a loss of income due to contracting

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[4] Section 2626 of California's UC law reads:
(a) An individual shall be deemed disabled on any day in which, because of his or her physical or mental condition, he or she is unable to perform his or her regular or customary work.
(b) For purposes of this section, "disability" or "disabled" includes [among other conditions]: (1) Illness or injury, whether physical or mental, including any illness or injury resulting from pregnancy, childbirth, or related medical condition. (2) Inability to work because of a written order from a state or local health officer to an individual infected with, or suspected of being infected with, a communicable disease.

SARS or being unable to work, or were under documented quarantine because of possible exposure. The other basic eligibility criterion was that the employee could not qualify for ordinary UC. Ontario eventually extended similar compensation more broadly to "employed and self-employed Ontario residents who lost income because they were isolated, sick with SARS, or gave care to someone directly affected by SARS" (SARS Commission, December 2006, Volume 5). Creation of programs in Wisconsin similar to those available in California and Canada would foster compliance with social distancing.

Extend the moratorium on utility termination

Like many states, Wisconsin has a "winter moratorium" to prevent utility companies from disconnecting customers during the winter—specifically, between November 1 and April 15. If a pandemic occurs at another time of year, extending this moratorium to cover the duration of the pandemic (or its peak phases) would assist in reducing the cash needs of those families financially stressed by loss of work. (This moratorium does not cover users of heating oil and propane, but presumably there would be greatly reduced charges associated with use of heating oil and/or propane outside of the winter season in any case.)

The way this program currently works is that during the winter moratorium, families are allowed to accrue unpaid utility bills without risking termination of service. Many subsequently receive heating-assistance grants from the state of Wisconsin; others simply pay off their unpaid utility bills on their own. Operated primarily with federal funding, the program provides assistance to approximately 140,000 households annually through grants made to community agencies and Indian tribal agencies under the direction of the Division of Energy in the Wisconsin Department of Administration.

Expand the availability of funding for heating assistance

As noted above, utility bills for low-income households can be paid through grants from the utility assistance program administered by Wisconsin Department of Administration. Authorized at $20,500,000 per year, the program offers assistance to households with income at or below 150% of the federal poverty level. The program has limited funds available, and makes a single yearly payment to each recipient. The amount of the payment is not assured (i.e., it is not an entitlement), and in particular depends on the number of eligible applicants in a given year, and on the availability of federal grants. Section 16.957(2)(a) of the Wisconsin Statutes provides that, from the appropriation funding available to the program, "an amount equal to 47% of the sum [appropriated]…is [to be] spent for weatherization and other energy conservation services." Note that funds can be used for not only for utility bills, but also for unpaid heating-oil and propane bills (even though these are not subject to the moratorium on termination).

Wisconsin's Home Energy Assistance Program (WHEAP) also provides home-heating assistance to eligible households. A household may be eligible for crisis assistance if it has no heat, if it has received a disconnection notice from its heating-fuel dealer, if it is nearly out of heating fuel and does not have any way to pay for heating, or if a heating

emergency can thereby be avoided. WHEAP heating assistance is a one-time payment per heating season (October 1 through May 15), and is intended to help pay only a portion of a household's heating costs, not the entire annual cost of heating a home. In particular, the amount of heating assistance depends on the household's size, income, and heating costs. In most cases, the heating assistance is applied directly to the household's bill from the fuel supplier. Eligibility levels are shown in Table 11 below.

Table 11: INCOME GUIDELINES FOR THE 2007-2008 HEATING SEASON

150 PERCENT OF FEDERAL POVERTY GUIDELINES

Size of Family	ONE MONTH	THREE MONTH	ANNUAL INCOME
1	1,276.25	3,828.75	15,315.00
2	1,711.25	5,133.75	20,535.00
3	2,146.25	6,438.75	25,755.00
4	2,581.25	7,743.75	30,975.00
5	3,016.25	9,048.75	36,195.00
6	3,451.25	10,353.75	41,415.00
7	3,886.25	11,658.75	46,635.00
8	4,321.25	12,963.75	51,855.00
Each Additional	435.00	1,305.00	5,220.00

If a pandemic occurs during the winter months (when seasonal flu generally hits), it is likely that additional numbers of households would need heating assistance compared to experience in ordinary years. Therefore, it would seem prudent to explore additional possible funding sources for this program in that eventuality.

