Community Mitigation Guidelines to Prevent Pandemic Influenza – United States, 2017

Technical Report 1: Chapters 1-4

The boxes, figures, and tables referred to in these chapters are in the affiliated MMWR RR report. The appendices referred to in this document can be found in Technical Report 2.

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Chapter 1: Introduction and NPI Overview

Introduction

NPIs: Our Earliest Line of Defense

Influenza pandemics are inherently unpredictable, caused by newly emerging viruses to which humans have little or no immunity and which develop the ability to infect and be transmitted efficiently for a sustained period of time in the community between humans. They differ in geographical and biological origin, transmissibility, and propensity for causing severe illness (1, 2). When a pandemic emerges, the most effective countermeasure – a vaccine against the new pandemic virus – may not be widely available for up to six months and may not be produced in sufficient quantities to immunize all risk groups (including school-aged children[*]) for 6-10 months (2). Moreover, antiviral medications, which can ameliorate symptoms if provided within 48 hours of onset, may be reserved for treatment only, may not be effective against a new pandemic strain, or may quickly become ineffective due to the emergence of drug resistance.

A comprehensive community strategy for mitigating the impact of a pandemic must, therefore, address not only medical countermeasures (3-6) but also nonpharmaceutical interventions (NPIs) – our first line of defense at the earliest stages of a pandemic. NPIs are actions, apart from getting vaccinated and taking medicine, which people and communities can take to help prevent the spread of respiratory illnesses like influenza. The basic concept is to reduce the occurrence and duration of human interactions by implementing social distancing measures in combination with personal and environmental hygiene measures. NPIs also are known as community mitigation strategies.

NPIs may be implemented in different settings, including homes, schools, workplaces, and places where people gather (e.g., parks, churches, theaters, and sports arenas). Personal protective measures include *"everyday preventive actions,"* such as voluntary home isolation of ill persons, respiratory etiquette, and hand hygiene (7). Community measures include temporary school closures and dismissals and other social distancing measures, such as minimizing face-to-face contact at workplaces or cancelling mass gatherings (8). To be effective, these measures must be implemented early and strategically targeted, layered, and tailored to pandemic severity, and their public health benefits must be balanced against economic and social costs.

NPIs that do not require medical resources or specialized equipment are universally available to all individuals and population groups. Their timely implementation can reduce illness and death while building the skills, self-reliance, and resourcefulness that enable individuals to cope with emergency situations. Enhanced understanding of NPIs and the capacity to implement these measures in response to an emerging pandemic has the potential to increase the resilience of communities as well as individuals. Building and sustaining *healthy, resilient communities* is one of five strategic objectives of the HHS *National Health Security Strategy and Implementation Plan 2015-2018,* which aims to "encourage social connectedness, enhance coordination of health and human services through partnerships, and build a culture of resilience" (https://www.phe.gov/Preparedness/planning/authority/nhss/Pages/communities.aspx). In 2015, the National Association of County and City Health Officials and the HHS Office of the Assistant Secretary for Preparedness and Response enrolled three local public health departments (in Kentucky, Nebraska, and Texas) into a pilot program to test whether Mobilizing for Action through Planning and Partnerships (MAPP) could be used as a strategy to improve local-level community resilience. By using this interactive community-driven/-owned process, all three pilot sites demonstrated marked improvements in community resilience (http://nacchopreparedness.org/using-mapp-to-improve-community-resilience/).

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[*]Healthy school-aged children are included in tier 3 (out of 5) of the vaccine prioritization strategy for responding to a severe pandemic outlined in the 2007 *HHS Guidance on Allocating and Targeting Pandemic Influenza Vaccine* (https://www.cdc.gov/flu/pandemic-resources/pdf/allocatingtargetingpandemicvaccine.pdf). Although this vaccine prioritization strategy was implemented during the 2009 H1N1 pandemic response, priority groups will need to be re-evaluated for future pandemics, given the unique features of each pandemic.

Updating the 2007 *Community Mitigation Strategy*

In 2007, CDC issued the *Interim Pre-pandemic Planning Guidance: Community Strategy for Pandemic Influenza Mitigation in the United States – Early, Targeted, Layered Use of Nonpharmaceutical Interventions* to provide planning guidance for state, tribal, local, and territorial public health authorities (stacks.cdc.gov/view/cdc/11425/cdc_11425_DS1.pdf). This document – the *Community Mitigation Guidelines to Prevent Pandemic Influenza – United States, 2017* – updates the 2007 *Community Strategy*, taking into account recent scientific findings as well as lessons learned during the influenza A (H1N1)pdm09 pandemic (hereafter referred to as the 2009 H1N1 pandemic) (Box 1). The 2017 guidelines include a "Toolbox" of NPIs recommended as effective tools for preventing disease spread, based on research evidence summarized in Appendix 5.

The 2007 *Community Strategy* was developed with a severe pandemic in mind, amid fears that the highly pathogenic avian influenza A (H5N1) virus – which re-emerged in Asia in 2003 among domestic poultry and spread to Africa, the Middle East, and Europe among poultry with sporadic zoonotic transmission – would cause an influenza pandemic. Moreover, it was thought that a novel influenza A (H5N1) virus would most likely emerge overseas, providing the United States (U.S.) with lead time to prepare for a response that would make use of pre-pandemic H5N1 vaccine in the Centers for Disease Control and Prevention (CDC) Strategic National Stockpile. Instead, the next pandemic influenza A virus was a novel H1N1 strain that apparently emerged in southern Mexico and was first identified when two cases were reported in California (https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5815a5.htm). Although the impact of the 2009 H1N1 pandemic in the United States was moderate in terms of overall morbidity and mortality, severe outcomes from H1N1 infection were common in children, young adults, and specific risk groups, such as pregnant women (Box 1; https://www.cdc.gov/h1n1flu/estimates_2009_h1n1.htm).

The H1N1 experience taught us that effective pre-pandemic planning must be broad and flexible because we cannot know in advance when a human novel influenza A virus will emerge, how quickly the virus may spread, or how severely it may affect adults, children, or vulnerable sub-groups. The 2017 guidelines therefore provide four pre-pandemic planning scenarios to help partners prepare for implementing NPIs during different pandemic situations (Chapter 2).

NPI Overview

NPI Goals and Rationale

As shown in Figure 1, specific NPI implementation goals include:

- **Slowing acceleration of the number of cases in a community** to buy time for the development, distribution, and wide-scale administration of a well-matched pandemic vaccine to targeted populations.
- **Reducing the peak number of cases during the pandemic and related health care demands on hospitals and infrastructure**, to the extent possible, by reducing peak daily cases of illness to put less stress on the healthcare system and to protect critical infrastructure and key resources (e.g., public health and healthcare systems and utility services) that might otherwise be affected by high rates of worker absenteeism.
- **Decreasing overall cases and health effects** by reducing the overall risk of infection in the community and thereby protecting the most vulnerable from acquiring an infection that may lead to severe outcomes.

The collective impact of early, layered, and strategically targeted NPIs (Table 1) may be monitored over the course of a pandemic by measuring their ability to reduce the "Basic Reproductive Number, R_0" – the average number of new infections produced by a typical infectious person who transmits the virus to others in a fully susceptible population in the absence of interventions (9-11). A pandemic with a reduced R_0 will spread more slowly through the population and have a lower peak attack rate, thus delaying the peak of the outbreak and resulting in a smaller percentage of the population infected.

An analysis of R_0 measurements made during seasonal, pandemic, and zoonotic influenza outbreaks found that R_0 is significantly higher during pandemics (median: 1.45–1.80) than during seasonal (1.27) or zoonotic (0.34) influenza outbreaks (12). Assuming a typical serial interval of 2.6 days (13-15) and a population with an even distribution of susceptible persons – the number of influenza cases at the very beginning of an unmitigated pandemic could double every 3-4 days, causing a 10-fold increase every 1-2 weeks. However, a growing body of evidence – summarized in Appendix 5 – suggests that early use of multiple NPIs can reduce R_0 and slow this rapid spread, helping to achieve the three NPI goals as the pandemic moves through the community.[†,‡]

NPI Pre-pandemic Planning Issues

Effective pre-pandemic planning requires consideration of which NPIs are likely to be needed at each stage. When a pandemic emerges, public health authorities will reiterate the importance of *personal protective measures for everyday use*, including voluntary home isolation of ill persons (i.e., staying home when ill or self-isolation), respiratory etiquette, and hand hygiene, as well as *environmental surface cleaning measures*, which are routinely recommended at all times (Table 1). Depending on the local situation, *personal protective measures reserved for a pandemic* – voluntary home quarantine of exposed household members (i.e., all household members stay home when a household member is ill) (16) and use of face masks by ill persons – also may be recommended (Table 1). A more difficult decision will be how and when to implement *community-level NPIs* that are more disruptive to society, such as temporary school closures and dismissals and cancellation of mass gatherings (8) (Table 1). This decision will be made by states and localities (see below), based on local conditions and guided by recommendations from CDC and state and local authorities (17). The aim will be to implement NPIs early enough and long enough to maximize effectiveness, while minimizing economic and social costs and ensuring that the NPIs are commensurate to the pandemic threat. When a pandemic virus emerges, challenges will include:

- Making decisions on NPI selection and timing that take into account uncertainty about:
  - The availability of epidemiologic data on the clinical severity and transmissibility of the new pandemic virus
  - Which population groups are most at-risk for severe health outcomes
  - The timeline for production, distribution, and administration of vaccines
  - The availability, effectiveness, and distribution of antiviral medications
- Balancing the public health benefits of NPIs against economic and social costs (including opportunity costs) and mobilizing the public to implement NPIs. CDC will work with state and local public health authorities to describe the overall response strategy and rationale for NPIs, the public health benefits of NPIs, and plans for mitigating any secondary consequences. Public acceptance of NPIs may be more difficult to achieve if the initial public health data do not match the public's perception of the pandemic's severity.[§]
- Understanding the need for flexible decision-making and possible course correction as the pandemic progresses (17) because guidance will likely change over the course of a response as new information is gathered.

Pre-pandemic planning – along with community engagement (see below) – is essential to meet these challenges. It is suggested that states and localities establish local planning councils[**]and/or hold public engagement meetings that focus on public health preparedness, pandemic education, and planning before a pandemic occurs. States and local communities also may draw on planning guidance provided in the CDC *Public Health Preparedness Capabilities: National Standards for State and Local Planning*, which lists NPIs as one of 15 capabilities. Based

[†]While achieving these goals is essential, public health authorities should ensure that the public health benefits and social costs of each NPI measure are appropriate and balanced for the severity of the pandemic (see *NPI Pre-pandemic Planning Issues*).

[‡]As described in Table 5, R_0 measurements taken at the earliest stages of a pandemic also can help public health authorities as one part of the assessment of a pandemic's potential severity and impact.

[§]Social media tools that can help state and local authorities gauge public perception of pandemic risk and the acceptability of school closures and other NPIs are under development (Appendix 7).

[**]Some states may consider re-constituting the planning group that developed that state's pandemic preparedness plan (https://www.cdc.gov/flu/pandemic-resources/planning-preparedness/state-local-government-planning.html).

on jurisdictional risk assessments, states and localities are encouraged to develop jurisdictional NPI "playbooks," detailing plans for recommending and/or implementing potential NPIs (https://www.cdc.gov/phpr/capabilities/DSLR_capabilities_July.pdf). Points to consider as part of pre-pandemic planning are summarized in Table 2; these include:

Ethical Considerations. Influenza pandemics will impact the lives of individuals, their daily activities, and the routine functioning of society. Some NPIs, especially community-level measures, may have secondary consequences for individuals, families, and communities, such that they may cause economic hardship and/or reduce availability of certain services. In addition, they may have to be recommended early in an evolving pandemic (i.e., before the pandemic's impact in terms of increased morbidity and mortality may be obvious to all). Therefore, public input into NPI planning (e.g., via public engagement meetings) is essential to ensure that the rationale for community mitigation is understood before a pandemic strikes; that public health resources are distributed equitably; and that NPIs benefit all groups, including people at high medical risk and people who live in medically underserved areas. For more information on ethical considerations when forming pandemic influenza plans, see: https://www.cdc.gov/od/science/integrity/phethics/panFlu_Ethic_Guidelines.pdf.

Feasibility of NPI Implementation. State and local planners should identify practical obstacles to NPI implementation and identify ways to overcome them. Examples include: a) financial issues (e.g., workers who cannot afford to stay home when they are ill or when a family member is ill because they do not have paid sick leave); b) legal issues (e.g., local jurisdictions that do not have the legal authority to close schools or cancel mass gatherings for public health reasons); and c) workplace issues (e.g., access to clean water, soap, or hand sanitizer in the workplace; ability for spacing people in the workplace; telework options; and flexible sick and other leave policies).

Activation Triggers, Layering, and Duration of NPIs. Computer simulations and historical studies suggest that NPIs are most effective when implemented early in a pandemic outbreak and used in a layered and sustained manner (Appendix 5). Studies of the 1918 pandemic found that early implementation of layered NPIs correlated with better public health outcomes in several American (18, 19) and Australian (20) cities. During the 1918 pandemic, cities such as St. Louis and Denver that implemented layered NPIs in a timely fashion (within 2-3 weeks of the earliest reported dates of the first influenza cases) experienced lower mortality rates than cities such as Pittsburgh that did not (roughly a month after the first influenza cases were reported) (19). Specific operational issues important for NPI planning and implementation may include:

Activation Triggers. State and local planners could use Pre-pandemic Planning Scenarios developed by CDC (page 15) to consider potential NPI activation triggers for their communities prior to a pandemic, keeping in mind that the public is more likely to accept temporary school closures and other social distancing measures during more severe pandemics.

