UC Berkeley

UC Berkeley Electronic Theses and Dissertations

Title

Employer Preparedness for Pandemic Influenza: Shifting the Conversation from Insurance to Investment

Permalink

https://escholarship.org/uc/item/0p05b5qx

Author

Lachance, Jennifer Alice

Publication Date

2010

Peer reviewed|Thesis/dissertation

eScholarship.org Powered by the California Digital Library
University of California

Employer Preparedness for Pandemic Influenza: Shifting the Conversation from Insurance to Investment

By

Jennifer Alice Lachance

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctorate of Public Health

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Arthur Reingold, chair
Professor Tomás Aragón
Professor Karlene Roberts
Professor Thomas Rundall

Spring 2010

Copyright page

Abstract

Employer Preparedness for Pandemic Influenza:
Shifting the Conversation from Insurance to Investment

by

Jennifer Alice Lachance

Doctor of Public Health

University of California, Berkeley

Professor Arthur Reingold, Chair

Pandemic influenza is currently one of the most visible public health threats of concern to the general public, and private businesses are an important part of pandemic preparedness. The health of communities is affected by the local economy, which is driven by the businesses in that economy. To date, public health authorities' efforts to engage businesses in pandemic influenza preparedness efforts have justified preparedness based on potential losses due to future, uncertain threats. However, this approach has not successfully engaged businesses on a broad scale. This dissertation proposes that a more effective way to engage the private sector may be to shift the conversation away from justifying preparedness only as a long-term insurance strategy and toward justifying it as an investment strategy with short-term benefits such as improved employee health during interpandemic cold and influenza seasons. The viability and acceptability of this new approach are explored here via three distinct but complementary studies using both quantitative and qualitative methods.

The first study, a prospective observational cohort study, examined the individual characteristics and situations that predicted changes in hand and respiratory hygiene and social distancing behaviors among university students during an interpandemic cold and influenza season. This analysis reveals that individuals have higher adherence to behaviors in situations such as when they are ill. Additionally, some individual characteristics predict higher behavior adherence. In particular, individuals who perceive peer expectations concerning adherence to hygiene behaviors tend to have better adherence to those behaviors over the course of a cold and influenza season.

The second study, a cost-effectiveness analysis of a hand and respiratory hygiene intervention among university students, assessed whether an intervention could be cost-effective in reducing influenza-like illness and associated time lost from productive activities during an interpandemic cold and influenza season. This analysis finds that hand and respiratory hygiene interventions can be cost-effective and may even become cost-saving during a severe cold and influenza season, especially using group-level interventions that may create peer expectations to influence behaviors.

Finally, the third study, an exploratory analysis based on key informant interviews with private sector business continuity managers, consultants, and public sector planners, examined private sector preparedness for pandemic influenza. This analysis assessed the key components

of employer pandemic influenza preparedness plans, including whether short-term benefits are a consideration in business planning. The results indicate that the most important components of private sector pandemic influenza plans before and during the 2009 H1N1 influenza pandemic included communications and employee education around hygiene behaviors. Participants further identified that implementation of these initiatives during interpandemic cold and influenza seasons is of interest to organizations due to potential short-term and long-term benefits.

These results together provide evidence that education and provision of materials for hygiene behaviors at a group level can be cost-effective in reducing influenza-like illnesses during interpandemic cold and influenza seasons and are an acceptable strategy to the private sector. This provides a basis for the hypothesis that employer preparedness for public health events such as pandemic influenza can be justified as a short-term business investment strategy rather than only as a long-term insurance strategy.

TABLE OF CONTENTS

Chapter I: Introduction **1**
Background & significance **1**
Seasonal and pandemic influenza 1
Interventions 2
Private sector preparedness 4
Theoretical framework **7**
Risk-based incentives versus short-term return on investment 7
Use of cost-effectiveness analysis to demonstrate short-term return on investment for preparedness activities 10
Overview of dissertation **11**
References **13**

Chapter II: Barriers to and Predictors of Changes in Hand and Respiratory Hygiene and Social Distancing Behaviors among University Students Enrolled in a Longitudinal Study **19**
Introduction **19**
Methods **20**
Study design and population 20
Measurements 22
Statistical approach 25
Hypotheses 25
Results **27**
Discussion **29**
Conclusion **32**
References **34**

Chapter III: Cost-Effectiveness of a Hand and Respiratory Hygiene Intervention in Reducing Influenza-like Illness among University Students **48**
Introduction **48**
Methods **49**
Study design and population 49
Cost-effectiveness approach 52
Data for cost-effectiveness analysis 54
Results **60**
Study participants 60
Baseline characteristics of study participants 60
Effectiveness 60
Cost-effectiveness 61
Discussion **63**
Conclusion **66**
References **67**

Chapter IV: An Exploratory Qualitative Analysis of Pandemic Plan Components and Planning Considerations in the Private Sector **89**
Introduction **89**
Methods **90**
Study design and data collection methods 90
Analysis 93

Results **94**
Study participants 94
Participant-identified plan components and planning considerations 95
Description of most frequently mentioned plan components and planning considerations 96
Least important actions 111
Validation 112
Discussion **113**
Conclusion **117**
References **119**
Chapter V: Conclusion **132**
References **135**
Appendix: Interview guide **136**

Acknowledgements

I had the good fortune to have the support and encouragement of many different people during this process, for which I am incredibly grateful. First, my dissertation committee has been supportive on many different fronts. Art Reingold, my dissertation chair, provided valuable guidance on the direction of my research and encouraged me as to the value of that work. Tom Rundall provided detailed and meaningful feedback on each part of my dissertation, continually pushing me to make it better. His positive reinforcement was critical to my success. Tomás Aragón was very helpful with early discussions to brainstorm potential research ideas, and continually enthusiastic about my work during my time in the DrPH program. Karlene Roberts encouraged my efforts and pushed me to think about the interdisciplinary aspects of this work, which ultimately strengthened my entire thesis. In addition, several individual faculty members spent time working with me and encouraging me through the process, especially UC Berkeley faculty Maureen Lahiff, Cheri Pies, and Ellie Schindelman, and Stanford faculty Eran Bendavid. I leave Berkeley a better scholar, researcher, and teacher for having worked with each of them.

I would not have been able to accomplish as much without the support of three important groups. First, my fellow doctoral student researchers at the Center for Catastrophic Risk Management provided a great deal of critical feedback to strengthen my research. My work is much improved because of the collaborative and mutually supportive approach this group took with each person's research. Second, I benefited from having the opportunity to conduct research as part of the REDucing Influenza-like illness among University Students (REDI-US) study team on campus. This small team accomplished a great deal on a challenging research question, due in no small part to each of the team members who contributed to the efforts, as well as the support staff at the Center for Infectious Diseases and Emergency Readiness. Finally, I was fortunate to have found the Business Recovery Managers Association in San Francisco, where I had the opportunity to interact with business continuity managers who gave me ongoing encouragement and guidance, both individually and collectively, from the perspective of those actually doing employer preparedness work in the field.

My experience in the DrPH program would not have been nearly as fulfilling without the opportunity to be in a cohort of such diverse and inspiring individuals. In particular, Diego Castaneda, Marty Martinson, and Sarah Roberts experienced every bit of the process with me. They provided the structure and encouragement I needed to see me through the whole process. I feel incredibly lucky for having had the opportunity to share this experience with them. I am also grateful to Beth Carlton, who was available to help with any question big or small, and who was always ready to provide a good dose of humor throughout the process.

I am also fortunate to have been supported by many good friends who helped keep me focused and moving forward, celebrating each of the small and large milestones with me along the way. In particular, Susan Burwick, Catherine Cella, Emily Cotter, Ronit and Carlos Dedesma, Sidra Goldman, Mae Hsu, Kiersten Israel-Ballard, Dawn Mackey, Chrissa Pagitsas, Leslie Wallace, and Susie Welty offered support, understanding, care packages, homemade pasta sauce, coffee dates, and lots of laughs.

Finally, I am blessed to have the support of a wonderful family, without whom I would not have been able to achieve this goal. My in-laws, Kathy and Connie Kronholm and Jim Norden supported my passion for this work and encouraged me in my pursuit of this degree. My siblings – both by birth and marriage – each inspired me in different ways, especially Amy and

Katie, who kept me motivated through many phone calls during commutes on the other side of the country and visits to California, and Liz and Neil, who helped make California a home away from home. My parents, Jerry and Barbara, are a constant source of support and inspiration. They have supported me in everything I have strived for over the years and have always reminded me that anything is within reach. They have also endured many long phone calls at any time of day or night, through laughter and tears, to keep me moving forward in pursuit of those goals. I would not have achieved what I have without their support. Finally, my husband Eric has seen me through this effort and supported me, from helping me choose Berkeley to picking up my graduation regalia five years later. He was a sounding board for each of my research ideas, and challenged my early ideas to strengthen and improve them. He also provided support in other ways, from doing countless extra dishes to being willing to go camping on a moment's notice when I needed clear my head. Ultimately, he helped me laugh along the way and reminded me to enjoy the experience. Which I very much did.

The research for Chapters II and III of this work was made possible by a grant from the Centers for Disease Control and Prevention (Award #U01 CI000428-01), "Effectiveness of Selected NPIs in Reducing ILI among University Students." The key informant interviews (Chapter IV of this work) were supported by grant #CMMI 0624296 from the National Science Foundation, "How Institutions Think About the Unthinkable: Organizational Learning and Communication About Catastrophic Events."

CHAPTER I: INTRODUCTION

Background & significance

Pandemic influenza is currently one of the most visible public health threats of concern to the general public, and private businesses are an important part of pandemic preparedness. The health of communities is affected by the local economy, which is driven by the businesses in that economy (1, 2). Given the role of businesses in sustaining the economy of their surrounding communities, public health authorities would be remiss in their pandemic preparedness efforts if they did not encourage businesses to participate in these efforts.

Following the first emergence of H5N1 avian influenza in 1997 and Severe Acute Respiratory Syndrome (SARS) in 2002-2003, awareness of the potential for another influenza pandemic increased (3, 4). These events jumpstarted pandemic preparedness efforts within many private sector organizations and these preparedness activities became immediately useful in April 2009, when a novel influenza A(H1N1) virus emerged and a pandemic ensued. However, leading up to and even during the 2009 H1N1 influenza pandemic, many other organizations did not prepare or respond meaningfully, highlighting a gap in public health preparedness and an opportunity to improve engagement with the private sector around these potential hazards. In particular, public health agencies' efforts to that point had justified private sector preparedness on avoidance of potentially staggering costs in the event of a pandemic. This dissertation is predicated on the hypothesis that more effective ways to engage the private sector exist and proposes a new approach: to shift the conversation with the private sector from justifying preparedness as an insurance strategy to justifying it as investment strategy. This investment would be realized via proactive implementation of influenza interventions in the workplace to introduce short-term benefits through reduction in the spread of other respiratory infections that occur more regularly, such as seasonal influenza.

A brief introduction and theoretical framework for this work is provided here, followed by three separate but complementary studies, which explore and provide a basis upon which to justify this hypothesis. The first paper examines predictors of changes in adherence to hand and respiratory hygiene behaviors during an interpandemic cold and influenza season. The second paper examines whether interventions aimed at hand and respiratory hygiene interventions can be cost-effective. The third paper explores components of private sector pandemic preparedness plans and whether organizations would consider implementing hygiene interventions in the short-term for benefits during seasonal cold and influenza events. The conclusion ties the three studies together and recommends strategies for engaging the private sector in preparedness efforts going forward as well as future research opportunities.

Seasonal and pandemic influenza

Understanding public health preparedness for pandemic influenza first involves knowing the differences between pandemic influenza and seasonal influenza. Seasonal influenza is an acute viral infection of the respiratory tract. It typically occurs between October and May in the United States each year, when a new variation of the previous season's virus is introduced via point mutations on the hemagglutinin and neuraminidase proteins (5). This process is known as "antigenic drift," and occurs for both influenza A and influenza B (6). Seasonal influenza affects an estimated 5% to 20% of the United States population annually, resulting in more than 200,000

hospitalizations and 36,000 deaths each year (5). The incidence of seasonal influenza is highest in school-age children (7), but morbidity and mortality is greatest among the elderly and infants (8, 9), and those with chronic diseases (10, 11).

A pandemic is "a global disease outbreak" (12). In the case of influenza, several conditions must be met for a pandemic to occur. First, a new strain of the influenza virus must emerge, to which there is little or no immunity in humans; second, the strain must cause serious illness; and third, the strain must be able to be easily transmitted person-to-person (12). The emergence of a strain of influenza to which there is little or no immunity in humans is known as "antigenic shift," where large changes occur to the virus within a short period of time (6). This phenomenon only occurs in Influenza A and has the potential to cause a pandemic (6).

Influenza pandemics occur irregularly but with some level of frequency. For example, three pandemics occurred in the twentieth century (12): 1918-19, 1957-58, and 1968-69. In terms of susceptible populations, pandemics can differ from seasonal influenza in that those at highest risk may not be just the young and the old. For example, in the 1918 pandemic, those aged 25-34 years had the highest rates of excess mortality due to influenza (13).

The most recent pandemic influenza virus, novel influenza A(H1N1), emerged in April 2009. It was first recognized in two children in the United States, with initial disease spread occurring predominantly in Mexico (14). The World Health Organization (WHO) escalated the pandemic alert phase over the next two months as the virus spread globally, declaring it a pandemic in June of that year (15). In the United States, the initial wave of disease occurred in the spring, with low levels of continued transmission over the summer months and a second pandemic wave starting in the fall (16). Incidence was highest among children and young adults (17), and serious complications were most common among people age 65 and older, children younger than 5 years, pregnant women, and those with certain chronic medical conditions such as asthma (18). In general, however, this pandemic virus was characterized by low severity in much of the population (16).

It is generally accepted that influenza (both seasonal and pandemic) is transmitted person-to-person via respiratory secretions (19). It is also believed that the influenza virus can remain viable on environmental surfaces and be transmitted by hands or fomites (20-22), although this has been debated in the literature (23-25). The mode of transmission defines the types of interventions that may be put in place to interrupt transmission of the virus.

Interventions

Available interventions to stop the spread of influenza can be divided into two categories: pharmaceutical and non-pharmaceutical. The primary responses currently in use for human seasonal influenzas are pharmaceutical in nature, including vaccines and chemoprophylaxis with antiviral drugs (11). However, in the event of a pandemic, vaccines and antiviral drugs will initially be in short supply (26); this was the case during the 2009 H1N1 influenza pandemic (27). Therefore, an important part of any pandemic response must include alternative, non-pharmaceutical interventions (NPIs) that are not as resource-limited and may help delay the spread and reduce the effects of a pandemic influenza virus. NPIs include patient isolation and quarantine of contacts, social distancing, hand and respiratory hygiene/cough etiquette, facemask use, and surface disinfection (28). Patient isolation and quarantine of contacts are actions that need to be initiated and coordinated by local public health authorities, and therefore are not strategies a business would employ. The latter four are most relevant in a business setting. They

are defined here and the evidence for their effectiveness in reducing respiratory illness is reviewed.

First, the purpose of social distancing measures is to limit interactions between people in order to interrupt disease transmission. Social distancing entails limiting the frequency of crowded situations in which individuals have increased interactions in locations such as schools, public transportation, and other public places. The World Health Organization Writing Group provides a summary of the evidence that exists, and notes that while there are some anecdotal reports of the effectiveness of these measures, it is not consistent across all situations. Rather, some reports cite no impact of social distancing measures on the spread of an epidemic, while others do report some level of impact (28). It is hoped that curtailing these individual interactions will result in reducing the risk of transmission, however given the scarce evidence to support the effectiveness of social distancing, recommendations are justified primarily on a 'common sense' basis.

Second, hand and respiratory hygiene, including cough etiquette, is one of the most fundamental interventions considered to limit the transmission of respiratory illnesses. The purpose is to limit the spread of respiratory secretions, especially from those who may have a respiratory infection. Hand hygiene is defined as "any method that removes or destroys microorganisms on hands" (29). Hand hygiene for respiratory illnesses involves washing hands with non-antimicrobial soap and water, alcohol-based hand rub, or antiseptic hand wash following contact with any respiratory secretions and/or contaminated materials, and utilizing effective hand drying (29, 30). Respiratory hygiene/cough etiquette recommendations include covering the nose or mouth while sneezing or coughing, respectively; using tissues to capture any respiratory secretions; immediate and safe disposal (i.e., in an appropriate trash container) of tissues after use; and practicing hand hygiene after contact with any respiratory secretions and/or contaminated tissues (30). Concerns regarding hand hygiene in particular center around the question of whether cleaning hands can really be effective at preventing the spread of influenza viruses, which are believed to be spread primarily via droplet transmission (23, 25). However, hand hygiene may still be effective in limiting spread of other respiratory pathogens that can cause influenza-like illness (ILI) (31-33), which makes them an important part of interventions for respiratory illnesses.

Third, the intent of facemask use is to limit risk of transmission from infected individuals to susceptible individuals by interfering in the dissemination of respiratory droplets; this is especially important for infected individuals. Prior to the emergence of the 2009 H1N1 influenza pandemic, no controlled studies had been published to assess efficacy of facemask use (28); however, studies have since been published and found that use of facemasks, coupled with hand hygiene, can be effective in reducing the rate of ILI (34).

Finally, in addition to the transmission of influenza person-to-person, transmission via fomites is of concern (28). Although there is no evidence that the virus can be spread via self-inoculation after touching contaminated environmental surfaces, a case-control study in Hong Kong during the 2003 SARS outbreak found that disinfection, in concert with frequent hand washing and use of facemasks in public, was protective against acquisition of SARS (35). Therefore, it is believed that disinfection of commonly touched or used objects may still be an important recommendation for situations involving influenza.

During the 2009 H1N1 influenza pandemic, each of these NPIs was utilized to varying degrees to slow the spread of the pandemic virus. Given their widespread use, it is important to look not only at effectiveness but also at how to target interventions to have maximum impact in

terms of changing individual behaviors. NPIs have been directed to a range of groups of individuals (e.g., school children, households, university students) with mixed results regarding changing behaviors and/or reducing occurrence of respiratory illnesses (31-34, 36-39). Better understanding the situations in which individuals do (and do not) naturally change their hand and respiratory hygiene behaviors will assist in making future interventions more targeted for maximum effectiveness. This is important to consider throughout a cold and influenza season because these interventions have the potential to prevent many respiratory illnesses.

More streamlined interventions will in turn help achieve organizations' goals of reducing illness using the minimum amount of resources necessary. This will increase the potential for short-term financial benefits, which will help build a business case for preparedness activities. This business case will provide an additional way to engage private sector organizations in pandemic preparedness efforts.

Private sector preparedness

Given the importance of businesses in local and national economies (1, 2), public health authorities did take initial steps toward engaging businesses in pandemic preparedness efforts prior to the emergence of the 2009 H1N1 influenza pandemic. These initial steps included recommendations for businesses by federal, state, and local public health authorities (12, 40-42). Tools to support business preparedness for pandemic influenza included information such as the U.S. Department of Health and Human Services Business Planning Checklist, which is a static two-page document that includes general information for all businesses initiating pandemic planning (43). The most recent version of this document is from 2005, despite the many changes in preparedness efforts and especially lessons learned during the 2009 H1N1 influenza pandemic. Recommendations were predicated on the potential economic impact of a pandemic, using cost avoidance concerns to justify preparedness.

Prior to the emergence of the 2009 novel influenza A(H1N1) virus, several simulations of the impact of a potential influenza pandemic were done to justify preparedness efforts. These simulations predicted staggering impacts (26, 44). Meltzer et al. estimated the economic impact of a pandemic at $71.3 to $166.5 billion, "excluding disruptions to commerce and society" (44). This secondary impact, that of the commercial disruptions, is of great concern to businesses. In the short time SARS was a global issue in 2003, it was forecast that Toronto would experience a drop in its gross domestic product (GDP) of 0.5%(45). In 2006, the World Bank estimated that mild, moderate, and severe pandemics could cause 0.6%, 1.4%, and 3.0% declines in the GDP of the United States (46). The World Bank updated this information in June 2009 based on the initial emergence of the novel influenza A(H1N1) influenza virus, estimating it would cost from 0.7% to 4.8% of the global GDP depending on severity, with most severe impacts experienced in developing countries (47). However, while an estimate of the actual costs incurred from the 2009 H1N1 influenza pandemic will not be available for some time, Homeland Security Secretary Janet Napolitano estimated in October 2009 that the economic impact of the pandemic in the United States would not be different from a "normal" cold and influenza season (48).

Despite the potential impact of a pandemic on economies and the businesses in those economies, especially the impacts predicted before and in the early stages of the 2009 H1N1 influenza pandemic, and public health agencies' efforts to reach the private sector, not all businesses prepared, and those that did had highly variable levels of preparedness. This is clear from conferences, industry research, and trade magazines and publications (49-51). For example, in a 2006 survey of 450 employers globally, Mercer Human Resources Consulting found that

while 90% of respondents thought absenteeism due to a pandemic would have a moderate to high impact on their business, only 47% had a business continuity plan in place. Among those employers in the United States, only 7% had allocated a budget to address pandemic preparedness (52). Given the prediction by Secretary Napolitano that economic impacts of the 2009 H1N1 influenza pandemic would be minimal, justifying private sector preparedness on worst-case pandemic scenarios may be even more difficult at this point and result in fewer organizations participating in preparedness efforts.

Therefore, there is an opportunity for public health authorities to improve the way they are engaging the private sector to have broader appeal to employers. This may involve framing preparedness initiatives in such a way that they are relevant for more employers. How to do this can be learned by looking at the types of employee initiatives businesses are investing in and determining if there are parallel opportunities for pandemic preparedness. For example, many businesses have demonstrated that they will invest in employee health promotion programs with short-term benefits. It is apparent from businesses' direct employee healthcare costs alone that the health of a business is directly related to the health of its employees: U.S. businesses pay for 26% of the total $1.9 trillion spent annually on healthcare in the United States (53). Additionally, businesses are affected by indirect employee healthcare costs: productivity losses due to family and personal health problems cost U.S. businesses $225.8 billion per year (54).

It is not surprising, therefore, that employers are concerned with employee health and productivity and are willing to invest in such initiatives. Employee health initiatives have been proven to have a positive impact on employee health behaviors in the short-term in both research and employer-sponsored projects (55) and have demonstrated a positive, short-term return on investment (ROI) (56-58). For example, in a review of the literature relating to the financial impact of health promotion programs, Aldana (59) found that for every $1 invested, healthcare cost savings ranged from $2.30 to $5.90; savings from decreased absenteeism ranged from $2.50 to $10.10; and savings from lower healthcare costs and decreased absenteeism combined ranged from $3.40 to $6.00. While the specific estimates of the savings vary greatly, the noteworthy point is that the ROI is positive in each case.

In addition, the savings from decreased presenteeism are likely just as large, if not larger: it is estimated that presenteeism, the situation in which sick employees go to work despite their illness, costs businesses in the United States one-fifth to three-fifths the total costs of illness in terms of lost productivity. In the case of seasonal or other illnesses prone to "flare-ups" such as migraines, these productivity losses cost employers more than the medical costs of the illness (60). In particular, respiratory infections are one of the top conditions associated with at-work productivity losses, with costs from absenteeism, short-term disability, and presenteeism on average higher than total medical costs ($71.98 per employee per year versus $61.86 per employee per year, respectively) (60). This implies that productivity losses due to both absenteeism and presenteeism pose a significant cost to employers in general, and respiratory infections represent a substantial portion of those losses.

If pandemic influenza preparedness can reduce seasonal influenza, then these efforts can be significantly cost-saving in the short-term as well as in the long-term. Savings would include the costs of illness, as well as the costs of lost productivity in the form of both absenteeism and presenteeism, as outlined above. In fact, the magnitude of the costs for respiratory illness justify why they are a real concern for employers during an interpandemic cold and influenza season. Therefore, one would expect employers to be open to preparing if it might lower the costs of absenteeism and presenteeism for seasonal colds and influenzas. Additionally, illness during a

pandemic is expected to increase, leading to even greater cost savings and creating a stronger case for implementing these initiatives. However, in order to understand whether short-term cost-savings would be a driver for employers to prepare for an influenza pandemic, it is important to first understand the types of decisions involved for employers.

Types of decisions

Programmed and nonprogrammed decisions. There are many ways to classify problems and the decisions they require within organizations. One way is by differentiating between routine issues and novel issues. Simon identified these as programmed and nonprogrammed decisions, respectively (61). Programmed issues are those within an organization that occur with some level of frequency, allowing standard procedures to be developed for dealing with them. In contrast, nonprogrammed decisions are those that are unique and new to an organization, and as such no procedures exist for addressing the problem (61). Seasonal cold and influenza preparedness and mitigation represent a programmed decision, while pandemic influenza preparedness represents a nonprogrammed decision.

Risk versus uncertainty. Beyond the decision categories of programmed versus nonprogrammed, there is an additional taxonomy for characterizing those problems that may be classified as threats: risks versus uncertainties. Risks are defined as those threats that can be quantified or known, while uncertainties are defined as those that cannot be quantified (62). Given that seasonal influenza is a known and predictable threat, it is categorized as an organizational risk. In contrast, due to the unpredictable nature of pandemic influenza, it represents an uncertainty for organizations.

Milliken went on to further characterize uncertainties as either state, effect, or response uncertainties (63). In particular, "administrators experience 'state' uncertainty when they perceive the organizational environment, or a particular component of that environment, to be unpredictable" (63, p. 136). Effect uncertainty is "uncertainty about whether an event or change in the environment will have an impact on the focal organization at all as well as uncertainty about the nature, severity, and timing of the impact" (63, p. 137). Response uncertainty "is defined as a lack of knowledge of response options and/or an inability to predict the likely consequences of a response choice" (63, p. 137).

Pandemic influenza involves an element of uncertainty at each of these levels. There are questions of whether a pandemic will occur (state uncertainty). If a pandemic does occur, there are questions about whether it will affect a given organization (effect uncertainty). Finally, if a pandemic does occur and affects the organization, there are questions about what can be done, and to what effect, to minimize the impact on a given organization (response uncertainty). A shift to consider proactive implementation of pandemic influenza mitigation strategies would address this third level of uncertainty, response uncertainty, by identifying opportunities to stem the effect of a pandemic. However, the novel aspect of shifting to proactive implementation is that it would also remove the relevance of questions related to state uncertainty (will a pandemic occur?) and effect uncertainty (if a pandemic occurs, will it impact my organization?). This would be achieved by refocusing the efforts on seasonal influenza, for which state uncertainty and effect uncertainty are minimal and the effect on response uncertainty can be reliably demonstrated via empirical studies. In this way, the levels of uncertainty related to pandemic influenza would become irrelevant as attention turned to interventions that are effective for both pandemic and seasonal influenza. This would also introduce short-term benefits as employee illness, and associated absenteeism and presenteeism, would be expected to decrease as a result

of the interventions. This immediate benefit could form the basis of a discussion of short-term financial ROI for preparedness and this shift would move the conversation from one solely focused on insurance for pandemic influenza to one of investment for seasonal influenza, with the added benefit of insurance for pandemic influenza.

Theoretical framework

The proposed approach to shift the focus of private sector preparedness efforts from insurance to investment, and the supporting research presented here, are based on two theories: first, that investment to achieve short-term ROI, rather than insurance against an uncertain event, will motivate businesses to prepare for pandemic influenza; and second, that cost-effectiveness analysis is appropriate to demonstrate short-term ROI for preparedness activities. These two frameworks are explored in more detail below.

Risk-based incentives versus short-term return on investment

In recent history, some businesses have become negative about extensive preparedness planning because they invested in such planning for events they then perceived to have "never happened," such as Year 2000 (Y2K) database issues (64, 65). This highlights the true dilemma for businesses: is it worth it to invest in preparedness planning when a pandemic event is a highly uncertain event? Can employers justify pandemic influenza preparedness when the ROI is unknown? To understand this, it is important to first consider how organizations make investment decisions.