Protect employee job security

Prohibit unconditional firing of employees taking time off work in the absence of allowable sick leave. An emergency statute of limited applicability could be considered. Such a statute would presumably apply only during a pandemic period, and could take into account both business circumstances and employee needs.

Such an act was passed by the government of Ontario during the 2003 SARS outbreak in Toronto (SARS Assistance and Recovery Strategy Act, 2003, http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_03s01_e.htm). This legislation protected the jobs of quarantined and isolated individuals on SARS-related leave, and also allowed employers to require employees to leave work in response to concerns that their presence might expose other individuals in the workplace to SARS.

The act (which took effect on March 26, 2003, and was designed to end on a day specified by the provincial chief executive) authorized "leave of absence without pay for any day or part of a day during which…[an employee] falls into one or more of the following categories":

> "1. The employee is unable to work because he or she is under individual medical investigation, supervision or treatment related to SARS.
>
> "2. The employee is unable to work because he or she is acting in accordance with a SARS related order under section 22 or 35 of the *Health Protection and Promotion Act*.
>
> "3. …[T] he employee is unable to work because he or she is in quarantine or isolation or is subject to a control measure in accordance with SARS related information or directions issued to the public, a part of the public or one or more individuals, by the Commissioner of Public Security, a public health official, a physician or a nurse or by Telehealth Ontario, the Government of Ontario, the Government of Canada, a municipal council or a board of health, whether through print, electronic, broadcast or other means.
>
> "4. The employee is unable to work because of a direction given by his or her employer in response to a concern of the employer that the employee may expose other individuals in the workplace to SARS.
>
> "5. The employee is unable to work because he or she is needed to provide care or assistance to an individual…because of a SARS related matter that concerns that individual."

The act required an employee taking leave to contact a physician within two days. The physician was required to determine whether the employee should continue to stay home. With certain restrictions concerning businesses that were adversely affected by SARS, the employees were guaranteed reinstatement upon returning to work.

Protect renters from eviction

Housing is both a basic need and, for many households, a major expense. People displaced from their current housing must relocate somewhere. Without financial ability to pay, many will relocate to shelters, or to the homes of friends or relatives. Any arrangements causing crowding will be especially inappropriate in a pandemic.

The needs of homeowners are substantially different than the needs of renters. The 2000 Housing Census reports that 68.4% of Wisconsin households own their own homes, while 31.6 % rent.[5] In 2002, there were 1,222,467 owner-occupied units in the state of Wisconsin. The majority of these (59%, or 721,631 households) had monthly mortgage payments ranging between $500 and $2,000.[6] Although homeowners may default on mortgage payments, grace periods exist under federal law. Mortgage foreclosures require substantial lead time, and are governed by federal rules. As in the aftermath of Katrina, the federal government might choose to extend payment times and/or limit foreclosure actions if it appeared that mortgage defaults would become a serious problem.

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[5] http://quickfacts.census.gov/qfd/states/55000.html

[6] http://factfinder.census.gov/servlet/QTTable?_bm=y&-geo_id=04000US55&-qr_name=DEC_2000_SF3_U_DP4&-ds_name=DEC_2000_SF3_U

As noted above, tenants are more vulnerable than homeowners, since they are more easily evicted and on average have vastly lower financial resources. According to Merill (2004), more than 207,200 Wisconsin renters (roughly one in three, or 32.3%) paid 30 percent or more of their income for rent. Of those, 93,100 Wisconsin renters (roughly one in seven, or 14.5%) paid 50 percent or more of their income for rent (14.5 percent). Statewide, rent burdens ranged from a low of 18.3% in Calumet County to a high of 38.4% in Dane County. Households that are already paying large fractions of their income for rent are obviously especially at risk of default and eviction in the event of economic hardships such as job loss.