Table 3 lists examples of possible *early* influenza surveillance indicators that states and localities might use as potential activation triggers for NPI implementation (e.g., increased patient visits to healthcare providers for influenza-like illness [ILI]; increased ILI activity within a school (21, 22); increased ILI activity in a state, especially outside of the annual influenza season; or increased geographic spread of influenza within a state, coupled with resulting moderate to severe health impacts that require medical intervention). However, these indicators are not based on real-time data, nor are they sensitive enough to detect the initial circulation of a novel virus. More sensitive triggers – like one or two newly detected novel influenza virus cases in an area known to have less-sensitive surveillance mechanisms in place – for implementation of additional social distancing measures, such as school closures – may be warranted at the start of an evolving pandemic for which an initial assessment indicates elevated clinical severity and/or transmissibility. These triggers will have to be adjusted and refined as more data become available and as the virus circulation becomes more widespread. Table 3 also includes *late* influenza surveillance indicators that could provide confirmation that NPI implementation should continue (e.g., increased influenza-associated hospitalizations; or increases in adult or pediatric deaths attributed to influenza). As found in a 2013 national assessment of state-level epidemiology and surveillance capacity, many states may not have the technological capacity needed to conduct modern methods of surveillance (e.g., they lack cluster-detection software [71% of states], outbreak management systems [55%], and/or electronic laboratory reporting [34%]) (http://www.cste2.org/2013eca/CSTEEpidemiologyCapacityAssessment2014-final2.pdf). Thus, the use of *early* or *late* influenza surveillance indicators may differ across and/or within states and localities, depending on the availability and capacity of their public health resources. CDC will work with public health authorities to help provide decision-support data to assist them in improving surveillance capacity and implementing NPIs.

In some states and localities, ILI monitoring in local schools could provide additional surveillance indicators that might trigger school closures and dismissals during a severe, very severe, or extreme pandemic, especially in communities with limited or no access to laboratory testing. For example, in one study, correlations were calculated between laboratory-confirmed influenza and ILI-related absenteeism, all-cause absenteeism, and ILI-related school health office visits. The authors found that ILI-related absenteeism, as a school-based surveillance indicator, correlated best, in terms of the timeliness and rate of cases identified, with the standard laboratory-confirmed influenza indicator (21). However, any indicator used as a trigger for school closures would need to be activated early enough for maximal effectiveness. Implementing school closures after the virus circulation has already been established among children (as suggested by high ILI-related school absenteeism) and in the community might not be effective if the goal of school closures is to reduce transmission of the novel virus in schools and the surrounding community (23). Lower-threshold triggers might be considered when targeting NPIs to high-risk groups (see below). For example, even during a pandemic characterized by mild or moderate clinical severity, public health authorities may still recommend that pregnant women and persons with underlying chronic diseases avoid places where people congregate and other protective measures.

Layering. Optimal use of NPIs to help prevent virus transmission requires the application of multiple, partially effective NPIs that are phased-in – or "layered" – over the course of the pandemic, depending on the pandemic's severity and on local transmission patterns (Figure 5) (see *Chapter 3, NPI Toolbox: Evidence Base, Implementation Issues, and Research Gaps*). For example, trials conducted during the 2009 H1N1 pandemic found that early combined use of face masks and hand hygiene reduced influenza transmission within households (24, 25). A systematic literature review of hand hygiene trials and observational studies concluded that a combination of NPIs – including hand hygiene, face masks, and isolation of ill persons – provides the largest degree of protection (26). Modeling studies also suggest that NPIs, vaccines, and antivirals may have a greater total effect when used in combination than when implemented separately (27). NPIs used in combination can act in complementary (or even synergistic) ways to "plug holes" that facilitate virus transmission in different circumstances and settings (e.g., in homes, schools, and workplaces). The combined effect of applying multiple NPIs has been likened to layering slices of Swiss cheese until every hole is covered (28).

Duration. Premature discontinuation of NPIs may risk reintroduction of the virus. The duration of an NPI may be too short to achieve significant reductions in attack rates. In addition, lengthy periods of NPI implementation may not be acceptable, or may lead to intervention fatigue and/or substantial economic costs and social disruption (29). Intervention fatigue is most likely to occur when the public does not perceive the health risk to be high, particularly when interventions are implemented over long periods of time. In that case, CDC will work with state and local public health authorities to provide ongoing justification and rationale for continuing the use of NPIs. For example, when implementing school closures and dismissals, local authorities might issue health assessments every few days or once a week, until a decision is made to re-open the schools. Advance planning and public funding also may be needed to reduce secondary consequences of NPIs (e.g., by substituting or redesigning certain services, such as school-based lunches and routine educational activities, until schools re-open).

Targeting NPIs to At-risk and Vulnerable Groups. State and local planners should identify community-level mechanisms for protecting children and adults at risk for severe outcomes of influenza for all pandemic scenarios. Whether a pandemic is mild or severe, targeting NPIs to at-risk individuals (along with their prioritization for vaccination and treatment with antiviral medications) can reduce illness and save lives while minimizing economic costs and social disruption (30).

We cannot know in advance which groups will be most at-risk for severe outcomes during the next pandemic. However, state and local planners may want to plan in advance to ensure timely implementation of community-level measures that protect groups typically at higher risk for influenza complications, such as pregnant women; the very young and very old; persons with certain health conditions (like heart, lung, or kidney disease or weakened immune systems); individuals with extreme obesity; or people who are institutionalized. They also may want to identify strategies to target NPIs to socially vulnerable groups, such as people who are culturally, geographically, or socially isolated; people with physical disabilities, limitations, or impairments; people living in congregate settings; individuals and families experiencing homelessness; or people living in medically underserved communities.

Public Acceptance of NPIs. During a pandemic, consistent and frequent public health risk communications will be essential to sustain community resilience and promote active participation in NPI implementation by individuals, institutions, and public and private community partners. Planning guidance on the development, coordination, and dissemination of emergency public health information (including alerts, warnings, and notifications to the public and incident management responders) is provided in the CDC *Public Health Preparedness Capabilities: National Standards for State and Local Planning* (https://www.cdc.gov/phpr/capabilities/DSLR_capabilities_July.pdf).

As discussed in the next section, it is suggested that state and local planners conduct public engagement meetings as part of pandemic preparedness, which will provide stakeholder groups and members of the public with opportunities to discuss the benefits, challenges, and trade-offs associated with implementing NPIs during a pandemic.[††] State and local planners also might use the four Pre-pandemic Planning Scenarios (page 15) to stimulate public dialogue on the possible need for school closures and dismissals and other social distancing measures during a pandemic and ways to mitigate their secondary consequences. In addition, they might consider preparing scenario-specific public health messages on the use of particular NPIs.

Balancing Public Health Benefits and Social Costs. It is especially important for planners to consider, in advance, how their communities might balance the public health benefits of NPIs – in terms of reduced illness and death – against the economic and social costs associated with different pandemic scenarios (31). In regard to school closures and dismissals, this might involve consideration of such costs as loss of education hours for students, loss of income for parents who remain home with their children, students being left at home alone, students missing school-provided meals, and healthcare workers missing shifts when they must stay home with their children. Planners also might consider ways to mitigate these costs. For example, loss of school time might be off-set by distance-learning courses that may be taken at home (e.g., via the Web, e-mail, or local TV or radio), and loss of income by parents might be off-set by having local businesses adopt flexible leave policies during the pandemic. Communities also might consider making alternative arrangements for providing school-based meals and health services. Depending on local resources and preferences, different communities may reach different conclusions about the degree of pandemic severity required before (for example) schools dismiss students and businesses start encouraging workers to telecommute.

Monitoring and Evaluation (M&E) of NPIs. During a pandemic, CDC and state and local public health departments are advised to collect data on:

- Degree of transmission and severity of the evolving pandemic
- Type and degree of NPI implementation

[††]Examples of public engagement efforts conducted by state and local health departments and/or CDC in collaboration with the Keystone Center may be found at: https://www.keystone.org/our-work/health/health-past-projects/.

- Level of compliance with NPI measures and the emergence of intervention fatigue
- Effectiveness of NPIs in mitigating pandemic impact (e.g., effect on virus transmission, hospitalizations, and deaths)
- Secondary consequences of NPIs and the effectiveness of strategies to mitigate them

Planning challenges include developing appropriate M&E tools before a new pandemic occurs; building M&E capacity and capabilities; identifying or establishing public health surveillance systems that can access all groups (particularly vulnerable populations) within the community (e.g., survey mechanisms using social media tools; Appendix 7); developing databases for the collection, storage, and analysis of NPI M&E data; and securing the necessary funds to conduct these studies.

Public health authorities should not expect to have information on the effectiveness and secondary consequences of NPIs while the pandemic is ongoing. Instead, most of the analysis and evaluation of the M&E data is likely to occur after the pandemic subsides, providing insight into how to improve NPI use during future pandemics (i.e., how to maximize effectiveness while minimizing secondary consequences and how to improve risk communications about the need for – and optimal use of – NPIs). Monitoring and evaluating the effectiveness of NPIs in mitigating pandemic impact poses special challenges because it is not ethical or feasible to compare disease rates with and without NPIs.

Community Engagement and Preparedness

Community engagement in pre-disaster planning – involvement of the public and of local leaders, organizations, and stakeholders – is essential to ensure timely and effective use of NPIs to limit disease spread during a pandemic. Effective use of NPIs will depend on active participation by individuals and families (e.g., to implement voluntary home isolation of ill persons, respiratory etiquette, hand hygiene, voluntary home quarantine of exposed household members, and face mask use when ill) and by communities (e.g., to implement temporary school closures and dismissals, workplace social distancing measures, and mass gathering cancellations; Table 1). The specific aims of NPI-related community engagement efforts are to ensure that:

- Local health authorities are prepared to make decisions and recommendations about NPIs that reflect community values, especially when faced with data gaps and uncertainty; and
- Individuals and communities are prepared to implement NPIs over the course of a pandemic.

Principles of Community Engagement to Protect the Public's Health. The CDC/ATSDR document *Principles of Community Engagement* (Box 2) emphasizes that community involvement and collaboration are cornerstones of public health action. It lays out nine principles to guide the planning, initiation, and maintenance stages of community engagement efforts. The principles for the *planning stage* stress the need for clear goals and an appreciation of the aims and activities of potential community partners. The principles for the *initiation stage* stress the need to establish relationships and build trust, based on common goals and a shared understanding that collective self-determination is the responsibility and right of all people in a community. The principles for the *maintenance stage* stress the need to sustain effective partnerships and long-term commitment; to recognize diversity within a community; to identify and mobilize community assets and strengths; and to be prepared to release control of actions to the community and be flexible enough to meet its changing needs.

These principles are in good accord with NPI guidance provided in *Public Health Preparedness Capabilities: National Standards for State and Local Planning*. The *National Standards* include *Community Preparedness* – the ability to prepare for, withstand, and recover from public health incidents – as the first of 15 capabilities that underlie local emergency preparedness, and *Non-Pharmaceutical Interventions* – the ability to implement strategies for disease, injury, and exposure control – as the eleventh capability. Implementation of the *Community Preparedness* capability includes building community partnerships to support health preparedness, engaging with community organizations, and coordinating training and guidance to ensure community engagement in preparedness efforts. Implementation of the *Non-Pharmaceutical Interventions* capability includes engaging partners, identifying factors that impact NPIs, and determining, implementing, and monitoring NPIs. The

Principles of Community Engagement also are in good accord with emergency preparedness guidance provided in:

- *A Whole Community Approach to Emergency Management: Principles, Themes, and Pathways for Action,* FEMA's strategic framework for community engagement to increase community security and resilience (http://www.fema.gov/library/viewRecord.do?id=4941). This document emphasizes the need to understand and meet the needs of the whole community; to engage and empower all parts of the community; and to strengthen what works well in communities on a daily basis. In September 2011, at FEMA's request, the CDC Foundation, in partnership with the CDC Office of Public Health Preparedness and Response, selected seven U.S. communities – in Arizona, California, Louisiana, Michigan, Missouri, New York, and Oregon – to receive resources and expertise to expand their preparedness efforts and identify and share promising practices (http://www.cdcfoundation.org/whole-community-promising-examples). An example of a best practice that might be used to encourage community engagement before and during a pandemic is the use of broadcast alerts sent via cell phone texts by the NYC *Partners in Preparedness* project.
- *The National Health Security Preparedness Index (NHSPI)* (http://www.nhspi.org/), administered by the Association of State and Territorial Health Officials in partnership with CDC, to measure and advance national preparedness by looking collectively at the health security preparedness of U.S. states. The 2013 NHSPI identified *Community Planning and Engagement* – working across the whole of a community, including the full network of neighborhoods, schools, community-based organizations, governmental agencies, and individual citizens – as an area in need of further development to ensure better preparedness and improved health security.

Leadership and Outreach. A national survey conducted in 2012 by the Center for Health Security at the University of Pittsburgh Medical Center and the National Association of County and City Health Officials found that health departments across the nation are engaging individuals, community partners (particularly community- and faith-based organizations [CBOs/FBOs]), and stakeholders in collaborative activities to enhance emergency preparedness at the local level (32). As part of these activities, it is suggested that state and local health departments also lead community-wide efforts to advance NPI preparedness and planning, guided by the *Principles of Community Engagement* and assisted by public health partners (e.g., professional societies, schools of medicine or public health, foundations, or non-governmental organizations concerned with public policy). Community partners and stakeholders may include healthcare facilities, pharmacies, first responders, educational institutions, local businesses and corporations, and CBOs/FBOs, including organizations that represent groups who may be at high risk during a pandemic (e.g., children, the elderly, and individuals with disabilities). Some of these partners and stakeholders may have participated in earlier efforts to develop state-level pandemic influenza preparedness plans (https://www.cdc.gov/flu/pandemic-resources/planning-preparedness/state-local-government-planning.html).

Outreach to community leaders, organizations, and stakeholders may involve a series of meetings that focus on specific questions or policy issues related to implementation of NPIs during a pandemic. Other forums for raising issues and exchanging ideas may include web-based dialogues, tabletop exercises, social media platforms, community meetings, surveys, and opinion polls (Box 1). In each case, the aim is to elicit input from a large and diverse group of people to illuminate core public values and identify approaches to NPI implementation that are in good accord with the community's requirements and needs.