George and Jones define decision-making, in the context of organizations, as "the process by which members of an organization choose a specific course of action to respond to both opportunities and problems" (66, p.500). Within this framework, decisions can be classified at the individual or organizational level.

Individual decision-making

Two types of individual decision approaches are of particular relevance to the question of pandemic influenza. The first is the rational approach, in which the decision maker utilizes a systematic process for analyzing, choosing, and implementing a problem solution. The process includes the following steps: monitor the decision environment, define the decision problem, specify decision objectives, diagnose the problem, develop alternative solutions, evaluate alternatives, choose the best alternative, and implement the chosen alternative (67).

There are many limitations to the rational decision-making model, mostly having to do with whether this approach, while conceptually sound, is feasible in practice. That is, there are very few situations in which all alternatives and their outcomes can be exhaustively identified and evaluated or that additional information necessarily aids in producing improved decisions and outcomes (68, 69). In response to the limitations of rational decision-making, Simon developed the concept of bounded rationality (70). Bounded rationality recognizes the obstacles to any individual's ability to consider all potential alternatives to a problem, including limitations to information and resource availability, as well as cognitive processing capabilities. Instead, Simon suggested that individuals' ability to be rational is bounded by the options that are known and understandable to them (71).

Organizational decision-making

There is a wide range of theories related to organizational decision-making. Five in particular are highlighted here, including classical, administrative, incremental, mixed scanning, and garbage can models.

Classical model. Classical decision-making describes the "ideal" situation, in which there is one clear "best" solution to the given problem and decision-makers are able to identify this solution through analysis of complete information with no uncertainty (68). Classical decision-making represents an organizational parallel to the rational approach for individuals.

Similar to the limitations of the rational approach for individual decision-making, there are also limitations to the classical conceptualization of organizational decision-making. These include the fact that, for any given problem, decision makers often do not know every alternative available and the consequences to expect from each alternative, in addition to the fact that many do not have a fully clarified idea of the goals for a given decision (66). The result is that, in reality, decisions cannot be made according to the approach prescribed by the classical model.

Administrative model. Instead of the classical model of decision-making, which is normative, Simon and March proposed the descriptive administrative model, which focuses on how decisions are actually made in organizations rather than how they should be made (72). This administrative model is meant to be a more realistic alternative to the classical model, and is related to the idea of bounded rationality at the individual level. A key component of the administrative model is the concept of satisficing. Satisficing is a process through which an organization determines the ends in which it is interested, and the decision-maker selects the first satisfactory alternative identified that provides the means to achieve the desired ends (72, 73).

In addition to the satisficing principle, the administrative model considers the political and social factors involved in decision-making. In particular, it recognizes that individual decision-makers form alliances, or coalitions, with others who share similar views of the organization's goals and priorities. Problems and situations are defined not just on objective information, but also based on psychological (e.g., the decision-makers' backgrounds, knowledge, and experiences) and sociological (e.g., the groups and organizational culture of which the decision-makers are members) factors (68). Given these considerations, decision-makers in coalitions work together to determine a satisfactory solution to the problem.

Incremental model. The incremental model allows for successive limited comparisons in which incremental changes are made over time (74). This is key when alternatives are not known or outcomes of actions or decisions are unable to be predicted (i.e., situations in which satisficing does not work well) (75). The model includes three phases: the identification phase, in which a problem is recognized; the development phase, in which a solution is developed for the problem; and the selection phase, in which the solution to the problem is chosen for implementation. This approach does not include as much recognition of the political and social factors involved in the administrative model (68).

Mixed scanning approach. Proposed by Etzioni, the mixed scanning approach is an adaptive strategy to decision-making that accounts for a mix of the rational and incremental models (76, 77). In this strategy, decision-makers identify overall organizational goals (fundamental changes) and then proceed with incremental changes toward those goals, using targeted trial and error. This allows the organization to achieve change that is consistent with the organization's policies and mission. In this way, change is tentatively achieved following an incremental approach but with the overall organizational goals established to prevent "organizational drift."

Garbage Can model. A "garbage-can" model of decision-making occurs within "organized anarchies," or those organizations with "inconsistent and ill-defined preferences," unclear technology, and fluid participation (78). In sum, these are "organizations with high uncertainty" (75). Within these organizations, four independent streams affect decision-making: problems, solutions, participants, and choice opportunities (78). The result of these streams is that there are problems searching for solutions, solutions searching for problems, and decision-makers searching for work, with the result that decisions match the correct problem with the correct solution only by chance. Dean and Sharfman have shown that procedural rationality in decision-making is positively related to decision success (79). Given the lack of procedural rationality in garbage can approaches, a decreased success of this approach to decision-making would not be surprising.

Determining the decision-making option

Different situations lend themselves to different decision-making processes. The Contingency Model can be utilized to determine which of the above options are applicable in the context of a specific decision, which in this case is pandemic influenza preparedness (68). The Contingency Model is based on whether the ends are clear (problem consensus is certain) and information is complete (solution knowledge is certain) for any given decision (68, 75). The table below summarizes the types of decisions that are appropriate in different situations using the Contingency Model.

Table. Contingency framework for using decision models. From (68, p.471)

		Problem Consensus	
		Certain	Uncertain
Solution Knowledge	Certain	Box 1 • Individual: Rational Approach, Computation • Organization: Classical Model	Box 2 • Individual: Bargaining, Coalition Formation • Organization: Administrative Model
	Uncertain	Box 3 • Individual: Judgment, Trial and Error • Organization: Incremental Model	Box 4 • Individual: Bargaining and Judgment, Inspiration and Imitation • Organization: Administrative and Incremental Models, Evolving to Garbage Can Model

In the case of organizational preparedness for pandemic influenza, the question around whether, when, or with what severity a pandemic will occur is something that cannot be predicted, so the problem consensus by its nature stays uncertain over time. However, shifting the approach to preparedness to focus on short-term benefits for seasonal influenza provides more certainty related to solution knowledge, which would move decision-makers toward an administrative model decision option (Box 2 in Table). Without this shift, organizations will have less certain solution knowledge and are likely to utilize the administrative or incremental models, evolving to the Garbage Can model (Box 4 in Table).

Applying a satisficing approach to employer investment in pandemic influenza preparedness

Within the administrative model, the question of pandemic preparedness has historically been framed as an insurance decision. Using a satisficing approach, one can understand why

many organizations had not yet engaged in preparedness work prior to the 2009 H1N1 influenza pandemic, and still did not during the pandemic. Before the 2009 H1N1 influenza pandemic, the threat was uncertain in terms of when a pandemic might occur; during the pandemic, the threat was uncertain in terms of whether the impact on an organization was going to be severe enough to warrant action. For many resource-limited organizations, the decision that was therefore "good enough" was to not invest in preparedness. Once employers have more certain information, they will be more likely to choose preparedness as a satisfactory alternative.

Unfortunately, information on when, how, and with what severity a pandemic will occur is not and can't be known before such an event occurs. Additionally, as was seen with the 2009 H1N1 influenza pandemic, some of this information can't even be known during the early stages of a pandemic when preparedness and response are most critical. However, the interpandemic period is the timeframe in which planning is critical. Therefore, the goal of the present research was to address issues related to the uncertainty of a pandemic event by refocusing efforts on the benefits of interventions for seasonal influenza. Uncertainty is less of an issue for seasonal influenza and yet interventions for seasonal influenza can still have utility in a pandemic. Ultimately, this information will ideally make the decision to proceed with preparedness efforts the one that is "good enough" for private organizations. This research is therefore based on the theory that shifting the conversation from one related to ROI based on unknown future events (an insurance strategy) to one based on short-term ROI for known benefits (an investment strategy) may result in more businesses engaging in preparedness activities.

Use of cost-effectiveness analysis to demonstrate short-term return on investment for preparedness activities

This research is also predicated on the theory that cost-effectiveness analysis is an appropriate tool to justify pandemic influenza preparedness planning in workplaces in the short-term, before a pandemic occurs. In this case, benefits would be derived from proactive implementation of NPIs to limit spread of seasonal influenza or other respiratory infections in the interpandemic period.

Cost-effectiveness analysis considers the inputs and outputs of a given program or intervention, and compares the two to assist in decision making. In particular, this type of analysis "compares (mutually exclusive) alternatives in terms of the ratio of their costs and a single quantified, but not monetized, effectiveness measure" (80, p. 463). That is, the units of the costs and benefits achieved are different in a cost-effectiveness analysis, and therefore the output is the costs incurred to achieve one unit of the benefit. This is a variation of cost-benefit analysis, which looks at "a systematic cataloging of impacts as benefits and costs, valuing in dollars, and then determining the *net benefits* of the proposal relative to the status quo (net benefits equal benefits minus costs)" (80, p. 1; emphasis in the original). Cost-benefit analyses compare the costs and benefits of a program in the same units, and compare the total output received for the total input, in those units. The units are typically monetary. Both cost-benefit and cost-effectiveness analyses are used widely in business and public health, although cost-effectiveness is generally preferred in public health.

Cost-effectiveness analysis is based on utilitarian principles. Beauchamp and Childress define utilitarianism as "the moral theory that there is one and only one basic principle of ethics, the principle of utility, which asserts that one ought always to produce the greatest possible balance of value over disvalue" (81, p.26). In other words, utilitarianism is based on the idea that what is best is that which maximizes the "good." In those situations in which measurement of

benefits (value) and costs (disvalue) of a decision is possible, the decision-maker should choose the option that produces the most benefit for the least cost. Cost-effectiveness analysis provides an objective tool to do this.

However, given the staggering economic impacts predicted related to potential pandemics (26, 44), any cost-benefit or cost-effectiveness analysis seems non-informative, or even trivial, when working under the assumption that pandemic influenza will occur with those levels of severity and during the timeframe in which current plans are still applicable or useful. In particular, based on those analyses, the cost of any preparedness planning efforts would easily be lower than the avoided costs of a pandemic event, as long as the threat occurred before the plans became obsolete. However, this must not be fully compelling because prior to and even during the 2009 H1N1 influenza pandemic, there were still employers that had not yet started any pandemic preparedness efforts. As stated above, this may be due to the uncertainty of the event itself in terms of when it might occur, or with what severity.

This analysis therefore proposes considering the cost-effectiveness of preparedness activities from the frame of their ability to improve business functions on a day-to-day basis, regardless of the occurrence of a pandemic event. The impact of these activities can be analyzed on a "best-case" scenario, where the "best-case" is the situation in which a pandemic does not occur. The cost-benefit ratio in any other scenario on the continuum from "best-case" to "worst-case" will only result in higher benefits to relatively static costs. In particular, the "best-case" scenario will be the most conservative estimate of the benefits of investing in prevention activities that have parallel impacts in a pandemic.

Because interventions for pandemic influenza also have relevance for seasonal influenza, it is reasonable to expect that implementation of these interventions in the interpandemic period will have real monetary costs and employee productivity benefits from an employer's perspective. Cost-effectiveness analysis (CEA) is therefore an appropriate and informative tool for assessing these interventions to inform employer decisions.

Overview of dissertation

Business preparedness for pandemic influenza is a critical component of a comprehensive and effective public health preparedness plan. One of the most prominent messages from public health authorities to encourage employers to engage in preparedness efforts to date is based on the economic impact of a potential pandemic, using cost avoidance to justify preparedness activities as a type of "insurance" against the effects of a pandemic. A novel and unexercised option for such efforts is to base them on the benefits of building such capacities within a business as an investment, regardless of when a pandemic occurs. One way in which this investment may be manifested is through proactive implementation of preparedness activities in the interpandemic period. If the dilemma for employers is whether to invest in preparedness for an unknown event, then this approach will shift the conversation from a discussion of unknown future benefits (insurance) to one related to the potential for current benefits (investment) in an effort to influence businesses to act. This issue may be further underscored by the mild nature of the 2009 H1N1 influenza pandemic, which many in the general public perceived to be similar to a seasonal influenza in terms of impact, undermining efforts to prepare for a pandemic that are justified only on staggering impacts.

Using the above theories as the guiding framework, this dissertation aims to understand how interventions aimed at changing individual hand and respiratory hygiene behaviors can be

best targeted; measure the cost-effectiveness of such interventions; and assess the components of private sector preparedness initiatives to understand whether these interventions would be an acceptable strategy among businesses. This is done through three independent but complementary analyses to address the gaps in the current knowledge base.

The first paper, "Barriers to and Predictors of Changes in Hand and Respiratory Hygiene and Social Distancing Behaviors among University Students Enrolled in a Longitudinal Study," examines the factors that predict individual changes in adherence to hand and respiratory hygiene behaviors among students attending the University of California, Berkeley (UC Berkeley) during an interpandemic cold and influenza season. This analysis identifies individual characteristics as well as situations that prompt changes in hygiene behaviors in order to better target future interventions.

The second paper, "Cost-Effectiveness of a Hand and Respiratory Hygiene Intervention in Reducing Influenza-like Illness among University Students," presents the results of a cost-effectiveness analysis based on a randomized controlled trial conducted among students attending UC Berkeley during an interpandemic cold and influenza season. The analysis examines the potential for financial ROI based on proactive implementation of specific NPIs during the interpandemic period.

Finally, the third paper, "An Exploratory Qualitative Analysis of Pandemic Plan Components and Planning Considerations in the Private Sector," is based on key informant interviews conducted with a range of individuals involved in pandemic influenza planning for the private sector, including private sector business continuity managers, consultants, and public sector planners. These interviews were conducted both before and during the 2009 H1N1 influenza pandemic and profile the preparedness work underway within businesses. This included the main components of organizations' pandemic plans and the considerations planners contemplated in developing and implementing those plans during the 2009 H1N1 influenza pandemic. In particular, the analysis captures those components and considerations that participants thought were most and least important to their pandemic preparedness and response efforts, as well as lessons learned and model practices that emerged during those efforts. This analysis also explores whether short-term benefits for preparedness activities are of concern for businesses in their pandemic efforts.

Pandemic influenza poses a significant public health risk to the population, and private sector preparedness is an important part of readiness for such an event. However, despite public health authorities' calls for businesses to develop pandemic plans over the past several years, many did not, even during the 2009 H1N1 influenza pandemic. This dissertation aims to address important gaps in the knowledge base to determine whether a strategy of justifying preparedness to the private sector as a short-term investment strategy instead of as a long-term insurance strategy can be feasible. Such a strategy would represent a novel approach for engaging businesses in preparedness work, with potentially wider appeal that could lead to more robust preparedness for public health events overall.

References

1. World Bank. 2007 World development indicators. U.S.A.; 2007.

2. Brenner MH. Mortality and the national economy. A review, and the experience of England and Wales, 1936-76. Lancet. 1979;2(8142):568-73.

3. Avian influenza (" bird flu") [homepage on the Internet]. Geneva, Switzerland: World Health Organization. 2006 February [cited 2010 April 6]. Available from: http://www.who.int/mediacentre/factsheets/avian_influenza/en/#history.

4. Severe acute respiratory syndrome (SARS) [homepage on the Internet]. Geneva, Switzerland: World Health Organization. 2004 October [cited 2010 April 6]. Available from: http://www.who.int/csr/sars/en/.

5. Centers for Disease Control and Prevention. Key facts about influenza and the influenza vaccine. Atlanta, GA: U.S. Department of Health and Human Services; 2008 [cited 2010 April 6]. Available from: http://www.cdc.gov/flu/pdf/keyfacts.pdf.

6. Hampson AW, Mackenzie JS. The influenza viruses. Med J Aust. 2006 Nov 20;185(10 Suppl):S39-43.

7. Glezen WP. Serious morbidity and mortality associated with influenza epidemics. Epidemiol Rev. 1982;4:25-44.

8. Perrotta DM, Decker M, Glezen WP. Acute respiratory disease hospitalizations as a measure of impact of epidemic influenza. Am J Epidemiol. 1985 Sep;122(3):468-76.

9. Barker WH. Excess pneumonia and influenza associated hospitalization during influenza epidemics in the United States, 1970-78. Am J Public Health. 1986 Jul;76(7):761-5.

10. Barker WH, Mullooly JP. Impact of epidemic type A influenza in a defined adult population. Am J Epidemiol. 1980 Dec;112(6):798-811.

11. Cox NJ, Subbarao K. Influenza. Lancet. 1999 Oct 9;354(9186):1277-82.

12. PandemicFlu.gov [homepage on the Internet]. U.S. Department of Health & Human Services. 2008 January 15. Available from: http://www.pandemicflu.gov/index.html.

13. Luk J, Gross P, Thompson WW. Observations on mortality during the 1918 influenza pandemic. Clin Infect Dis. 2001 Oct 15;33(8):1375-8.

14. Centers for Disease Control and Prevention.
Swine influenza A (H1N1) infection in two children - Southern California, March-April 2009. MMWR Morb Mortal Wkly Rep. 2009 April 24;58(15):400-402.

15. World Health Organization. World now at the start of 2009 influenza pandemic. 2009 June 11.

16. CDC estimates of 2009 H1N1 influenza cases, hospitalizations and deaths in the United States, April 2009 – February 13, 2010 [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2010 March 29 [cited 2010 April 6]. Available from: http://www.cdc.gov/h1n1flu/estimates_2009_h1n1.htm.

17. 2009 H1N1 early outbreak and disease characteristics [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2009 October 27 [cited 2010 April 6]. Available from: http://www.cdc.gov/h1n1flu/surveillanceqa.htm.

18. 2009 H1N1 flu ("swine flu") and you [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2010 February 10 [cited 2010 April 6]. Available from: http://www.cdc.gov/h1n1flu/qa.htm.

19. Goldmann DA. Transmission of viral respiratory infections in the home. Pediatr Infect Dis J. 2000 Oct;19(10 Suppl):S97-102.

20. Bean B, Moore BM, Sterner B, Peterson LR, Gerding DN, Balfour HH, Jr. Survival of influenza viruses on environmental surfaces. J Infect Dis. 1982 Jul;146(1):47-51.

21. Morens DM, Rash VM. Lessons from a nursing home outbreak of influenza A. Infect Control Hosp Epidemiol. 1995 May;16(5):275-80.

22. Boone SA, Gerba CP. The occurrence of influenza A virus on household and day care center fomites. J Infect. 2005 Aug;51(2):103-9.

23. Bridges CB, Kuehnert MJ, Hall CB. Transmission of influenza: Implications for control in health care settings. Clin Infect Dis. 2003;37:1094-101.

24. Lowen AC, Mubareka S, Steel J, Palese P. Influenza virus transmission is dependent on relative humidity and temperature. PLoS Pathog. 2007 October 19, 2007;3(10):e151.

25. Brankston G, Gitterman L, Hirji Z, Lemieux C, Gardam M. Transmission of influenza A in human beings. Lancet Infect Dis. 2007 April;7(4):257-65.

26. U.S. Department of Health and Human Services. HHS pandemic influenza plan. Washington, DC: U.S. Department of Health and Human Services; 2005.

27. 2009 H1N1 vaccine doses allocated, ordered, and shipped by project area [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2010 February 2 [cited 2010 April 6]. Available from: http://www.cdc.gov/h1n1flu/vaccination/vaccinesupply.htm.

28. World Health Organization Writing Group. Nonpharmaceutical interventions for pandemic influenza, national and community measures. Emerg Infect Diseases. 2006;12(1):88-94.

29. OPRP - general information on hand hygiene [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2007. Available from: http://www.cdc.gov/nceh/vsp/cruiselines/hand_hygiene_general.htm.

30. Respiratory hygiene/cough etiquette in healthcare settings [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention Website. 2003 December 17 [cited 2009 May 14]. Available from: http://www.cdc.gov/flu/professionals/infectionControl/resphygiene.htm.

31. Jefferson T, Del Mar C, Dooley L, Ferroni E, Al-Ansary LA, Bawazeer GA, et al. Physical interventions to interrupt or reduce the spread of respiratory viruses: Systematic review. Br Med J. 2009;339:b3675.

32. Aiello AE, Coulborn RM, Perez V, Larson EL. Effect of hand hygiene on infectious disease risk in the community setting: A meta-analysis. Am J Public Health. 2008;98(8):1372-81.

33. Aledort JE, Lurie N, Wasserman J, Bozzette SA. Non-pharmaceutical public health interventions for pandemic influenza: An evaluation of the evidence base. BMC Public Health. 2007 Aug 15;7:208.

34. Aiello AE, Murray GF, Perez V, Coulborn RM, Davis BM, Uddin M, et al. Mask use, hand hygiene, and seasonal influenza-like illness among young adults: A randomized intervention trial. J Infect Dis. 2010;201:491-8.

35. Lau JT, Tsui H, Lau M, Yang X. SARS transmission, risk factors, and prevention in Hong Kong. Emerg Infect Diseases. 2004 Apr;10(4):587-92.

36. Cowling BJ, Chan KH, Fang VJ, Cheng CKY, Fung ROP, Wai W, et al. Facemasks and hand hygiene to prevent influenza transmission in households: A randomized trial. Ann Intern Med. 2009;151:437-46.

37. White C, Kolble R, Carlson R, Lipson N. The impact of a health campaign on hand hygiene and upper respiratory illness among college students living in residence halls. J Am Coll Health. 2005;53(4):175-81.

38. Larson EL, Ferng YH, McLoughlin JW, Wang S, Morse SS. Effect of intensive education on knowledge, attitudes, and practices regarding upper respiratory infections among urban Latinos. Nurs Res. 2009 April 16;58(3):150-7.

39. Stebbins S, Downs JS, Vukotich CJ, Jr. Using nonpharmaceutical interventions to prevent influenza transmission in elementary school children: Parent and teacher perspectives. J Public Health Manag Pract. 2009 Mar-Apr;15(2):112-7.

40. CDC business home [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2009 October 15 [cited 2010 April 6]. Available from: http://www.cdc.gov/business/.

41. Be prepared California: Businesses [homepage on the Internet]. Richmond, CA: California Department of Public Health. 2008. Available from: http://bepreparedcalifornia.ca.gov/EPO/BePrepared/Businesses/Businesses.htm.

42. Pandemic flu - H1N1 influenza (swine flu): General information for employers [homepage on the Internet]. Seattle, WA: Seattle & King County Public Health. 2010 February 25. Available from: http://www.kingcounty.gov/healthservices/health/preparedness/pandemicflu/swineflu/employers.aspx.

43. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. Business pandemic influenza planning checklist. 2005 December 6, 2005:1-2.

44. Meltzer MI, Cox NJ, Fukuda K. The economic impact of pandemic influenza in the United States: Priorities for intervention. Emerg Infect Diseases. 1999 Sep-Oct;5(5):659-71.

45. Darby P. The economic impact of SARS. Ottawa, ON: The Conference Board of Canada; 2003 May.

46. McKibbin WJ, Sidorenko A. Global macroeconomic consequences of pandemic influenza. Lowy Institute for International Policy; 2006.

47. The World Bank. Global development finance: Charting a global recovery. Washington, DC: The World Bank; 2009 June.

48. Morgan D. U.S. sees no "undue" H1N1 economic impact. Reuters. 2009 October 19.

49. Center for Catastrophe Preparedness & Response. New York's small and medium sized businesses are not prepared for emergencies. Why? New York, N.Y.: New York University; 2006.

50. Deloitte Center for Health Solutions. Business preparations for pandemic flu. 2006.

51. Marsh Inc., The Albright Group. Corporate pandemic preparedness: Current challenges to and best practices for building a more resilient enterprise. Marsh Inc. and The Albright Group; September 28, 2007.

52. Mercer Human Resource Consulting. Avian flu pandemic preparedness survey report. Mercer; 2006 Spring.

53. Benjamin GC. Putting the public in public health: New approaches. Health Aff (Millwood). 2006 Jul-Aug;25(4):1040-3.

54. Stewart WF, Ricci JA, Chee E, Morganstein D. Lost productive work time costs from health conditions in the United States: Results from the American Productivity Audit. J Occup Environ Med. 2003 Dec;45(12):1234-46.

55. Aldana SG, Greenlaw RL, Diehl HA, Salberg A, Merrill RM, Ohmine S. The effects of a worksite chronic disease prevention program. J Occup Environ Med. 2005;47(6):558-64.

56. Fielding JE. Worksite health promotion programs in the United States: Progress, lessons and challenges. Health Promot Internation. 1990;5(1):75-84.

57. Kerr M. Toward a healthier ROI: More employers are realizing that the health of their employees has a big impact on the health of their business - special report: Benefits. Risk & Insurance. 2004 Feb.

58. Chapman LS. Meta-evaluation of worksite health promotion economic return studies. Am J of Health Promot. 2003;17(3):1-10.

59. Aldana SG. Financial impact of health promotion programs: A comprehensive review of the literature. Am J of Health Promot. 2001;15(5):296-320.

60. Goetzel RZ, Long SR, Ozminkowski RJ, Hawkins K, Wang S, Lynch W. Health, absence, disability, and presenteeism cost estimates of certain physical and mental health conditions affecting U.S. employers. J Occup Environ Med. 2004 Apr;46(4):398-412.

61. Simon HA. The new science of management decision. Englewood Cliffs, N.J.: Prentice-Hall; 1960.

62. Knight FH. Risk, uncertainty and profit. Houghton Mifflin Company; 1921.

63. Milliken FJ. Three types of perceived uncertainty about the environment: State, effect, and response uncertainty. Acad Manage Rev. 1987;12(1):133-43.

64. Cardozo LR. In: Panel discussion on "Pandemic preparedness: What local funders can do". Council on foundations fall conference for community foundations; 2006 September 18; Boston, MA. Council on Foundations; 2006.

65. Prashad S. Preparing for the worst. Toronto Star. 2006 May 21;Sect. News (A.18).

66. George JM, Jones GR. Understanding and managing organizational behavior. 5th ed. Upper Saddle River, NJ: Pearson Education, Inc.; 2008.

67. Archer ER. How to make a business decision: An analysis of theory and practice. Manage Rev. 1980 Feb;69(2):54-61.

68. Daft RL. Organization theory and design. 8th ed. United States: Thomson Southwestern; 2004.

69. Glazer R, Steckel JH, Winer RS. Locally rational decision making: The distracting effect of information on managerial performance. Manage Sci. 1992;38(2):212-26.

70. Simon HA. Administrative behavior. New York: Macmillian; 1947.

71. Simon HA. A behavioral model of rational choice. Quarterly J of Econ. 1955;69(1):99-118.

72. March JG, Simon HA. Organizations. John Wiley & Sons Inc; 1958.

73. Simon HA. Rational decision-making in business organizations. Economic Sciences, 1969-1980: the Sveriges Riksbank (Bank of Sweden) prize in economic sciences in memory of Alfred Nobel. 1992.

74. Mintzberg H, Raisinghani D, Theoret A. The structure of "unstructured" decision processes. Adm Sci Q. 1976;21(2):246-75.

75. Tarter CJ, Hoy WK. Toward a contingency theory of decision making. J Educ Admin. 1998;36(3):212-28.

76. Etzioni A. Mixed-scanning: A" third" approach to decision-making. Public Adm Rev. 1967;27(5):385-92.

77. Etzioni A. Mixed scanning revisited. Public Adm Rev. 1986;46(1):8-14.

78. Cohen MD, March JG, Olsen JP. A garbage can model of organizational choice. Adm Sci Q. 1972;17(1):1-25.

79. Dean Jr JW, Sharfman MP. Does decision process matter? A study of strategic decision-making effectiveness. Acad Manage J. 1996;39(2):368-96.

80. Boardman A, Greenberg D, Vining A, Weimer D. Cost-benefit analysis: Concepts and practice. Upper Saddle River, NJ (EUA). Prentice Hall; 2006.