A landlord must give notice to quit before starting a court proceeding to evict a tenant. Several possible changes could provide greater protection to renters in the event of a pandemic. In particular, a statutory change could prohibit evictions during a medical emergency. However, such a change might require the state to compensate landlords for lost revenues. Other strategies may also be possible. For example, courts (which would undoubtedly be struggling with staffing shortages of their own) ordinarily choose which cases should have highest priority to be heard during an emergency such as a pandemic. Therefore, discussions could be held with the administrator of the Wisconsin Court System about plans to triage cases during a public-health emergency like a pandemic.

Strengthen social capital

Community engagement is critical for successful implementation of social distancing, since it can build a foundation of community preparedness to help ensure compliance with measures for pandemic mitigation. However, it can also provide tangible forms of support (such as informal childcare or emergency food supplies) to the working poor and other households that find themselves in difficult circumstances during a pandemic. Therefore, community planners might begin working with community organizations such as churches, neighborhood associations, and parent/teacher organizations to discuss how members can help support one another (and other community residents) in the event of an emergency. Klinenberg (2003) has documented the ways in which low-income communities with high levels of social capital were able to substantially reduce mortality in the Chicago heat wave of 1995; such efforts would undoubtedly also reduce the number of individuals dependent on scarce state resources. Note that community planning should be in addition to general public-health education on pandemic influenza (e.g., explaining the concept of pandemic preparedness, and describing what individuals and families can do to be better prepared).

5. Possible Directions for Future Work

A severe pandemic would create a sufficiently large and complex set of challenges that we believe there is room for substantial additional work on how best to meet those challenges. Some possible directions for future work fall squarely within the purview of traditional public health. Such topics include issues like: whether to use scarce antiviral drugs for prophylaxis or treatment of healthcare workers and other critical employees; when to open mass clinics (and what capacity and capability such clinics should have in order to be maximally effective); and when to initiate isolation, quarantine, and other NPIs (such as school closure).

Other possible topics relate more to public risk perceptions. Examples include: how to achieve sufficient awareness of pandemic risks among the public to achieve compliance with public-health measures, without such high levels of fear as to induce hopelessness or despair; how and when to most effectively teach hygiene, social distancing, and financial survival strategies to members of the public; and design of effective outreach programs to communities (especially poor communities, and the organizations that serve them). These issues are particularly important since, as noted by the CDC (February 2007):

> The timing of initiation of various NPIs will influence their effectiveness. Implementing these measures prior to the pandemic may result in economic and social hardship without public health benefit and over time, may result in "intervention fatigue" and erosion of public adherence. Conversely, implementing these interventions after extensive spread of pandemic influenza illness in a community may limit the public health benefits of employing these measures. Identifying the optimal time for initiation of these interventions will be challenging because implementation needs to be early enough to preclude the initial steep upslope in case numbers and long enough to cover the peak of the anticipated epidemic curve while avoiding intervention fatigue.

Moreover, even if particular programs are adopted well in advance of a pandemic, they are likely to be more effective if people know about them in advance, and can therefore make effective use of the resources available to them.

Finally, we believe that there is extensive need for further work on the economic effects of a possible pandemic. To our knowledge, our analysis of the effects of a pandemic on the working poor, and the strategies and policy options for helping to address their needs, is the first one of its kind to be conducted nationwide. There is certainly room for more rigorous economic analysis of these issues, to revise some of the simplifying assumptions made in our analysis (such as consideration of only direct effects, rather than second- and third-order economic effects).