NPI Issues for Community Discussion. Group discussions might begin by considering ways to coordinate pre-pandemic planning efforts by local government agencies, healthcare organizations, businesses, educational institutions, CBOs/FBOs, and other stakeholders (e.g., by sharing pandemic plans, arranging collaborative training programs, and participating in community-wide exercises). It also might be useful to identify specific resources that each partner can provide during a pandemic (e.g., the ability to organize volunteers or provide information on NPIs to vulnerable groups). Other discussion topics might include:

- How can individuals and families be better prepared to implement personal protective measures during a pandemic?
- What actions can be taken by local businesses and CBOs/FBOs to make it easier for people to stay home when ill or when a household member is ill?
- What measures can be taken by businesses, educational institutions, and CBOs/FBOs to reduce social contact during a pandemic?
- What criteria will public health authorities use to decide whether and how to implement school closures or cancellations of mass gatherings?
- What actions can be taken to mitigate the secondary consequences of temporary school closures?

As part of these discussions, participants may want to review lessons learned about NPI implementation during the 2009 H1N1 pandemic (Box 1) or consider the references and resources listed in Appendix 7.

Follow-Up. State and local public health authorities may provide community partners with written minutes for each public engagement meeting (or other discussion forum), along with notices of follow-up meetings and meeting agendas. The goal is to continue discussions of each NPI issue until roles and responsibilities for NPI implementation are clearly defined and agreed upon. Thereafter, the meetings may take place less frequently, serving as a way to:

- Continue to exchange information about new issues, resources, and scientific developments;
- Introduce new individuals to the group, as positions turn over; and
- Ensure that partnerships are well-established when an actual pandemic occurs.

A community that has come together to consider NPI implementation as part of pre-pandemic planning will be more likely to remain engaged and active once an influenza pandemic has begun. Such a community will be better able to communicate, coordinate, and access the public and private resources needed to prevent disease spread and protect its most vulnerable members.

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Chapter 2: New Tools for Assessment, Planning, and Guidelines Development

Our experience during the response to the 2009 H1N1 pandemic underscored the need for improved ways to characterize an emerging pandemic and assist states and localities in planning for a range of potential scenarios (Box 1). Since 2009, CDC and its partners developed a planning tool called the Novel Influenza Virus Pandemic Intervals, which describes sequential units of time in the progression of a pandemic (1); evaluation tools for assessing the pandemic potential of influenza A viruses circulating in animals (the Influenza Risk Assessment Tool [IRAT]) (2) and the severity of an emerging pandemic (the Pandemic Severity Assessment Framework [PSAF]) (3); and four Pre-pandemic Planning Scenarios that can help guide the use of NPIs during different pandemic situations (page 15). This chapter also summarizes World Health Organization (WHO) guidance on pandemic phases, pandemic severity assessments, and planning for NPI implementation (4).

Novel Influenza Virus Pandemic Intervals

The Novel Influenza Virus Pandemic Intervals were created to advance and harmonize pandemic preparedness efforts in U.S. states and localities by providing a common framework for planning and response (1).[‡‡] The Intervals – which align with the Pandemic Phases defined by WHO (Figure 2) – include:

- Investigation of novel influenza cases (which might or might not be the first indication of an emerging pandemic)
- Recognition of potential for ongoing transmission
- Initiation of the pandemic wave
- Acceleration of the pandemic wave
- Deceleration of the pandemic wave
- Preparation for a future pandemic

The Intervals are defined by surveillance indicators that delineate transitions from one Interval to the next (Table 4). They can be used in pre-pandemic planning and also serve as tools to support public health decision-making during a pandemic. Each Interval is associated with particular response activities (Figure 2), including the implementation of select NPIs during the Initiation and Acceleration Intervals, and the coordinated discontinuation of select community-level NPIs reserved for pandemics during the Deceleration Interval.

Influenza Risk Assessment Tool (IRAT) for Influenza A Viruses Circulating in Animals

The Influenza Risk Assessment Tool (IRAT) is used by CDC to measure the potential pandemic risk posed by influenza A viruses that circulate in animals, but not yet in humans, by evaluating two factors: *Emergence* and *Public Health Impact* (2). *Emergence* refers to the risk that a novel influenza virus will acquire the ability to spread easily and efficiently in people. *Public Health Impact* refers to the potential severity of human disease caused by a novel virus if it were to spread efficiently and sustainably among people.

The IRAT uses 10 scientific criteria to produce a quantitative measure of *Emergence* and *Public Health Impact* for any given novel influenza virus. The criteria fall into three categories: 1) properties of the virus, 2) attributes of the affected population, and 3) ecology and epidemiology of the virus. The novel virus receives a score for each criterion, and those scores are averaged to calculate a composite score that allows ranking and comparison of viruses in terms of pandemic risk. Those viruses that have a high score (e.g., the H5N1 virus) are flagged for continued and intensive public health surveillance. The ongoing identification of newly emerged avian influenza

[‡‡]The Intervals replace the USG stages described in the 2007 *Community Strategy* (https://stacks.cdc.gov/view/cdc/11425/cdc_11425_DS1.pdf). Of note, though the surveillance indicators described in Tables 3 and 4 are different, they can be used to complement, support, and inform each other.

A viruses that can cause disease in humans (e.g., the H7N9 virus) underscores the need to be prepared to implement response measures, including NPIs.

Pandemic Severity Assessment Framework (PSAF)

Assessing Pandemic Severity and Health Impact

When a novel influenza virus emerges that can spread easily and efficiently and cause a pandemic, CDC and partners must gauge its projected impact and recommend rapid action to reduce virus transmission, protect vulnerable population groups, and minimize societal disruption (5). Historically, the severity of influenza pandemics has been estimated by calculating case-fatality ratios.[§§] However, as we learned during the 2009 H1N1 pandemic (Box 1), case-fatality ratios may be difficult to measure early in a pandemic because of care-seeking behavior and testing practices (i.e., not everyone will seek care for their illness, and not everyone will be tested and diagnosed with pandemic influenza). As a result, severe and fatal cases may be more likely to be reported, creating a bias.

Due to such limitations, reliance on any single measure of viral transmission or clinical outcomes is unlikely to provide an accurate estimate of the potential impact of an emerging pandemic. CDC has, therefore, developed a new assessment framework that uses multiple clinical and epidemiologic indicators to create a comprehensive picture of the potential impact of an emerging pandemic (3). As indicated in Tables 5 and 6, the Pandemic Severity Assessment Framework (PSAF) estimates *pandemic severity* (or *health impact*) by synthesizing multiple measurements of:

- **Viral transmissibility**, including school, workplace, and/or community attack rates, secondary household attack rates, school and/or workplace absenteeism rates, and rates of emergency department and outpatient visits for ILI.
- **Clinical severity**, including case-fatality ratios, case-hospitalization ratios, and deaths-hospitalizations ratios.

Additional PSAF data may be obtained by characterizing genetic markers in a pandemic virus and by conducting animal studies on its transmissibility and virulence.

Guiding Development of NPI Recommendations When a Pandemic Begins

Initial Assessment and Response Recommendations

When a pandemic emerges – in the United States or anywhere in the world – CDC will make an initial assessment of its transmissibility and clinical severity using multiple PSAF measures (Table 5). Although data will be limited within the first 3-4 weeks of the pandemic, these early measures will provide the basis for a broad, preliminary assessment of the potential impact of the pandemic. As indicated in Figure 3, CDC will use PSAF scores of viral transmissibility and clinical severity to place the pandemic within one of four assessment "quadrants:"

- Quadrant A: Severity and transmissibility similar to an annual influenza season
- Quadrant B: Severity similar to an annual influenza season; transmissibility greater than an annual influenza season
- Quadrant C: Severity greater than an annual influenza season; transmissibility similar to an annual influenza season
- Quadrant D: Severity and transmissibility greater than an annual influenza season

On the basis of the ***initial assessment***, CDC will recommend that affected U.S. jurisdictions respond – and other jurisdictions prepare to respond – in accordance with one of the four Pre-pandemic Planning Scenarios described

[§§]For example, the Pandemic Severity Index described in the 2007 *Community Strategy* relied primarily on case-fatality ratios.

below and in Table 9. These Scenarios are intended to provide state and local public health authorities with familiar and well-studied templates for rapid mobilization, including rapid selection of appropriate NPIs.

As noted above, the initial assessment will necessarily involve a high degree of uncertainty because it will be based on limited data. Viral transmissibility may be overestimated at the beginning of a pandemic because measurements are likely to be made during investigations of large outbreaks, which are more easily recognized than small ones. Initial measurements of clinical severity also may be high because severe illnesses are more likely to be recognized and reported than mild ones.

Refined Assessment and Response Recommendations

Information on viral transmissibility and clinical severity is likely to accumulate as influenza cases are reported and outbreaks are investigated. Once sufficient data have become available – which could take 4-8 weeks or longer, depending on the characteristics and capacity of the local surveillance systems where pandemic cases are first reported – CDC will prepare a refined and more robust assessment of pandemic severity, based on PSAF scores that use the clinical and epidemiologic measures listed in Table 6. To illustrate this process, CDC has compared the pandemic severity of four past pandemics (2009, 1968, 1957, and 1918) and three past influenza seasons (2007-8, 2006-7, and 1977-8) by plotting refined-assessment PSAF scores for viral transmissibility (on a scale of 1-5) against scores for clinical severity (on a scale of 1-7), based on historical data (Figure 4).

On the basis of the ***refined assessment***, CDC will issue new NPI guidance that is tailored more precisely to the specific pandemic situation. This guidance will address the selection, triggers, timing, and duration of NPIs and take into account the availability (or projected availability) of vaccines and antiviral medications. In developing NPI guidance, CDC may consider other available information, such as data on age-specific health outcomes; pre-existing population immunity; population groups with high attack rates and/or high rates of severe outcomes; and the public perception of pandemic severity, which may influence the acceptability of particular NPIs. As the pandemic progresses – and more data become available – CDC will continue to update assessments of pandemic severity and revise its NPI recommendations accordingly.

Pre-pandemic Planning Scenarios to Guide NPI Implementation

CDC has developed four, historically-referenced Pre-pandemic Planning Scenarios to guide NPI implementation during the early stages of a pandemic (Figure 6) (Table 9). In terms of pandemic severity, the Pre-pandemic Planning Scenarios correspond to PSAF assessments for:

- A 2009-like mild or moderate pandemic (Quadrant A)
- A 1968-like moderate or severe pandemic (Quadrant B)
- A 1957-like severe pandemic (Quadrant B)
- A 1918-like very severe or extreme pandemic (Quadrant D)

Although two of the historical pandemics fall in Quadrant B, they have distinct features and thus call for different NPI recommendations. No observed historical pandemic falls in Quadrant C, which is characterized by high clinical severity but relatively low transmissibility. For planning purposes, NPI recommendations for possible pandemics corresponding to Quadrant C would be similar to those recommended for Quadrant D, though the scope and scale of recommended social distancing NPIs might be different. Clearly, there is a continuum of clinical severity and viral transmissibility even within each quadrant of the framework that requires tailoring NPI recommendations (including the scope and scale of each recommendation) to each pandemic's unique characteristics, as well as to the specific needs of individual communities.

As noted above, during the early stages of an emerging pandemic, CDC will prepare an initial assessment of pandemic severity and indicate which pre-pandemic planning scenario may be most applicable. During pre-pandemic planning, state and local planners can use the four Pre-pandemic Planning Scenarios to stimulate discussion, build consensus, and set realistic expectations about the public health benefits and social costs of implementing NPIs during different pandemic situations. These efforts also will enhance community preparedness and resilience. For each scenario, Table 9 provides information about:

- Our historical experience during the pandemic on which the scenario is based.
- A comparative assessment of the clinical severity of the pandemic on which the scenario is based and the transmissibility of the scenario's pandemic virus.
- The possible health impact, in terms of hospitalizations and deaths, stratified by age range, if such a pandemic occurred today and NPIs were *not* implemented before a vaccine became available.

Although some NPIs – including personal protective measures (like voluntary home isolation or staying home when ill) and environmental surface cleaning measures (like routine cleaning of frequently touched surfaces) – are recommended during all influenza seasons, other NPIs are reserved for use during pandemics (Table 1). These include personal protective measures for implementation in homes across the country (like voluntary home quarantine of exposed household members), and social distancing measures for implementation in schools, workplaces, and other settings where people gather. Scenario-based recommendations for NPI selection and use are provided in Table 10, in the context of an overall community mitigation strategy that also may include vaccines and antiviral medications (if available).

The Pre-pandemic Planning Scenario descriptions in Table 9 and the scenario-based recommendations for NPI selection in Table 10 are intended to help state and local planners think through each scenario, keeping in mind additional factors that will likely impact local decision-making, such as population demographics and density, overall health status and wellbeing of the community, needs of vulnerable populations, and NPI feasibility and acceptability. For example, in planning for a mild or moderate pandemic situation like the 2009 H1N1 pandemic, state and local planners might consider targeting NPIs to high-risk and younger populations that could be severely affected.

WHO Guidance on Pandemic Phases, Severity Assessments, and NPI Implementation

Pandemic Influenza Risk Management – WHO Interim Guidance was issued in 2013 to inform and harmonize national and international pandemic preparedness and response activities (4). This document augments and updates guidance provided in the 2005 *WHO Global Influenza Preparedness Plan* (5) in several areas, including:

Pandemic Phases. The WHO Pandemic Phases describe pandemic progression at the global level. Based on lessons learned during the 2009 H1N1 pandemic, the number of pandemic phases has been reduced from 6 to 3 (*Alert*, *Pandemic*, and *Transition*, along with an *Interpandemic* phase; Figure 2), and their use has been uncoupled from public health decisions made at the country level. Thus, during a pandemic (or any other health emergency), WHO Member States are encouraged to act on the basis of national and local risk assessments taking into account, as needed, global health assessments made by WHO. The CDC Pandemic Intervals described previously are aligned with the WHO Pandemic Phases (Figure 2).