81. Beauchamp TL, Childress JF. Principles of biomedical ethics. New York: Oxford University Press; 1989.

CHAPTER II: BARRIERS TO AND PREDICTORS OF CHANGES IN HAND AND RESPIRATORY HYGIENE AND SOCIAL DISTANCING BEHAVIORS AMONG UNIVERSITY STUDENTS ENROLLED IN A LONGITUDINAL STUDY

Introduction

Respiratory illness, including influenza-like illness (ILI), has a significant public health impact each year. Among college students, at least 84% of individuals experience one or more upper respiratory illnesses during the cold and influenza season (1). For example, during the 2002-2003 cold and influenza season, 83% of students enrolled in a study at the University of Minnesota Twin Cities (Minneapolis – St. Paul) had one or more colds, and 37% had one or more ILIs, resulting in 91% of students total having one or more respiratory illnesses (2). Upper respiratory illnesses have a significant impact on the utilization of healthcare resources, in addition to causing absences from activities such as work and school (2, 3).

Both pharmaceutical interventions and non-pharmaceutical interventions (NPIs) are available to reduce the occurrence of respiratory illness. Pharmaceutical interventions, such as the influenza vaccine, are highly effective in reducing respiratory illnesses (4-12) but uptake among university students is low (13).

Non-pharmaceutical behaviors at the individual level, including hand and respiratory hygiene/cough etiquette and social distancing, are another important tool in the effort to reduce the occurrence of respiratory illness and interventions to promote the uptake. Proper employment of these behaviors at the individual level are at the forefront of public health efforts to prepare for seasonal and pandemic influenza events (14-19). Many studies have been done to examine the effectiveness of such behaviors in reducing the incidence of respiratory illness, with mixed results, including among university students (20-30). A retrospective analysis of the SARS epidemic showed that population-based education on NPIs in Hong Kong resulted in increased adherence to recommended behaviors during the epidemic, and that the proportion of positive specimens for various respiratory viruses decreased during this time, suggesting an impact on the transmission of selected viral respiratory pathogens (31).

Prospective studies of hand hygiene and respiratory hygiene/cough etiquette interventions have also reported effectiveness as measured by increased knowledge (28) and reported behavior change (26, 28, 32) although again this has not been consistent for all studies (17). In addition, others have found hand and respiratory hygiene/cough etiquette behaviors to be highly acceptable to the general public (33). Evidence for the possible effectiveness of social distancing, which reduces contact rates between people (34), is based primarily on computer simulations. Multiple models suggest that implementation of social distancing measures could be a key component of a public health strategy to decrease influenza attack rates, timing, and magnitude of spread, but must be done in concert with other interventions (35-37).

NPIs will continue to be a critical piece of the public health response to respiratory illness events. However, what is not currently understood are the individual characteristics and

situations that may positively or negatively influence individual behavior change during cold and influenza season. In fact, of the many studies that have been done regarding NPIs to protect against respiratory illnesses, none have examined whether individual behaviors change over the course of the cold and influenza season independent of an intervention. It is possible that individuals change their behaviors during the cold and influenza season in general, regardless of interventions aimed at those behaviors, and it is important to understand whether these within-person changes account for a significant portion of the variation in behaviors. A robust analysis of individual behavior over time would therefore complement initial findings and provide an improved understanding of the factors that influence behaviors. This would then help public health authorities better target future interventions.

Additionally, if individuals' behaviors do change over time, it is important to understand the characteristics and situations that correlate with those changes. Related to individual characteristics, interventions against respiratory illness are typically targeted to different types of individuals, based on demographic factors such as living arrangements (e.g., households), race/ethnicity, or age (17, 28, 30, 32, 33, 38). Important individual characteristics that are typically accounted for in such programs include those that might indicate a higher risk for respiratory illness or having complications from such an illness, such as smoking or asthma (39, 40).

In terms of participant situations, recent research has found that perception of risk is an important determinant of individuals' intentions to increase adherence to hygiene behaviors to prevent respiratory illness. For example, studies have found that individuals intend to change behaviors during a pandemic in response to a perceived increase in risk (41); studies have also found improvements in hygiene behaviors during the 2009 H1N1 influenza pandemic itself (42, 43). Examples of situations of increased risk include individual illness (indicating increased risk for people around the sick individual), illness in close contacts, travel, or exposure to children (44-48).

Given these gaps in the literature, this study examined two questions related to individual adherence to recommended hand and respiratory hygiene/cough etiquette and social distancing behaviors among university students, independent of any intervention: (1) is adherence to recommended NPI behaviors static over the course of the cold and influenza season or do individual behaviors change over time? and (2) do participant situations (experience of ILI symptoms, illness in close contacts, travel, and living arrangements) and characteristics (demographic factors, individual attitudes toward getting sick, and individual beliefs about behaviors) predict changes in adherence to behaviors? Answers to these questions will help in the design of future interventions targeting behavior change related to NPIs for respiratory illness.

Methods

Study design and population

This analysis is based on a prospective observational study, nested within a randomized controlled trial, the REDucing Influenza-like illness among University Students (REDI-US) study. The study was conducted among students attending the University of California, Berkeley (UC Berkeley). The methods for this study are described in detail in Chapter III, "Cost-

Effectiveness of a Hand and Respiratory Hygiene Intervention in Reducing Influenza-like Illness among University Students" and summarized below.

Recruitment and enrollment

The target population was the UC Berkeley student population, including all graduate and undergraduate students enrolled at least half-time at UC Berkeley in Fall 2007 except those under 17 years of age, those recruited for or participating in other university studies, those with knowledge of the study design, and those who had participated or actively declined participation in a Spring 2007 pilot REDI-US study.

The University Office of Student Research provided a representative random sample of UC Berkeley students for recruitment. Pilot study data indicated lower enrollment rates among males, so males were over-sampled by a ratio of two to one. Study recruitment was done via postal mail and email. Recruitment and enrollment were conducted from October 15, 2007 to November 6, 2007.

Informed consent was obtained prior to enrollment and randomization using a secure online survey software, Illume™ (Datstat, Seattle, Washington), which was also used to administer all study surveys. Upon consenting to participate, students were directed immediately to an online baseline survey. The final questions on the baseline survey related to participant contact information, which was necessary for all following surveys; therefore, completion of the baseline survey was required for full enrollment in the study.

The UC Berkeley Committee for the Protection of Human Subjects (CPHS) approved the study in August 2007.

Restriction and group assignments

Only 263/1,726 (15%) participants reported receiving the influenza vaccine for the 2007-2008 influenza season. Therefore, this analysis was restricted to those participants who did not report receiving the influenza vaccine for that influenza season.

As part of the broader randomized controlled trial, participants randomly allocated to the intervention program were given access to a password-protected online website for education on hand and respiratory hygiene behaviors and were provided with a kit containing the materials necessary for compliance with recommended behaviors (hand sanitizer, facemasks, and facial tissues). Kits were mailed to the mailing address specified by participants on the baseline survey. In order to assess predictors of changes in behaviors independent of the intervention program, analyses were performed separately for participants randomly assigned to the intervention (Group 1) and control (Group 2) groups.[*]

Data collection

Two types of surveys were administered: a demographic survey and a symptoms and behavior survey. The demographic survey was administered upon enrollment (baseline survey) and at the completion of the data collection period (end-of-study survey). All participants completed the baseline survey as part of enrollment, and all were asked to complete the end-of-

[*] A third group, which received abbreviated versions of weekly surveys, was also created to allow for an assessment of any potential effect of weekly survey questions on adherence to NPI behaviors. The abbreviated surveys did not gather the information of interest for this analysis (adherence to behaviors) and therefore this group was not included in the analysis.

study survey. The second type of survey was the weekly symptoms and behavior survey, administered each week for the 23 weeks of the study from November 2007 to April 2008. This survey collected information on respiratory illness symptoms during the previous week and hand and respiratory hygiene/cough etiquette and social distancing behaviors during the previous 48 hours.

If participants developed any respiratory symptoms between weekly surveys, they were encouraged to fill out a Respiratory Illness Report Form (RIRF), on which they reported just their symptoms.

Retainment

Students received incentives for participation in the study. An incentive of a one dollar equivalent (one Napster music download, one dollar toward a Starbucks Card, or one dollar toward an Amazon.com Gift Certificate) was given for each weekly survey completed, with an additional ten dollars in the chosen incentive provided at the end of the study to participants who completed all weekly surveys throughout the course of the study.

In addition, a raffle drawing was held at the end of the study for all participants. Participant names were entered into their choice of one of two raffle drawings for each survey they completed throughout the course of the study. The raffle drawings were for one $500 Visa Gift Card or one of ten $50 Visa Gift Cards. Participants in the intervention group also had the opportunity to enter a weekly drawing for a $25 Visa Gift Card by taking a short weekly quiz with three questions based on the information included on the website.

Measurements

Outcome variables

Adherence to behaviors: Theoretical framework. Several theories exist related to impacting individual behavior change. This analysis utilized the Theory of Reasoned Action to select situations and characteristics of interest in understanding participant behaviors related to hand and respiratory hygiene and social distancing (49-51). The Theory of Reasoned Action conceives of behavioral intentions, which directly influence actual behaviors, as being impacted by individuals' attitudes toward a behavior (whether the behavior is desirable in terms of the consequences of the behavior and whether those consequences are important to the individual) and their perception of subjective norms around those behaviors (whether those around them approve or disapprove of the behavior). Surveys included questions on both of these considerations. For attitudes toward a behavior, questions were posed regarding participants' beliefs that hand washing was useful, and their concern about getting sick with a respiratory illness during the academic year. Questions about friends' expectations to cover a cough or sneeze, and to wash hands after coughing or sneezing into them, were used to assess subjective norms regarding behaviors.

Adherence to behaviors: Composite score. The primary outcome of interest in this analysis was change in self-reported adherence to recommended hand and respiratory hygiene/cough etiquette and social distancing behaviors. Adherence to behaviors at baseline, during the course of the study, and at the end of the study was assessed as a composite score. The composite score was comprised of the following components: Hand Hygiene - Situations; Hand Hygiene - Technique; Hand Awareness; Respiratory Hygiene - Cover Cough; Respiratory Hygiene - Technique; and Social Distancing. Each component score ranged from zero to three,

with three representing optimal behavior. The composite score represented an average of the component scores and therefore also ranged from zero to three, with three representing optimal behavior across all components. Participants' scores were not affected by questions that did not apply to them or that they declined to answer.

Adherence to behaviors: Components. "Hand Hygiene - Situations" was defined as how often (always, sometimes, rarely, never) participants reported cleaning their hands in the following five situations: after handling raw meats, poultry, or fish; after riding public transportation; before eating; after using the bathroom; and after blowing or wiping their nose. "Hand Hygiene - Technique" was scored based on the average length of time (seconds) participants reported washing their hands with soap and water and/or the amount of hand sanitizer used when cleaning hands with sanitizer. "Hand Awareness" was based on how often (always, sometimes, rarely, never) participants reported avoiding touching their eyes, nose, and/or mouth when their hands were not clean. "Respiratory Hygiene - Cover Cough" was based on how often (always, sometimes, rarely, never) participants reported covering their mouth and nose when coughing or sneezing around other people. "Respiratory Hygiene - Technique" was scored based on what participants reported using to cover their cough or sneeze when around other people. Options included hands, tissue or handkerchief, and elbow. The "hands" component was based on a follow-up question related to how often (always, sometimes, rarely, never) participants reported cleaning their hands after coughing or sneezing into them, believed to be an important aspect of effective respiratory hygiene (52).

The "Social Distancing" behavior adherence score component was based on two questions. First, participants reported how often (always, sometimes, rarely, never) they avoided close contact with people because they feared getting sick. Second, participants reported how often (always, sometimes, rarely, never) they avoided close contact with people because they were feeling sick. Close contact was defined as within six feet. Questions on the baseline and end-of-study surveys referred to general behaviors, and questions on weekly surveys referred to specific behaviors in the last 48 hours. Social distancing questions were not asked on the baseline survey and therefore were not included in the baseline composite score.

Predictor variables

Participant situations. Participant situations of interest were assessed for each week of the study for all participants. These situations included participant experience of ILI symptoms; illness in participants' close contacts; participant travel, and participant living arrangements (one or more roommates, group living situation, and interaction with children). Questions on participant situations were not included in the end-of-study survey.

The Centers for Disease Control and Prevention (CDC) defines ILI as fever (temperature of 100°F (37.8°C) or greater) and a cough and/or a sore throat in the absence of a known cause other than influenza (53). Despite provision of thermometers to all participants, however, fewer than half (444/1,112 (40%)) of total Group 1 and Group 2 participants reporting fever as a symptom also reported their actual temperature. Therefore, a modified version of the CDC definition of ILI that did not specify the temperature was used for this analysis: fever or feverishness (indicated by chills) and a cough and/or a sore throat in the absence of a known cause other than influenza. The case definition timeline was further specified that symptoms had to be clustered within five days for onset of the ILI episode and an episode lasted 15 days. A binary indicator (yes or no) was utilized to indicate ILI during each week of the study. Baseline illness was assessed by asking participants to indicate any respiratory illness symptoms they had

experienced in the two weeks prior to the baseline survey. Those who indicated symptoms consistent with the ILI case definition were considered to have been ill at baseline. However, it was not possible to assess whether symptoms were clustered within five days; therefore, this measure may have identified more individuals as having ILI at baseline than actually met the case definition described here.

Close contacts were defined as anyone residing in the same suite, apartment, or single-family home as the participant, or in the same room as the participant if he or she lived in a dormitory or other group-living arrangements (e.g., fraternity or sorority house, cooperative housing), or other individuals with whom the participant had either prolonged and frequent face-to-face contact (within six feet) for several hours, several days a week, or close physical contact (such as hugging or kissing). Participants were asked during each weekly survey if any of their close contacts had experienced symptoms of a respiratory illness during the past week. A binary indicator was constructed based on this question reflecting whether participants reported illness in any of their close contacts each week. Close contact illness information was gathered in each weekly survey; it was not collected at baseline.

Participant travel was constructed as a binary indicator of whether participants reported being away from their regular living residence for at least 24 hours at one time during a given week, including during winter break (five weeks) and spring break (one week). To account for potential changes in survey completion during breaks, participants were also asked generally about their travel during the first weekly survey following the end of each break. If participants had not completed the survey or responded to the travel question for any of the weeks during the breaks, their response to the general question about where they primarily spent their winter break (regular academic year living arrangements, parents' or family's residence, friend's residence, hotel, or other) was assigned to their travel information for that week of the given break. Participant travel information was gathered in each weekly survey; it was not collected at baseline.

Participants reported their living arrangements (number of roommates and type of living situation) and regular interaction with children on the baseline survey. Roommates were defined as individuals sharing the same bedroom with the participant. Among the types of living situations specified, group living arrangements were defined as residence halls, fraternity and sorority houses, and cooperative housing; other options, which were not considered group living arrangements, included private rental apartments or houses, rooms in private homes, university-owned apartments, or houses or units owned by the participant or his or her family. Interaction with children was defined as living with a child or having regular interaction with children one or more times per week. Each weekly survey included a question about whether the participant's living arrangements had changed, and if so, what his or her new living arrangements were. Therefore, a participant's status related to having roommates, living in a group environment, and regular child interaction could change throughout the course of the study and was treated as variable over time.

Participant characteristics. Participant characteristics of interest included demographic factors, participant attitudes toward getting sick, and participant beliefs about behaviors (usefulness and social expectations). Questions related to participant characteristics were asked of all participants on the baseline survey.

Baseline demographic factors included graduate versus undergraduate student status, international versus United States student status, gender, current smoking behaviors, asthma, age, race/ethnicity, and health status. Health status was assessed using the Medical Outcomes Study

36-Item Short-Form Health Survey (SF-36), which asks participants to assess their general health as excellent, very good, good, fair, or poor. Due to the limited number of "poor" responses, this category was collapsed with the "fair" category for analyses.

Participant attitudes toward getting sick were assessed via the question "In general, how concerned are you about getting sick with a respiratory illness (e.g., cold or influenza) during the academic year?" Response choices included extremely concerned, somewhat concerned, minimally concerned, and not at all concerned.

Participant beliefs regarding behaviors were assessed through three separate questions. First, participants were asked how useful they believed it was to clean their hands after coughing or sneezing into their hands. Response choices included completely worthless in removing germs from their hands, somewhat worthless, somewhat useful, and extremely useful. A binary indicator was created to reflect whether participants believed hand washing was useful; those who chose completely worthless or somewhat worthless were coded as zero, and those who chose somewhat or completely useful were coded as one. The next two questions addressed social expectations regarding compliance. Participants were presented the statements "My friends expect me to cover my mouth and nose each time I cough or sneeze when I am around other people" and "After I cough or sneeze into my hands, my friends expect me to clean my hands." Response options for both questions included strongly disagree, somewhat disagree, somewhat agree, and strongly agree. A binary indicator was created for each question to reflect agreement with the statement; those who chose strongly or somewhat disagree were coded as zero, and those who chose somewhat or strongly agree were coded as one.

Statistical approach

R (R Foundation for Statistical Computing, Vienna, Austria), an open-source data management and statistical program, was used for data cleaning and preparation. Stata SE 10.1 (Stata Corporation, College Station, Texas) was used for statistical analyses. All analyses utilized a significance level of 0.05. Specific analyses for both hypotheses are described below.

Hypotheses

This analysis examined two hypotheses. The first considered whether individuals' adherence to behaviors changed over time; the second considered the factors that predict changes in adherence to behaviors. Both analyses were conducted independent of the intervention by examining Groups 1 and 2 separately, and within Group 1, controlling for level of intervention uptake (described below).

Hypothesis 1

The first hypothesis was that individuals' adherence to NPI behaviors changed over the course of the 2007-2008 cold and influenza season (i.e., behaviors are not static over time). The outcome of interest for Hypothesis 1 was self-reported behavior adherence scores for each week of the study. Behavior adherence scores were calculated as described above. Potential confounders and effect modifiers for this analysis included each of the variables described above: participant situations (experience of illness, illness in close contacts, travel, and living arrangements) and participant characteristics (demographic factors, attitudes toward getting sick, and beliefs about behaviors). A mixed effects model that accounted for the correlation of repeated measures within individuals was utilized to assess this hypothesis. Unadjusted and adjusted models were examined. The relative contribution of within-subject variability

(compared to between-subject variability) was utilized to assess individual change in behaviors throughout the course of the cold and influenza season.

Hypothesis 2

The second hypothesis posited that over the course of the 2007-2008 cold and influenza season, participant situations (experience of ILI symptoms, illness in close contacts, travel, and living arrangements) and characteristics (demographic factors, participant attitudes toward getting sick, and participant beliefs about behaviors) would significantly predict changes in adherence to behaviors. Similar to Hypothesis 1, the outcome of interest for Hypothesis 2 was behavior adherence scores for each week of the study. Linear regression was utilized to assess the impact of predictor variables on the outcome (weekly behavior adherence scores). A generalized estimating equation was used to obtain robust standard errors and adjusted for the correlations between repeated measures within individuals.

Each of the participant situations and participant characteristics identified above was analyzed as an individual predictor of interest. Participant situations were assessed throughout the course of the study and could change over time, whereas participant characteristics were assessed at baseline and were treated as constants for the duration of the study.

The models for changing (participant situations) and constant (participant characteristics) predictors of interest also differed slightly to account for the different variable structures. Weekly behavior adherence scores, clustered by individual, were the outcome for both models. Predictors for the model with changing variables included the participant situation each week and the status of that situation as assessed at baseline. This allowed for interpretation of the results as change in adherence to behaviors as situations changed, holding all other factors constant. Close contact illness and travel were not assessed at baseline, so Week 1 was treated as the baseline for the models examining these variables as the predictors of interest.

The model with constant predictors included each participant characteristic and participant's baseline adherence score as the covariates of interest, which allowed for interpretation of the results as the difference in adherence scores over time between different groups (e.g., graduate versus undergraduate students), holding all other factors constant.

Indicator variables were used to indicate each level of concern about getting sick with a respiratory illness and level of participant health status. In addition, ordinal variables for concern and health status were created, and parallel analyses were executed to test for a trend within the levels. Primary results reflect models utilizing the indicator variables; results from the tests for trend are also noted below.

Unadjusted and adjusted models were analyzed for each predictor variable.

Potential confounders and effect modifiers

For Hypothesis 2, each of the participant situations and characteristics identified above was considered a predictor variable for change in adherence to behaviors over time. In addition, these variables were also treated as potential confounders for one or more of the other predictor variables. In particular, a model for each predictor was developed and potential confounders were identified specific to that predictor. Intermediate variables on the causal pathway between the predictor and the outcome of weekly behavior adherence scores were not included in individual models. Therefore, models in which situations were the predictors of interest included both characteristics and other situations as confounders as appropriate for each causal relationship (Table 1). In contrast, the models in which characteristics were the predictor

variables did not include any participant situations as confounders, because changes in situations occurring after baseline would not confound the causal relationship between a characteristic and adherence scores at baseline (Table 2).

The study intervention was designed to impact participant behaviors among participants randomly assigned to the intervention group, so this was an important confounder to control for in Group 1 (intervention group) analyses. Intervention uptake in Group 1 was specified in terms of logging in to the intervention and confirming receipt of the hygiene kit in the mail. In particular, participants who logged in to the intervention website at least once during the course of the intervention *and* confirmed receipt of the hygiene kit in the mail were specified as adopting the intervention.[†] A binary indicator was created to indicate uptake of the intervention. This indicator was included in all analyses to control for the potential confounding effect of intervention exposure in Group 1.

Results

965/1,150 (84%) Group 1 and 498/576 (86%) Group 2 participants reported no vaccination during the 2007-2008 influenza season and were included in this analysis. Table 3 presents information on participant situations experienced during the course of the study. Participants reported experiencing between zero and eight distinct episodes of ILI during the study period. The majority of participants (Group 1: 542/929 (58%); Group 2: 271/481 (56%)) did not experience any episodes of ILI throughout the study period. Participants reported illness in one or more close contacts with varying frequency during the 23 weeks of the study (range: 0 to 19 weeks). Most participants (Group 1: 425/929 (46%); Group 2: 247/481 (51%)) reported close contact illness for one to four weeks during the study period.

Participants reported traveling away from their regular living residence between 0 and 23 weeks during the 23 weeks of the study. 284/929 (31%) Group 1 and 142/481 (30%) Group 2 reported traveling between one and four weeks during the study period, while 412/929 (44%) Group 1 and 207/481 (43%) Group 2 reported traveling between five and nine weeks during the study period. This included the five weeks of winter break and one week of spring break. Looking at travel during weeks of academic instruction only (i.e., excluding the six weeks of winter and spring breaks), participants reported travel between 0 and 17 weeks of the 17 weeks in question (0 weeks: Group 1: 130/929 (14%), Group 2: 60/481 (12%); 1 to 4 weeks: Group 1: 581/929 (63%), Group 2: 292/481 (61%); 5 to 9 weeks: Group 1: 172/929 (19%), Group 2: 100/481 (21%); 10 or more weeks: Group 1: 46/929 (5%), Group 2: 29/481 (6%)).

At baseline, 504/799 (63%) Group 1 and 272/426 (64%) Group 2 participants reported having one or more roommates. With changes over time (i.e., moving into and out of roommate situations), 681/860 (79%) Group 1 and 349/454 (77%) Group 2 participants reported having one or more roommates at any point during the study period. Similarly, at baseline, 287/958 (30%) Group 1 and 163/496 (33%) Group 2 participants reported living in a group situation, and with changes over time (moving into and out of group situations), 289/958 (30%) Group 1 and 165/496 (33%) Group 2 participants reported living in a group situation at some point during the study period. While the number of people moving into a group living situation during the study period was quite low, many people moved out of group living situations. In particular, at

[†] Participants were asked during the Week 12 survey (January 22, 2008) and in the end-of-study survey (April 15, 2008) whether they received their hygiene kit in the mail.

baseline, 671/958 (70%) Group 1 participants and 333/496 (67%) Group 2 participants did not live in a group situation; by the end of the study, 901/963 (94%) Group 1 participants and 462/497 (93%) Group 2 participants reported not having lived in a group situation at some point during the course of the study. Finally, at baseline, 128/964 (13%) Group 1 and 79/498 (16%) Group 2 participants reported regular interaction with children. With changes in living arrangements over time, 193/964 (20%) Group 1 and 110/498 (22%) Group 2 participants reported regular child interaction at some point during the study period.

Table 4 presents baseline demographic characteristics of the participants. At baseline, the majority of participants were undergraduates, not international students, male, not currently smokers, and did not have asthma. The mean age in Group 1 was 22.1 years (range: 17 to 61 years), and in Group 2 was 22.2 years (range: 17 to 58 years). In terms of race/ethnicity, most participants self-identified as White/Caucasian or Asian, consistent with the race/ethnicity profile of the student population at UC Berkeley. Most students reported their health status as excellent, very good, or good (Group 1 total: 911/965 (94%); Group 2 total: 468/498 (94%)).

Most participants were minimally or somewhat concerned about illness during the academic year, and almost all reported believing hand washing was either somewhat or extremely useful in removing germs from hands. Similarly, in terms of social expectations regarding behaviors, almost all participants either somewhat or strongly agreed that their friends expected them to cover their mouth and nose each time they coughed or sneezed when they were around other people. In contrast, a much smaller proportion, but still a majority, reported somewhat or strongly agreeing that their friends expected them to clean their hands after they coughed or sneezed into their hands (Group 1: 446/760 (59%); Group 2: 243/394 (62%)).[‡]

Participants completed between 1 and 25 surveys during the course of the study (one baseline survey, which was required for enrollment; 23 weekly surveys; and one end-of-study survey). 466/965 (48%) Group 1 and 280/498 (56%) Group 2 participants completed all 25 surveys administered. Approximately half (534/963 (55%)) of Group 1 participants logged into the intervention education website one or more times during the course of the study, and almost all (781/788 (99%)) of Group 1 participants who responded to the questions regarding receipt of kits reported getting their hygiene kit in the mail. Together, 491/936 (52%) Group 1 participants logged into the intervention website *and* confirmed receipt of the hygiene kit, the criteria for uptake of intervention. Adherence scores across all participants (Groups 1 and 2) included in the analysis and all weeks of data were normally distributed (Figure).

Table 5 presents the results of Hypothesis 1, in which variance due to within- versus between-person variability was examined. This revealed that approximately 58% of the variance was due to between-person differences and 42% of the variance was due to within-person changes over time. These estimates were consistent across unadjusted and adjusted models for both Groups 1 and 2.

Table 6 presents the results concerning Hypothesis 2, in which variable participant situations were the main predictors of interest. Results for participant situations were generally similar for the two groups. Those who reported symptoms consistent with ILI reported significantly higher adherence to behaviors than those who did not, in both unadjusted and adjusted models (Group 1 adjusted coefficient, 0.15; 95% confidence interval (CI), 0.10, 0.20; $p<0.001$; Group 2 adjusted coefficient, 0.18; 95% CI, 0.11, 0.25; $p<0.001$). Participants also

[‡] Approximately 18% of participants who answered this question (Group 1: 169/929 (18%) and Group 2: 87/481 (18%)) chose the response option "I don't know."

appeared to have higher adherence to behaviors when one or more of their close contacts were ill, although this was not significant. In contrast, participants who were traveling reported significantly lower adherence to behaviors compared to those who did not travel (Group 1 adjusted coefficient, -0.04; 95% CI, -0.06, -0.01; p=0.005; Group 2 adjusted coefficient, -0.05; 95% CI, -0.08, -0.01; p=0.05). Finally, participants living in a group situation generally reported better adherence to behaviors than those not living in a group situation, although this difference was not consistently significant (Group 1 adjusted coefficient, 0.05; 95% CI, -0.01, 0.11; p=0.097; Group 2 adjusted coefficient, 0.10; 95% CI, 0.00, 0.20; p=0.052). Participant situations that did not have an association with change in behaviors were having one or more roommates and regular interaction with children.

Table 7 provides the results concerning Hypothesis 2, in which constant participant characteristics were the main predictors of interest. For many variables, unadjusted and adjusted models returned different results in terms of the significance of variables as predictors of adherence to behaviors, but point estimates between models were often similar. For example, Group 1 participants who reported believing hand washing was useful also reported significantly higher adherence to behaviors in the unadjusted model than those who did not (unadjusted coefficient, 0.12; 95% CI, 0.02, 0.22; p=0.016); however, once potential confounders were included in the model, this was no longer significant (adjusted coefficient, 0.07; 95% CI, -0.06, 0.20; p=0.281), although the point estimates were similar between the two models.