There is also a need for extensive work to craft affordable strategies for addressing the needs of the working poor in a pandemic (such as enhancing social capital in poor communities, and drafting model ordinances to provide for enhanced job security in a pandemic). Realistically, the possible scale of a pandemic makes it unlikely that

substantial aid programs could be supported out of general-purpose revenue (nor would extensive federal assistance likely be available). However, that makes it if anything even more important to identify some key elements of possible financial-assistance programs, such as: whether a means test would be used; the appropriate balance between providing job security and providing compensation; whether to limit any protections to those formally isolated or quarantined under orders of public health; how to balance the needs of businesses against the needs of employees; and any creative "stopgap" measures that can blunt the worst economic impacts of a pandemic at relatively modest cost.

Another critical economic impact of a pandemic would be its effect on businesses. There also, there is room for additional work. For example, it would be useful to thoroughly understand the criticality of particular industrial sectors to the state economy, both to be able to better prioritize business closures (if such closures should be advisable), and to identify which sectors may have the greatest call on state assistance during a pandemic (such as state loan guarantees). Further legal analysis could also clarify under which circumstances public-health authorities would have the right to close private businesses.

Finally, we believe that cost/benefit analysis (or cost-effectiveness analysis) could be used to better understand the linkages between the epidemiological and economic effects of a pandemic. For example, it seems plausible that early, sustained, and layered use of NPIs (including hygiene measures) could pay for itself in reduced attack rates in a pandemic, and therefore reduced economic losses (including losses to the tax base in the state). If true, it could be important to document that, since measures for pandemic preparedness are more likely to be adopted if they are perceived to "pay for themselves."

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Appendix 1. Entertainment-Oriented Businesses and Community Events

NAICS Code 71111: Theater Companies and Dinner Theaters

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Broadway theaters					
Comedy troupes					
Community theaters					
Dinner theaters					
Improvisational theaters					
Mime theaters					
Musical theater companies or groups					
Musical theater productions, live					
Puppet theaters					
Repertory companies, theatrical					
Summer theaters					
Theaters, dinner					
Theaters, live theatrical production (except dance)					
Theaters, musical					

NAICS Code 71112: Dance Companies

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Dance theaters					
Theater, dance					

NAICS Code 71119: Other Performing Arts Companies

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Carnival traveling shows					
Circuses					
Ice skating shows					
Magic shows					
Traveling shows, carnival					

NAICS Code 71121: Spectator Sports

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Baseball clubs, professional or semiprofessional					
Baseball teams, professional or semiprofessional					
Basketball clubs, professional or semiprofessional					
Basketball teams, professional or semiprofessional					
Boxing clubs, professional or semiprofessional					
Football clubs, professional or semiprofessional					
Football teams, professional or semiprofessional					
Hockey clubs, professional or semiprofessional					
Hockey teams, professional or semiprofessional					
Ice hockey clubs, professional or semiprofessional					
Jai alai teams, professional or semiprofessional					
Major league baseball clubs					
Minor league baseball clubs					
Professional baseball clubs					
Professional football clubs					
Professional sports clubs					
Roller hockey clubs, professional or semiprofessional					
Semiprofessional baseball clubs					
Semiprofessional football clubs					
Semiprofessional sports clubs					
Soccer clubs, professional or semiprofessional					
Soccer teams, professional or semiprofessional					
Sports clubs, professional or semiprofessional					
Sports teams, professional or semiprofessional					

NAICS Code 711212: Racetracks

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Automobile racetracks					
Dog racetracks					
Drag strips					
Greyhound dog racetracks					
Harness racetracks					
Horse racetracks					
Motorcycle racetracks					
Racetracks (e.g., automobile, dog, horse)					
Snowmobile racetracks					
Speedways					
Stock car racetracks					
Thoroughbred racetracks					

NAICS Code 711310: Promoters of Performing Arts, Sports, and Similar Events with Facilities