Pandemic Severity Assessments. The WHO *Interim Guidance* discusses national assessments of pandemic severity as major components of comprehensive risk assessments conducted as part of pandemic planning and response. It recommends that "data derived from existing influenza disease and virological surveillance, coupled with field investigations and other data sources" should be used to guide global and national responses. These data may include indicators of: 1) *transmissibility*, 2) *seriousness of disease* (clinical severity), and 3) *impact* (on health systems and other sectors of society). Annex 6 of the *Interim Guidance* provides a list of "representative parameters for core severity indicators" that is in good accord with the clinical and epidemiologic indicators used by the U.S. Pandemic Severity Assessment Framework (page 14).

Non-Pharmaceutical Interventions. The WHO *Interim Guidance* recommends that national health authorities prepare for NPI implementation – based on national and local risk assessments, resources, and needs – by:

- Identifying the range of NPIs that might be recommended and developing protocols and communications to support their implementation.

- Developing a framework to facilitate decision-making for activation and de-escalation of specific measures, such as school closures or cancellation or restriction of mass gatherings based on appropriate risk-assessment criteria.
- Planning for implementation of temporary recommendations issued by WHO under the International Health Regulations (IHR 2005) (6), which provide a modern legal and political framework for addressing public health events of international concern (PHEICs). For example, recommendations to implement NPIs or other response measures might be issued if pandemic influenza or another emerging respiratory disease were determined by the WHO Director-General to be a PHEIC.[***]

The WHO *Interim Guidance* includes an Annex on Containment Measures, which states that country-level efforts to contain influenza at its source are not likely to be successful in preventing international spread, due to "the large amount of resources (antiviral drugs, geographical cordon, health-care personnel) that would need to be mobilized." However, measures associated with *community containment* – including NPIs such as social distancing and respiratory hygiene, along with judicious use of antiviral drugs – "may be effective in mitigating the impact of outbreaks of a new influenza subtype in individual countries." Therefore, these measures "could be considered as part of a country's national preparedness plan, depending on available resources." (http://www.who.int/influenza/preparedness/pandemic/GIP_PandemicInfluenzaRiskManagementInterimGuidance_2013.pdf)

In 2009, soon after the H1N1 pandemic began, WHO issued *Pandemic Influenza Prevention and Mitigation in Low Resource Communities*, which focuses on NPIs that can be implemented by individuals and communities, including social distancing and respiratory etiquette (7). This document also considers best practices for caring for patients with mild cases of illness in their homes (e.g., separation of ill from well individuals within a household), as well as patient management and infection control measures for use in healthcare settings (e.g., triage, patient separation, and prioritization of use of antiviral medicines and personal protective equipment according to risk of exposure).

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[***] As stated in the *Pandemic Influenza Risk Management – WHO Interim Guidance,* the global phases and their application in risk management "are distinct from (1) the determination of a PHEIC under the IHR (2005) and (2) the declaration of a pandemic. These are based upon specific assessments and can be used for communication of the need for collective global action or by regulatory bodies and/or for legal or contractual agreements, should they be based on a determination of a PHEIC or on a pandemic declaration."

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Chapter 3: NPI Toolbox: Evidence Base, Implementation Issues, and Research Gaps

Chapter 3 provides supplementary information on the development of recommendations on the use of Personal, Community, and Environmental NPIs (see *MMWR-RR Recommendations* section). For each recommended NPI, this supplementary information includes:

- The evidence base on the effectiveness of the NPI in helping to prevent the spread of seasonal or pandemic influenza when used alone or in combination with other NPIs (see also Table 8 and Appendix 5);
- A review of implementation issues (including secondary consequences) that may require advance planning and preparation; and
- Research gaps recommended for further study.[†††]

Optimal use of NPIs requires the phased-in (or "layered") application of multiple NPIs – each of which is only partially effective when used alone (see *Chapter 1, NPI Pre-pandemic Planning Issues, Activation Triggers, Layering, and Duration of NPIs* section). Therefore, the evidence base presented here includes not only evidence supporting the effectiveness of each recommended NPI when used alone, but also evidence supporting its effectiveness when used in combination with other NPIs (see text below highlighted in **blue**). Information about how the evidence base on NPIs has expanded over the past decade is provided in the *Methods* section of the *MMWR-RR.*

PERSONAL NPIS

NPIs that can be implemented by individuals include:

- **Personal Protective Measures for Everyday Use**, including Voluntary Home Isolation of Ill Persons, Respiratory Etiquette, and Hand Hygiene
- **Personal Protective Measures Reserved for Pandemics**, including Voluntary Home Quarantine of Exposed Household Members and Use of Face Masks in Community Settings When Ill

Personal Protective Measures for Everyday Use

EVIDENCE BASE

Data on the effectiveness of voluntary home isolation, respiratory etiquette, and hand hygiene is summarized below. The evidence base for voluntary home isolation also applies to voluntary home quarantine, which is addressed on page 23 as a Personal Protective Measure Reserved for Pandemics.

Voluntary Home Isolation. As for all NPIs that keep ill and well persons apart – including school closures and dismissals and other social distancing measures – recommendations on voluntary home isolation (and voluntary home quarantine) are based on: 1) studies on influenza transmission dynamics that suggest a major role for person-to-person spread of virus via contaminated droplets generated by coughs and sneezes (1, 2) and possibly a role for aerosols (3); and 2) practical experience in controlling influenza outbreaks in hospitals and nursing homes using infection control precautions for droplet transmission. The evidence base for voluntary home isolation (and voluntary home quarantine) also includes:

[†††]Most of the research gaps described in Chapter 3 were identified during the review of the published literature supporting the NPI recommendations (Table 8) (Appendix 5). Additional gaps in evidence were identified from other sources, such as subject matter experts internal and external to CDC. The research questions suggested for each NPI are not provided in priority order.

- A historical review which concluded that isolation and quarantine measures can help prevent the spread of influenza and other infectious diseases (4).

- Studies conducted during the 2009 H1N1 pandemic, including: 1) a randomized, controlled trial which found that allowing ill workers to stay home on full pay reduced the risk of H1N1 infection in the workplace by 20% (5); and 2) a workplace survey which demonstrated that higher influenza-like illness (ILI) incidence was correlated with lack of access to paid sick leave, as well as to structural factors such as the number of children in the household (6). The availability of paid sick leave reduced not only the number of persons who went to work when ill, but also the number of persons who stayed home to care for an ill family member.

- Mathematical modeling studies which concluded that case isolation (at home or in a healthcare facility) or household quarantine can be effective in reducing disease attack rates when compliance is high (7). One study found that a combination of case isolation, household quarantine, and prophylactic use of antivirals can be effective at preventing virus transmission (8). Another study found that sick leave policies that enable ill workers to stay home without losing pay can reduce the burden of influenza illness in workplaces (9). A third modeling study found that the mandatory 60-day quarantine in Beijing, China implemented during the 2009 H1N1 pandemic significantly delayed the peak of the pandemic (10).

Additional evidence that supports the effectiveness of voluntary home isolation when used in combination with other NPIs can be found in the evidence bases on *Hand Hygiene* (reference 14); *School Closures and Dismissals* (reference 84); and *Social Distancing Measures* (references 121-123, 125-128, 130).

Respiratory Etiquette. Respiratory etiquette is widely supported in the literature and recommended by experts despite a lack of direct evidence. Like other NPIs that keep ill and well persons apart, recommendations on respiratory etiquette are based on: 1) studies on influenza transmission dynamics that suggest a major role for person-to-person spread of virus via contaminated droplets generated by coughs and sneezes (1, 2) and possibly a role for aerosols (3); and 2) practical experience in controlling influenza outbreaks in hospitals and nursing homes using infection control precautions for droplet transmission. Support for respiratory etiquette includes indirect evidence from experimental studies, which confirm that:

- Droplets generated by coughing or sneezing of individuals who do not practice respiratory etiquette can travel for distances of up to six feet, potentially infecting individuals within that distance (2).
- Influenza viruses spread in this way can survive on hard, nonporous surfaces for 24-48 hours, during which time they can spread to human hands (11) (*Environmental Surface Cleaning Measures,* page 36).

Hand Hygiene. Hand hygiene has been widely studied as a way to prevent influenza and respiratory virus transmission. The evidence base includes:

- Systematic literature reviews and meta-analyses, including a meta-analysis of 30 studies which concluded that hand hygiene is associated with a statistically significant reduction in transmission of respiratory illness (not specifically influenza) (12). One study considered in the meta-analysis found that use of antibacterial soap or non-antibacterial soap with hand-hygiene education reduced respiratory illness among small children in Pakistan by half (13). A systematic literature review of 61 studies (including 9 case control studies) concluded that hand hygiene reduces transmission of acute respiratory infections, but should be combined with other NPIs to provide the greatest degree of protection (14). Another review of 16 studies found that hand hygiene reduces transmission of influenza and other acute respiratory infections in the community, although the degree of effectiveness may vary with rates of compliance and with use in different settings (15). In addition, a systematic review and meta-analysis of randomized controlled trials conducted in 13 primary schools and five daycare facilities or pre-schools found that hand hygiene interventions may decrease respiratory tract infections (not specifically influenza) among younger children, although most evidence on infection incidence in educational settings is ambiguous (16). Another review of eight studies found that handwashing is associated with lowered respiratory infections, though the studies had several limitations including poor quality, none related to developing countries, and only one focused on severe disease (17).

- Studies conducted during the 2009 H1N1 pandemic, including: 1) a prospective cohort study conducted in Chicago elementary schools which found that students who received hand-hygiene instruction had a significantly lower percentage of illness-related absenteeism and total days of absenteeism than students who received no instruction (18); and 2) a randomized, controlled trial conducted in elementary schools in Cairo, Egypt, which reported a 47% reduction in cases of influenza in an intervention group that received hand-hygiene instruction and conducted twice-daily hand washing (19). This study demonstrates the potential impact of hand hygiene in a population that normally has little or no access to soap or hand drying material, and where frequent hand washing is not the norm. In addition, a study conducted in Spanish hospitals found that hand washing and information on influenza prevention prevented hospitalization (20); and a study conducted in workplaces in Finland found that intensified hand hygiene using soap and water significantly reduced respiratory illness (21). However, a study conducted in New Zealand primary schools found that the provision of hand sanitizer – in addition to usual hand-hygiene measures – did not reduce absences related to illness (22).
- Studies conducted during annual influenza seasons, including: 1) a pilot, office-based randomized cluster trial conducted at a U.S. Midwestern government center, which found a modest but statistically significant reduction in self-reported respiratory and/or gastrointestinal tract infections among participants in a multimodal intervention involving a hand hygiene training video, educational posters, and provision of hand sanitizers (23); 2) a case control study conducted in five cities in Fujian Province, in southeastern China, which found a substantially lower risk of laboratory-confirmed influenza associated with self-reported frequent handwashing and with infrequent touching of eyes, nose, or mouth (which can result in self-inoculation) (24); and 3) a population-based, cross-sectional survey conducted in Beijing, which found that handwashing is associated with a lower incidence of influenza-like infections among adults (25).
- A laboratory study which found that use of either soap and water or alcohol-based sanitizer is effective in reducing H1N1 on hands, although soap and water is more effective (26). Another study found that alcohol-based hand sanitizer can inactivate influenza A virus within 30 seconds (27).

Additional evidence that supports the effectiveness of hand hygiene when used in combination with other NPIs can be found in the evidence bases on *Use of Face Masks in Community Settings* (references 43-44, 56-59); and *Environmental Surface Cleaning Measures* (references 11, 147, 150, 154).

IMPLEMENTATION ISSUES

Voluntary Home Isolation. The effectiveness of voluntary home isolation is limited by: a) the onset of viral shedding prior to the development of symptoms; and b) the large percentage of influenza cases that are asymptomatic (http://www.cdc.gov/flu/professionals/acip/clinical.htm).

Persons who do not know that they are infected – either because they are pre-symptomatic or because symptoms never develop – are not likely to stay home and may, therefore, pass their infections to persons outside their households. In addition, ill persons may be unable to stay home due to concerns about job security and loss of income. Based on responses to a National Health Interview Survey question, approximately 60% of employed men and women had paid sick leave at their main job during 2009-2013. For both men (90%) and women (88%), paid sick leave was most common in the public administration sector and least common in the agriculture, forestry, and fishing sector (24% for men and 22% for women) (https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6425a8.htm).

Although compliance with voluntary home isolation is more likely when appropriate and flexible workplace leave policies are in place (6, 9), a survey conducted during the first weeks of the 2009 H1N1 pandemic found that 55% of Americans reported they had made preparations to stay home if they (or a family member) got ill (28). The Center for Infectious Disease Research and Policy (CIDRAP) provides a toolkit to help organizations of all sizes deal with these issues during a pandemic (http://www.cidrap.umn.edu/sites/default/files/public/downloads/cidrap-shrm-hr-pandemic-toolkit.pdf).

Respiratory Etiquette. Studies conducted during the 2009 H1N1 pandemic suggest high levels of compliance with public health recommendations on respiratory etiquette; for example: 1) a random digit-dial telephone poll conducted simultaneously in Argentina, Mexico, and the United States found that 55%-85% of individuals more frequently adopted coughing or sneezing into their elbow or shoulder and covering their mouth or nose with a tissue when coughing or sneezing (29); 2) a survey of households in Argentina found that more than 89% of respondents believed that covering their mouth when sneezing was important for disease control (30); and 3) a survey of urban households in Mexico found that 14%-22% of participants reported increased coverage of coughs and sneezes with a tissue or an elbow (31).