Specific categories of race/ethnicity varied between the two groups in terms of predicting adherence to behaviors. In particular, Asian participants in both groups reported significantly higher adherence to behaviors than White/Caucasian participants (Group 1 adjusted coefficient, 0.13; 95% CI, 0.07, 0.19; p<0.001; Group 2 adjusted coefficient, 0.18; 95% CI, 0.10, 0.25; p<0.001). Latino participants, multiracial participants, and those in the "Other" race/ethnicity category also reported higher adherence to behaviors than White/Caucasian participants in both groups, although significance varied. African-American/Black participants' adherence was not significantly different from that of White/Caucasian participants.

Two participant characteristics, concern about getting sick and social expectations to wash hands after coughing or sneezing, were predictive of adherence to behaviors in both the unadjusted and adjusted models, in Groups 1 and 2. Concern about getting sick with a respiratory illness during the academic year was a significant predictor of behavior change (Group 1 adjusted p=0.002; Group 2 adjusted p=0.018), with adherence to behaviors increasing as concern increased. A test for trend supported this result and revealed the relationship to be linear in both Group 1 (adjusted coefficient, 0.08; 95% CI, 0.04, 0.12; p<0.001) and Group 2 (adjusted coefficient, 0.08; 95% CI, 0.02, 0.14; p=0.005).

Finally, in both groups those who reported social expectations to wash their hands after they coughed or sneezed reported higher adherence to behaviors than those who did not report experiencing these social expectations (Group 1 adjusted coefficient, 0.07; 95% CI, 0.01, 0.13; p=0.025; Group 2 adjusted coefficient, 0.13; 95% CI, 0.05, 0.21; p=0.001).

Discussion

This analysis provides important information regarding university students' changes in adherence to behaviors over the course of a cold and influenza season; this information may help in the development and targeting of future interventions. First, while the majority of variance in behaviors was due to differences between people, a large minority of the variance was due to

within-person changes over time. This tells us that individuals do change their behaviors over time, and that it is worthwhile to explore the types of people who do and do not change their behaviors, and in response to what situations.

A subsequent exploration of participant situations as a predictor of changes in behaviors found that experience of several situations, especially related to perceptions of risk, led to increases in participant adherence to behaviors. Morrison and Yardley conducted qualitative focus groups to examine individuals' perceptions of different non-pharmaceutical infection control measures and found that perception of risk from a pandemic has an impact on intentions to adhere to behaviors; this perception of risk may also explain the increases in adherence to behaviors among university students for several situations (54). In particular, experience of ILI symptoms was strongly predictive of increasing adherence to behaviors. Similarly, experience of close contact illness also appeared to result in increased adherence to behaviors, although this was not significant. The increased risk to others due to ILI may explain individual increases in adherence to behaviors as a mechanism protective of others, while increased risk due to close contact illness may explain individual increases in adherence to behaviors as a self-protective mechanism. With regard to exposures related to living arrangements, moving into a group living situation also resulted in increased adherence to behaviors; such changes are helpful because group living arrangements likely represent a higher level of exposure to respiratory pathogens on a day-to-day basis than non-group living arrangements. Interaction with children was not predictive of higher adherence scores, despite the potential for increased risk of illness due to contact with children. This may highlight an opportunity for interventions to educate university students about this risk.

Of the participant situations examined, travel was the only one to predict negative change in adherence to behaviors, with participants decreasing their adherence to behaviors when traveling. One explanation may be that this measure is affected by the inclusion of winter and spring break travel in the variable. However, a sub-analysis of travel data excluding winter and spring breaks found similar results (Group 1 adjusted coefficient, -0.05; 95% CI, -0.08, -0.02; p=0.002; Group 2 adjusted coefficient, -0.04; 95% CI, -0.08, -0.00; p=0.028). This consistent effect of greater adherence to behaviors when not traveling away from campus may reflect the fact that students' contact patterns and activities are different on campus than they are off campus, and students are more careful about adherence to behaviors when on campus. This also highlights a potential opportunity for more education of university students around risks associated with travel and increased exposure to pathogens causing respiratory illness in other communities. This is particularly important in light of research concerning individuals' intentions to change behaviors due to increased perception of risk of respiratory illness (41).

While changes in participant situations give valuable information about when to deploy interventions aimed at increasing adherence to behaviors, participant characteristics give us additional information about to whom interventions should be targeted. One characteristic that showed a consistent pattern was the lower levels of adherence to behaviors among graduate students compared to undergraduate students. This may reflect differences in contact patterns and perceptions of exposure based on those contact patterns and offers an opportunity for further exploration to understand the differences between these groups and to tailor some interventions to the graduate student population on campuses.

Another characteristic that showed a consistent pattern was concern about getting sick with a respiratory illness during the academic year, which was part of the assessment of attitudes toward behaviors as a predictor of behavioral intentions. Concern about illness was highly

predictive of adherence to behaviors, with adherence to behaviors increasing as levels of concern increased. This shows that those who expressed greater concern about illness at baseline reported higher adherence to behaviors during the course of the study.

Finally, subjective norms were also predictive of behavioral intentions. Those who reported social expectations to wash their hands after coughing or sneezing into them reported higher adherence to behaviors over the course of the study than those who did not report these social expectations. This increased level of adherence to behaviors may reflect a response to the social expectation to increase hygiene when ill or when illness is circulating. Similarly, it is important to note that social expectations around covering coughs or sneezes also led to increased adherence to behaviors, although this was not significant. This may have been due to the limited variation in the data around this point at baseline, with 839/873 (96%) and 437/461 (95%) of Groups 1 and 2, respectively, reporting social expectations to cover coughs or sneezes.

In summary, this unique analysis gives public health authorities important data with which to better design future interventions around hygiene and risk, and groups to whom those interventions might be best targeted. For example, in terms of targeting future initiatives, some interventions may focus on specific groups such as those who currently have lower adherence to behaviors (e.g., graduate students, those less concerned about getting sick with a respiratory illness) to reach the groups with the greatest opportunity for improvement. An alternative approach may be to focus more on social expectations and positive peer pressure because those who perceived social expectations around hygiene behaviors reported greater adherence to behaviors over the course of a cold and influenza season. This may involve delivering interventions at a group level to create collective peer expectations.

In terms of when to target interventions, another important finding relates to individuals' changes in behaviors in response to specific risk situations, as this may represent a critical opportunity for public health authorities to develop targeted information among those experiencing the specific situations under consideration. For example, the increase in adherence to behaviors when individuals were ill suggests that individuals may be most susceptible to hygiene interventions during illness, and most likely to respond positively to education around improved hygiene behaviors. Similarly, even though the relationship was not significant, behavior adherence scores increased when close contacts were ill, which may represent an opportunity to target interventions to sick individuals' contacts, with messaging around keeping oneself healthy when a close contact has a respiratory illness.

Hygiene behaviors in group living situations are an important consideration on a university campus, and while these results suggest individuals do increase their adherence to behaviors when they are in group living arrangements, this may reveal an important opportunity to further improve hygiene by targeting interventions to group living arrangements on college campuses. This may be complementary with the opportunity to emphasize positive peer pressure. Social expectations in a group situation could be an important way to approach interventions around preventing spread of respiratory illness among university students. Similarly, the lack of differences in adherence between those who have regular interaction with children and those who do not may represent an opportunity to tailor an intervention program toward students living with or otherwise regularly interacting with children, to educate them on the potential for higher rates of transmission of respiratory illness among and from children. Finally, the decrease in behavior adherence seen during periods of travel represents an opportunity for education and outreach to help clarify for individuals the risks of different situations and exposures (college

campus versus other areas) and how changes in exposure can be a risk, especially when traveling to different communities where different respiratory illnesses may be circulating.

This study had several limitations. First, data in this analysis were based on participant self-report, which may be subject to misclassification. Similarly, behavior reporting each week was based on participant behaviors in the 48 hours prior to taking each survey, which means an individual's responses may have varied from week to week depending on which day of the week a participant took the survey, if his or her contact patterns or interactions varied by day of the week (e.g., a participant's behaviors may have been different on a weekend versus a weekday). Additionally, minor differences between questions on the baseline (general questions about adherence to behaviors) and weekly surveys (questions related to actual behaviors in the prior 48 hours) may have resulted in varied adherence scores between baseline and weekly surveys if a participant's general behaviors were not similar to his or her behaviors in the prior 48 hours. Second, experience of ILI symptoms was based on the case definition described here; however, participants may change their behaviors in response to milder respiratory symptoms that do not meet the specific case definition, therefore biasing the results toward the null by causing the behaviors of those with ILI to look like the behaviors of those with other respiratory symptoms that did not meet the ILI case definition but did still potentially result in behavior change. Experience of ILI symptoms was still a consistent predictor of change in adherence to behaviors, despite this potential limitation in the analysis, but future analyses may consider examining this same question for respiratory illness in general. Finally, it was out of the scope of this paper to compare results between Groups 1 and 2 and draw inference from those comparisons; this may be of interest for future analyses.

In addition to the proposed future studies identified above, additional opportunities for research include similar studies to be done during different cold and influenza seasons and on different campuses to determine how student populations change over time and in different geographic settings. In the meantime, pilot public health interventions targeted to different groups based on this analysis, such as those with the greatest opportunity for improvements in hygiene or when individuals experience different situations, should be implemented to determine how these results can best be leveraged to reach individuals and improve hygiene related to respiratory illness.

Conclusion

This study examined predictors of changes in behaviors related to respiratory illness prevention among students at UC Berkeley during the 2007-2008 cold and influenza season. Limited recent data suggest that individuals intend to change their behaviors as risk changes; this study provides evidence this is true for some but not all situations among university students, one of the major groups of concern for the spread of respiratory infections. In particular, this analysis finds that individuals significantly increased their adherence to hand and respiratory hygiene/cough etiquette and social distancing behaviors when they were sick, and the results suggest the same may be true when individuals' close contacts are ill. The analysis also finds that when living in group arrangements such as dormitories, students reported higher adherence to behaviors, but when traveling away from their regular living arrangements (e.g., during the semester or for semester breaks), adherence decreased. Interaction with children did not predict differences in adherence, which may represent an opportunity for education and intervention. In addition, this study includes an analysis of individuals' demographic characteristics that may

predict adherence to behaviors over time, providing important information for groups to whom future public health interventions should be targeted. Finally, this analysis identified the importance of student perceptions of social expectations concerning adherence to hygiene behaviors in predicting adherence to behaviors over time. Together these findings provide unique and important information for targeting future public health interventions around hand and respiratory hygiene/cough etiquette and social distancing to prevent respiratory illness among university students.

References

1. Nichol KL, D'Heilly S, Ehlinger E. Burden of upper respiratory illnesses among college and university students: 2002–2003 and 2003–2004 cohorts. Vaccine. 2006;24(44-46):6724-5.

2. Nichol KL, D'Heilly S, Ehlinger E. Colds and influenza-like illnesses in university students: Impact on health, academic and work performance, and health care use. Clin Infect Dis. 2005;40(9):1263-70.

3. Li S, Leader S. Economic burden and absenteeism from influenza-like illness in healthy households with children (5–17 years) in the US. Respir Med. 2007;101(6):1244-50.

4. Nichol KL, D'Heilly S, Ehlinger EP. Influenza vaccination among college and university students: Impact on influenzalike illness, health care use, and impaired school performance. Arch Pediatr Adol Med. 2008;162(12):1113-8.

5. Muennig PA, Khan K. Cost-effectiveness of vaccination versus treatment of influenza in healthy adolescents and adults. Clin Infect Dis. 2001 Dec 1;33(11):1879-85.

6. Nichol KL. Cost-benefit analysis of a strategy to vaccinate healthy working adults against influenza. Arch Intern Med. 2001 Mar 12;161(5):749-59.

7. Rothberg MB, Rose DN. Vaccination versus treatment of influenza in working adults: A cost-effectiveness analysis. Am J Med. 2005;118(1):68-77.

8. Bridges CB, Thompson WW, Meltzer MI, Reeve GR, Talamonti WJ, Cox NJ, et al. Effectiveness and cost-benefit of influenza vaccination of healthy working adults. a randomized controlled trial. JAMA. 2000;284(13):1655-63.

9. Campbell DS, Rumley MH. Cost-effectiveness of the influenza vaccine in a healthy, working-age population. J Occup Environ Med. 1997 May;39(5):408-14.

10. Lee PY, Matchar DB, Clements DA, Huber J, Hamilton JD, Peterson ED. Economic analysis of influenza vaccination and antiviral treatment for healthy working adults. Ann Intern Med. 2002;137(4):225-31.

11. O'Brien BJ, Goeree R, Blackhouse GMBA, Smieja M, Loeb M. Oseltamivir for treatment of influenza in healthy adults: Pooled trial evidence and cost-effectiveness model for Canada. Value Health. 2003;6(2):116-25.

12. Kaiser L, Keene ON, Hammond JMJ, Elliott M, Hayden FG. Impact of zanamivir on antibiotic use for respiratory events following acute influenza in adolescents and adults. Arch Intern Med. 2000;160(21):3234-40.

13. Enanoria WTA, Misegades L, Lachance JA, Cotter LE, Wallace LE, Aragon TA. Factors associated with influenza vaccination among university students. (under review).

14. World Health Organization Writing Group. Nonpharmaceutical interventions for pandemic influenza, national and community measures. Emerg Infect Diseases. 2006;12(1):88-94.

15. Influenza (flu) - preventing seasonal flu [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2009 March 12 [cited 2009 June 16]. Available from: http://www.cdc.gov/flu/protect/preventing.htm.

16. Monto AS. The risk of seasonal and pandemic influenza: Prospects for control. Clin Infect Dis. 2009;48(S1):20-5.

17. Cowling BJ, Chan KH, Fang VJ, Cheng CKY, Fung ROP, Wai W, et al. Facemasks and hand hygiene to prevent influenza transmission in households: A randomized trial. Ann Intern Med. 2009;151:437-46.

18. Influenza (flu) - cover your cough [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2007 January 16 [cited 2009 June 16]. Available from: http://www.cdc.gov/flu/protect/covercough.htm.

19. Pandemic flu - individuals & family planning [homepage on the Internet]. U.S. Department of Health and Human Services [cited 2009 June 16]. Available from: http://www.pandemicflu.gov/plan/individual/index.html.

20. Jefferson T, Del Mar C, Dooley L, Ferroni E, Al-Ansary LA, Bawazeer GA, et al. Physical interventions to interrupt or reduce the spread of respiratory viruses: Systematic review. Br Med J. 2009;339:b3675.

21. Falsey AR, Criddle MM, Kolassa JE, McCann RM, Brower CA, Hall WJ. Evaluation of a handwashing intervention to reduce respiratory illness rates in senior day-care centers. Infect Control Hosp Epidemiol. 1999 Mar;20(3):200-2.

22. Ryan MAK, Christian RS, Wohlrabe J. Handwashing and respiratory illness among young adults in military training. Am J Prev Med. 2001;21(2):79-83.

23. Lee T, Jordan NN, Sanchez JL, Gaydos JC. Selected nonvaccine interventions to prevent infectious acute respiratory disease. Am J Prev Med. 2005;28(3):305-16.

24. Aledort JE, Lurie N, Wasserman J, Bozzette SA. Non-pharmaceutical public health interventions for pandemic influenza: An evaluation of the evidence base. BMC Public Health. 2007 Aug 15;7:208.

25. Aiello AE, Coulborn RM, Perez V, Larson EL. Effect of hand hygiene on infectious disease risk in the community setting: A meta-analysis. Am J Public Health. 2008;98(8):1372-81.

26. Cowling BJ, Fung ROP, Cheng CKY, Fang VJ, Chan KH, Seto WH, et al. Preliminary findings of a randomized trial of non-pharmaceutical interventions to prevent influenza transmission in households. PLoS ONE. 2008;3(5):e2101.

27. Sandora TJ, Shih MC, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: A randomized, controlled trial of an infection-control intervention. Pediatrics. 2008;121(6):e1555-62.

28. White C, Kolble R, Carlson R, Lipson N. The impact of a health campaign on hand hygiene and upper respiratory illness among college students living in residence halls. J Am Coll Health. 2005;53(4):175-81.

29. White C, Kolble R, Carlson R, Lipson N, Dolan M, Ali Y, et al. The effect of hand hygiene on illness rate among students in university residence halls. Am J Infect Control. 2003;31(6):364-70.

30. Aiello AE, Murray GF, Perez V, Coulborn RM, Davis BM, Uddin M, et al. Mask use, hand hygiene, and seasonal influenza−like illness among young adults: A randomized intervention trial. J Infect Dis. 2010;201:491-8.

31. Lo JYC, Tsang THF, YiuHong L, Yeung EYH, Wu T, Lim WWL. Respiratory infections during SARS outbreak, Hong Kong, 2003. Emerg Inf Diseases. 2005;11(11):1738-41.

32. Larson EL, Ferng YH, McLoughlin JW, Wang S, Morse SS. Effect of intensive education on knowledge, attitudes, and practices regarding upper respiratory infections among urban Latinos. Nurs Res. 2009 April 16;58(3):150-7.

33. Stebbins S, Downs JS, Vukotich CJ, Jr. Using nonpharmaceutical interventions to prevent influenza transmission in elementary school children: Parent and teacher perspectives. J Public Health Manag Pract. 2009 Mar-Apr;15(2):112-7.

34. Nigmatulina KR, Larson RC. Living with influenza: Impacts of government imposed and voluntarily selected interventions. Eur J Oper Res. 2009;195(2):613-27.

35. Kelso JK, Milne GJ, Kelly H. Simulation suggests that rapid activation of social distancing can arrest epidemic development due to a novel strain of influenza. BMC Public Health. 2009;9:117.

36. Ferguson NM, Cummings DAT, Fraser C, Cajka JC, Cooley PC, Burke DS. Strategies for mitigating an influenza pandemic. Nature. 2006;442(7101):448-52.

37. Germann TC, Kadau K, Longini Jr IM, Macken CA. Mitigation strategies for pandemic influenza in the United States. Proceedings of the National Academy of Sciences. 2006;103(15):5935-40.

38. Whitley RJ, Monto AS. Prevention and treatment of influenza in high-risk groups: Children, pregnant women, immunocompromised hosts, and nursing home residents. J Infect Dis. 2006;194:S133-8.

39. MacKenzie J, MacKenzie I, Holt P. The effect of cigarette smoking on susceptibility to epidemic influenza and on serological responses to live attenuated and killed subunit influenza vaccines. Epidemiol Infect. 2009;77(03):409-17.

40. Fiore A, Shay D, Broder K, Iskander J, Uyeki T, Mootrey G, et al. Prevention and control of influenza: Recommendations of the Advisory Committee on Immunization Practices (ACIP), 2008. MMWR Morb Mortal Wkly Rep. 2008 August 8;57(RR-7):1-60.

41. Yuan J, Zhang L, Xu W, Shen J, Zhang P, Ma H. Reported changes in health-related behaviours in Chinese urban residents in response to an influenza pandemic. Epidemiol Infect. 2009:1.

42. Murray R, Chandler C, Clarkson Y, Wilson N, Baker M, Cunningham R, et al. Sub-optimal hand sanitiser usage in a hospital entrance during an influenza pandemic, New Zealand, August 2009. Euro Surveill. 2009 Sep 17;14(37):19331.

43. Manning S, Barry T, Wilson N, Baker MG, Schmidt WP, Pebody R, et al. Update: Follow-up study showing post-pandemic decline in hand sanitiser use, New Zealand, December 2009. Euro Surveill. 2010;15(3).

44. Brankston G, Gitterman L, Hirji Z, Lemieux C, Gardam M. Transmission of influenza A in human beings. Lancet Infect Dis. 2007 April;7(4):257-65.

45. Moser MR, Bender TR, Margolis HS, Noble GR, Kendal AP, Ritter DG. An outbreak of influenza aboard a commercial airliner. Am J Epidemiol. 1979;110(1):1-6.

46. Wenzel RP. Airline travel and infection. N Engl J Med. 1996 April 11;334(15):981-2.

47. Viboud C, Boėlle PY, Cauchemez S, Lavenu A, Valleron AJ, Flahault A, et al. Risk factors of influenza transmission in households. Br J Gen Pract. 2004 September 1;54(506):684-9.

48. Ferguson NM, Cummings DAT, Fraser C, Cajka JC, Cooley PC, Burke DS. Strategies for mitigating an influenza pandemic. Nature. 2006 April 26;442(7101):448-52.

49. Fishbein M, Ajzen I. Belief, attitude, intention and behavior: An introduction to theory and research. Reading, MA: Addison-Wesley; 1975.

50. Ajzen I, Fishbein M. Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice Hall; 1980.

51. Hale JL, Householder BJ, Greene KL. The theory of reasoned action. In: Dillard JP, Pfau M, editors. The persuasion handbook: Developments in theory and practice. Thousand Oaks, CA: Sage Publications; 2002. p. 259-86.

52. Respiratory hygiene/cough etiquette in healthcare settings [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention Website. 2003 December 17 [cited 2009 May 14]. Available from: http://www.cdc.gov/flu/professionals/infectionControl/resphygiene.htm

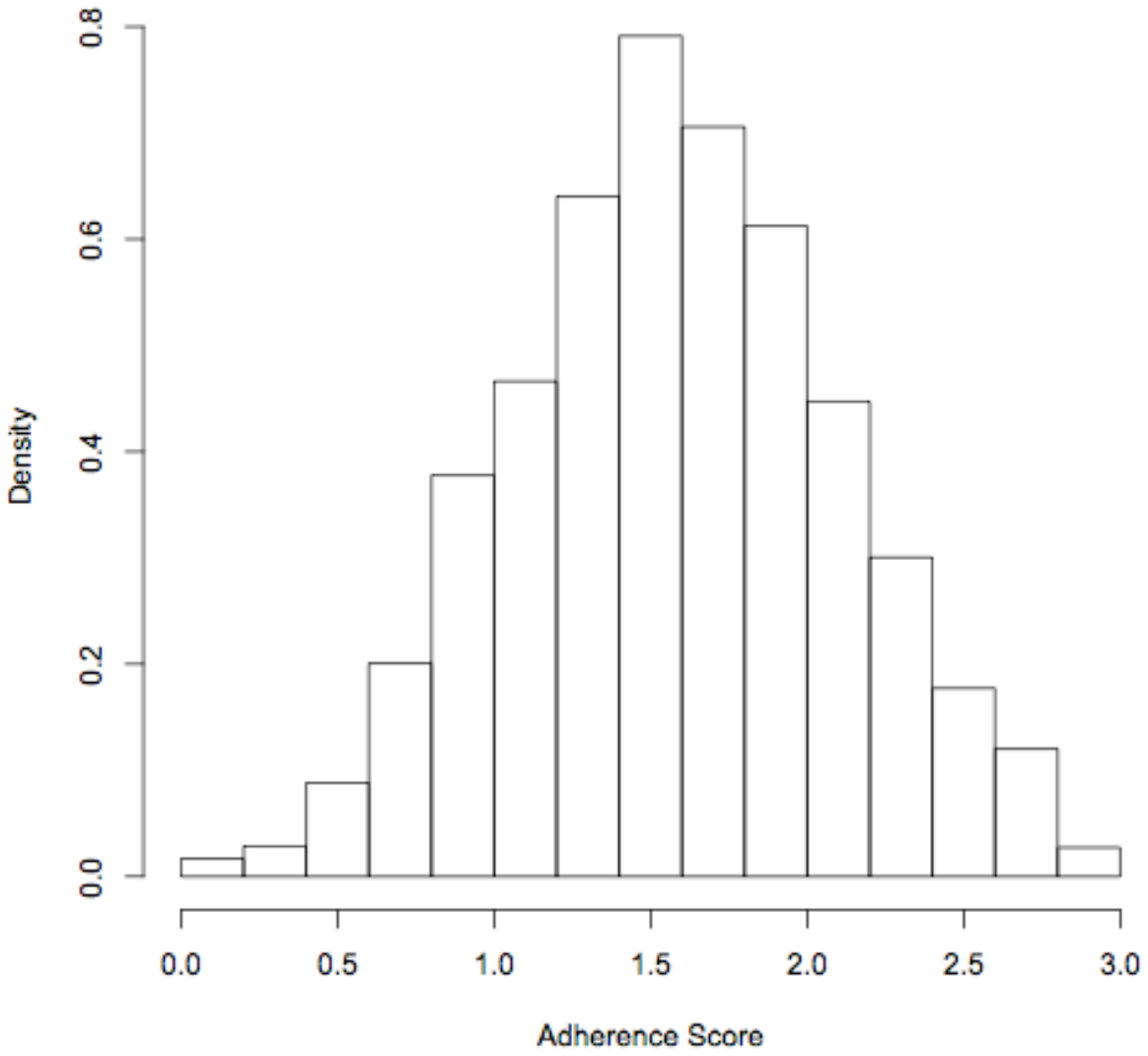


Figure. Histogram of adherence scores across all participants (Groups 1 and 2) and all weeks of data.

Table 1. Potential confounders included in adjusted models for participant situations as predictor variables.

	Predictor Variables: Participant Situations					
Potential Confounders	ILI	Close contact illness	Travel away from school-year residence	One or more roommates	Group living situation	Regular interaction with children
Participant Situations						
ILI	-	X	X			
Close contact illness	X	-				
Travel away from school-year residence	X	X	-			
One or more roommates	X	X		-	X	X
Group living situation	X	X		X	-	X
Regular interaction with children	X	X	X			-
Participant Characteristics						
Graduate student	X	X	X	X	X	X
International student	X	X	X	X	X	X
Gender				X	X	X
Currently smoke	X			X	X	X
Asthma	X					
Age	X	X	X	X	X	X
Race/ethnicity	X	X	X	X	X	X
General health status	X			X	X	X
Concern about getting sick with a respiratory illness	X	X	X	X	X	X
Believe hand washing useful	X	X				
Friends expect to cover cough or sneeze	X	X				
Friend expect to wash hands after coughing or sneezing	X	X				

Abbreviations: ILI, influenza-like illness.

Table 2. Potential confounders included in adjusted models for participant characteristics as predictor variables.

	Predictor Variables: Participant Characteristics											
Potential Confounders: Participant Characteristics	Graduate student	International student	Gender	Currently smoke	Asthma	Age	Race/ ethnicity	Health status	Concern about getting sick with a respiratory illness	Believe hand washing useful	Friends expect to cover cough or sneeze	Friend expect to wash hands after coughing or sneezing
Graduate student	-	X		X		X		X	X	X	X	X
International student	X	-	X	X	X	X	X	X	X	X	X	X
Gender	X	X	-	X	X	X	X	X	X	X	X	X
Currently smoke				-				X	X		X	X
Asthma				X	-			X	X			
Age	X	X	X	X		-	X	X	X	X	X	X
Race/ethnicity	X	X	X	X	X	X	-	X	X	X	X	X
General health status				X				-	X	X		
Concern about getting sick with a respiratory illness				X				X	-	X	X	X
Believe hand washing useful								X	X	-	X	X
Friends expect to cover cough or sneeze				X				X	X	X	-	X
Friend expect to wash hands after coughing or sneezing				X				X	X	X	X	-

Table 3. Participant situations during study period.

Situation	Group 1 (n=965) n	(%)*	Group 2 (n=498) n	(%)*
Number of ILI episodes				
0	542	(58)	271	(56)
1	264	(28)	154	(32)
2 or more	123	(13)	56	(12)
Weeks reporting close contact illness				
0	129	(14)	48	(10)
1 to 4	425	(46)	247	(51)
5 to 9	290	(31)	141	(29)
10 or more	85	(9)	45	(9)
Weeks reporting travel away from regular semester residence†				
0	55	(6)	30	(6)
1 to 4	284	(31)	142	(30)
5 to 9	412	(44)	207	(43)
10 or more	178	(19)	102	(21)
One or more roommates at any point during study period				
No	179	(21)	105	(23)
Yes	681	(79)	349	(77)
Group living situation at any point during study period				
No	669	(70)	331	(67)
Yes	289	(30)	165	(33)
Regular interaction with children at any point during study period‡				
No	771	(80)	388	(78)
Yes	193	(20)	110	(22)

Abbreviations: ILI, influenza-like illness.