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Air show with facilities					
Arts event with facilities					
Arts festival with facilities					
Beauty pageant with facilities					
Boxing event with facilities					
Concert					
Dance festival with facilities					
Ethnic festival with facilities					
Fair with facilities, agricultural					
Festival with facilities					
Heritage festival with facilities					
Horse show with facilities					
Live theater operators					
Music festival with facilities					
Organizers of sports events with facilities					
Performing arts center operators					
Rodeo with facilities					
Sports arena					
Sports events					
Sports stadium					
Stadium					
Theater festival with facilities					
Wrestling event with facilities					

NAICS Code 712110: Museums

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Art galleries (except retail)					
Art museums					
Community museums					
Contemporary art museums					
Decorative art museums					
Fine arts museums					
Galleries, art (except retail)					
Halls of fame					
Herbariums					
Historical museums					
Human history museums					
Interactive museums					
Marine museums					
Military museums					
Multidisciplinary museums					
Museums					
Natural history museums					
Natural science museums					
Planetariums					
Science and technology museums					
Sports halls of fame					
War museums					
Wax museums					

NAICS Code 712120: Historical Sites

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Archeological sites (i.e., public display)					
Battlefields					
Heritage villages					
Historical forts					
Historical ships					
Historical sites					
Pioneer villages					

NAICS Code 712130: Zoos and Botanical Gardens

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Animal exhibits, live					
Animal safari parks					
Aquariums					
Arboreta					
Aviaries					
Botanical gardens					
Conservatories, botanical					
Gardens, zoological or botanical					
Parks, wild animal					
Petting zoos					
Reptile exhibits, live					
Wild animal parks					
Zoological gardens					
Zoos					

NAICS Code 712190: Nature Parks and Other Similar Institutions

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Bird sanctuaries					
Caverns (i.e., natural wonder tourist attractions)					
Conservation areas					
Interpretive centers, nature					
National parks					
Natural wonder tourist attractions (e.g., caverns, waterfalls)					
Nature centers					
Nature parks					
Nature preserves					
Nature reserves					
Parks, national					
Parks, nature					
Provincial parks					
Waterfalls (i.e., natural wonder tourist attractions)					
Wildlife sanctuaries					

NAICS Code 713110: Amusement and Theme Parks

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Amusement parks (e.g., theme, water)					
Parks (e.g., theme, water), amusement					
Piers, amusement					
Theme parks, amusement					
Water parks, amusement					

NAICS Code 713120: Amusement Arcades

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Amusement arcades					
Amusement device (except gambling) parlors, coin-operated					
Amusement devices (except gambling) operated in own facilities					
Arcades, amusement					
Electronic game arcades					
Family fun centers					
Indoor play areas					
Pinball arcades					
Video game arcades (except gambling)					

NAICS Code 713210: Casinos (except Casino Hotels)

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Casinos (except casino hotels)					
Cruises, gambling					
Floating casinos (i.e., gambling cruises, riverboat casinos)					
Gambling cruises					
Riverboat casinos					
Stand alone casinos (except slot machine parlors)					

NAICS Code 713290: Other Gambling Industries

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Bingo halls					
Bingo parlors					
Bookies					
Bookmakers					
Card rooms (e.g., poker rooms)					
Gambling control boards, operating gambling activities					
Gambling device arcades or parlors, coin-operated					
Off-track betting parlors					
Slot machine parlors					

NAICS Code 713910: Golf Courses and Country Clubs

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Country clubs					
Golf and country clubs					
Golf courses (except miniature, pitch-n-putt)					

NAICS Code 713920: Skiing Facilities

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Alpine skiing facilities without accommodations					
Cross country skiing facilities without accommodations					
Downhill skiing facilities without accommodations					
Four season ski resorts without accommodations					
Ski lift and tow operators					
Ski resorts without accommodations					
Skiing facilities, cross country, without accommodations					
Skiing facilities, downhill, without accommodations					

NAICS Code 713930: Marinas

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Boating clubs with marinas					
Sailing clubs with marinas					
Yacht clubs with marinas					