Hand Hygiene. A cross-sectional study conducted in Sweden found that the majority of respondents strongly agreed with the intention to perform hand hygiene during both mild and severe pandemics (77% and 85%, respectively) (32). However, implementation of hand hygiene in some settings could be limited by the availability of hand-washing stations and supplies (e.g., clean water, towels, and soap or hand sanitizers) (33). Although acceptability of hand hygiene is generally good, compliance and adherence may vary among different population groups. For example, a hand-washing survey – conducted as part of a larger study by the American Society for Microbiology and the American Cleaning Institute – found that only 39% of respondents reported always washing their hands after coughing or sneezing (34). Moreover, those who do wash their hands may not use the proper technique, which entails washing all surfaces of the hands (including between and around fingernails), using friction. Another survey, conducted by the Bradley Corporation, found that 62% of respondents reported rinsing their hands without using soap after they used the bathroom. Using soap is important as it not only kills bacteria, but it also acts as an emulsifier to remove the bacteria from the hands (34). A cross-sectional survey conducted in Hong Kong showed that most respondents thought hand hygiene helped reduce the risk of influenza transmission (88.5%), and had high compliance with hand washing (72.6%). Low perceived severity and infectivity of influenza can affect individual hygiene behaviors (35).

Studies conducted during the 2009 H1N1 pandemic suggested high levels of compliance with public health recommendations on hand hygiene; for example: 1) a national opinion poll conducted during the first few weeks of the pandemic indicated that two-thirds of Americans (59%-67%) reported that they or someone in their family had begun to wash their hands or clean them with hand sanitizer more frequently during the early weeks of the pandemic (28); 2) a random digit-dial telephone poll conducted simultaneously in Argentina, Japan, Mexico, the United Kingdom, and the United States found that – across all 5 countries – 53%-89% of individuals adopted washing their hands and using hand sanitizer more often during the pandemic (29); 3) two cross-sectional telephone surveys – conducted as part of one study in 2008 and in 2009 in Germany – found that the perception of the efficacy of hand hygiene as being very good increased significantly from 50.9% in 2008 to 61.1% in 2009. Additionally, the study found that the perception of coughing into one's sleeve was the best etiquette for coughing increased from 4.8% in 2008 to 38.3% in 2009 (36); and 4) focus groups and patient interviews conducted at the University of Delaware found that participants followed at least one of the university's H1N1 recommendations, especially hand hygiene (37).

Evidence that intensified hand-hygiene education can increase rates of hand washing includes: 1) a 5-school educational-intervention study conducted in Pittsburgh (38); 2) a study on school absenteeism related to illness conducted in Chicago (18); 3) a study conducted in Thailand among households with a child who tested positive for influenza (39); and 4) a survey conducted at a university in South Korea during the 2009 H1N1 pandemic (40). Increased frequency of hand hygiene has been reported to cause skin irritation (41), and use of alcohol-based hand sanitizers has raised some concerns about eye contamination and flammability, particularly in school settings (42), and has been associated with skin reactions (22). Additionally, consumption of alcohol-based hand sanitizers by children can lead to alcohol poisoning. Therefore, hand sanitizers should be stored out of reach of children (particularly very young children) at all times, and should be used with adult monitoring and supervision (https://www.cdc.gov/handwashing/show-me-the-science-hand-sanitizer.html).

RESEARCH GAPS

Additional study is needed to answer these questions:

- How do the frequency, quality, and timing of hand hygiene affect influenza transmission?
- Are hand sanitizers as equally effective as hand washing?
- What is the effect of the combined use of respiratory etiquette and hand hygiene on influenza transmission?
- How do age, education level, and the availability of hand-hygiene materials affect hand-hygiene behavior?
- Which educational interventions and social media tools are most effective at impacting behavior change and improving adherence to recommendations on respiratory etiquette and hand hygiene in different population groups?
- How do school policies for hand hygiene and availability of soap and water influence hand-washing behaviors in school-aged children?

<u>Personal Protective Measures Reserved for Pandemics</u>

EVIDENCE BASE

Voluntary Home Quarantine. The evidence base for voluntary home quarantine is the same as for voluntary home isolation (page 19). Additional evidence that supports the effectiveness of voluntary home quarantine when used in combination with other NPIs can be found in the evidence base on *Social Distancing Measures* (references 121-123, 125-126, 129-130, 132). For example, a social distancing modeling study that considered NPIs used in different combinations found that school closures plus home quarantine provided the greatest reduction in disease spread (reference 129).

Use of Face Masks in Community Settings. Multiple systematic literature reviews have focused on the use of face masks to help reduce virus transmission. For example, a systematic literature review of 12 articles on face mask use found a substantial gap in the scientific literature on the effectiveness of face masks to reduce transmission of influenza virus infection (43). The review concluded that there is some evidence to support use of face masks by ill persons to protect others, but little evidence to support use of face masks by well persons to avoid infection. A second review of 17 articles reported that "none of the studies established a conclusive relationship between mask/respirator use and protection against influenza infection" (44). However, the authors concluded that mask use by well persons might be effective in reducing secondary transmission within a household if used early and consistently in combination with other measures, especially hand hygiene. A third review of 10 articles found that face mask use combined with hand hygiene was effective at preventing influenza, but the evidence did not show efficacy of hand hygiene alone (45). A fourth review found that pooled data from 13 studies revealed a significant protectiveness of face masks against respiratory infections in general among pilgrims to the Hajj ($p<0.01$) (46). A fifth review of nine articles concluded that face mask use alone and face mask use with hand hygiene may prevent infection in community settings, subject to early use and compliance (47).

Although there is experimental evidence that face masks provide a physical barrier that can reduce person-to-person transmission of virus-laden droplets when worn by ill persons (48, 49) or well persons (50, 51), there is less evidence that face masks are effective in natural settings, including community settings such as households, schools, and workplaces. Three randomized, controlled trials – in which masks were worn by a household's index case (52), by healthy household members (53), or by all members of an affected household (54) – found little or no effect on disease spread. However, these results might be due to study limitations, such as poor compliance and/or the early termination of one study (52). A modeling study suggests that community-wide use of face masks may help delay and contain a pandemic, though efficacy estimates were not based on randomized controlled trial data (55).

Evidence that face mask use by well persons might be effective if used with other NPIs comes from trials conducted during the 2009 H1N1 pandemic, which found that early combined use of face masks and hand hygiene prevented virus transmission within households (56, 57) and among students in university residence halls (58, 59). A systematic literature review of articles on hand hygiene concluded that a combination of NPIs – including hand hygiene, face masks, isolation, and social distancing measures – provides the largest degree of protection against influenza (see evidence base on *Hand Hygiene*, reference 14). In addition, a study conducted with healthy persons found that surgical masks were three times more effective at blocking transmission of microorganisms than homemade masks. However, using either type of mask will have minimal effect if not used in conjunction with other preventative measures (60).

IMPLEMENTATION ISSUES

Voluntary Home Quarantine. The effectiveness of voluntary home quarantine is limited by: a) the onset of viral shedding prior to the development of symptoms; b) the large percentage of influenza cases that are asymptomatic; and c) the likelihood of transmitting infection to close contacts at home, school, or work. In addition, household contacts of ill persons may not stay home if they are concerned about job security and loss of income.

Nevertheless, a survey conducted during the first weeks of the 2009 H1N1 pandemic found that 55% of Americans said they had made preparations to stay home if they (or a family member) got ill (28). Higher rates of compliance may be associated with:

- Appropriate and flexible leave policies (9) and assurance that workers will not lose their jobs or income if they implement voluntary home quarantine (61).
- Clear and coordinated public health communications that foster a high level of public trust (62, 63).

Use of Face Masks in Community Settings. Face masks should not be shared. They should be worn only once and then safely discarded. Face masks should be changed when damaged, soiled, or wet. They cannot be worn while eating or drinking, and may impair communication. If not worn properly, the use of a face mask could increase the risk of influenza transmission due to contamination of the face mask or to creating a false sense of protection, leading to neglect of respiratory etiquette and hand hygiene (64). Access to face masks could be limited in some communities during a pandemic because they will be prioritized for use in healthcare settings.

Compliance with face mask use is likely to be lower than with other personal protective measures like hand hygiene that are considered everyday health behaviors (54, 56). Perceived susceptibility and severity also are factors that influence face mask compliance (65, 35), as well as discomfort and difficulty breathing (46). A survey conducted in Hong Kong showed that the proportion of actual mask use was far lower than the perceived usefulness of mask wearing (35). However, a study conducted in households in Germany showed that most participants considered wearing face masks to be a feasible and tolerable protective measure (66); and a study conducted in Japan showed that face mask use can be a marker of additional, positive hygiene practices and other healthy behaviors (67).

RESEARCH GAPS

Additional study is needed to answer these questions:

- What are the relative contributions of aerosol, droplet, and contact transmission to the spread of influenza, including the relative contributions of infectious aerosols and droplet particles generated by coughs and sneezes?
- How do different types of surgical face masks, weather conditions (humidity and temperature), and socio-cultural and behavioral factors influence the effectiveness of face masks in preventing influenza transmission?
- What are the optimal triggers (e.g., number of cases, transmissibility of the virus, and/or severity of influenza) for recommending face mask use in community settings?

COMMUNITY NPIS

NPIs that can be implemented by communities include:

- **School Closures and Dismissals**, including temporary closures of childcare facilities, K-12 schools, and institutions of higher education
- **Social Distancing Measures**, including measures for schools, workplaces, and mass gatherings

School Closures and Dismissals

EVIDENCE BASE

Systematic literature reviews published by the U.S. Community Preventive Services Task Force (CPSTF) in 2012 and by researchers at the London School of Hygiene and Tropical Medicine (LSHTM) in 2013 find consistent evidence that pre-emptive, coordinated school closures and dismissals can help prevent or reduce the spread of influenza. Nevertheless, the U.S. CPSTF concludes that there is insufficient evidence to determine whether the health benefits of school closures balance their social and economic costs during a pandemic that does not cause severe illness (68). The LSHTM review notes that the potential health benefits of school closures and dismissals are greatest among school-aged children, but that it is difficult to assess overall effectiveness when school closures are implemented late during a pandemic or in combination with other interventions (69). The effectiveness of school closures and dismissals in helping to prevent disease spread is supported by:

- Studies conducted during the 2009 H1N1 pandemic, including: 1) a study which found H1N1 surged in many U.S. communities in fall 2009, about 2-3 weeks after schools re-opened after summer break (70); and 2) a comparison of school districts in Texas, in the beginning of the first wave of the 2009 H1N1 pandemic, which found that the odds of reporting acute respiratory illness rates were 51% lower in the community surrounding the school district that closed schools compared to the adjacent school district where schools remained open (71). In Canada, school closure was associated with reduced transmission of more than 50% among school children that may have helped attenuate the first wave of the 2009 H1N1 epidemic (72). The greater Mexico City area saw a 29%-37% reduction in H1N1 transmission following mandatory 18-day school closures and implementation of other social distancing measures (73). A comparative case study in Japan showed that full school closures reduced the impact of the pandemic more than single class closures. This same study also found that a longer duration of school closure was significantly correlated with a reduction in H1N1 incidence after classes resumed (74). In India, three school holidays that occurred between August 2009 and January 2010 had a significant impact on the spread of H1N1 influenza, reducing the transmission rate by 14%-27% in different regions (75).
- Other studies – unrelated to the 2009 H1N1 pandemic – of respiratory disease rates among students whose schools temporarily closed for vacations or other non-health-related reasons, including a study which found the incidence of respiratory tract infections among children (ages 6-12 years) decreased by 42% during a 2-week elementary school strike in Israel in 2000, and then rose again after the strike ended. The decrease corresponded with a 28% reduction in outpatient and emergency department visits (76). School closures due to the strike also helped prevent seasonal upper respiratory viral spread in communities (77). An analysis of 1984-2006 surveillance data found that respiratory infections decreased 16%-18% (18%-21% in children) during winter school holidays in France (78). A comparison of 2005-2008 data from Argentina schools that closed for the winter holidays at different times found that ILI decreased 17%-37% during school holidays. ILI decreased more in school-aged children than in younger children or adults (79). An analysis of 2004-2007 data from Arizona found a mean 42% reduction in potential laboratory-diagnosed influenza cases among school-aged children during annual 2-week school closures for the winter holidays, with similar results when analyzing hospital discharge data (80).
- Mathematical models of school closures, which suggested that: 1) school closures may significantly reduce the number of influenza cases during a pandemic (81-83); 2) the health impact is greater when school closures are coupled with other interventions, including home isolation (84), antiviral prophylaxis

of household contacts[‡‡‡] (7, 85, 86), and workplace-based social distancing measures (87); 3) closure of individual schools (triggered by each school's first influenza cases) is likely to be more effective than closure of an entire school system (83, 86); and 4) simultaneous closure of all schools in a district is more effective only when perfectly timed (86).

- Economic modeling studies, which concluded that the cost-effectiveness of school closures is greater when a pandemic causes severe illness (68, 88, 89). A cost-effectiveness study based on population data from the state of Texas recommended early-as-possible school closures for both severe and mild pandemics, but with longer durations (24 weeks) for severe pandemics (88). This same finding – the need to close schools early on – was supported by a simulation model using data from the 2009 H1N1 pandemic in Hong Kong. The modelers reported that individual school closure strategies that used a lower threshold to trigger school closures (three confirmed cases at a particular school), that involved all types of schools (kindergarten, primary, and secondary), and that closed for two weeks performed best, preventing about 830,000 cases and costing about $1,145 (USD) per case prevented (90). However, a study based on population data from Oslo, Norway concluded that school closures are unlikely to be cost-effective during a mild, HIN1-like pandemic (89). This finding is in good accord with the conclusions of the U.S. CPSTF (68).
- Historical analyses of school closures during the 1957 and 1918 pandemics, including: 1) a historical analysis of school closures during the 1957 pandemic which found that influenza did not become widespread until after schools opened in the fall, despite widespread seeding during the preceding summer (91); and 2) a historical analysis of the 1918 pandemic which found that school closures correlated with reductions in cumulative attack rates in Australia (92).