* Percentages may not total to 100 due to rounding.

† Includes Winter Break (5 weeks) and Spring Break (1 week).

‡ Regular interaction defined as child living in the household or other interaction with children one or more times per week.

Table 4. Baseline participant characteristics and participant follow-up during study period.

Characteristic	Group 1 (n=965) n	Group 1 (n=965) (%)*	Group 2 (n=498) n	Group 2 (n=498) (%)*
Student status				
Undergraduate	668	(69)	350	(71)
Graduate	295	(31)	145	(29)
International student				
No	866	(92)	452	(92)
Yes	74	(8)	37	(8)
Gender				
Female	406	(42)	215	(43)
Male	553	(58)	280	(57)
Currently smoke				
No	932	(97)	487	(98)
Yes	31	(3)	10	(2)
Asthma				
No	879	(91)	432	(87)
Yes	82	(9)	63	(13)
Age in years, mean (standard deviation)	22.1	(4.7)	22.2	(5.2)
Race/ethnicity				
White/Caucasian	340	(36)	204	(43)
Asian	377	(40)	190	(40)
African-American/Black	17	(2)	7	(1)
Latino	87	(9)	38	(8)
Multiracial	62	(7)	22	(5)
Other†	50	(5)	18	(4)
General health status				
Excellent	216	(22)	103	(21)
Very good	442	(46)	231	(46)
Good	253	(26)	134	(27)
Poor or fair	54	(6)	30	(6)
Concern about getting sick with a respiratory illness during academic year				
Not at all	88	(9)	55	(11)
Minimally	341	(35)	192	(39)
Somewhat	443	(46)	211	(42)
Extremely	93	(10)	39	(8)

Table 4 (cont). Baseline participant characteristics and participant follow-up during study period.

Characteristic	Group 1 (n=965) n	Group 1 (n=965) (%)*	Group 2 (n=498) n	Group 2 (n=498) (%)*
Believe hand washing useful				
No	41	(5)	24	(5)
Yes	857	(95)	450	(95)
Friends expect to cover cough or sneeze				
No	34	(4)	24	(5)
Yes	839	(96)	437	(95)
Friends expect to wash hands after coughing or sneezing				
No	314	(41)	151	(38)
Yes	446	(59)	243	(62)
Number of surveys completed during study period				
1 to 9	146	(15)	65	(13)
10 to 19	110	(11)	55	(11)
20 to 24	243	(25)	98	(20)
25	466	(48)	280	(56)
Intervention uptake‡§				
No	445	(48)	n/a	n/a
Yes	491	(52)	n/a	n/a

* Percentages may not total to 100 due to rounding.

† Includes American Indian/Alaskan Native; Native Hawaiian or other Pacific Islander; and participant-identified "Other" category.

‡ Only Group 1 participants were provided access to the intervention education website and sent a hygiene kit.

§ Uptake of intervention among Group 1 specified as participants randomly assigned to the intervention group who logged in to the intervention website at least once during the course of the intervention *and* confirmed receipt of the hygiene kit.

Table 5. Percent of variance in behavior adherence scores explained by between- versus within-person variability.*

	Group 1 (n=965)		Group 2 (n=498)	
Percent variance in behavior adherence scores	Unadjusted	Adjusted	Unadjusted	Adjusted
Between-person	57	58	59	58
Within-person	43	42	41	42

* Individuals observed from 1 to 25 weeks (1 baseline survey, 23 weekly surveys, and 1 end-of-study survey.

Table 6. Linear regression of change in adherence to behaviors based on experience of situations.

	Group 1 (n=965)				Group 2 (n=498)			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
Situation	Coef. (95% CI)	*p*	Coef. (95% CI)	*p*	Coef. (95% CI)	*p*	Coef. (95% CI)	*p*
Experience of ILI symptoms	0.17 (0.13,0.21)	<0.001	0.15 (0.10,0.21)	<0.001	0.22 (0.16,0.28)	<0.001	0.18 (0.11,0.25)	<0.001
Close contact illness	0.02 (-0.01,0.05)	0.112	0.01 (-0.02,0.05)	0.404	0.03 (-0.01,0.07)	0.196	0.02 (-0.02,0.07)	0.369
Travel away from school-year residence	-0.05 (-0.07,-0.02)	0.001	-0.04 (-0.06,-0.01)	0.005	-0.05 (-0.09,-0.02)	0.006	-0.05 (-0.08,-0.01)	0.005
One or more roommates	0.03 (-0.04,0.09)	0.408	0.04 (-0.02,0.11)	0.207	0.01 (-0.05,0.08)	0.671	0.00 (-0.08,0.09)	0.953
Group living situation	0.07 (0.02,0.12)	0.003	0.05 (-0.01,0.11)	0.097	0.05 (-0.03,0.14)	0.234	0.10 (0.00,0.20)	0.052
Regular interaction with children	0.01 (-0.11,0.12)	0.926	-0.06 (-0.19,0.07)	0.345	0.07 (-0.06,0.20)	0.288	0.02 (-0.13,0.18)	0.752

Abbreviations: Coef, linear regression coefficient; CI, confidence interval; ILI, influenza-like illness.

Table 7. Linear regression of change in adherence to behaviors based on participant characteristics.

	Group 1 (n=965)				Group 2 (n=498)			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
Characteristic	Coef. (95% CI)	*p*	Coef. (95% CI)	*p*	Coef. (95% CI)	*p*	Coef. (95% CI)	*p*
Graduate students	-0.05 (-0.10,0.00)	0.071	-0.03 (-0.09,0.04)	0.445	-0.11 (-0.18,-0.03)	0.004	-0.08 (-0.17,0.00)	0.062
International students	0.05 (-0.08,0.17)	0.461	0.01 (-0.11,0.13)	0.835	0.08 (-0.08,0.25)	0.308	0.10 (-0.06,0.27)	0.222
Male	0.00 (-0.05,0.05)	0.909	-0.01 (-0.06,0.05)	0.838	-0.01 (-0.08,0.06)	0.732	-0.03 (-0.09,0.04)	0.455
Smokes	-0.15 (-0.30,0.00)	0.049	-0.17 (-0.34,0.01)	0.062	-0.11 (-0.36,0.13)	0.364	0.05 (-0.22,0.32)	0.741
Asthma	-0.03 (-0.12,0.05)	0.459	-0.03 (-0.12,0.06)	0.507	0.05 (-0.05,0.15)	0.304	0.11 (0.00,0.21)	0.050
Age	0.00 (-0.01,0.00)	0.346	0.00 (0.00,0.01)	0.374	-0.01 (-0.01,0.00)	0.077	0.00 (-0.01,0.01)	0.811
Race/ethnicity		<0.001		<0.001		<0.001		<0.001
White/ Caucasian	0.00 referent	-	0.00 referent	-	0.00 referent	-	0.00 referent	-
Asian	0.13 (0.08,0.19)	<0.001	0.13 (0.07,0.19)	<0.001	0.19 (0.11,0.26)	<0.001	0.18 (0.10,0.25)	<0.001
African-American/ Black	0.04 (-0.15,0.22)	0.687	0.03 (-0.19,0.24)	0.807	-0.05 (-0.22,0.12)	0.582	-0.05 (-0.24,0.13)	0.571
Latino	0.15 (0.04,0.25)	0.005	0.13 (0.03,0.24)	0.014	0.08 (-0.05,0.22)	0.233	0.07 (-0.06,0.21)	0.290
Multiracial	0.09 (0.00,0.19)	0.046	0.09 (-0.01,0.19)	0.063	0.02 (-0.17,0.22)	0.811	0.02 (-0.18,0.22)	0.853
Other*	0.09 (-0.04,0.21)	0.161	0.08 (-0.05,0.21)	0.224	0.06 (-0.11,0.22)	0.504	0.06 (-0.11,0.23)	0.503
General health status		0.042		0.995		0.538		0.606
Excellent	0.00 referent	-	0.00 referent	-	0.00 referent	-	0.00 referent	-
Very good	0.03 (-0.04,0.09)	0.382	0.01 (-0.08,0.09)	0.898	0.03 (-0.06,0.13)	0.501	-0.03 (-0.14,0.08)	0.596
Good	0.10 (0.03,0.17)	0.008	0.01 (-0.08,0.10)	0.826	0.07 (-0.03,0.18)	0.174	0.02 (-0.09,0.14)	0.692
Poor or fair	0.06 (-0.05,0.18)	0.269	0.02 (-0.13,0.16)	0.829	0.07 (-0.10,0.24)	0.400	-0.07 (-0.31,0.16)	0.547

Table 7 (cont). Linear regression of change in adherence to behaviors based on participant characteristics.

	Group 1 (n=965)				Group 2 (n=498)			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
Characteristic	Coef. (95% CI)	*p*	Coef. (95% CI)	*p*	Coef. (95% CI)	*p*	Coef. (95% CI)	*p*
Concern about getting sick with a respiratory illness during academic year		<0.001		0.002		<0.001		0.018
Not at all	0.00 referent	-	0.00 referent	-	0.00 referent	-	0.00 referent	-
Minimally	0.06 (-0.03,0.15)	0.192	0.10 (-0.01,0.22)	0.070	0.01 (-0.12,0.14)	0.888	0.02 (-0.12,0.17)	0.758
Somewhat	0.15 (0.06,0.23)	0.002	0.17 (0.06,0.29)	0.002	0.15 (0.03,0.28)	0.019	0.14 (-0.01,0.30)	0.070
Extremely	0.27 (0.14,0.40)	<0.001	0.26 (0.10,0.42)	0.001	0.29 (0.11,0.47)	0.001	0.19 (-0.01,0.39)	0.068
Believe hand washing useful	0.12 (0.02,0.22)	0.016	0.07 (-0.06,0.20)	0.281	-0.10 (-0.21,0.01)	0.076	-0.06 (-0.20,0.09)	0.450
Friends expect to cover cough or sneeze	0.11 (0.01,0.22)	0.035	0.08 (-0.03,0.18)	0.155	0.08 (-0.06,0.22)	0.246	0.04 (-0.10,0.19)	0.549
Friends expect to wash hands after coughing or sneezing	0.11 (0.05,0.16)	<0.001	0.07 (0.01,0.13)	0.025	0.14 (0.07,0.22)	<0.001	0.13 (0.05,0.21)	0.001

Abbreviations: Coef, linear regression coefficient; CI, confidence interval.

* Includes American Indian/Alaskan Native; Native Hawaiian or other Pacific Islander; and participant-identified "Other" category.

CHAPTER III: COST-EFFECTIVENESS OF A HAND AND RESPIRATORY HYGIENE INTERVENTION IN REDUCING INFLUENZA-LIKE ILLNESS AMONG UNIVERSITY STUDENTS

Introduction

Influenza-like illness (ILI) has a high public health impact, accounting for 2% of outpatient visits in the United States each year (1). Incidence is fairly consistent across years, with the lowest rates in August and September and generally increasing from October to February (2). ILI incidence among adults aged 15–44 years is approximately 50 per 100,000 people per week (2, 3), with 36% of college students or more experiencing at least one episode of ILI in a given influenza season (4). Significant impacts of ILI illness have been reported among other age groups, including healthy working adults aged 50-64 (5) and households with school-aged children (6). Costs associated with illness include the direct costs of healthcare and productivity losses due to absenteeism (decreased productivity due to time lost from work) and presenteeism (decreased productivity while ill at work) (4, 7, 8). In the 2009 H1N1 influenza pandemic, levels of ILI were higher than normal for the summer and fall months (1), especially on college campuses, resulting in concerns about high healthcare utilization rates and surge capacity of the healthcare system.

ILI is a respiratory illness defined by a constellation of symptoms, most often including fever and cough or sore throat, although multiple definitions exist (7, 9-11). ILI is caused by a wide range of pathogens (12, 13). Of these, influenza viruses cause approximately 30-40% of ILI episodes (3, 13) and respiratory syncytial virus causes approximately 20% (3).

Non-pharmaceutical interventions (NPIs) serve as one of the primary defenses against the spread of respiratory illness in healthy adults and as such have the potential to limit the spread of influenza and other pathogens that cause ILI (14, 15). NPIs include hand hygiene, which consists of hand washing and/or hand antisepsis (16); respiratory hygiene, which includes cough etiquette and consists of measures to contain respiratory secretions such as covering coughs and sneezes (17); and facemask use.

However, the research base related to the effectiveness of NPIs against ILI is limited. Prior research has included retrospective analyses of NPIs in the context of specific disease outbreaks, such as SARS[*] and the 1918 influenza pandemic.[†] Prospective studies of the effectiveness of NPIs are scarce. Of the prospective studies that have been done related to hand hygiene, some studies have reported minimal or null results concerning the effectiveness of hand

[*] For example, a case-control study in Hong Kong during the 2003 SARS outbreak found that disinfection, in concert with frequent hand washing and use of facemasks in public, was protective against acquisition of SARS (69).

[†] One retrospective analysis focused on 43 cities during the 1918-19 pandemic found that early use and extended duration of population-based NPI strategies such as school closures, cancellation of public gatherings, and isolation and quarantine was associated with reduced mortality (70).

hygiene in general (18-20), although hand sanitizer and soap and water have been found to be effective in reducing the presence of the influenza virus on hands (21, 22) and a meta-analysis of the literature related to hand hygiene interventions found an overall reduction in respiratory illness of 21% (23). Among college students in particular, White et al. report that hand hygiene education at the dormitory level, coupled with provision of hand sanitizer, resulted in increased knowledge about hand hygiene, improved hand hygiene (including both hand washing and hand sanitizer use), and a reduction in respiratory illness symptoms and absenteeism of 26% and 40%, respectively (24). Similarly, in an intervention among university students cluster-randomized at the dormitory level and focused on hand hygiene and facemask use, Aiello et al. reported 35% to 51% reductions in ILI (25).

Evidence related to respiratory hygiene interventions specifically, separate from hand hygiene, is very limited, with no well-designed studies on effectiveness of interventions related to these behaviors (14, 26). Similarly, evidence related to facemask use is scarce, with most studies showing either minimal or no effect (18, 21, 27, 28) although one recent study among university students showed an effect of facemask use and hand hygiene together (25).

In a period of limited resources for public health interventions, an important question is not only whether NPIs can be effective in reducing ILI during an interpandemic cold and influenza season, but also whether they can be cost-effective. While many cost-effectiveness analyses related to pharmaceutical interventions such as influenza vaccination (8, 29-34) and use of antiviral drugs (34-36) exist, cost-effectiveness analyses of NPIs in reducing rates of ILI in healthy adults are limited.

To address these gaps in the literature on the cost-effectiveness of NPIs for ILI among healthy young adults, we conducted a randomized controlled trial of a hand and respiratory hygiene intervention among university students. The REDI-US (REDucing Influenza-like illness among University Students) Study was conducted among students at the University of California, Berkeley (UC Berkeley) during the 2007-2008 cold and influenza season. This paper presents a cost-effectiveness analysis of select NPIs in reducing ILI and associated absenteeism and presenteeism at school, work, and volunteer activities among students attending a large, urban university during an interpandemic cold and influenza season. This analysis utilizes a societal perspective by considering the costs and benefits of the intervention program for all interested stakeholders, regardless of to whom they accrue.

Methods

Study design and population

The REDI-US Study was a randomized controlled trial of select NPIs among students attending UC Berkeley in Fall 2007. It followed a cohort of students prospectively from November 2007 to April 2008. The UC Berkeley Committee for the Protection of Human Subjects approved the study in August 2007.

Recruitment and enrollment

The target population for this study was the UC Berkeley student population. All graduate and undergraduate students enrolled at least half-time at UC Berkeley in Fall 2007 (n=34,953) were eligible to participate, with the exception of those under 17 years of age (n=15); those recruited to participate in other university studies (n=391); those who had participated

(n=880) or actively declined participation (n=18) in a REDI-US pilot study during Spring 2007; and those who had knowledge of the study design, for example through participation in discussions in classes with core REDI-US Study staff (n=305). The age eligibility criterion was set at 17 years and older because students younger than 17 years at the start of Fall semester represented a minimal subset of the cohort of interest.

Influenza vaccination status did not affect eligibility for enrollment in the study; however, this information was gathered for inclusion in analyses because vaccination lowers but does not eliminate risk of illness (32, 37-39). This proved to be particularly important because the influenza vaccine for the 2007-2008 influenza season was not a full match with the circulating strain (9).

The study utilized online surveys conducted in English to collect participant data. This was not expected to affect student participation because all students must demonstrate English proficiency for enrollment at UC Berkeley and all enrolled students have access to the Internet via computer laboratories.

Based on the eligibility criteria, the University Office of Student Research identified a representative random sample of UC Berkeley students for recruitment. Pilot data indicated lower enrollment rates among males, therefore males were over-sampled by a ratio of two to one in the random sample for recruitment. The study staff was blinded to the sample selection process.

Students were recruited for study participation via postal mail and email, using the mailing and email addresses students had on file with the university. One paper mailing and three emails were sent to each recruited student. Recruitment and enrollment for the study was conducted for three weeks from October 15, 2007 to November 6, 2007.

Informed consent was obtained prior to enrollment and randomization using a secure online survey software, Illume™ (Datstat, Seattle, Washington), which was also used to administer all study surveys. Upon consenting to participate, students were directed immediately to an online baseline survey. The final questions on the baseline survey related to participant contact information, which was necessary for all following surveys; therefore, completion of the baseline survey was required for full enrollment in the study.

Randomization

Random allocation of students to the intervention and control groups occurred after participant completion of the baseline survey, and was performed using a random number generator in R (R Foundation for Statistical Computing, Vienna, Austria), an open-source data management and statistical program. A stratified block randomization mechanism was used to randomly assign graduate, undergraduate, male, and female students equally to the intervention and control groups. The control group was divided in two to further assess any potential effect related to weekly survey questions on adherence to NPI behaviors. However, no survey intervention effect was observed in the data; the two control groups are therefore collapsed in this analysis, and referred to in total as the "control group."

Intervention

Participants randomly allocated to the intervention group were educated on recommended hand and respiratory hygiene behaviors, including use of facemasks when ill. The intervention reinforced these behaviors in two ways. First, participants in the intervention group were given access to a password-protected website, which provided education on recommended behaviors.

The basic educational messages included Wash ("wash your hands frequently"), Cover ("cover your coughs and sneezes with your sleeve"), and Wear ("wear a mask when you are ill and around others"). Information included the importance of and tips for adhering to these measures in protecting oneself and one's contacts from illness during cold and influenza season; the site also had links to additional resources for participants interested to learn more. Participants were encouraged to visit the site each week through email reminders and prompts in the weekly surveys.

Second, participants in the intervention group were sent a hygiene kit, which consisted of a pouch filled with supplies necessary for adherence to the recommended behaviors: three small containers (one 0.25 ounce container, and two 0.50 ounce containers) of alcohol-based hand sanitizer, two surgical facemasks, one pocket pack of facial tissues, one study information card with the key intervention messages and instructions on how to fill out the study surveys, and a thermometer for self-assessment of fever. The intervention allowed for the provision of one and only one of these kits to each participant in the intervention group. The thermometer had the REDI-US Study logo printed on it. The pouch and 0.25 ounce hand sanitizer had the REDI-US Study logo and intervention website URL printed on them as further reinforcement of the online education component of the intervention.

Participants randomly allocated to the control group were mailed a study information card with instructions on how to fill out the study surveys and a thermometer for self-assessment of fever. The control group pouch and the thermometer had just the REDI-US logo printed on them.

Intervention group kits and control group thermometers were mailed to the mailing address specified by participants on the baseline survey.

Blinding

Participants were blinded to the design of the study and to which group they had been randomly allocated. Recruitment materials indicated that participants *might* learn about strategies for reducing the risk of cold and influenza, but did not specifically refer to an intervention and control group. Study personnel were not blinded to participant group assignments.

Data collection

Two types of surveys were administered, a demographic survey and a symptoms and behavior survey. The demographic survey was administered upon enrollment (baseline survey) and at the completion of the data collection period (end-of-study survey). The purpose of this survey, which took approximately 15-20 minutes to complete, was to obtain demographic data and information on participants' living situation (e.g., housing type, number of household and close contacts), student status (graduate versus undergraduate), vaccination status, and hand and respiratory hygiene behaviors. In addition, this survey gathered information on student activities related to productivity, such as attending classes, working at a job for pay, and volunteering. All participants completed the baseline survey as part of enrollment, and all were asked to complete the end-of-study survey.

The second type of survey was the weekly symptoms and behavior survey, administered each week for the 23 weeks of the study; each took an average of three to five minutes to complete. This survey gathered information on respiratory symptoms and adherence to recommended NPI behaviors for each participant during the previous week. Follow-up questions were asked of participants who reported fever and cough or sore throat (symptoms consistent

with the Centers for Disease Control and Prevention (CDC) case definition of ILI) (1). Follow-up questions inquired about use of medications, visits to healthcare providers, and hospitalizations. Participants were also asked about participation in activities such as taking classes, working at a job for pay, and volunteering, including how many hours of these activities they missed in the previous week due to illness (indicating absenteeism) and how many hours of these activities they participated in while they were ill (indicating presenteeism).

A new weekly survey opened each Tuesday and closed the following Monday, with the exception of winter and spring break, when surveys were left open until the resumption of classes to accommodate student travel and potential changes in internet access. A reminder email for the weekly survey was sent to all participants on Tuesdays; a second reminder was sent on Fridays for those who had not yet taken that week's survey. Participants were not able to submit a survey after it had been closed.

If participants developed any respiratory symptoms between weekly surveys, they were encouraged to proactively fill out a Respiratory Illness Report Form (RIRF), on which they reported just their symptoms. This survey was open for the duration of the study and available on the general study website.

Retainment

Students received incentives for participation in the study. Participants received an incentive of a one dollar equivalent (one Napster music download or one dollar toward a Starbucks Card or an Amazon.com Gift Certificate) for each weekly survey completed, with an additional ten dollars in the chosen incentive provided at the end of the study for participants who completed all 23 weekly surveys. Additionally, a raffle drawing was held at the end of the study for all participants. Participant names were entered into their choice of raffle drawings for each survey they completed throughout the course of the study. The raffle drawings were for one $500 Visa Gift Card or one of ten $50 Visa Gift Cards. Finally, intervention group participants also had the opportunity to take a short weekly quiz with three questions based on the information included on the intervention website. Participants who took the quiz were entered into a weekly drawing for a $25 Visa Gift Card.

Cost-effectiveness approach

The cost-effectiveness analysis was based on a decision tree with two primary health states: (1) sick with ILI and (2) healthy (Figure 1). Participants who developed ILI returned to a healthy state at the end of the ILI episode. Individuals transitioned between health states based on actual participant reports of illness for each day of the trial; participants could experience multiple episodes of ILI during the course of the study. Individuals sick with ILI were further considered as being in one of two illness states: requiring healthcare (physician visit and/or hospitalization), or without need of healthcare. This analysis adhered to the recommendations of the Panel on Cost-Effectiveness in Health and Medicine (40-42).

Effectiveness analysis

Intention-to-treat and as-treated analyses were performed. This work was based on the hypothesis in the intention-to-treat analysis that participants randomly allocated to the intervention group would report a lower rate of ILI than those randomly allocated to the control group. The hypothesis in the as-treated analysis was that participants with greater uptake of the intervention would report a lower rate of ILI than those in the control group.

Two models were used to assess effectiveness for the intention-to-treat and as-treated analyses: (1) a negative binomial regression model was used to assess effectiveness based on count data for the number of ILI events per participant, and (2) a logistic regression model was used to assess effectiveness based on a binary indicator for any ILI events versus no ILI events per participant. Person-time was accounted for directly in the models using count data, and as a predictor variable in the models using binary outcomes. Results presented here are based on the count data assessed using the negative binomial regression; results of the analysis using the binary indicator were similar unless otherwise noted.

It was expected that randomization would result in even distribution of potential confounders between groups for the intention-to-treat analysis; this was assessed using chi-square and ANOVA tests for categorical and continuous variables, respectively. Initial intention-to-treat models included indicators for subgroups (male/female, graduate/undergraduate, and a male*graduate interaction term); the interaction term male*graduate was not significant in any of the models. This indicated that it was not necessary to perform subgroup-specific analyses. Therefore, the results presented here are based on full-group analyses only.

The as-treated analysis was performed including all potential confounders. This analysis utilized a nested model approach, in which potential confounders were added in groups to each subsequent model. Model 1, or the baseline analysis, used the intervention treatment categories as the only predictors; Model 2 added physical attributes (smoking, asthma, influenza vaccination, general health status); Model 3 added household attributes (one or more roommates, group living situation such as a dormitory or fraternity/sorority house, interaction with children one or more times per week); Model 4 added adherence attributes (concern about getting sick, baseline adherence behaviors), and Model 5 added demographic attributes (graduate versus undergraduate student status, gender, race/ethnicity).

In addition, the association of potential confounders with the exposure (as-treated groups) and the outcome was assessed using chi-square and ANOVA tests for categorical and continuous variables, respectively, and the as-treated analysis was also performed incorporating only those potential confounders showing an association ($p < 0.20$) with both. Results from the model incorporating all potential confounders are presented; results of the latter model were largely unchanged.

Cost-effectiveness analysis

Quality-adjusted life measures. Due to the acute nature of ILI, quality-adjusted life days (QALDs) were utilized, and converted to quality-adjusted life years (QALYs) to provide estimates comparable to those in the cost-effectiveness literature. QALDs and QALYs range from zero to one, with zero indicating death and one indicating perfect health. The reference case used an estimate of 0.61 QALD for the first seven days of ILI illness (initial illness phase) and 0.79 QALD for the duration of illness (days 8 to 15; recovery phase) (30).

The estimate of 0.61 QALDs during the first seven days of an ILI episode was obtained using the Quality of Well-Being scale for ILI, and is similar to the average results obtained using a visual analog scale assessment (35). The latter, a day-by-day assessment of quality of life during an ILI episode, had a range of QALDs from 0.40 to 0.79, with utilities increasing over time. A lower range estimate of 0.25 QALDs was used for the initial illness phase, based on an assessment using the Health Utilities Index (43). The highest utility from the visual analog scale assessment, 0.79, was used as the upper range value for sensitivity analyses, and as the reference case value for QALDs during the recovery phase (35). Finally, the reference case value of 0.61

QALDs during initial illness was used as the lower range value for QALDs during the recovery phase and QALDs of 1.00, indicating a return to perfect health, as the upper range for the recovery phase.

Discounting. An annual discounting rate of 3% was utilized, with a sensitivity analysis using a lower range rate of 0% (undiscounted) and an upper range rate of 5%, in keeping with the recommendations of the Panel on Cost-Effectiveness in Health and Medicine (41, 42). The discount rate was adjusted to the daily equivalent of the annual discount rate for both cost and benefit calculations.

Inclusion of absenteeism and presenteeism in the cost-effectiveness ratio. Whether quality of life measurements inherently account for productivity losses or whether the monetary costs of such losses should be explicitly added in cost-effectiveness models is a point of debate (44-50). Therefore, two cost-effectiveness ratios were calculated: one that assumed productivity losses to be implicit in the QALDs estimate, and one that explicitly added the monetary costs of absenteeism and presenteeism. Results reported here are based on the former definition, except where otherwise noted.

Reference case analysis. The reference case analysis took a societal perspective (40, 41). The total costs and QALDs per person, for both healthy and ill states, were summed across the duration of the study. This analysis included both direct and time costs of illness and of the intervention, regardless of the payer (51). The incremental cost-effectiveness ratio was calculated as the difference in costs divided by the difference in effectiveness between the intervention and control groups.