NAICS Code 713940: Fitness and Recreational Sports Centers

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Aerobic dance and exercise centers					
Athletic club facilities, physical fitness					
Body building studios, physical fitness					
Dance centers, aerobic					
Exercise centers					
Fitness centers					
Fitness salons					
Fitness spas without accommodations					
Gymnasiums					
Handball club facilities					
Health club facilities, physical fitness					
Health spas without accommodations, physical fitness					
Health studios, physical fitness					
Ice skating rinks					
Physical fitness centers					
Physical fitness facilities					
Physical fitness studios					
Racquetball club facilities					
Recreational sports club facilities					
Rinks, ice or roller skating					
Roller skating rinks					
Spas without accommodations, fitness					
Sports club facilities, physical fitness					
Squash club facilities					
Strength development centers					
Swimming pools					
Tennis club facilities					
Tennis courts					
Wave pools					
Weight training centers					

NAICS Code 713950: Bowling Centers

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Bowling alleys					
Bowling centers					
Candle pin bowling alleys					
Candle pin bowling centers					
Duck pin bowling alleys					
Duck pin bowling centers					
Five pin bowling centers					
Ten pin bowling alleys					
Ten pin bowling centers					

NAICS Code 713990: All Other Amusement and Recreation Industries

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Amateur sports teams, recreational					
Archery ranges					
Athletic clubs (i.e., sports teams) not operating sports facilities, recreational					
Aviation clubs, recreational					
Ballrooms					
Baseball clubs, recreational					
Basketball clubs, recreational					
Bathing beaches					
Beach clubs, recreational					
Beaches, bathing					
Billiard parlors					
Billiard rooms					
Boating clubs without marinas					
Bocce ball courts					
Bowling leagues or teams, recreational					
Boxing clubs, recreational					
Boys' day camps (except instructional)					
Bridge clubs, recreational					
Camps (except instructional), day					
Canoeing, recreational					
Concession operators, amusement device (except gambling) and ride					

NAICS Code 713990: All Other Amusement and Recreation Industries (continued)					
Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Curling facilities					
Dance halls					
Discotheques (except those serving alcoholic beverages)					
Driving ranges, golf					
Fireworks display services					
Fishing clubs, recreational					
Fishing guide services					
Fishing piers					
Flying clubs, recreational					
Football clubs, recreational					
Galleries, shooting					
Girls' day camps (except instructional)					
Go-cart raceways (i.e., amusement rides)					
Go-cart tracks (i.e., amusement rides)					
Golf courses, miniature					
Golf courses, pitch-n-putt					
Golf driving ranges					
Golf practice ranges					
Gun clubs, recreational					
Hockey clubs, recreational					
Hockey teams, recreational					
Horse rental services, recreational saddle					
Horseback riding, recreational					
Hunting clubs, recreational					
Hunting guide services					
Ice hockey clubs, recreational					
Kayaking, recreational					
Lawn bowling clubs					
Miniature golf courses					
Mountain hiking, recreational					
Night clubs without alcoholic beverages					
Nudist camps without accommodations					
Observation towers					
Outdoor adventure operations (e.g., white water rafting) without accommodations					
Pack trains (i.e., trail riding), recreational					
Para sailing, recreational					
Picnic grounds					
Ping pong parlors					
Pool halls					
Pool parlors					
Pool rooms					
Racetracks, slot car (i.e., amusement devices)					

NAICS Code 713990: All Other Amusement and Recreation Industries (continued)