Additional evidence that supports the effectiveness of school closures and dismissals when used in combination with other NPIs can be found in the evidence base on *Social Distancing Measures*; these include additional historical analyses of the 1918 pandemic (references 125-126); modeling studies (references 127-132), including a study which found that home quarantine combined with school closure is the most effective strategy (reference 129); and a review of social distancing measures which found that (proactive or reactive) school closure is moderately effective and acceptable in reducing virus transmission and delaying the peak of an epidemic, but associated with high secondary (economic and social) effects (reference 122).

IMPLEMENTATION ISSUES

Public Health Objectives of Pre-emptive, Coordinated School Closures and Dismissals. Optimal use of pre-emptive, coordinated school closures and dismissals to help prevent the spread of the pandemic virus depends on the pandemic situation. Implementation objectives may include:

Preventing disease spread while gaining time for initial assessment of transmissibility and clinical severity of the novel virus, if initial data suggest that the pandemic may be severe (closures up to two weeks, or until severity is determined to be either mild or moderate)

- During the first weeks of the epidemic – after circulation of the novel influenza virus has been detected among people in a certain locale and when initial data suggest that the pandemic may be severe – pre-emptive, coordinated school closures may be implemented on a limited geographic scale around that locale out of caution and to allow time to collect information on the characteristics and epidemiology of the novel virus. The initial assessment of transmissibility and clinical severity will strive to provide sufficient data to help public health and education authorities make informed decisions about further implementation of school closures and other NPIs (see *Chapter 2, Guiding Development of NPI Recommendations When a Pandemic Begins*).

[‡‡‡]CDC is unlikely to recommend targeted prophylaxis during a pandemic, due to concerns about the availability of sufficient antivirals and the potential development of drug resistance.

Preventing disease spread while gaining time for the local healthcare system to prepare additional resources for responding to increased demand for healthcare services (closures up to six weeks)

- Federal pandemic guidance regarding the potential use of pre-emptive, coordinated school closures will be based on the initial assessment of transmissibility and clinical severity of the novel virus (Table 5) (Figure 3). Decisions about the geographic scope and duration of school closures will be made locally to take into consideration the local epidemiologic situation and operational circumstances. Although such closures may not be sustained long enough to reduce the magnitude of the peak of the epidemic, some studies suggest that closures maintained for short periods of time may delay the local peak of virus transmission (see *Timing and Duration of School Closures and Dismissals*).

Preventing disease spread while gaining time for pandemic vaccine production and distribution during a severe pandemic (closures up to six months)

- Current estimates indicate that it may take up to six months from initial detection of a novel influenza virus with pandemic potential for a pandemic influenza vaccine to be widely available (see *Chapter 1, Introduction*). A vaccine may be available sooner for distribution if a stockpiled pandemic influenza vaccine is determined to be effective in protecting against infection from the novel virus (https://www.medicalcountermeasures.gov/barda/pandemic-influenza.aspx). The feasibility of implementing school closures to allow time for pandemic influenza vaccine development and production will depend on timing of the emergence of the pandemic virus relative to the normal school year. For example, if a pandemic starts just before or during the regularly-scheduled summer school break, the summer holiday will act as a prolonged school closure, and delaying when schools re-open may not be as disruptive for the educational process as a prolonged school closure implemented during an entire school semester.

Timing and Duration of School Closures and Dismissals. Mathematical modeling studies suggest that the effectiveness of school closures and dismissals depends on early implementation and adequate duration (81-89, 93, 94) which, in turn, depends on parental and community acceptance and participation (see *Parental Perceptions, Opinions, and Acceptance of School Closures and Dismissals*). One group of modelers proposed a standard school-closure activation trigger, based on a school's absentee data collected over a 2-day period (95). Another study found that short delays in closing schools did not substantially impact reductions in disease attack rates, as long as schools were closed for long durations (i.e., throughout most of the epidemic) (83).

Other modelers concluded that the optimal duration of school closures depends on viral transmissibility and pandemic severity (86, 88, 96). For example, a study based on data from a small city in Western Australia concluded that, during mild pandemics, schools should close once a pre-determined threshold of community case counts has been exceeded. However, during severe pandemics, long-duration closures should begin as soon as possible and be combined with other interventions (86). Another study suggests that, during severe pandemics, a significant reduction in cumulative disease incidence may be possible only when school closures are implemented for at least 16 weeks at a county-wide or wider geographic scale. This study also found that the effect of school closures is likely to be more pronounced for less transmissible strains that cause severe disease, even when shorter dismissals are implemented on a narrower geographical scale (96).

Some modeling studies asked whether school closures of adequate duration could delay the epidemic peak, reducing the incidence of influenza when a pandemic vaccine is not yet available (93, 94). A transmission model, based on age-stratified U.S. demographic data, concluded that closing schools for less than 84 days (12 weeks) would delay the epidemic peak significantly, although it would not reduce the estimated total number of cases (94). Assuming a 30% clinical attack rate scenario, this study found that every additional week of school closure introduced on day 5 of the pandemic would delay the peak by approximately five days; for a 15% clinical attack rate scenario, every additional week of school closure would delay the epidemic peak by nine days (94). A simulation model, based on data collected in Oita City, Japan, during the 2009 H1N1 pandemic, found that school closures implemented for more than four days decreased the number of students infected at the pandemic's peak by 24%, while reducing the total number of infected students by 8% (93).

In contrast, other modelers found that the optimal strategy would be: 1) early, joint implementation of school closures and workplace measures maintained for 10 weeks (87); or 2) early-as-possible implementation of school closures for 6-8 weeks. This last group of modelers concluded that closing schools for more than eight weeks would provide little additional benefit, and that closures implemented for less than six weeks might begin later (i.e., at a higher threshold) without reducing their effectiveness (82).

Other modeling studies considered whether the effectiveness of school closures depends on coordinated timing within a county, state, or larger geographical area. A U.S. study found that shorter closures (1-4 weeks) implemented on an individual community-by-community basis as soon as initial cases are detected among school children would be more effective than coordinated county-wide, multi-county, or state-wide dismissals of the same duration that are implemented in a less timely manner (96). A model-based analysis of four different strategies for closing schools during a pandemic in the United Kingdom concluded that the optimal – and more feasible and practical – strategies are county-wide closures and reactive, gradual class-by-class closures for one week each, separated by a timeout to break the chain of transmission in the schools/classes and to avoid long periods of learning interruption (97). A take-home message common for many of these modeling studies is that rapid and effective implementation of school closures (and other community-based interventions) requires an aggressive surveillance system capable of early detection of initial influenza cases, coupled with pre-pandemic planning (96).

Secondary Consequences of School Closures and Dismissals. Community preparedness is essential to address secondary consequences of school closures and dismissals that could affect their feasibility and acceptance. These consequences include:

- Missed educational opportunities for affected children
- Missed work and income for parents who stay home to care for their children
- Disruptions and expenses for parents who arrange alternative care for their children
- Loss of ancillary school services such as free/subsidized student meals, school-based healthcare, and after-school services for children with disabilities
- Loss of access to, and use of, schools as "safe havens" for children (98, 99)

Community-based strategies to mitigate these consequences might include providing distance-learning courses to students and developing alternative childcare strategies. Also, state and local authorities should:

- Ensure legal preparedness to close schools (i.e., understand which government officials or departments have the authority to close schools for public health purposes)
- Ensure that decisions on whether to close schools will be informed by data on disease transmission in local communities and schools (100)
- Understand how school closures will be implemented in their jurisdictions
- Be prepared to explain the public health benefits of closing schools during a pandemic to parents/ guardians and the general public
- Be familiar with U.S. Department of Agriculture (USDA) programs that may provide eligible school children with meals during school closures (Appendix 7)

A retrospective analysis of school closures in the United States during the 1918 influenza pandemic suggests that smooth implementation of school closures requires clear delineation of legal authority, good municipal organization, and transparent communications between public health authorities and the general public that establish a high level of trust (101). During the 2009 H1N1 pandemic, trust was established in some Australian communities by sharing the rationale for school closures openly and transparently, including school community members in the decision-making process, and being responsive to the changing situation (102). In the United

Kingdom, a risk-based approach used for public health decision-making in the West Midlands also highlighted the need for: a) clear identification of public health roles and responsibilities; b) reliable and validated surveillance systems to facilitate risk assessments; and c) clear communication with parents, school officials, and other community stakeholders (103).

In the United States, a qualitative, historical evaluation of the experiences of 30 cities and the decision-making process, social factors, and political concerns surrounding school closures during the spring wave of the 2009 H1N1 pandemic emphasized the importance of local public health departments participating in the development of local school closure protocols and plans; developing better methods to communicate the (public health) rationale for school closures to the public; working more closely with education officials to better understand the complexities and sensitivities of closing schools (particularly urban public schools); and resolving issues of legal authority to close schools during public health emergencies (104). Responses from 937 K-12 school principals in Michigan during the fall wave of the 2009 H1N1 pandemic revealed that most schools had an influenza preparedness plan in place; invested substantial time and resources preparing for pH1N1 influenza; communicated with parents and students about preventing the spread of disease; and implemented NPI measures in their schools (e.g., recommending ill children and staff stay home, dedicating a separate room for ill children and staff, and providing hand sanitizer and tissues) (105). Based on school district-level data from the 2012 School Health Policies and Practices Study, 69% of school districts required schools to have procedures in place for responding to pandemic influenza or other infectious disease outbreaks. When developing their crisis preparedness, response, and recovery plans, 66% of school districts collaborated with the local health department (106).

Parental Perceptions, Opinions, and Acceptance of School Closures and Dismissals. Implementation of school closures and dismissals that are instituted early enough – and maintained long enough – to help prevent the spread of infection requires sustained support and participation by parents and other members of the community. Long-duration school closures are more likely to be acceptable during severe pandemics (86), and it is more practical to close schools for definite time periods (as opposed to waiting until case counts go down) because fixed-duration closures allow families to plan in advance (88). Data collected during the 2009 H1N1 pandemic suggest that school closures are acceptable to most parents when the reasons behind them – including why school closures may be implemented before the community is hard-hit by the pandemic – are well-understood. According to a randomized telephone poll of 523 parents from 39 U.S. states whose childcare center or school closed temporarily in response to the 2009 H1N1 pandemic, 90% of parents agreed with the dismissal decision, and 85% believed the dismissal effectively reduced influenza transmission. Seventy-five percent of respondents reported that the dismissal was not a problem, and 3% said it was a major problem. Approximately 20% of parents reported that an adult in the household missed work because of the dismissal. Nineteen percent had a child who missed a free or reduced-cost lunch, but only 2% and <1%, respectively, said these were major problems (107). Parental acceptance of school closures has been reported in other studies (108-113). For example, most households in two Argentinean cities – 78% in Ushuaia and 72% in Jujuy – agreed with the 2-week closures of schools with laboratory-confirmed pH1N1 cases. Furthermore, most respondents – 75% in Ushuaia and 61% in Jujuy – reported that the school closures did not affect their household's economy, as they made alternative childcare arrangements with a family member or friend (114).

However, a study from Perth, Western Australia, found parental opinion divided on the benefits of H1N1-related school closures. Among 233 families affected by 1-week school closures in three middle schools, 47% of parents thought that school closures were an appropriate way to protect the community, and 33% thought school closures were not needed because most influenza cases were mild. Fifty-five percent of parents reported that school closures caused moderate or severe disruption to family routines, while 45% indicated they were well prepared. Forty-five percent of parents reported taking > 1 day off work to care for a child, while 35% made special childcare arrangements (median 2 days) (115). Another study investigated parental attitudes and behaviors during a hypothetical pandemic influenza situation. There were 1,510 parents of school children from six schools in Nagano, Japan, who responded to a survey regarding their behaviors and attitudes – in the event of school closures – toward: a) actively taking care of their child (i.e., in person); b) taking time off work; and c) not confining their child to their home. In the event of school closures, parents with children in kindergarten and elementary schools reported being more likely to actively take care of their children. Parents with children in elementary and special education needs schools were more likely to take time off work, and parents with children who had older siblings were more likely to confine them to home activities (116).

Assessing parental perceptions of the socio-economic burden of school closures during localized, elevated seasonal influenza activity or outbreaks is equally important. For example, 25% of 99 households reported experiencing difficulties related to a 4-day closure in a western Kentucky rural school district, which included making alternative childcare arrangements (13%), students missing school meals (5%), and reduced income from parents' missing work (4%) (117). Similarly, during a 4 ½-day closure in a Colorado school district outside of metropolitan Denver, 20% of 35 households reported experiencing challenges like missed work to care for children at home (14%), lost pay (6%), and missed subsidized school meals (3%) (118). These same issues were identified when analyzing 619 (67%) of the 930 publicly-available, relevant social media posts about a 9-day district-wide school closure due to a teachers' strike in Chicago, confirming the potentially disruptive and negative impact of unplanned closures on students and their families (119).

Re-congregation of Students during School Closures and Dismissals. Children do not have the same frequency, density, or duration of social contacts outside of school as they do when attending school (108, 109, 120). Nevertheless, parents are advised to limit the frequency of social contacts among school-aged children during influenza pandemics.

During the 2009 H1N1 pandemic, several studies found that social interactions and out-of-school activities often continued during school closures and dismissals (120). Moreover, school closures lasting more than a few weeks might lead to increased contact rates in the community (78). For example:

- In Perth, Western Australia, 74% of middle school students participated in activities outside the home on more than one occasion (e.g., sporting events, outdoor recreation, shopping, and parties) (115).
- In a Pennsylvania school district, 69% of elementary students left home at least once to visit routine venues (e.g., stores, sports events/practices, and restaurants) (109).
- In two Argentinean cities, 67% of households reported that children visited public places – like supermarkets, plazas, recreation areas, and shopping malls – at least once during the 2-week school closures, and 45% left home several times (114).
- In Japan, 20.5% of households reported that children left home for non-essential reasons, with fewer children leaving home in families who believed that school closures were an appropriate response to the pandemic (112).