Sensitivity analysis. A level of uncertainty existed for each of the individual variables included in the analysis. This uncertainty was addressed using several sensitivity analyses. First, one-way sensitivity analyses for all variables were performed, including a detailed threshold sensitivity analysis of intervention effectiveness in which effectiveness was varied to determine the levels of illness prevention necessary to achieve different cost-effectiveness ratios (52). Second, two-way sensitivity analyses, which vary pairs of inputs together, were also performed to understand the joint impact of key variables on the cost-effectiveness ratio. Finally, scenario-based sensitivity analyses were performed in which multiple inputs were varied together to simulate mild, moderate, and severe cold and influenza seasons. The lower range, reference case, and upper range estimates were used based on whether variables were considered low, average, or high, respectively. In keeping with standard cost-effectiveness levels for interventions in the United States, $100,000 per QALY gained and $50,000 per QALY gained were considered important thresholds of interest for all sensitivity analyses (53, 54).

Data for cost-effectiveness analysis

Effectiveness data

Outcome measures. The primary outcome measure for this analysis was occurrence of ILI using self-reported symptom data, and associated healthcare utilization and lost productivity at school, work, and volunteer activities.

The ILI incidence rate was calculated using data for the entire study population. Case definitions of ILI vary widely; therefore three case definitions were used for a sensitivity analysis approach (7, 9-11, 55). The lower range definition, the most specific of the three ("high specificity"), was the CDC definition of ILI: fever (temperature ≥100°F (37.8°C)) and cough and/or sore throat in the absence of a known cause other than influenza (9). Despite provision of

thermometers to all participants, fewer than half (617/1,515 (41%)) of those reporting fever also reported their temperature. Therefore, the reference case analysis used a modified version of the CDC case definition that did not specify the fever temperature, and included feverishness as well ("reference case"): fever or feverishness (indicated by chills) and cough and/or sore throat in the absence of a known cause other than influenza. The upper range case definition, the most sensitive of the three ("high sensitivity"), used a definition from Monto et al.: fever or feverishness (indicated by chills) plus two or more of the symptoms headache, myalgia, cough, or sore throat (10). A unique episode of ILI for each case definition was defined as the above symptoms occurring within five days of each other and ending 15 days after onset of the first symptom.

Primary analyses presented here are based on the reference case definition. The sensitivity analysis utilized the high specificity and high sensitivity case definitions for the lower and upper ranges, respectively; differences in results are noted.

Exposure (predictor) measures. Intention-to-treat and as-treated effectiveness analyses were performed. The primary exposure variable for the intention-to-treat analysis was random allocation to the control or intervention group. The primary exposure variable for the as-treated analysis was level of participation in the intervention program. Participation was defined based on logins to the intervention website and confirmed receipt of the hygiene kit. In particular, two "treatment" groups were defined for the intervention group in the as-treated analysis: (1) High intervention participation: participants randomly allocated to the intervention group who logged in to the intervention website at least once during the course of the intervention *and* confirmed receipt of the hygiene kit[‡]; and (2) Moderate intervention participation: participants randomly allocated to the intervention group who either logged in to the intervention website *or* confirmed receipt of the hygiene kit. Those participants who did not confirm receipt of the hygiene kit and did not log into the website were not included in the as-treated analysis. Control group assignments remained the same as in the intention-to-treat, but for consistency with intervention group definitions only those control group participants who confirmed receipt of the thermometer were included in the analysis. A sensitivity analysis was performed using a second definition of as-treated categories that did not incorporate kit or thermometer receipt information and considered only website logins; the results using this definition were largely unchanged.

Potential confounders and effect modifiers. Potential confounders and effect modifiers included the following baseline characteristics: smoking; asthma; influenza illness in Fall 2008 prior to enrollment in the study or influenza vaccination during the 2007-2008 cold and influenza season (confirmed at baseline or end-of-study); general health status; having one or more roommates; group living arrangement (e.g., dormitory, fraternity/sorority house); interaction with children; concern about getting sick; baseline adherence to hand and respiratory hygiene behaviors; graduate versus undergraduate status; gender; and race/ethnicity. The block randomization scheme helped ensure balance between the intervention and control groups for the last two variables, allowing subgroup and full group analyses.

Scores were developed for five components of baseline adherence to hand and respiratory hygiene recommendations (Hand Hygiene – Situations; Hand Hygiene – Technique; Hand Awareness; Respiratory Hygiene – Cover Cough; and Respiratory Hygiene – Technique). Each component score ranged from zero to three, with three representing optimal behavior adherence.

[‡] Participants were asked whether they received their hygiene kit during the Week 12 survey (January 22, 2008) and in the end-of-study survey (April 15, 2008).

"Hand Hygiene – Situations" was defined as how often (always, sometimes, rarely, never) participants reported cleaning their hands in the following five situations: after handling raw meats, poultry, or fish; after riding public transportation; before eating; after using the bathroom; and after blowing or wiping their nose. "Hand Hygiene – Technique" was scored based on the average length of time (seconds) participants reported washing their hands with soap and water and/or the amount of hand sanitizer used when cleaning hands with sanitizer. "Hand Awareness" was based on how often (always, sometimes, rarely, never) participants reported avoiding touching their eyes, nose, and/or mouth when their hands were not clean. "Respiratory Hygiene – Cover Cough" was based on how often (always, sometimes, rarely, never) participants reported covering their mouth and nose when coughing or sneezing around other people. Finally, "Respiratory Hygiene – Technique" was scored based on what participants reported using to cover their cough or sneeze when around other people. Options included hands, tissue or handkerchief, and elbow. The "hands" component was based on a follow-up question related to how often (always, sometimes, rarely, never) participants reported cleaning their hands after coughing or sneezing into them, believed to be an important aspect of effective respiratory hygiene (17). Each component score was constructed to be an average of participant responses for only those situations that applied to each participant.

Utilization and cost data

Where possible, reference case estimates and ranges were based on REDI-US Study data. All other estimates were based on data from the published literature.

Utilization data. The incidence rate of ILI was based on the data for the entire study population. According to the reference case definition, 1,361 participants reported symptoms consistent with ILI over 44,502 weeks of person-time, yielding a reference case rate of 0.031 ILI episodes per person-week. In contrast, 248 unique episodes ILI consistent with the high specificity case definition were identified, for a lower range rate of 0.005 episodes per person-week (82% fewer than those identified using the reference case definition). Finally, 1,497 ILI episodes consistent with the high sensitivity case definition were identified, yielding an upper range rate of 0.034 episodes per person-week (10% more than those identified using the reference case definition). These estimates were in keeping with ILI rates among healthy working adults reported in other studies (31, 32, 56).

Using the reference case ILI definition (fever or feverishness and cough and/or sore throat in the absence of a known cause other than influenza) among the 2,230 participants who completed one or more weekly surveys, 1,282 (58%) experienced no episodes of ILI, 654 (28%) experienced one episode of ILI, and 294 (13%) experienced two or more episodes of ILI.

The reference case value for each utilization probability was based on the current study. The lower ranges for the probability of antibiotic use, antiviral use, and physician visits used data from the current study; the upper ranges for each used data from the published literature. The range for the probability of hospitalization used data from the published literature.

The reference case and lower range estimates of the number of students enrolled were based on the number of participants actually enrolled in the REDI-US Study (n=1,150); the upper range was based on the total number of students enrolled at UC Berkeley in Fall 2007 (n=34,953), which would represent an implementation of the intervention for the entire student body.

Cost Data. The analysis included the costs necessary for future implementations of this intervention; it did not include charges related to study-specific activities, such as weekly survey

data collection. All costs were adjusted to 2008 U.S. dollars using a gross domestic product deflator (57).

Direct costs of illness included the costs of physician visits and hospitalizations, as well as medications, including antibiotics, antiviral drugs, and over-the-counter medications. Time costs of illness included the time required for physician visits and hospitalizations, and absenteeism and presenteeism. Direct costs of the intervention included the costs of the hygiene kit per person and costs of program implementation (costs of setting up and hosting the intervention website, program recruitment costs, staff support costs, and general administration costs). Participants' time costs for the intervention included time spent on the intervention website each week.

Direct costs of illness were based on data reported in the literature. Costs of a physician visit for ILI used the results of several published studies (32, 58-60). The reference case costs of over-the-counter medications per episode of ILI used data from the current study, in which participants reported taking an average of two over-the-counter medications during the first week of each ILI episode. This was multiplied by an estimated five dollars per medication for an overall average cost of ten dollars for over-the-counter medications per ILI episode. This assumed medications would last for multiple weeks, and therefore did not add costs for use of medications reported during the second and third weeks of illness. This estimate was consistent with those in the literature, which were used for the upper and lower range values (32, 58). The costs for antiviral drugs (34, 43), antibiotics (43, 58), and hospitalizations (32, 61) used values reported in the literature. The average direct cost per case of ILI was calculated from the component direct costs of illness (physician visits; antibiotic, antiviral, and over-the-counter medications; and hospitalizations), multiplied by the probability of each event per episode of ILI. Using this calculation, the total average direct cost per case of ILI was $49.

Study data were used for the reference case estimates for time costs except productive time lost for hospitalizations. Time for hospitalizations was based on average length of stay reported in the literature (61-63), with the assumption that one day of hospitalization represented eight hours of productive time lost. Ranges were based on estimates in the literature, with the exception of time for the intervention. For this measure, intervention group participants were asked how long they spent on the website during the given week in Week 2 (survey opened November 13, 2007), Week 6 (survey opened December 11, 2007), and Week 15 (survey opened February 12, 2008). In addition, intervention group participants were asked on the end-of-study survey (opened April 15, 2008) how frequently they visited the website during the course of the study. The reference case value for time spent on the intervention each week was calculated as the mean amount of time among all intervention group participants who reported spending between one and sixty minutes on the site during Weeks 2, 6, and 15, accounting for frequency of visits. For example, for those participants who reported at the end of the study that they had visited the website every two to three weeks, the number of minutes reported for each week was divided by 2.5.

The lower range of time spent on the intervention website was calculated as the mean amount of time among all participants who reported spending between zero and sixty minutes on the site for the weeks in question, and accounted for frequency of visits to the site as described above. The upper range was calculated as the mean amount of time among all participants who reported spending between one and sixty minutes on the site during the selected weeks and did not account for frequency of visits to the website, resulting in higher time estimates.

The number of weeks for the intervention reference case and upper range values was based on the program design of 23 weeks; the lower range value was based on the fewest number of weeks of widespread influenza activity during the 2005-2006, 2006-2007, and 2007-2008 influenza seasons (1).

The value of student time was calculated from participant responses related to their hourly wage among those who worked at jobs for pay. For those reporting weekly wages, the hourly wage was calculated by dividing the total weekly wage by the number of hours worked per week. The lower range was based on participant reports and the upper range was based on average hourly wages for all civilian workers during the study period (64).

Costs for the hygiene kit were considered variable costs of the intervention program (per person) because the cost depends on the number of participants. The reference case cost of $10.13 for hygiene kits was based on actual REDI-US Study costs, which included $1.24 for the pouch, $4.11 for the thermometer, $1.82 for the 0.25-ounce custom-logo hand sanitizer; $0.29 for the facial tissues; $0.93 for the study information card with the Wash, Cover, Wear instructional messages; and $0.30 for the facemasks.[§] Purell® (Johnson and Johnson Consumer Companies, New Brunswick, New Jersey) donated the two 0.50-ounce hand sanitizers for each kit; their cost was estimated at $1.43 for two based on the retail price in local drugstores near the UC Berkeley campus. In anticipation of an enrollment of 1,500 intervention group participants, 1,500 units of each item were purchased. Therefore, the price per kit reflects volume discount pricing.

Participants indicated in the end-of-study survey which kit items they used and if they had purchased additional quantities of any of the supplies. In particular, 756/842 (90%) participants who responded to this question indicated they did not use the facemasks. 613/848 (72%) of participants who responded to this question reported using none or less than half of the hand sanitizer provided in the kit. Therefore, the lower range value for the kits excluded the costs of the facemasks and the two 0.50-ounce hand sanitizers.

In contrast, 126/923 (14%) participants who responded to this question indicated they bought additional hand sanitizer in varying sizes and three participants bought additional facemasks. Therefore, the upper range value for the kits included the reference case, plus the cost of these additional supplies averaged across all participants. The costs for these items were based on the retail price of the items in local drugstores near the campus.

Fixed costs of the intervention program were those that did not vary based on the number of participants. These were incurred before (setting up the intervention website and participant recruitment) and during (staff support and general administration) the implementation of the intervention program. Costs for setting up the intervention website and for participant recruitment were based on REDI-US Study data. The website used Plone, an open-source content management system. The reference case for the intervention website included $682 for the domain name and hosting for seven months[**]; $2,681 for one-time consultant fees to set up the basic site[††]; $63 for fees for site images; and $653 for 23 Visa Gift Cards ($25 each, plus shipping and handling) to raffle among participants who took the online quiz related to site content each week. The lower range value excluded the costs of the consultant, the fees for site

[§] Numbers may not sum to the total kit cost due to rounding.

[**] In the reference case intervention duration of 23 weeks, this allowed one month for site setup and six months of hosting during the intervention period.

[††] Based on non-profit consulting rate of $75 per hour.

images, and the Visa Gift Card incentives for taking the online quiz. The upper range value included the costs in the reference case, plus an additional $1,379 in consultant fees for developing a computer code to track participant logins to the site.

Costs of recruitment were included in the analysis, based on the assumption that similar interventions would also require recruitment to engage students. The reference case recruitment costs were based on a fixed cost of $511 for data service fees to obtain a random sample of students and their contact information from the university and a variable cost of $0.28 per person for paper recruitment materials (printing costs, envelopes, and postage) for the 1,150 intervention group participants who enrolled in the study. The lower range estimate excluded paper recruitment, based on the alternative to recruit students electronically only; the upper range estimate included the data service fees in the reference case, plus paper recruitment costs for all 14,992 potential participants recruited for the study.

Staff support and general administration costs were based on actual REDI-US Study costs. The reference case estimate for staff support included 1.0 full-time equivalent (FTE; includes salary and fringe benefits) resource for one year to initiate, implement, and provide support to the program. The lower range estimate for staff time included limited staffing of 0.5 FTEs; the upper range estimate for staff time included expanded staffing of 1.5 FTEs.

The reference case for general administration costs included $455 for office supplies, such as paper, staff business cards, and a staff telephone line/voicemail; $1,002 per FTE per month for rent; and $1,753 for a staff computer and external harddrive. The lower range estimate was based on a situation in which a staff computer and harddrive were already available for use and did not need to be purchased. The upper range estimate was based on a situation in which only minimal infrastructure existed, and included an additional $780 for an office desk and lamp.

Due to students' unique range of productive activities, estimates of absenteeism and presenteeism due to ILI included time lost from school, work, and volunteering. Absenteeism and presenteeism measures were not combined because they reflect different levels of loss of productivity. The reference case values for number of hours of absenteeism and presenteeism caused by illness were based on participant reports of the average number of hours or days of productivity missed or attended while ill, respectively.

Absenteeism from work was assessed through the question "Did you miss any hours of work at a *paid* job on the referenced days?" with the following answer choices: "Yes, I missed __ hours of paid work"; "No, I was not scheduled to work on these days"; "No, I did not miss any hours of paid work on these days"; "No, I do not work at a paid job"; or "Decline to answer." Parallel questions were used to assess absenteeism from school and volunteer activities, and presenteeism for school, work, and volunteer activities. The lower ranges for absenteeism and presenteeism hours were calculated from participant data by assigning a value of zero hours missed for any people who did not explicitly report any hours of missed activities or activities attended while ill. The number of hours of absenteeism due to ILI among healthy working adults reported in the literature had a higher range than that observed in the REDI-US Study, so the upper range used these published estimates (4, 32). The reference case for the presenteeism estimate was also used as the upper range value. The percent productivity reduction due to presenteeism used estimates presented in the literature (65).

R was used for data cleaning and preparation. Stata SE 10.1 was used for statistical analyses (Stata Corporation, College Station, Texas). Microsoft Excel 2004 (Microsoft Corporation, Redmond, Washington) was used for development of the decision tree, cost-

effectiveness analysis, and sensitivity analysis. All analyses utilized a significance level of 0.05 except the assessment of association of potential confounders with the exposure and outcome variables, which utilized a significance level of 0.20.

Results

Study participants

The flow of participants through the study is depicted in Figure 2. 34,953 students were enrolled at UC Berkeley in Fall 2007; of these, 33,334 were eligible to participate. A random sample of 15,000 students was taken from those eligible to participate, of whom 14,992 had sufficient contact information for recruitment. 2,300 students enrolled in the study, of whom 1,150 were randomly allocated to the intervention group, and 1,150 were randomly allocated to the control group. 2,300/2,300 (100%) participants completed the baseline survey, as this was required for enrollment in the study. 819/1,150 (71%) intervention group participants and 907/1,150 (79%) control group participants completed 20 or more weekly surveys. 922/1,150 (80%) intervention group participants and 989/1,150 (86%) control group participants completed the end-of-study survey.

Of those randomly allocated to the intervention group, 619/1,150 (54%) met the criteria for the "high intervention participation" group (accessed the intervention website one or more times during the course of the study *and* confirmed receipt of their hygiene kit) and 381/1,150 (33%) met the criteria for the "moderate intervention participation" group (accessed the intervention website one or more times during the course of the study *or* confirmed receipt of their hygiene kit). 996/1,150 (87%) control group participants confirmed receipt of the thermometer.

Baseline characteristics of study participants

Table 1 shows the baseline characteristics of the participants using the intention-to-treat and as-treated assignments, including potential confounders. All potential confounders were equally distributed between the intention-to-treat intervention and control groups. In contrast, several potential confounders were unevenly distributed among the as-treated groups (high intervention participation, moderate intervention participation, and control). In particular, males were more likely to be in the moderate intervention participation group (229/379 (60%)) than the high intervention participation group (304/616 (51%)) or the control group (552/992 (56%)) (p=0.009). The percent of participants vaccinated in the high intervention participation group (125/584 (21%)) was higher than that in the moderate intervention participation (48/314 (15%)) and the control (153/944 (16%)) groups (p=0.017). Race/ethnicity was evenly distributed between groups, with the exception of the multiracial category; 47/619 (8%) of the high intervention participation group, 15/381 (4%) of moderate intervention participation group, and 49/996 (5%) control group participants selected more than one race/ethnicity category (p=0.023).

Effectiveness

The intention-to-treat analysis using count data for the reference case definition did not show an effect of the intervention (incidence rate ratio (IRR), 0.99; 95% confidence interval (CI), 0.88, 1.11; p=0.871). The number of surveys submitted was directly correlated with the risk

of ILI in the logistic regression models using binary outcome data (OR, 1.05; 95% CI, 1.04, 1.07; $p<0.001$). The same pattern held for the high sensitivity case definition.

The results of the as-treated analysis, using count data based on the reference case definition, are shown in Table 2. This analysis did not show an intervention effect among the high intervention participation group compared to the control group in any of the nested models (Model 5: IRR, 1.07; 95% CI, 0.93, 1.24; $p=0.346$). In contrast, a protective effect against ILI was observed in the moderate intervention participation group, which was significant in Models 2 and 3 and approaching significance in Models 4 and 5 (Model 5: IRR, 0.84; 95% CI, 0.69, 1.01; $p=0.069$). Neither moderate intervention participation nor high intervention participation was significantly associated with ILI using count data with the high specificity or high sensitivity case definitions. In the models using a binary indicator for any ILI, neither high intervention participation nor moderate intervention participation was a significant predictor of ILI for any of the three case definitions. Similar to the intention-to-treat analysis, however, the number of surveys submitted in these models was a highly significant predictor of ILI across all models for all three case definitions, with those submitting more surveys more likely to report symptoms consistent with ILI.

Cost-effectiveness

Reference case analysis

The primary analysis compared the cost-effectiveness of intervention to no intervention. Because the intervention in question did not demonstrate effectiveness, the reference case instead utilized effectiveness estimates from the literature. The reference case values, their ranges, and the data sources for each input are shown in Table 3. In particular, this analysis utilized a reference case value of a 21% reduction in illness based on a meta-analysis of hand hygiene interventions (23); this was a more conservative estimate of effectiveness than the results for two studies similar to this one, which found reductions in illness ranging from 26% to 51% among college students (24, 25). A lower range value of 1% and an upper range value of 55% was used for sensitivity analyses, based on a systematic literature review related to physical interventions against respiratory viruses (27).

Compared with no intervention, this analysis estimated that a hand and respiratory hygiene intervention that prevented 21% of illness would result in 0.6 additional QALDs and cost approximately $93 per person to implement, including $7 in savings for direct costs of ILI; $69 in direct costs of the intervention program; $1 in savings for the time costs of ILI; and $31 in time costs of the intervention program. This results in a total cost of $160 per QALD gained or $58,310 per QALY gained, which is within the cost-effectiveness range typically utilized in the United States (Table 4). Figure 3 presents the incremental costs and QALYs per person for the reference case analysis ("intervention group") graphically.

Sensitivity analysis

Threshold analysis. Because the intervention was not shown to be consistently effective in this population in the various intention-to-treat and as-treated analyses using different case definitions and count versus binary ILI outcomes, a threshold analysis examining intervention effectiveness was utilized to assess the level of effectiveness that would have to be achieved for the intervention to be considered cost-effective.

Two cost-effectiveness threshold values of $100,000 and $50,000 per QALY gained were used, in keeping with standard cost-effectiveness levels in the United States. The sensitivity analysis of intervention effectiveness showed this intervention would achieve the $100,000 cost-effectiveness threshold if it prevented 13% of ILI episodes or more, and the $50,000 threshold if it prevented 24% of ILI episodes or more assuming that productivity losses are implicit in QALDs estimates. Figure 4 shows the cost-effectiveness of this intervention across a range of potential effectiveness values for these two threshold levels.

The model that explicitly included the costs of absenteeism and presenteeism showed that the intervention would need to prevent 12% or more of ILI episodes to reach the cost-effectiveness threshold of $100,000 per QALY gained and 22% or more of ILI episodes to reach the threshold of $50,000 per QALY gained.

One-way sensitivity analysis. The reference case intervention effectiveness value of 21% was used for sensitivity analyses. The results of the one-way sensitivity analyses for all input variables are shown in Table 5 and represented visually in Figure 5 for those variables that caused the cost-effectiveness ratio to vary 10% or more. One-way sensitivity analyses found the cost-effectiveness ratio was most sensitive to the rate of ILI, value of QALDs assigned to illness (initial illness phase and recovery phase), number of students enrolled in the program, participant time required for the intervention (minutes on the intervention website per week), costs for program staff support, length of absenteeism (hours), value of student time, and length of the intervention (number of weeks).

Two-way sensitivity analysis. Two-way sensitivity analyses examined three pairs of inputs together to understand their joint effect on the cost-effectiveness ratio. In particular, these examined the joint effect of (1) the rate of ILI and intervention effectiveness; (2) the rate of ILI and the value of QALDs assigned to illness; and (3) intervention length (number of weeks) and self-reported participant time required for the intervention (minutes per week). The results of these analyses are reflected in Figure 6.

When examining the joint effect of the ILI rate and intervention effectiveness (Figure 6a), the intervention did not cross the $50,000 or $100,000 cost-effectiveness thresholds at any rates of illness for 5% intervention effectiveness. The intervention effectiveness levels of 21% and 55% met the thresholds at varying ILI rates, with cost-effectiveness ratios lower at higher rates of ILI. In particular, an intervention that prevented 21% of ILI episodes cost $100,000 per QALY gained when ILI rates were 0.018 episodes per person-week; it would not achieve the $50,000 threshold within the range of ILI rates considered. An intervention that prevented 55% of ILI episodes cost $100,000 and $50,000 per QALY gained when ILI rates were 0.006 and 0.013 episodes per person-week, respectively.

A similar result was observed related to the joint effect of the ILI rate and the QALDs assigned to ILI illness (Figure 6b). The intervention did not reach the $100,000 cost-effectiveness threshold at any rates of illness when QALDs were high, suggesting the intervention would not be cost-effective for less severe illness. For moderate and more severe illness, the intervention reached and exceeded the threshold values as rates of ILI increased. In particular, moderate illness (0.61 QALDs during initial illness and 0.79 QALDs during recovery) resulted in a cost of $100,000 per QALY gained when ILI rates were 0.018 episodes per person-week; the $50,000 threshold was not achieved within the range of ILI rates considered. Severe illness (0.25 QALDs during initial illness and 0.61 QALDs during recovery) resulted in a cost of $100,000 and $50,000 per QALY gained when ILI rates were 0.009 and 0.019 episodes per person-week, respectively.

Finally, Figure 6c shows the intervention was cost-effective at the $100,000 per QALY gained threshold for all ranges of weeks and weekly amount of participant time spent on the intervention website. However, the intervention did not reach the $50,000 cost-effective threshold at any point if participants spent 5.2 minutes or more on the intervention website each week. In contrast, the intervention was cost-effective at the $50,000 threshold for any intervention length if participants spent an average of only 1.6 minutes per week on the intervention website.

Scenario-based sensitivity analysis. Finally, three scenarios representing mild, moderate, and severe cold and influenza seasons varied multiple inputs together and showed a wide range of cost-effectiveness ratios (Table 6). In the mild scenario, the cost-effectiveness ratio was much higher than the threshold values of $50,000 and $100,000 per QALY gained. However, the cost-effectiveness ratios for the moderate and severe scenarios were well below the thresholds. In particular, the cost-effectiveness ratio that explicitly incorporated absenteeism and presenteeism was cost-saving in the severe scenario with a net savings of $8,825 per QALY gained. Figure 3 presents the incremental costs and QALYs per person for each of these scenarios graphically, compared to the control group in each situation.

Discussion

The results of the effectiveness analysis do not indicate a consistent intervention effect, using either intention-to-treat or as-treated analyses. Using an as-treated approach, a protective effective was observed in the moderate intervention participation group. There are several possible explanations for this effect. It may indicate an intervention effect; however, it may also indicate that individuals with only moderate participation levels were less likely to report symptoms. In particular, the higher incidence rate in the high participation group may indicate that those individuals who are interested in learning about prevention strategies tend to be more aware of illness, and therefore more likely to report symptoms.

Utilizing effectiveness estimates in the literature for other hand hygiene and facemask interventions, this analysis evaluated the costs, benefits, and cost-effectiveness of an NPI program for preventing ILI among university students. The results show that an intervention that prevents 21% of ILI events is cost-effective with an incremental cost per QALY of $58,310, which is in line with the standard thresholds used for cost-effectiveness in the United States. A similar intervention would cost $100,000 per QALY if it prevented 13% of ILI episodes among university students, and $50,000 per QALY if it prevented 24% of ILI episodes. When considering the costs of absenteeism and presenteeism separately from QALYs, a similar intervention would cost $100,000 per QALY if it prevented 12% or more of ILI episodes among university students, and $50,000 per QALY if it prevented 22% or more of ILI episodes. These effectiveness values are within the range observed for NPIs to prevent respiratory illness.

Several sensitivity analyses were performed to further understand the impact of variables on the cost-effectiveness ratio individually and together. In a simulation of a cost-benefit analysis for an influenza vaccination program among healthy working adults, Nichol found the analysis to be most sensitive to influenza illness rate, hourly wages, and work absenteeism due to influenza, while the analysis was least sensitive to healthcare costs and utilization (8). Similarly, this analysis was most sensitive to the rate of ILI (illness rate), value of participant time (hourly wages), and absenteeism (work absenteeism due to influenza), and least sensitive to healthcare costs and utilization. With regards to absenteeism, Nichol examined illness from influenza rather

than ILI and utilized much higher estimates of absenteeism due to illness (2 days; range: 0.75-4 days). When the reference case value (2 days, or 16 hours) used by Nichol was incorporated into this analysis, the intervention cost-effectiveness ratio was $34,080 per QALY gained in the model that explicitly added costs of absenteeism and presenteeism. Using Nichol's range for absenteeism, the cost-effectiveness ratio in this analysis was even more sensitive to this measure. In fact, the cost-effectiveness ratio varied more than 50% from that reference case in a one-way sensitivity analysis (lower range of 0.75 days, or 6 hours: cost-effectiveness ratio (CER), $47,641 per QALY gained, 40% increase from baseline value; upper range of 4 days, or 32 hours: CER, $12,382 per QALY gained, 64% decrease from baseline value).