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Recreational day camps (except instructional)					
Recreational sports clubs (i.e., sports teams) not operating sports facilities					
Recreational sports teams and leagues					
Riding clubs, recreational					
Riding stables					
Rifle clubs, recreational					
River rafting, recreational					
Rowing clubs, recreational					
Saddle horse rental services, recreational					
Sailing clubs without marinas					
Sea kayaking, recreational					
Shooting clubs, recreational					
Shooting galleries					
Shooting ranges					
Skeet shooting facilities					
Slot car racetracks (i.e., amusement devices)					
Snowmobiling, recreational					
Soccer clubs, recreational					
Sports clubs (i.e., sports teams) not operating sports facilities, recreational					
Sports teams and leagues, recreational or youth					
Stables, riding					
Summer day camps (except instructional)					
Tourist guide services					
Trail riding, recreational					
Trampoline facilities, recreational					
Trapshooting facilities, recreational					
Waterslides (i.e., amusement rides)					
White water rafting, recreational					
Yacht clubs without marinas					
Youth sports leagues or teams					

Community Events

Entertainment	Number of People	Density	Indoor / Outdoor	Adults, Children, or Mixed	Means of Transmission (Coughing, Touching, etc.)
Parades					
Festivals					
Carnivals					

Appendix 2. Temporary Disability Insurance

Source: Office of Policy, U.S. Social Security Administration, Annual Statistical Supplement, 2006

Five states, Puerto Rico, and the railroad industry have social insurance programs that partially compensate for the loss of wages caused by temporary nonoccupational disability or maternity. Those programs are known as *temporary disability insurance* (TDI) because the duration of the payments is limited.

Federal law does not provide for a federal-state system of short-term disability comparable with the federal-state system of unemployment insurance. However, the Federal Unemployment Tax Act (FUTA) was amended in 1946 to permit states where employees made contributions under the unemployment insurance program to use some or all of these contributions for the payment of disability benefits (but not for administration). Three of the nine states that could have benefited by this provision for initial funding for TDI took advantage of it: California, New Jersey, and Rhode Island. The first state law was enacted by Rhode Island in 1942, followed by legislation in California and the railroad industry in 1946, New Jersey in 1948, and New York in 1949. Then came a hiatus of two decades before Puerto Rico and Hawaii passed laws in 1968 and 1969, respectively.

The temporary disability insurance laws of the five states and Puerto Rico cover most commercial and industrial wage and salary workers in private employment if the employer has at least one worker. In no state is coverage under TDI identical with that of the unemployment insurance program. Principal occupational groups excluded are domestic workers, family workers (parent, child, or spouse of the employer), government employees, and the self-employed. State and local government employees are included in Hawaii, and the other state programs generally provide elective coverage for some or all public employees.

Agricultural workers are covered to varying degrees in California, Hawaii, New Jersey, and Puerto Rico, but they are not covered in other jurisdictions. The California law permits self-employed individuals to elect coverage on a voluntary basis. Workers employed by railroads, railroad associations, and railroad unions are covered by TDI under the national system included in the Railroad Unemployment Insurance Act.
The methods used for providing this protection vary. In Rhode Island, the coverage is provided through an exclusive, state-operated fund into which all contributions are paid and from which all benefits are disbursed. In addition, covered employers may provide supplemental benefits in any manner they choose. The railroad program is also exclusively publicly operated in conjunction with its unemployment insurance provisions. In California, New Jersey, and Puerto Rico, coverage is provided through a state-operated fund, but employers are permitted to "contract out" of the state fund by purchasing group insurance from commercial insurance companies, by self-insuring, or by negotiating an agreement with a union or employees' association. Coverage by the state fund is

automatic unless or until an employer or the employees take positive action by substituting a private plan that meets the standards prescribed in the law and is approved by the administering agency. Premiums (in lieu of contributions) are then paid directly to the private plan, and benefits are paid to the workers affected.

The laws in Hawaii and New York require employers to provide their own disability insurance plans for their workers by setting up an approved self-insurance plan, by reaching an agreement with employees or a union establishing a labor-management benefit plan, or by purchasing group insurance from a commercial carrier. In New York, the employer may also provide protection through the State Insurance Fund, which is a state-operated competitive carrier. Both Hawaii and New York operate special funds to pay benefits to workers who become disabled while unemployed or whose employers have failed to provide the required protection. In other jurisdictions, benefit payments for the disabled unemployed are made from the regular state-operated funds.