On the other hand, a study conducted in Melbourne, Australia, reported that compliance with recommendations for children to stay at home was high (84.5%), and that contact with children outside the immediate family was infrequent. This high rate of compliance may have been due to heightened public concern during the early stage of the pandemic, when the survey was conducted, as compared to later stages, when the public had learned about the generally mild nature of H1N1 infection. Children who were cared for at home by their parents were more likely to comply with the social restrictions (63). A knowledge, attitudes, and practices survey of students' caregivers and teachers at 48 elementary schools in Michigan during the pandemic found that 11%-36% of caregivers reported going to fewer places (e.g., movies, sporting events, concerts, and shopping malls) and avoiding crowds and events (e.g., parties, weddings, and family gatherings). These behaviors were similar for households impacted by school dismissals and those that were not. Teachers experiencing school dismissals were more likely to support cancelling or rescheduling sport practices and games (68%), after-school activities (67%), school field trips (40%), and school performances (36%) compared to teachers at schools that remained open (113).

Re-congregation of students also occurs during localized, elevated seasonal influenza activity or outbreaks. When a western Kentucky rural school district closed for four days due to high ILI-related student absenteeism, 77% of the children visited a location outside of the home (e.g., a mall or department store, a grocery store, or religious services), or visited with non-household members (117). Similarly, when a Colorado school district closed for 4 ½ days due to increasing ILI-related absenteeism among staff and students, the majority of 67 students visited at least one venue outside the home (e.g., 58% visited grocery stores, 33% visited restaurants, and 25% visited sports practices, religious services, or friends' houses) (118).

Availability of Free or Reduced-price Student Lunches during School Closures and Dismissals. During the 2009 H1N1 pandemic, USDA helped provide free or reduced-price lunches to eligible children whose schools were closed by issuing waivers that allowed states to utilize the Summer Food Service Program (SFSP; http://www.fns.usda.gov/sfsp/summer-food-service-program-sfsp) or the Seamless Summer Option (SSO; http://www.fns.usda.gov/school-meals/opportunity-schools). Homeless children are categorically eligible for Supplemental Nutrition Assistance Program (SNAP) benefits (https://www.fns.usda.gov/sites/default/files/SP25_CACFP12_SFSP10-2012.pdf), and documentation that a child is homeless can be used in lieu of a free or reduced school meal application (http://frac.org/federal-foodnutrition-programs/school-breakfast-program/eligibility/). In addition, homeless or housed youth receiving SNAP benefits also are eligible for free school meals https://www.fns.usda.gov/fr-042511). As of April 2017, these important programs are still available for use.

RESEARCH GAPS

Additional study is needed to answer these questions:

- What are the optimal triggers, timing, and duration of school closures for reducing influenza transmission?
- What are the most effective strategies for coping with secondary consequences of school closures?
- What factors influence public acceptance of school closures?
- What is the impact of school-based social distancing measures on disease spread in the wider community?
- What are the social-mixing patterns in school and after-school settings?
- What are the ways to decrease the frequency of social contacts in childcare facilities, K-12 schools, and colleges and universities?

Social Distancing Measures for Schools, Workplaces, and Mass Gatherings

EVIDENCE BASE

Social distancing measures aim to prevent the frequency of face-to-face contact to decrease the risk of person-to-person influenza transmission through droplet transmission, which is believed to occur within 3-6 feet (2). As with respiratory etiquette (page 20), recommendations on social distancing are largely based on: 1) studies on influenza transmission dynamics that suggest a major role for person-to-person spread of virus via contaminated droplets generated by coughs and sneezes (1, 2) and possibly a role for aerosols (3); and 2) practical experience in controlling influenza outbreaks in hospitals and nursing homes by imposing infection control precautions for droplet transmission. These precautions were highlighted during the 2009 H1N1 pandemic (https://www.cdc.gov/h1n1flu/guidelines_infection_control.htm).

As described under *Implementation Issues* (see below), there are many ways to reduce social contacts in schools and workplaces, although there is little empirical evidence to support the effectiveness of any particular measure. With respect to mass gatherings, a systematic literature review of 24 studies confirmed that large public events may be associated with increased risk of influenza transmission, although the data are highly variable (121). The review concluded that cancellation of mass gatherings, in combination with other social distancing measures (e.g., patient isolation, quarantine of exposed persons, and school closures), may help reduce virus transmission. Another review, which considered a range of social distancing measures, found that mass gatherings occurring up to 10 days before the epidemic peak are likely to increase the risk of transmission of influenza and that workplace measures like workplace closures and telecommuting are modestly effective and highly acceptable, but likely to be economically disruptive (e.g., loss of income for workers and loss of essential goods for customers) (122). In addition, a descriptive case study involving a sports event held during the 2009 H1N1 pandemic suggested that intensive disease surveillance followed by patient isolation and quarantine of close contacts can help prevent disease spread during a mass gathering (123). A study conducted in Singapore military units found similar results, showing a significantly lower rate of infection (P<0.001) in the group that received enhanced surveillance with isolation as well as social distancing, when compared to the group that followed standard pandemic response policies (124). The effectiveness of social distancing measures when used in combination with other NPIs also is supported by:

- Historical analyses of the 1918 pandemic which found that: 1) cancellation of mass gatherings (e.g., at churches and theaters) combined with school closures was associated with lower peak death rates, although no single intervention showed an association with improved aggregate outcomes (125); and 2) cities with earlier implementation of multiple interventions (e.g., cancellation of mass gatherings, in combination with isolation and quarantine and school closures) had greater delays in reaching peak mortality, lower peak mortality rates, and lower total mortality, with a statistically significant association between increased NPI duration and reduced total mortality burden (126).

- Modeling studies which found that: 1) social distancing measures are effective in preventing disease spread when implemented in combination with school closures and patient isolation (127, 128), with school closures and household quarantine (129), or with targeted household prophylaxis[§§§] (130); 2) cancellation of mass gatherings in Mexico during the 2009 H1N1 pandemic – in combination with school closures – was strongly correlated with a decrease in influenza transmission, and discontinuation of these measures was strongly correlated with an increase in transmission (131); and 3) in low-income countries, social distancing measures may be as effective in preventing disease spread as targeted use of antivirals[§§§] (132).

Additional evidence that supports the effectiveness of social distancing measures, when used in combination with other NPIs, can be found in the evidence base on *School Closures and Dismissals*; these include modeling studies which found: 1) that school closures combined with staggered workforce shifts (which reduce social contacts) lower attack rates and the daily incidence of disease and delay the peak of a pandemic (reference 87); and 2) a significant reduction in transmission following 18-day school closures implemented in Mexico in combination with other social distancing measures (reference 73).

IMPLEMENTATION ISSUES

Active and sustained participation by individuals and communities is required for simultaneous implementation of social distancing measures in schools, workplaces, and other community venues. To be effective, all of these measures should be implemented early, over long periods, and in combination with other interventions.

School-based Social Distancing Measures other than School Closures and Dismissals. Administrators at childcare facilities and K-12 schools may employ a variety of practices that help reduce person-to-person influenza transmission if schools remain open during a pandemic, although there is no direct evidence for any specific measure. Appropriate social distancing measures to employ depend on the stage and severity of the pandemic in the community. Possible examples include:

- Seating students farther apart, dividing classes into smaller groups, moving classes to larger spaces, and/or holding classes outdoors, if feasible.

- Changing to staggered recess and/or lunch times or having lunch in the classroom.

- Cancelling gym classes and/or classes that bring students together from multiple classrooms.

- Postponing class trips and discouraging use of school buses and public transit, if feasible.

[§§§]CDC is unlikely to recommend targeted prophylaxis during a pandemic, due to concerns about the availability of sufficient antivirals and the potential development of drug resistance.

- Changing to half-day, shorter, and/or staggered school schedules because having fewer students in a classroom for a shorter period of time allows for more space and less contact between children (133).

- Promoting social distancing of children and teens outside the school setting by cancelling after-school and extracurricular group activities, and by advising parents to limit other social activities.

Implementers also should keep in mind that:

- Social distancing of students may be increased by offering distance learning, in which courses and school work are completed through the Internet. If resources permit, schools may provide laptops and other technological devices to students that do not have such resources in their households (e.g., http://ww2.k12.com/mod/home/).

- School-based social distancing measures should be coupled with use of personal protective measures for pandemics, including voluntary home quarantine when siblings or other household members are ill (page 23) and environmental surface cleaning measures (page 36).

- Because schools serve as the communications hub of many local communities, they can provide valuable public health information to parents/guardians, students, and teachers during a pandemic.

***Workplace Measures*.** Workplaces may employ a variety of practices that minimize face-to-face contact among workers and customers to help reduce person-to-person influenza transmission, although there is no direct evidence for any specific measure. Examples include:

- Ensuring that ill workers can stay home without penalty. Emergency-use human resources policies may be needed to permit ill workers to stay home until they have recovered. Other flexible leave policies may be needed as well if workers have to stay home to mind children when schools are closed.

    - A recent literature review of 22 articles – including social mixing studies, simulation models, and surveys – on sickness *presenteeism* (workers who continue to work while objectively ill) and influenza transmission in the workplace found that: 1) on average, 20% (range 4%-25%) of weekly contacts are made in the workplace; 2) on average, 16% (range of 9%-33%) of influenza transmission occurs in the workplace; and 3) workers' willingness to comply with public health recommendations to stay home when experiencing ILI symptoms ranges from 71%-95%. As part of this same review, 18 of 31 countries in the European Influenza Surveillance Network participated in a survey on European sick leave policies for influenza, which found that: 1) nine of 18 countries had official recommendations or policies for sick leave during the 2009 H1N1 pandemic to help reduce transmission in the population; and 2) one of 18 countries had national recommendations for sick leave during seasonal influenza (134).

- Increased use of telework, e-mail, and teleconferences.

- Flexible work arrangements that reduce the number of workers who must be at the workplace at one time or in a specific location (e.g., telecommuting and staggered work hours). Telecommuting and alternative work arrangements may be prioritized for workers at high medical risk.

- Spacing workers further apart at the worksite or keeping groups of workers together throughout the day ("cohorting") to decrease social contacts in the workplace.

- Discouraging use of public transit for commuting to work, if feasible.

- Limiting or postponing non-essential business travel.

- Greater use of delivery of goods and services to reduce the number of clients or customers who visit the workplace (e.g., using home delivery for retail businesses or other delivery methods to customers for wholesale businesses).

Implementers also should keep in mind that:

- Workplace measures should be coupled with use of personal protective measures for pandemics, including voluntary home quarantine (page 23), environmental surface cleaning measures (page 36), and workplace leave policies that promote the implementation of other NPIs (i.e., voluntary home quarantine and staying home to care for children when schools are closed).

- In addition to preventing disease spread, reducing workplace transmission during a pandemic is important to: a) limit the negative impact on economic and national security; b) maintain continuity of operations and preserve essential services and supply chains; c) protect key resources and critical infrastructure; and d) sustain economic activity as close to pre-pandemic levels as possible. A pandemic could easily and disproportionately impact certain sectors of the economy more than others, including education, health, and social services (135).

    - During a severe pandemic, businesses responsible for critical infrastructure systems – such as nuclear power and water purification plants – might consider housing workers who perform essential functions apart from the community (e.g., at nearby hotels) to prevent their potential exposure to ill persons in their households or in the community. In addition, some large businesses might consider developing pre-pandemic plans and instructions – in close collaboration with local public health authorities and healthcare partners – for assessing and managing health risks among workers (e.g., by conducting health screenings for ILI symptoms).

- Implementation of workplace-based social distancing measures may be difficult in some sectors because the legal obligations of private and public employers for hourly, non-hourly, and exempt workers differ (see https://www.dol.gov/whd/regs/compliance/hrg.htm). For example:

    - Hourly workers who are not paid if they do not work, regardless of the reason for the absence, may decide that they cannot financially afford to take time off, even when they are ill (6).

    - Additionally, if an employer decides to close for any reason, non-hourly workers must deduct accrued leave time from their leave banks. If they do not have accrued leave time, the employer must still pay non-hourly workers their full salaries.

    - For exempt workers, an employer cannot deduct pay if workers are not absent for a full day, regardless of the reason for the absence (https://www.dol.gov/whd/regs/compliance/hrg.htm).

    - It may be easier to implement staggered or half-day work schedules, as workplace closures can be less than ideal for both employers and workers.

    - Emergency leave policies can be developed in advance of a pandemic to enable time for discussion with key stakeholder groups and employee organizations.

- Workplace-based social distancing measures may decrease productivity, or may not be feasible, when business processes require face-to-face meetings, or when occupational settings require daily contact with other workers, clients, or customers (e.g., airport screeners or mass/rural transit operators). However, these negative effects may be outweighed by the benefits (both personal and economic) of having fewer workers fall ill under certain pandemic scenarios. Evidence suggests that employers who implement teleworking policies (136) or allow self-quarantine with full pay following illness onset in a family (5) may be able to reduce worker-to-worker transmission of respiratory illnesses, including seasonal and pandemic influenza.

Additional information on how workplaces can prepare for an influenza pandemic is described in the Occupational Safety and Health Administration's Guidance on Preparing Workplaces for an Influenza Pandemic (https://www.osha.gov/Publications/influenza_pandemic.html), the Center for Infectious Disease Research and Policy's toolkit for Doing Business During an Influenza Pandemic (http://www.cidrap.umn.edu/sites/default/files/public/downloads/cidrap-shrm-hr-pandemic-toolkit.pdf), and the

Society for Human Resource Management's sample Severe Influenza Pandemic Policy (https://www.shrm.org/resourcesandtools/tools-and-samples/policies/pages/influenzapandemicpolicy.aspx).

Modification, Postponement, or Cancellation of Mass Gatherings. Modifying, postponing, or cancelling mass gatherings to help reduce person-to-person influenza transmission will depend on:

- Expected benefits versus risks of altering the mass gathering for the community;
- Timing of the event in terms of the local pandemic situation;
- Duration and size of the event (i.e., whether a large number of people will be in close contact for a long period of time); and
- Whether people will be traveling to and from the event from other (affected or not-yet-affected) communities.