These results also indicate that interventions that avert a minimal percent of ILI events are likely to be cost-ineffective. However, the two-way sensitivity analyses find that at the upper range of ILI incidence rates, the intervention becomes cost-effective when reducing ILI events by 12% or more. Additionally, high severity of illness (reflected in a large decrement in QALDs while ill) is likely to result in an intervention that is cost-effective when 7% or more of ILI events are averted.

The two-way sensitivity analyses also suggest the design of the intervention program itself could have implications for cost-effectiveness. First, participant time spent on the intervention website impacted the cost-effectiveness ratio due to the value of this time for other activities such as school, work, or volunteering activities. An intervention that requires only 1.6 minutes of participant time on the intervention website per week allows participants to spend more time on other productive activities, resulting in a cost-effectiveness ratio of $44,648 per QALY gained for a 23-week intervention. Similarly, the length of the intervention impacted the outcome in terms of how many episodes of ILI can be prevented for the same direct costs. That is, if the direct costs of the intervention are fixed, then a shorter intervention timeframe would require the program to prevent more episodes of ILI per unit time to achieve the cost-effectiveness threshold. Therefore, decreasing the intervention timeframe from the reference case of 23 weeks to 16 weeks resulted in a decrease from the reference case cost-effectiveness ratio to $52,211 per QALY gained. Finally, increasing the number of participants is important due to program fixed costs. The reference case fixed costs of this intervention were $68,437 and number of participants was 1,150. This represents a fixed cost per participant of $60; increasing the number of participants to the upper range of 34,953 results in a fixed cost per participant of $2 and lowers the cost-effectiveness ratio to $22,493 per QALY gained.

The scenario sensitivity analysis further underscored these findings by looking at the same factors, while simultaneously incorporating other variables. The results indicate that this intervention was more likely to be cost-effective in moderate and severe influenza season scenarios, and much less likely in a mild season scenario. Three of the distinguishing factors were the rate of ILI, severity of ILI, and level of public interest or concern, in terms of the number of people interested in enrolling in the intervention and the amount of time individuals spend on the intervention website. In particular, the severe scenario resulted in net savings in the model that explicitly incorporated productivity losses, saving $8,825 per QALY gained.

These results together indicate that future implementation of such an intervention may be best utilized as a "just-in-time" program that can be deployed when a given influenza season or event is underway and key information can be reasonably determined or estimated. For example, this program might be best deployed when the ILI rate is expected to be moderate or high (e.g., 0.031 or more episodes per person-week), disease severity among those ill is expected to cause moderate or severe illness (e.g., QALDs of 0.61 or lower in the initial illness phase and 0.79 or

lower in the recovery phase), and public interest results in a large number of individuals (e.g., 14,000 or more) enrolling in such a program. In these situations, the scenario analysis suggests the intervention could be highly cost-effective. Public health authorities sometimes have the opportunity to anticipate such factors early in the season, especially related to level of public interest and concern, such as in anticipation of the resurgence of the novel 2009 H1N1 pandemic influenza virus during the 2009-2010 cold and influenza season (66). In these cases, interventions can be tailored for optimal use of limited public health resources.

This study had several strengths. The study and intervention design made participation simple, especially for a population of university students. The online intervention delivery mechanism, in addition to being a convenient and familiar interface for students, also scales easily to large and small groups alike, making it an attractive option for interventions for which the budget is restricted or fixed and/or enrollment interest cannot be estimated in advance. In addition, the cost of the hygiene kits is appropriate for interventions of a similar scale, and targeting larger numbers of individuals would likely incur a lower cost per participant as economies of scale increase. These aspects of the intervention were of particular interest in the analysis of whether such an intervention could be cost-effective.

This intervention also had several potential additional benefits not included in the economic analysis, which could further improve the cost-effectiveness ratio. First, the intervention may result in decreased risk of illness not only in participants but also in the surrounding community. In particular, while the major benefit of this program was avoided ILI among intervention participants, other individuals who may have been at risk of illness transmission from students enrolled in this program (such as other students, faculty, and staff) also had the benefit of decreased risk of illness. Additionally, if any students not participating in the study changed their behaviors to mimic intervention participants, they also may have experienced decreased risk of illness. Neither of these potential benefits was addressed in the current analysis because data for avoided community illness were not available. Second, this analysis assumed the intervention prevented illness during the current year only and did not affect illness avoidance in future years. However, it is possible that participant behavior change would continue in subsequent years, in the absence of any additional costs. Third, this intervention could potentially have an impact on other illnesses against which hand and respiratory hygiene are protective. This appears to be particularly likely for gastrointestinal illnesses, as improvements in hand hygiene have been found to reduce even more instances of gastrointestinal illness than instances of respiratory illness (23). Each of these potential benefits could further improve the cost-effectiveness ratio.

This study also had several limitations. First, hand and respiratory hygiene is not sufficient to protect against all organisms that cause ILI, and is not specific to ILI. In particular, a wide range of protective behaviors may prevent acquisition of ILI, including but not limited to hand and respiratory hygiene. Other behaviors might include interventions such as surface disinfection (67) or social distancing (14). Because this intervention focused only on hand and respiratory hygiene, it is possible that participants in the intervention group followed the recommended behaviors and still acquired ILI through other means. This would result in biasing the results to the null hypothesis. Second, all participant data collection was based on self-reports over time, which are subject to bias, including the correlation of within-subject responses and differences between student self-reports and actual behaviors and illnesses. Third, participants who enroll in such a study are more likely to be concerned about their health in general, which may limit the generalizability of the results to all university students. Finally, the cost-

effectiveness analysis used effectiveness levels observed in other interventions; it is possible that additional costs may be necessary for this intervention to achieve such effectiveness levels. However, this analysis utilized a more conservative intervention effectiveness estimate than that reported in interventions among college students that appear to be similar to the program described here (24, 25). Future interventions involving NPIs should further explore the mixed effectiveness results observed in the as-treated analysis and should include a cost-effectiveness element to determine whether these initiatives are an effective use of limited public health resources across a range of interventions.

Conclusion

This paper examines the cost-effectiveness of providing education and materials for adherence to select NPIs among students at a large, urban university to reduce the transmission and incidence of ILI. This analysis is unique, as the majority of cost-benefit and cost-effectiveness studies related to influenza-like illnesses to date have focused on pharmaceutical interventions such as influenza vaccination and use of antiviral drugs. The results suggest that this intervention program has the potential to be a cost-effective tool for ILI prevention among university students for both seasonal and pandemic events, especially with intervention design adjustments that could make it a just-in-time program with particular relevance for infectious disease events requiring targeted use of limited public health resources.

References

1. Flu activity and surveillance [homepage on the Internet]. Centers for Disease Control and Prevention Website. 2009 October 9 [cited 2009 October 15]. Available from: http://www.cdc.gov/flu/weekly/fluactivity.htm.

2. Fleming DM, Ayres JG. Diagnosis and patterns of incidence of influenza, influenza-like illness and the common cold in general practice. J R Coll Gen Pract. 1988;38(309):159.

3. Zambon MC, Stockton JD, Clewley JP, Fleming DM. Contribution of influenza and respiratory syncytial virus to community cases of influenza-like illness: An observational study. Lancet. 2001;358(9291):1410-6.

4. Nichol KL, D'Heilly S, Ehlinger E. Colds and influenza-like illnesses in university students: Impact on health, academic and work performance, and health care use. Clin Infect Dis. 2005;40(9):1263-70.

5. Nichol KL, D'Heilly SJ, Greenberg ME, Ehlinger E. Burden of influenza-like illness and effectiveness of influenza vaccination among working adults aged 50-64 years. Clin Infect Dis. 2009;48(3).

6. Li S, Leader S. Economic burden and absenteeism from influenza-like illness in healthy households with children (5–17 years) in the US. Respir Med. 2007;101(6):1244-50.

7. Nichol KL, D'Heilly S, Ehlinger E. Burden of upper respiratory illnesses among college and university students: 2002–2003 and 2003–2004 cohorts. Vaccine. 2006;24(44-46):6724-5.

8. Nichol KL. Cost-benefit analysis of a strategy to vaccinate healthy working adults against influenza. Arch Intern Med. 2001 Mar 12;161(5):749-59.

9. Centers for Disease Control and Prevention. Update: Influenza activity-United States, September 30, 2007-April 5, 2008, and composition of the 2008-09 influenza vaccine. 2008 April 18. Report No.: 57(15).

10. Monto AS, Gravenstein S, Elliott M, Colopy M, Schweinle J. Clinical signs and symptoms predicting influenza infection. Arch Intern Med. 2000;160(21):3243-7.

11. van Elden LJR, van Essen GA, Boucher CAB, van Loon AM, Nijhuis M, Schipper P, et al. Clinical diagnosis of influenza virus infection: Evaluation of diagnostic tools in general practice. Br J Gen Pract. 2001;51(469):630-4.

12. Lamson D, Renwick N, Kapoor V, Liu Z, Palacios G, Ju J, et al. MassTag polymerase chain reaction detection of respiratory pathogens, including a new rhinovirus genotype, that caused influenza−like illness in New York State during 2004–2005. J Infect Dis. 2006;194:1398-402.

13. Kelly H, Birch C. The causes and diagnosis of influenza-like illness. Aust Fam Physician. 2004;33(5):305-11.

14. World Health Organization Writing Group. Nonpharmaceutical interventions for pandemic influenza, national and community measures. Emerg Infect Diseases. 2006;12(1):88-94.

15. Monto AS. The risk of seasonal and pandemic influenza: Prospects for control. Clin Infect Dis. 2009;48(S1):20-5.

16. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings. Recommendations of the healthcare infection control practices advisory committee and the HICPAC/SHEA/APIC/IDSA hand hygiene task force. MMWR Morb Mortal Wkly Rep. 2002 October 25;51(RR 16):1-44.

17. Respiratory hygiene/cough etiquette in healthcare settings [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention website. 2003 December 17 [cited 2009 May 14]. Available from: http://www.cdc.gov/flu/professionals/infectionControl/resphygiene.htm.

18. Cowling BJ, Chan KH, Fang VJ, Cheng CKY, Fung ROP, Wai W, et al. Facemasks and hand hygiene to prevent influenza transmission in households: A randomized trial. Ann Intern Med. 2009;151:437-46.

19. Sandora TJ, Taveras EM, Shih MC, Resnick EA, Lee GM, Ross-Degnan D, et al. A randomized, controlled trial of a multifaceted intervention including alcohol-based hand sanitizer and hand-hygiene education to reduce illness transmission in the home. Pediatrics. 2005;116(3):587-94.

20. Sandora TJ, Shih MC, Goldmann DA. Reducing absenteeism from gastrointestinal and respiratory illness in elementary school students: A randomized, controlled trial of an infection-control intervention. Pediatrics. 2008;121(6):e1555-62.

21. Aledort JE, Lurie N, Wasserman J, Bozzette SA. Non-pharmaceutical public health interventions for pandemic influenza: An evaluation of the evidence base. BMC Public Health. 2007 Aug 15;7:208.

22. Grayson ML, Melvani S, Druce J, Barr IG, Ballard SA, Johnson PDR, et al. Efficacy of soap and water and alcohol-based hand-rub preparations against live H1N1 influenza virus on the hands of human volunteers. Clin Infect Dis. 2008;48(3):285-91.

23. Aiello AE, Coulborn RM, Perez V, Larson EL. Effect of hand hygiene on infectious disease risk in the community setting: A meta-analysis. Am J Public Health. 2008;98(8):1372-81.

24. White C, Kolble R, Carlson R, Lipson N. The impact of a health campaign on hand hygiene and upper respiratory illness among college students living in residence halls. J Am Coll Health. 2005;53(4):175-81.

25. Aiello AE, Murray GF, Perez V, Coulborn RM, Davis BM, Uddin M, et al. Mask use, hand hygiene, and seasonal influenza−like illness among young adults: A randomized intervention trial. J Infect Dis. 2010;201:491-8.

26. Jefferson T, Foxlee R, Mar CD, Dooley L, Ferroni E, Hewak B, et al. Physical interventions to interrupt or reduce the spread of respiratory viruses: Systematic review. Br Med J. 2008;336(7635):77.

27. Jefferson T, Del Mar C, Dooley L, Ferroni E, Al-Ansary LA, Bawazeer GA, et al. Physical interventions to interrupt or reduce the spread of respiratory viruses: Systematic review. Br Med J. 2009;339:b3675.

28. van der Sande M, Teunis P, Sabel R. Professional and home-made face masks reduce exposure to respiratory infections among the general population. PLoS ONE. 2008;3(7):e2618.

29. Nichol KL, D'Heilly S, Ehlinger EP. Influenza vaccination among college and university students: Impact on influenzalike illness, health care use, and impaired school performance. Arch Pediat Adol Med. 2008;162(12):1113-8.

30. Muennig PA, Khan K. Cost-effectiveness of vaccination versus treatment of influenza in healthy adolescents and adults. Clin Infect Dis. 2001 Dec 1;33(11):1879-85.

31. Rothberg MB, Rose DN. Vaccination versus treatment of influenza in working adults: A cost-effectiveness analysis. Am J Med. 2005;118(1):68-77.

32. Bridges CB, Thompson WW, Meltzer MI, Reeve GR, Talamonti WJ, Cox NJ, et al. Effectiveness and cost-benefit of influenza vaccination of healthy working adults. A randomized controlled trial. JAMA. 2000;284(13):1655-63.

33. Campbell DS, Rumley MH. Cost-effectiveness of the influenza vaccine in a healthy, working-age population. J Occup Environ Med. 1997 May;39(5):408-14.

34. Lee PY, Matchar DB, Clements DA, Huber J, Hamilton JD, Peterson ED. Economic analysis of influenza vaccination and antiviral treatment for healthy working adults. Ann Intern Med. 2002;137(4):225-31.

35. O'Brien BJ, Goeree R, Blackhouse GMBA, Smieja M, Loeb M. Oseltamivir for treatment of influenza in healthy adults: Pooled trial evidence and cost-effectiveness model for Canada. Value Health. 2003;6(2):116-25.

36. Kaiser L, Keene ON, Hammond JMJ, Elliott M, Hayden FG. Impact of zanamivir on antibiotic use for respiratory events following acute influenza in adolescents and adults. Arch Intern Med. 2000;160(21):3234-40.

37. Nichol KL, Mendelman PM, Mallon KP, Jackson LA, Gorse GJ, Belshe RB, et al. Effectiveness of live, attenuated intranasal influenza virus vaccine in healthy, working adults. A randomized controlled trial. JAMA. 1999;282(2):137-44.

38. Nichol KL, Mallon KP, Mendelman PM. Cost benefit of influenza vaccination in healthy, working adults: An economic analysis based on the results of a clinical trial of trivalent live attenuated influenza virus vaccine. Vaccine. 2003 May 16;21(17-18):2207-17.

39. Wilde JA, McMillan JA, Serwint J, Butta J, O'Riordan MA, Steinhoff MC. Effectiveness of influenza vaccine in health care professionals: A randomized trial. JAMA. 1999;281(10):908-13.

40. Russell LB, Gold MR, Siegel JE, Daniels N, Weinstein MC. The role of cost-effectiveness analysis in health and medicine. Panel on cost-effectiveness in health and medicine. JAMA. 1996;276(14):1172-7.

41. Weinstein MC, Siegel JE, Gold MR, Kamlet MS, Russell LB. Recommendations of the panel on cost-effectiveness in health and medicine. JAMA. 1996;276(15):1253-8.

42. Siegel JE, Weinstein MC, Russell LB, Gold MR. Recommendations for reporting cost-effectiveness analyses. Panel on cost-effectiveness in health and medicine. JAMA. 1996;276(16):1339-41.

43. Rothberg MB, He S, Rose DN. Management of influenza symptoms in healthy adults. J Gen Intern Med. 2003;18(10):808-15.

44. Gold MR, Siegel JE, Russell LB, Weinstein MC. Cost-effectiveness in health and medicine: Report of the panel on cost-effectiveness in health and medicine. Illustrated ed. New York: Oxford University Press; 1996.

45. Brouwer WBF, Koopmanschap MA, Rutten FFH. Productivity costs measurement through quality of life? A response to the recommendation of the Washington Panel. Health Econ. 1997;6(3):253-9.

46. Weinstein MC, Siegel JE, Garber AM, Lipscomb J, Luce BR, Manning Jr WG, et al. Productivity costs, time costs and health-related quality of life: A response to the Erasmus Group. Health Econ. 1997;6(5):505-10.

47. Brouwer WBF, Koopmanschap MA, Rutten FFH. Productivity costs in cost-effectiveness analysis: Numerator or denominator: A further discussion. Health Econ. 1997;6(5):511-4.

48. Brouwer WBF, Koopmanschap MA. On the economic foundations of CEA. Ladies and gentlemen, take your positions! J Health Econ. 2000;19(4):439-59.

49. Davidson T, Levin LÅ. Do individuals consider expected income when valuing health states? Int J Technol Assess Health Care. 2008;24(04):488-94.

50. Richardson J, Peacock SJ, Iezzi A. Do quality-adjusted life years take account of lost income? Evidence from an Australian survey. Eur J Health Econ. 2009;10(1):103-9.

51. Farnham PG, Ackerman SP, Haddix AC. Chapter 2: Study design. In: Haddix AC, Teutsch SM, Shaffer PA, Dunet DO, editors. Prevention effectiveness: A guide to decision analysis and economic evaluation. New York, NY: Oxford University Press; 1996. p. 12-26.

52. Boardman A, Greenberg D, Vining A, Weimer D. Cost-benefit analysis: Concepts and practice. Upper Saddle River, NJ (EUA). Prentice Hall; 2006.

53. Ubel PA, Hirth RA, Chernew ME, Fendrick AM. What is the price of life and why doesn't it increase at the rate of inflation? Arch Intern Med. 2003;163(14):1637-41.

54. Hirth RA, Chernew ME, Miller E, Fendrick AM, Weissert WG. Willingness to pay for a quality-adjusted life year: In search of a standard. Med Decis Making. 2000;20(3):332-42.

55. Hui DS, Woo J, Hui E, Foo A, Ip M, To KW, et al. Influenza-like illness in residential care homes: A study of the incidence, aetiological agents, natural history and health resource utilisation. Br Med J. 2008;63(8):690-7.

56. Akazawa M, Sindelar JL, Paltiel AD. Economic costs of influenza-related work absenteeism. Value Health. 2003 Mar-Apr;6(2):107-15.

57. National income and product accounts table: Table 1.1.9 implicit price deflators for gross domestic product.[homepage on the Internet]. U.S Department of Commerce Bureau of Economic Analysis. 2009 August 27 [cited 2009 September 12]. Available from: http://www.bea.gov/national/nipaweb/TableView.asp?SelectedTable=13&Freq=Qtr&FirstYear=2006&LastYear=2008.

58. Fendrick AM, Monto AS, Nightengale B, Sarnes M. The economic burden of non-influenza-related viral respiratory tract infection in the United States. Arch Intern Med. 2003;163(4):487-94.

59. Soni A, Hill SC. Average annual health care use and expenses for influenza, 2001-2003. Rockville, MD: Agency for Healthcare Research and Quality; 2006 March. Report No.: Statistical Brief #116.

60. Crane M. What you charge vs what you get. Med Econ. 2001 Oct 22;78(20):50,52, 55-57.

61. Cox FM, Cobb MM, Chua WQ, McLaughlin TP, Okamoto LJ. Cost of treating influenza in emergency department and hospital settings. Am J Manag Care. 2000;6:205-14.

62. Thompson WW, Shay DK, Weintraub E, Brammer L, Bridges CB, Cox NJ, et al. Influenza-associated hospitalizations in the United States. JAMA. 2004;292(11):1333-40.

63. Irwin DE, Weatherby LB, Huang WY, Rosenberg DM, Cook SF, Walker AM. Impact of patient characteristics on the risk of influenza/ILI-related complications. BMC Health Serv Res. 2001;1(1):8.

64. Bureau of Labor Statistics. Employer costs for employee compensation historical listing March 2004-June 2009. Washington, DC: 2009 September 10.

65. Goetzel RZ, Long SR, Ozminkowski RJ, Hawkins K, Wang S, Lynch W. Health, absence, disability, and presenteeism cost estimates of certain physical and mental health conditions affecting U.S. employers. J Occup Environ Med. 2004 Apr;46(4):398-412.

66. Rubin GJ, Amlot R, Page L, Wessely S. Public perceptions, anxiety, and behaviour change in relation to the swine flu outbreak: Cross sectional telephone survey. Br Med J. 2009;339:b2651.

67. Chen YC, Chang SC, Tsai KS, Lin FY. Certainties and uncertainties facing emerging respiratory infectious diseases: Lessons from SARS. J Formosan Med Assoc. 2008;107(6):432-42.

68. Nichol KL, Lind A, Margolis KL, Murdoch M, McFadden R, Hauge M, et al. The effectiveness of vaccination against influenza in healthy, working adults. N Engl J Med. 1995;333(14):889-93.

69. Lau JT, Tsui H, Lau M, Yang X. SARS transmission, risk factors, and prevention in Hong Kong. Emerg Infect Diseases. 2004 Apr;10(4):587-92.

70. Markel H, Lipman HB, Navarro JA, Sloan A, Michalsen JR, Stern AM, et al. Nonpharmaceutical interventions implemented by US cities during the 1918-1919 influenza pandemic. JAMA. 2007;298(6):644.

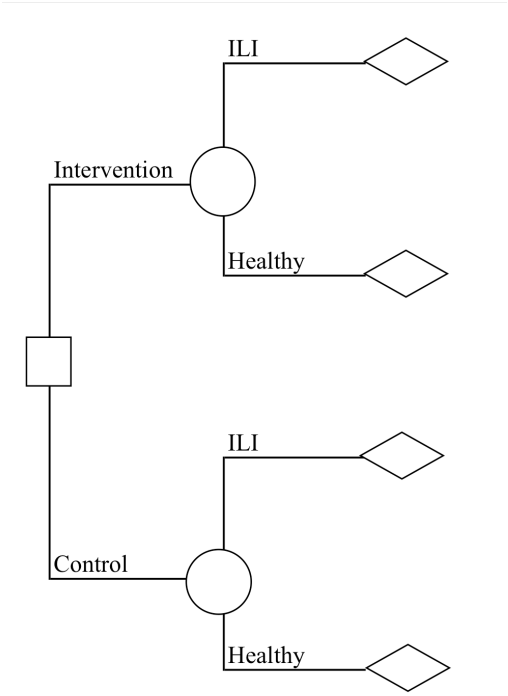


Figure 1. Decision tree. Participants could develop influenza-like illness (ILI) or stay healthy each day. Participants who developed ILI returned to a healthy state at the end of the ILI episode, 15 days after onset of symptoms. Individuals transitioned between health states based on actual reports of participant illness for each day of the trial; participants could experience multiple episodes of ILI during the course of the study. Individuals sick with ILI were further considered as being in one of two illness states: requiring healthcare (physician visit and/or hospitalization), or without need of healthcare. Squares denote a decision node; circles denote chance events where individuals may transition between health states; diamonds denote the return to the next transition cycle. Abbreviations: ILI, influenza-like illness.

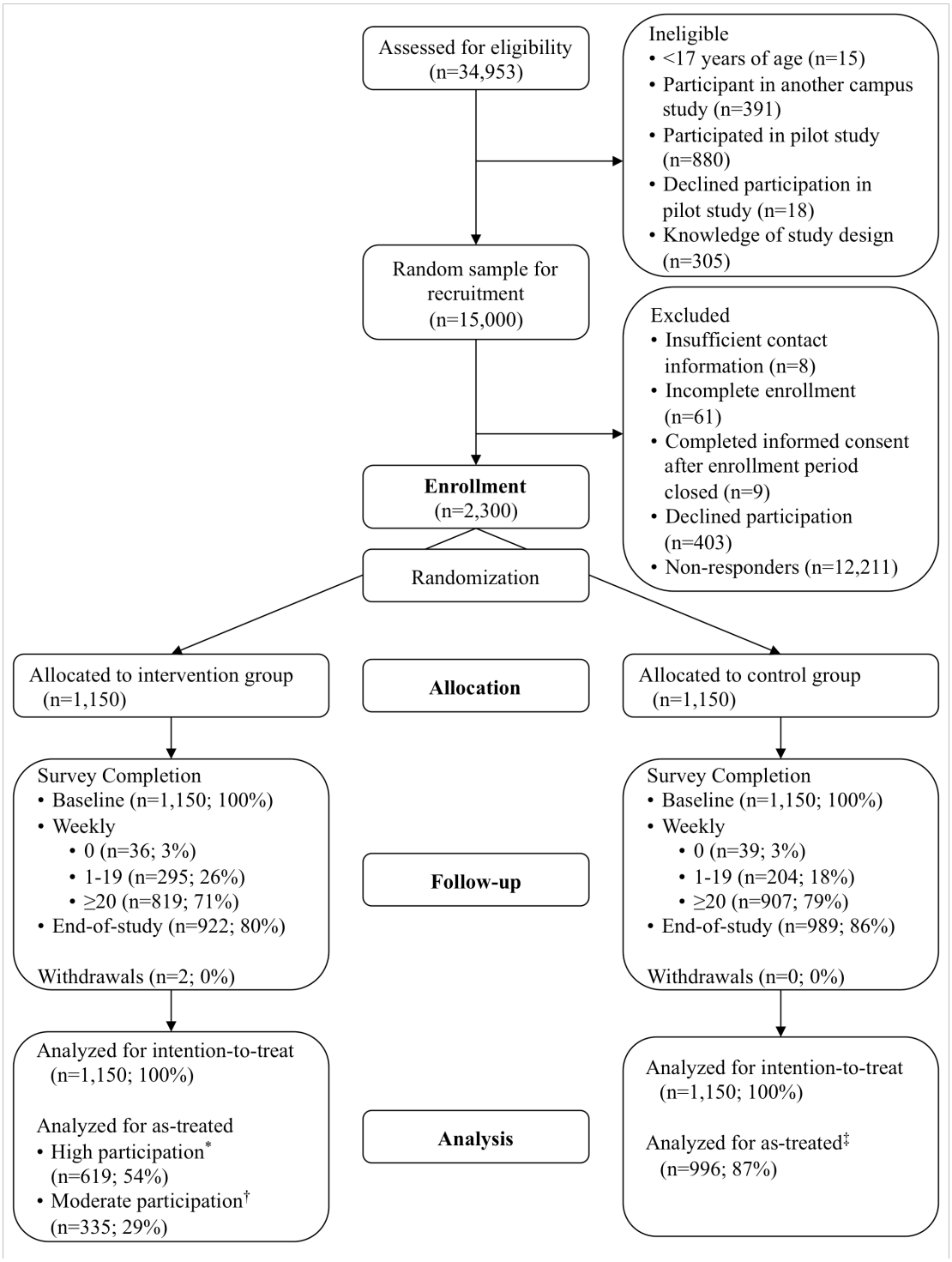


Figure 2. Participant flow diagram.

* Participants randomly allocated to the intervention group who logged in to the intervention website at least once during the course of the intervention *and* confirmed receipt of the hygiene kit.

† Participants randomly allocated to the intervention group who either logged in to the intervention website *or* confirmed receipt of the hygiene kit.

‡ Participants randomly allocated to the control group who confirmed receipt of thermometer.