Eligibility for Benefits

To qualify for benefits, a worker must fulfill certain requirements regarding past earnings or employment and must be disabled as defined in the law. In addition, claimants may be disqualified if they received certain types of income during the period of disability.

Earnings or Employment Requirements
A claimant must have a specified amount of past employment or earnings to qualify for benefits. However, in most jurisdictions with private plans, the plans either insure workers immediately upon their employment or, in some cases, require a short probationary period of employment, usually from 1 to 3 months. Upon cessation of employment after a specified period, workers generally lose their private plan coverage and must look to a state-created fund for such protection.

Disability Requirements

The laws generally define disability as inability to perform regular or customary work because of a physical or mental condition. Stricter requirements are imposed for disability during unemployment in New Jersey and New York. All the laws pay full benefits for disability due to pregnancy.

Disqualifying Income

All the laws restrict payment of disability benefits when the claimant is also receiving workers' compensation payments. However, the statutes usually contain some exceptions to this rule (for example, if the workers' compensation is for partial disability or for previously incurred work disabilities).

The laws differ with respect to the treatment of sick leave payments. Rhode Island pays disability benefits in full even though the claimant draws wage continuation payments. New York deducts from the benefits any payment from the employer or from a fund

contributed to by the employer, except for benefits paid pursuant to a collective bargaining agreement. In California, New Jersey, and Puerto Rico, benefits plus paid sick leave for any week during disability may not exceed the individual's weekly earnings before their disablement. Railroad workers are not eligible for TDI benefits while they receive sick leave pay.

In all seven TDI systems, as with unemployment insurance, weekly benefit amounts are related to a claimant's previous earnings in covered employment. In general, the benefit amount for a week is intended to replace at least one-half the weekly wage loss for a limited time. All the laws, however, specify minimum and maximum amounts payable for a week. The maximum duration of benefits varies from 26 weeks to 52 weeks. Hawaii, New York, and Puerto Rico provide for benefits of a uniform duration of 26 weeks for all claimants; California and the railroad program have maximum benefit periods of 52 weeks; New Jersey, 26 weeks; and Rhode Island, 30 weeks. Under the railroad program, duration of benefits varies from 26 weeks to 52 weeks, on the basis of the total number of years of employment in the industry. In the other jurisdictions, limited predisability "base period" wages reduce benefit duration. A noncompensable waiting period of a week or 7 consecutive days of disability (4 days for railroad workers) is generally required before the payment of benefits for subsequent weeks.

The statutory provisions described above govern the benefits payable to employees covered by the state-operated plans. In those states where private plans are permitted to participate, those provisions represent standards against which the private plan can be measured (in accordance with provisions in the state law).

Financing and Administration

Under each of the laws, except for that governing the railroad program, employees may be required to contribute to the cost of the temporary disability benefit. In five of the jurisdictions (all but California and Rhode Island), employers are also required to contribute. In general, the government does not contribute.

Four of the seven TDI programs are administered by the same agency that administers unemployment insurance. Under those five programs, the unemployment insurance administrative machinery is used to collect contributions, to maintain wage records, to determine eligibility, and to pay benefits to workers under the state-operated funds. The New York law is administered by the state Workers' Compensation Board, and the Hawaii law is administered separately in the Department of Labor and Industrial Relations.

By way of contrast, claims in New York and Hawaii are filed with and paid by the employer, the insurance carrier, or the union health and welfare fund that is operating the private plan. The state agency limits its functions with respect to employed workers to exercising general supervision over private plans, to setting standards of performance, and to adjudicating disputed claims arising between claimants and carriers. A similar

situation applies to claimants under private plans in California, New Jersey, and Puerto Rico.

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www.socialsecurity.gov/policy/docs/statcomps/supplement/2006/tempdisability.pdf