Other factors that may affect the risk of exposure include the type of living accommodations, the availability of health services for case isolation and treatment, whether the mass gathering is an open or confined event, and patterns of social mixing during the event (137, 121). For example, of the 468 questionnaires analyzed from Malaysian pilgrims performing Hajj 2013 rituals, 93% experienced respiratory illness symptoms (both ILI and non-ILI), which 81% acquired after a brief but intensely crowded stay at Arafat. 52% of the respondents had contact with other pilgrims suffering from respiratory illness (138).

If the severity of the pandemic does not warrant postponement or cancellation of a mass event, event planners may implement modifications that reduce social density, such as limiting attendance (121), staggering attendance schedules, or arranging for attendees to participate through remote viewing sites (139). Event planners also may supply tissues and hand sanitizers, work with local public health departments to implement event-specific surveillance (140, 123), and/or provide isolation areas for on-site medical assessment and care of people with ILI symptoms (140-143).

Communication is essential throughout an event to help mitigate disease spread and to identify, isolate, and treat cases of disease (123, 143, 144). Event planners should work with local public health authorities to:

- Provide public health information on how attendees can protect themselves and others and on what actions to take if they become ill while attending the event. Public health messages might include a recommendation that persons at high risk for medical complications due to influenza not attend the event or other mass gatherings (121).
    - For example, among 356 Australian pilgrims completing a pre-Hajj 2014 survey, approximately 66% obtained professional pre-travel health advice from general practitioners, a specialist travel clinic, a specific Hajj website, and/or the *Smartraveller* website. 46% of the respondents were aware of the annual Hajj health recommendations issued by the Saudi Ministry of Health. Of the 150 Australian pilgrims completing the post-Hajj 2014 survey, 94% practiced hand hygiene during the Hajj; 53% used face masks at least three times a day to protect themselves from infectious diseases; and 39% avoided contact with symptomatic people (145).
- Ensure a continuous process of risk assessment, including an ongoing review of the setting, social-mixing patterns, and the population attending the event and an ongoing evaluation of how the healthcare system and the community are coping with increased cases associated with the event (137).

Factors that may limit NPI implementation at mass gatherings include:

- Lack of legal authority in some jurisdictions to postpone or cancel mass gatherings or lack of resources to enforce those decisions;
- Opposition to event cancellations by event planners, local authorities, and the public, especially when cancellations have significant perceived value and/or financial and economic consequences;

- Cultural sensitivity to and implications of postponing or cancelling certain mass gatherings, particularly cultural or religious festivals/holidays;
- Resource and technological constraints that limit event-based surveillance or provision of remote viewing sites; and
- Epidemiologic, clinical, or virologic factors that may affect viral transmissibility within a group of people (121, 141).

RESEARCH GAPS

Additional study is needed to answer these questions:

Workplace-based Social Distancing Measures

- What is the potential effectiveness of social distancing measures in different workplace settings, including workplaces that provide critical services or infrastructure support?
- What is the potential impact of workplace-based social distancing and/or flexible sick leave policies on workplace absenteeism and on influenza transmission in homes and communities?
- When should social distancing measures be implemented in the workplace?
- What are the benefits and costs of workplace-based social distancing measures for businesses?
- What are the optimal measures for allowance/exclusion of ill persons from the workplace?
- What is the utility of workplace entry screening?

Modification, Postponement, or Cancellation of Mass Gatherings

- To help establish a baseline, what range of community settings host mass gatherings in a given community, including educational facilities, workplaces, and public places where people gather (e.g., parks, religious institutions, theaters, and sports arenas)?
- What types of mass gatherings (e.g., in terms of the age of the attendees, crowd density, duration, and location) are associated with the greatest likelihood of influenza transmission?
- What types of other NPI measures implemented at mass gatherings (e.g., promotion of personal protective measures) can be most effective in reducing influenza transmission?
- How can new technologies and real-time surveillance systems assist in facilitating the detection and response to ILI case reports at mass gatherings?
- What type of post-event surveillance should be conducted for gatherings of short duration (1-2 days) to help determine what happens when mass gathering attendees return home?

ENVIRONMENTAL NPIS

Environmental Surface Cleaning Measures can eliminate influenza viruses from frequently touched surfaces and objects, including tables, door knobs, toys, desks, and computer keyboards. These measures involve cleaning surfaces with detergent-based cleaners or Environmental Protection Agency (EPA)-registered disinfectants.[****]

EVIDENCE BASE

Of all microorganisms, influenza viruses are among the least resistant to disinfection (http://www.flu.gov/planning-preparedness/hospital/influenzaguidance.html). These viruses can be removed from surfaces by routine cleaning practices that use detergent-based cleaners (e.g., dish soap) or EPA-registered

[****]See: Antimicrobial Products Registered for Use Against the H1N1 Flu and Other Influenza A Viruses on Hard Surfaces (https://archive.epa.gov/pesticides/oppad001/web/pdf/influenza-a-product-list.pdf)

disinfectants (https://www.epa.gov/pesticide-registration/selected-epa-registered-disinfectants). Detergents lift dirt and pathogens off surfaces so they can be rinsed away with water, while disinfectants disrupt the lipid membrane that surrounds the viral RNA (146). Indirect evidence that elimination of viruses from surfaces can have a significant impact on contact transmission of influenza includes these findings:

- Influenza viruses in the respiratory secretions of infected persons remain viable on hard, nonporous materials (e.g., stainless steel, wood, and hard plastic) for 24-48 hours, during which time they can spread from those surfaces to human hands (11, 147). Although influenza viruses survive on hands for only 3-5 minutes (11), touching contaminated surfaces and then one's own mucous membranes can result in self-inoculation.
- The influenza virus becomes undetectable on highly porous materials (e.g., cloth and paper) if drying occurs within 15 minutes. However, it can remain viable for viral transfer to the hands and, thus, for virus transmission for up to 12 hours (11). One experimental study found that infectious particles of influenza A H1N1 survived on cloth surfaces for up to eight hours (147). Similarly, a review of 13 studies evaluating influenza survival on dry surfaces concluded that influenza can survive for extended periods on a variety of materials (148).
- Influenza viruses have been detected on surfaces in homes and daycare centers during regular influenza seasons (149), with higher rates of contamination found in some homes with young children (150). Influenza viral RNA has been detected on refrigerator handles, telephone receivers, TV remotes, and kitchen surfaces (e.g., microwave ovens) (149), and personal mobile phones (151).
- An experimental study found that influenza A viruses survived up to three days on banknotes that were intentionally contaminated with high concentrations of virus (152).

Other methods for inactivation of influenza viruses – in addition to common soaps and disinfectants – include heat treatments or ethylene oxide (used in hospitals; 153), quaternary ammonium compounds (used on poultry farms; 154), low vapor concentrations of hydrogen peroxide (used on airplanes, 155; or in healthcare settings, 156) or triethylene glycol (used on airplanes; 155), and glucoprotamin-containing disinfectants (used in hospitals or biopharmaceutical facilities; 157). However, these methods may not be appropriate for most household and community settings.

IMPLEMENTATION ISSUES

Most, if not all, disinfectants (like bleach) require a pre-cleaning step before applying the disinfectant, as organic material on surfaces and objects can reduce the effectiveness of the disinfectant. Regardless of the product selected, it is important to read the instruction labels on all cleaners first to make sure they are used safely and appropriately. Each cleaner and disinfectant has instructions that tell users:

- If the product is safe for the surface.
- If the surface needs to be cleaned first and rinsed after using the product.
- Precautions to take when applying the product, such as wearing gloves or aprons, or making sure you have good ventilation during application.
- Whether the product requires dilution with water before use.
- How to apply the product to a surface.
- How long to leave the product on the surface to be effective (contact or dwell time).

Special or extra cleaning and disinfecting processes – like wiping down walls and ceilings, frequently using room air deodorizers, and fumigating – are not necessary or recommended to help prevent the spread of influenza. Standard or routine cleaning and disinfecting practices are sufficient to remove influenza viruses from frequently touched surfaces and objects at home, school, and work.

RESEARCH GAPS

Additional study is needed to answer these questions:

- What is the relative contribution of contact transmission in the spread of influenza?
- What types of surfaces are most likely to be contaminated with influenza viruses?
- What is the optimal cleaning frequency to remove influenza viruses from contaminated surfaces in homes, schools, and workplaces?
- Are there consequences for increasing routine cleaning procedures in homes, schools, and workplaces during a pandemic (e.g., increasing allergic reactions to disinfectants, creating a toxic environment for young children)?
- Are there specific situations where surface cleaning should be emphasized or de-emphasized more than others (e.g., in households where active influenza infection exists in a person [excessive coughing or inability to control dispersal of sputum/secretions onto surfaces] versus in healthy households)?
- Are there sufficient stocks of cleaning supplies and/or disinfectants for a facility or a community to use during a pandemic?

References

The NPI Evidence Base includes:

Personal NPIs

- Personal Protective Measures for Everyday Use
  - Voluntary Home Isolation: *References 4-10*
  - Hand Hygiene: *References 12-27*
- Personal Protective Measures Reserved for Pandemics
  - Voluntary Home Quarantine: *References 4-10*
  - Use of Face Masks in Community Settings: *References 43-60*

Community NPIs

- School Closures and Dismissals: *References 7 and 68-92*
- Social Distancing Measures: *References 121-132*

Environmental NPIs

- Environmental Surface Cleaning Measures: *References 11 and 147-157*

First authors that are **bolded** are part of the NPI evidence base. See Appendix 5: NPI "Body of Evidence" Summary Table for more information about each article.

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Chapter 4: Conclusions

The purpose of the *Community Mitigation Guidelines to Prevent Pandemic Influenza – United States, 2017* is to help state, tribal, local, and territorial health departments with their future pre-pandemic planning and decision-making by providing them with lessons learned during the 2009 H1N1 pandemic response, the latest evidence based on extensive research of nonpharmaceutical interventions (NPIs), and updated pre-pandemic recommendations on the use of NPIs. Since it may take up to six months until a pandemic vaccine is widely available given current vaccine production technology (http://www.historyofvaccines.org/content/articles/vaccines-pandemic-threats), NPIs are the earliest line of defense in an evolving pandemic. Furthermore, they are universally available to individuals and communities, and can be quickly deployed to help prevent the transmission of a novel influenza virus with pandemic potential right after it emerges (i.e., even before a pandemic has been declared). Thus, NPI implementation in a pandemic remains critically important while a pandemic vaccine is being developed and until pandemic vaccination provides sufficient levels of population immunity to curb the pandemic influenza activity.

The 2017 guidelines consider the same set of NPIs presented in the 2007 *Community Strategy*, which first proposed a pandemic mitigation framework based on early application of multiple NPIs that are rationally targeted, layered, and tailored to pandemic severity. The updated guidelines provide evidence-based recommendations on the use of each NPI, which include: *personal protective measures for everyday use* (voluntary home isolation of ill persons, respiratory etiquette, hand hygiene), *personal protective measures reserved for pandemics* (voluntary home quarantine of exposed household members, use of face masks in community settings when ill), *community measures* aimed at increasing social distancing (school closures and dismissals, social distancing in workplaces, postponing or cancelling mass gatherings), and *environmental measures* (routine cleaning of frequently touched surfaces). The evidence base on the effectiveness of NPIs has expanded since 2007, especially after the 2009 H1N1 pandemic. The updated planning guidelines provide the current available evidence base, which was summarized, rated, and used to support the NPI recommendations.

The 2017 guidelines can be used for revising state and local pandemic plans during this inter-pandemic period. Pre-pandemic planning should be conducted in a coordinated and collaborative manner. The implementation of community-level NPIs will require the cooperation and coordination of families, schools, businesses, employers, and organizations. It is suggested that schools and businesses, in particular, be included in pre-pandemic planning since school closures and dismissals will directly affect workers and parents.

One of the key lessons learned from the 2009 H1N1 response is the importance of community engagement. For example, the Harvard Opinion Research Program (HORP) project conducted opinion polls on the American public's response to the H1N1 pandemic related to NPI implementation (https://www.hsph.harvard.edu/horp/%20project-on-the-public-response-to-h1n1/). Americans reported they washed their hands or used hand sanitizer more frequently. They also avoided mass gathering locations and distanced themselves from people who had influenza-like symptoms. There was support from parents when decisions were made to close schools and daycare centers, so children could be separated and not spread infection. Businesses also demonstrated support for their ill workers and offered paid sick leave in some instances. However, employers were less likely to approve paid leave for workers to take care of ill family members or to care for children if schools and daycare centers closed. Given that voluntary home isolation (self-isolation or staying home when ill) is one of the key strategies in preventing further spread of a pandemic virus in schools, workplaces, and other community settings, further progress is needed toward wider access to paid sick leave for workers to increase compliance with this important public health recommendation for future pandemics.

As before, in future pandemic responses, severity of disease will be the key consideration to appropriately match NPIs to the characteristics of the evolving pandemic. However, influenza pandemics are inherently unpredictable, and lack of data may limit the use of the Pandemic Severity Assessment Framework to estimate pandemic severity when the pandemic emerges (1). These factors should be taken into account during pre-pandemic planning, and response plans should remain flexible and include a phased approach that enables real-time adjustments of community mitigation measures.

The overall goal of pre-pandemic planning is to decrease morbidity, mortality, and the social and economic consequences that may result from a pandemic. To ensure maximum public health benefits from the whole suite of available pandemic response tools, including NPIs, NPI implementation during an influenza pandemic should be carefully coordinated with the use of antiviral medications and pandemic vaccination.

References

1. Reed C, Biggerstaff M, Finelli L, et al. Novel framework for assessing epidemiologic effects of influenza epidemics and pandemics. Emerg Infect Dis. 2013; 19:85-91.