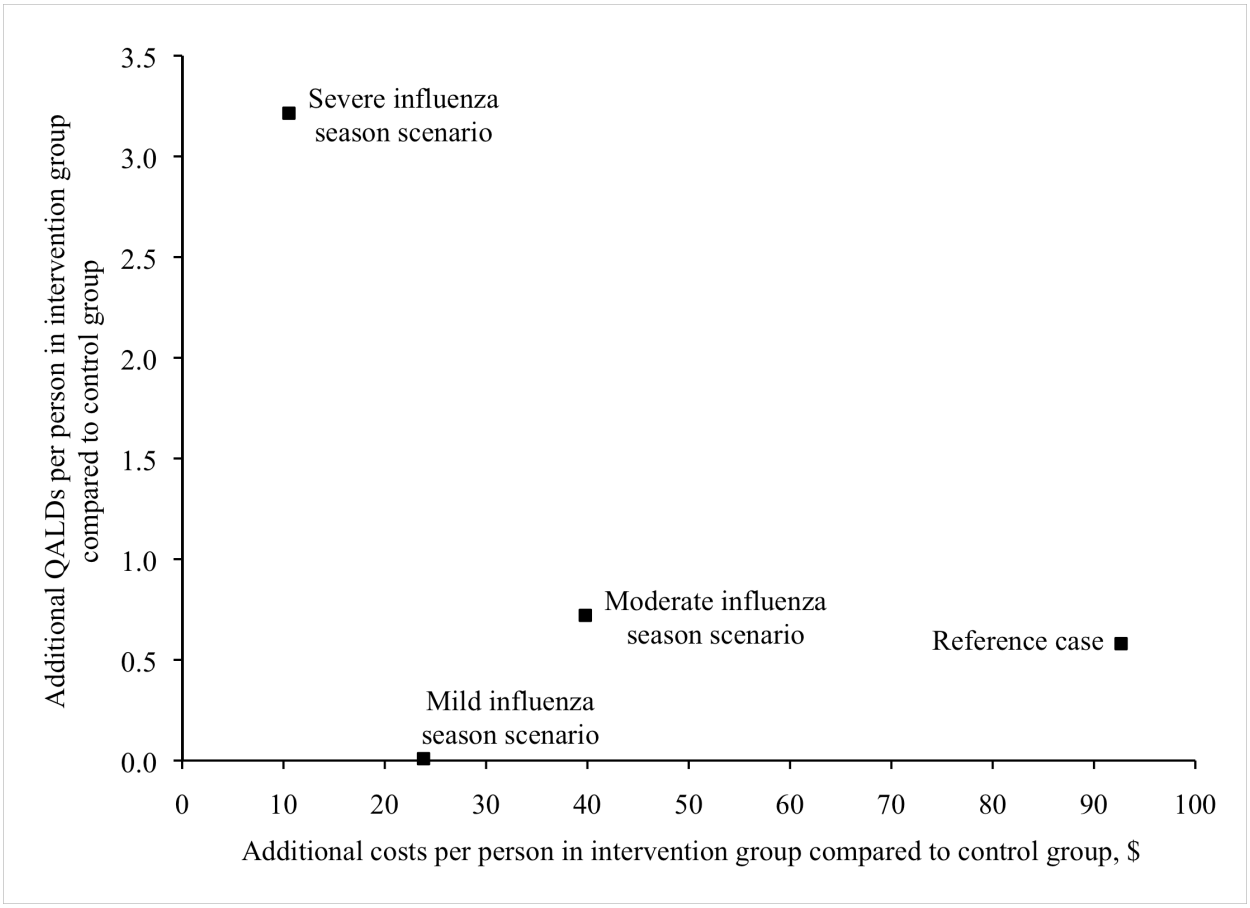


Figure 3. Incremental costs and QALDs per intervention participant for the reference case and three scenarios. Costs and QALDs per intervention participant are compared with those for control group participants for each situation. Abbreviations: QALD, quality-adjusted life day.

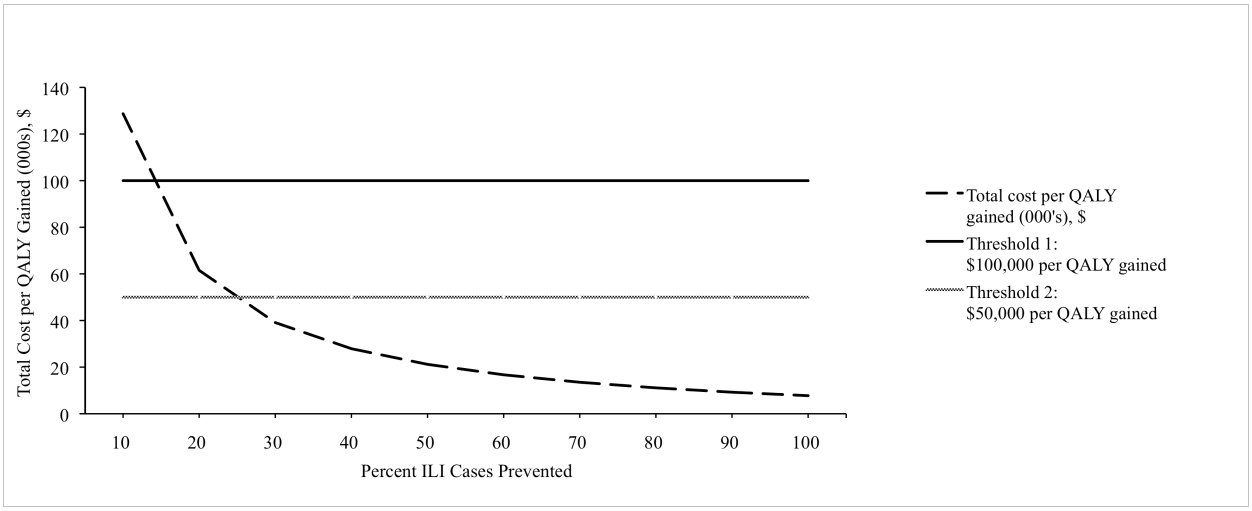


Figure 4. Threshold analysis of intervention effectiveness (percent of ILI episodes prevented). Abbreviations: ILI, influenza-like illness; QALY, quality-adjusted life year.

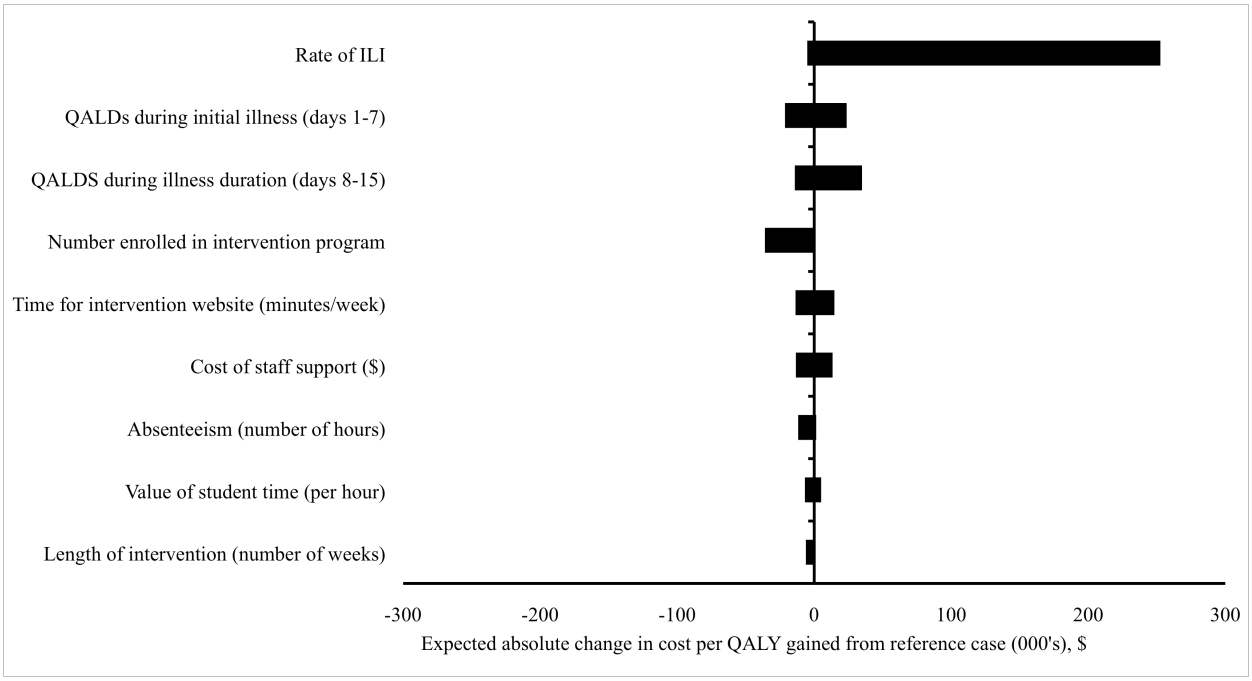


Figure 5. Tornado diagram of one-way sensitivity analysis results for variables that caused the cost-effectiveness ratio to change 10% or more. Abbreviations: ILI, influenza-like illness; QALD, quality-adjusted life day; QALY, quality-adjusted life year.

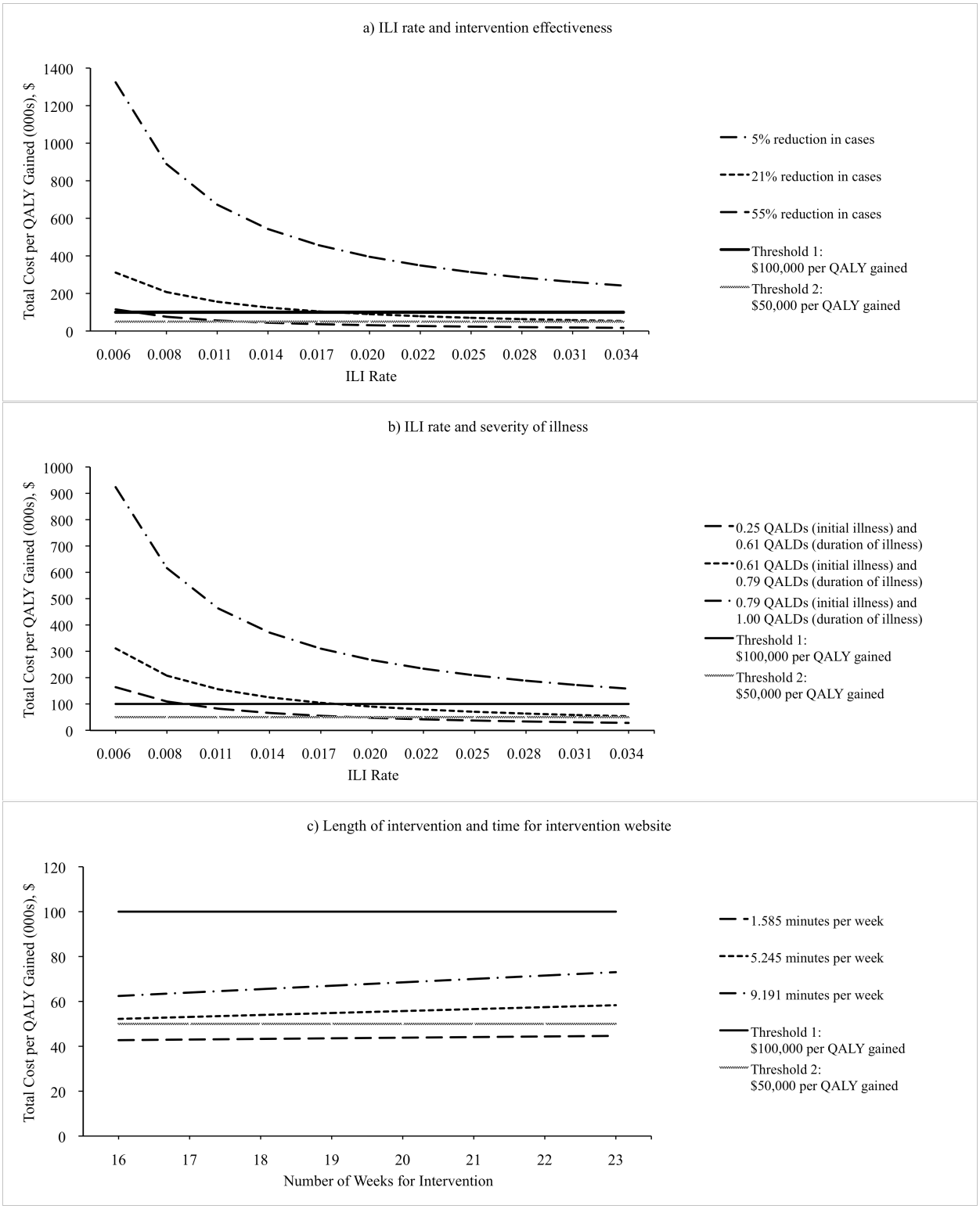


Figure 6. Two-way sensitivity analyses. a) ILI rate and intervention effectiveness. b) ILI rate and severity of illness. c) Length of intervention and time for intervention website. Intervention effectiveness represents percent of ILI episodes prevented by the intervention. Abbreviations: ILI, influenza-like illness; QALD, quality-adjusted life day; QALY, quality-adjusted life year.

Table 1. Baseline characteristics of participants.

	Intention-to-Treat Analysis			As-Treated Analysis*			
Characteristic	Intervention Group†	Control Group†	*p*	High intervention participation†	Moderate intervention participation†	Control Group	*p*
Total population, n	1,150	1,150		619	381	996	
Age (years), mean (sd)	22.4 (5.2)	22.5 (5.3)	0.583	22.5 (5.4)	21.9 (4.4)	22.7 (5.4)	0.066
Graduate student, n (%)	373 (32)	371 (32)	0.940	219 (35)	112 (29)	331 (33)	0.151
Male, n (%)	639 (56)	645 (56)	0.819	312 (51)	229 (60)	552 (56)	0.009
Smokers, n (%)	34 (3)	23 (2)	0.139	12 (2)	14 (4)	17 (2)	0.070
Asthma, n (%)	113 (10)	142 (12)	0.055	62 (10)	38 (10)	110 (11)	0.756
Influenza vaccination in '07-'08 season or influenza diagnosis prior to baseline, n (%)	183 (20)	162 (17)	0.068	125 (21)	48 (15)	153 (16)	0.017
Race/ethnicity			0.635				0.307
Asian, n (%)	441 (38)	430 (37)	0.636	243 (39)	147 (39)	381 (38)	0.922
African-American/Black, n (%)	18 (2)	18 (2)	1.000	8 (1)	7 (2)	11 (1)	0.562
White/Caucasian, n (%)	427 (37)	468 (41)	0.080	235 (38)	142 (37)	411 (41)	0.259
Latino, n (%)	100 (9)	95 (8)	0.708	42 (7)	37 (10)	76 (8)	0.238
Multiracial, n (%)	73 (6)	60 (5)	0.246	47 (8)	15 (4)	49 (5)	0.023
Other, n (%)‡	56 (5)	41 (4)	0.120	26 (4)	22 (6)	34 (3)	0.141
Decline to answer, n (%)	35 (3)	38 (3)	0.721	18 (3)	11 (3)	34 (3)	0.806
General health status§			0.562				0.540
Excellent, n (%)	259 (23)	232 (20)	0.173	137 (22)	91 (24)	204 (20)	0.366
Very good, n (%)	520 (45)	542 (47)	0.347	297 (48)	162 (43)	479 (48)	0.151
Good, n (%)	302 (26)	304 (26)	0.915	151 (24)	104 (27)	261 (26)	0.558
Fair or poor, n (%)	69 (6)	71 (6)	0.857	34 (5)	24 (6)	52 (5)	0.735
One or more roommates, n (%)	947 (82)	956 (83)	0.619	511 (83)	314 (82)	834 (84)	0.761
Group living situation, n. (%)¶	341 (30)	354 (31)	0.473	168 (27)	122 (32)	302 (31)	0.213
Interaction with children one or more times per week, n (%)	155 (13)	184 (16)	0.090	82 (13)	47 (12)	156 (16)	0.197

Table 1 (cont). Baseline characteristics of participants.

Characteristic	Intention-to-Treat Analysis			As-Treated Analysis*			
	Intervention Group†	Control Group†	*p*	High intervention participation†	Moderate intervention participation†	Control Group	*p*
Baseline adherence score							
Hand Hygiene: Situations, mean (sd)	2.2 (0.5)	2.2 (0.5)	0.198	2.2 (0.5)	2.2 (0.5)	2.2 (0.4)	0.129
Hand Hygiene: Technique, mean (sd)	2.1 (0.8)	2.2 (0.8)	0.398	2.2 (0.8)	2.2 (0.8)	2.1 (0.8)	0.630
Hand Awareness, mean (sd)	2.0 (0.7)	2.0 (0.7)	0.074	2.0 (0.7)	2.0 (0.8)	2 (0.7)	0.585
Respiratory Hygiene: Cover Cough, mean (sd)	2.8 (0.5)	2.8 (0.5)	0.777	2.8 (0.5)	2.8 (0.5)	2.8 (0.6)	0.215
Respiratory Hygiene: Technique, mean (sd)	1.6 (0.6)	1.6 (0.6)	0.634	1.6 (0.6)	1.6 (0.6)	1.6 (0.5)	0.969

Abbreviations: sd, standard deviation.

* High intervention participation: participants randomly allocated to the intervention group who logged in to the intervention website at least once during the course of the intervention *and* confirmed receipt of the hygiene kit; Moderate intervention participation: participants randomly allocated to the intervention group who either logged in to the intervention website *or* confirmed receipt of the hygiene kit. Control group: participants randomly allocated to the control group who confirmed receipt of the thermometer.

† Percentages may not total to 100 due to rounding.

‡ Includes American Indian/Alaskan Native; Native Hawaiian or other Pacific Islander; and participant-identified "Other" category.

§ Question based on Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36).

¶ Living arrangements that typically involve common living spaces, including university-owned residence halls; fraternity or sorority houses; cooperative housing; or International House (a multi-cultural residence hall).

Table 2. As-treated effectiveness analysis results using ILI count data (reference case definition).

	Model 1		Model 2		Model 3		Model 4		Model 5	
	IRR	*p*	IRR	*p*	IRR	*p*	IRR	*p*	IRR	*p*
Control Group*	1.00	referent	1.00	referent	1.00	referent	1.00	referent	1.00	referent
Moderate intervention participation†	0.86	0.092	0.82	0.038	0.82	0.041	0.83	0.064	0.84	0.069
High intervention participation‡	1.09	0.232	1.08	0.280	1.07	0.332	1.08	0.264	1.07	0.346
Smokers			1.41	0.079	1.40	0.086	1.50	0.042	1.51	0.037
Asthma			1.15	0.157	1.14	0.208	1.06	0.558	1.04	0.683
Influenza vaccination or influenza diagnosis prior to baseline			0.96	0.666	0.98	0.763	0.97	0.703	0.96	0.619
General Health Status										
Excellent			1.00	referent	1.00	referent	1.00	referent	1.00	referent
Very good			1.16	0.101	1.17	0.077	1.09	0.335	1.09	0.379
Good			1.55	<0.001	1.59	<0.001	1.50	<0.001	1.48	<0.001
Fair or poor			1.72	<0.001	1.75	<0.001	1.68	0.001	1.61	0.002
One or more roommates					1.17	0.072	1.21	0.039	1.22	0.036
Group Living Situation					0.92	0.251	0.97	0.633	0.94	0.440
Interaction with Children one or more times per week					1.10	0.286	1.07	0.463	1.03	0.752
Concern about getting sick during school year										
Extremely							1.00	referent	1.00	referent
Some							1.06	0.594	1.09	0.433
Minimally							0.95	0.663	0.98	0.854
Not at all							0.82	0.235	0.85	0.336
Baseline adherence score										
Hand Hygiene: Situations							0.91	0.271	0.90	0.208
Hand Hygiene: Technique							1.08	0.065	1.09	0.054
Hand Awareness							1.01	0.860	1.01	0.776
Respiratory Hygiene: Cover Cough							1.14	0.100	1.12	0.169
Respiratory Hygiene: Technique							1.03	0.625	1.02	0.730
Graduate student									0.98	0.821
Male									0.80	0.001

Table 2 (cont). As-treated effectiveness analysis results using ILI count data (reference case definition).

	Model 1		Model 2		Model 3		Model 4		Model 5	
	IRR	*p*	IRR	*p*	IRR	*p*	IRR	*p*	IRR	*p*
Race/Ethnicity										
White/Caucasian									1.00	referent
Asian									0.93	0.347
African-American/Black									0.68	0.270
Latino									1.28	0.040
Multiracial									1.03	0.856
Other									1.11	0.539
Decline to answer									0.75	0.188

Abbreviations: ILI, influenza-like illness; IRR, incidence rate ratio.

* Participants randomly allocated to the control group who confirmed receipt of the thermometer.

† Participants randomly allocated to the intervention group who either logged in to the intervention website *or* confirmed receipt of the hygiene kit.

‡ Participants randomly allocated to the intervention group who logged in to the intervention website at least once during the course of the intervention *and* confirmed receipt of the hygiene kit.

Table 3. Data inputs and ranges for reference case and sensitivity analyses.

	Reference case	Lower range	Upper range	References
Probabilities				
ILI episodes prevented because of intervention (intervention effectiveness), %	21	1	55	23, 24, 27
Physician visits among those with ILI	0.216	0.159	0.398	Current Study, 4, 32, 59, 63, 68
Antibiotic use among those with ILI	0.088	0.088	0.296	Current Study, 4, 32, 36
Antiviral use among those with ILI	0.010	0.010	0.040	Current Study, 63
Hospitalizations among those with ILI	0.004	0.000	0.011	Current Study, 4, 32, 63
Rates				
ILI, number of ILI episodes per person-wk*	0.031	0.006	0.034	Current Study
Discount rate, %	3	0	5	41, 42
Direct costs of ILI, $				
Physician visit	56	43	134	32, 58-60
OTC medications (total per episode of ILI)	10	7	13	Current Study, 32, 58
Antibiotics	29	6	50	43, 58
Antiviral drugs	50	12	84	34, 43
Hospitalizations	5,323	2,475	9,740	32, 61
Time costs				
Time for physician visit, hours	1.3	1.3	7.1	Current Study, 32
Length of stay for hospitalizations, days	4.4	2.9	5.8	61-63
Intervention website, minutes/week	5.2	1.6	9.2	Current Study
Length of intervention, # of weeks	23	16	23	Current Study, 1
Value of student time, per hour, $	16	10	20	Current Study, 64
Variable costs of intervention program, $				
Hygiene kit, per person	10	8	11	Current Study
Fixed costs of intervention incurred prior to program start, $				
Website set-up and maintenance	4,079	682	5,458	Current Study
Recruitment	838	511	4,783	Current Study
Fixed costs of intervention incurred across all weeks, $				
Staff support	49,284	24,642	73,926	Current Study
General administration	14,236	12,483	15,016	Current Study
Number enrolled in intervention program†	1,150	1,150	34,953	Current Study
QALDs				
Initial illness phase (days 1-7)	0.61	0.25	0.79	30, 35, 43
Recovery phase (days 8-15)	0.79	0.61	1.00	30, 35, 43
Productivity costs				
Absenteeism, hours‡	3.1	2.1	11.8	Current Study, 4, 32
Presenteeism, hours‡	10.9	6.0	10.9	Current Study
Productivity during presenteeism, %	83	79	87	65

Abbreviations: ILI, influenza-like illness; OTC, over-the-counter; QALD, quality-adjusted life day.

* Reference case definition: fever or feverishness (indicated by chills) and cough and/or sore throat in the absence of a known cause other than influenza. Lower range based on high specificity case definition: fever (temperature of 100°F (37.8°C) or higher) and cough and/or sore throat in the absence of a known cause other than influenza. Upper range based on high sensitivity case definition: fever or feverishness plus two or more of the symptoms headache, myalgia, cough, or sore throat.

† Reference case and lower range estimates based on number of intervention group participants; upper range estimate based on total number of students enrolled at UC Berkeley in Fall 2007, which would represent implementation of the intervention for the entire student body.
‡ Productivity losses from class, work, and/or volunteering.

Table 4. Reference case analysis.

	Per person*		Total group*	
	Control	Intervention	Control	Intervention
Total costs and QALDs				
Costs, $				
Direct costs of ILI	34	27	39,030	31,244
Direct costs of intervention program	0	69	0	79,663
Time costs of ILI	5	4	5,468	4,377
Time costs of intervention program	0	31	0	35,785
Productivity costs of ILI (absenteeism, presenteeism)	54	43	62,149	49,751
QALDs	157.0	157.6	180,579.3	181,246.9
Incremental costs and QALDs†				
Incremental costs - Ratio 1‡		93		106,572
Incremental costs - Ratio 1§		82		94,174
Incremental QALDs		0.6		667.6
ICER, $ per QALD gained ($ per QALY gained)†				
Ratio 1‡				160 (58,310)
Ratio 2§				141 (51,527)

Abbreviations: ICER, incremental cost-effectiveness ratio; ILI, influenza-like illness; QALD, quality-adjusted life day; QALY, quality-adjusted life year.

* Numbers may not sum to group totals due to rounding.

† Compares intervention group to control group.

‡ Assumes productivity losses are implicit in QALDs (QALYs) estimate.

§ Explicitly adds costs of absenteeism and presenteeism to estimate.

Table 5. One-way sensitivity analysis.[*]

	Lower range		Upper range	
	$/QALY	% Change[†]	$/QALY	% Change[†]
Probabilities				
Physician visits among those with ILI	58,693	1	57,106	-2
Antibiotic use among those with ILI	58,310	0	57,780	-1
Antiviral use among those with ILI	58,310	0	58,179	0
Hospitalizations among those with ILI	60,564	4	55,196	-5
Rates				
ILI	310,940	433	53,213	-9
Discount rate	58,278	0	58,332	0
Direct costs of ILI				
Physician visit	58,551	0	56,842	-3
OTC medications	58,630	1	58,062	0
Antibiotics	58,487	0	58,152	0
Antiviral drugs	58,343	0	58,281	0
Hospitalizations	59,403	2	56,615	-3
Time costs				
Time for physician visit	58,322	0	56,621	-3
Length of stay for hospitalizations	58,383	0	58,244	0
Intervention website	44,648	-23	73,041	25
Length of intervention	52,211	-10	58,310	0
Value of student time	51,512	-12	63,361	9
Variable costs of intervention program				
Hygiene kit	57,223	-2	58,922	1
Fixed costs of intervention incurred prior to program start				
Website set-up and maintenance	56,452	-3	59,065	1
Recruitment	58,131	0	60,468	4
Fixed costs of intervention incurred across all weeks				
Staff support	44,917	-23	71,704	23
General administration	57,358	-2	58,734	1
Number enrolled in intervention program	58,310	0	22,320	-62
QALDs				
Initial illness phase (days 1-7)	36,964	-37	81,983	41
Recovery phase (days 8-15)	44,145	-24	93,203	60
Productivity costs[‡]				
Absenteeism[§]	52,982	3	39,802	-23
Presenteeism[§]	52,652	2	51,527	0
Productivity during presenteeism	51,012	-1	52,161	1

Abbreviations: ILI, influenza-like illness; OTC, over-the-counter; QALD, quality-adjusted life day; QALY, quality-adjusted life year.

[*] Uses reference case intervention effectiveness value of 21%.

[†] Percent change from reference case $/QALY.

[‡] Based on cost-effectiveness ratio that explicitly includes costs of absenteeism and presenteeism in estimate.

[§] Productivity losses from class, work, and/or volunteer activities.

Table 6. Scenario analysis.

Scenario	Description*	$ per QALY gained: C-E Ratio 1†	$ per QALY gained: C-E Ratio 2‡
Mild	ILI incidence is low, with minor severity among those who become ill: • Mild cold and influenza season in which ILI incidence is low (0.006 episodes per person-week) • Student interest in the intervention is low, leading to intervention effectiveness of 5% • Time spent on intervention website is low (1.6 minutes per week) owing to minimal interest among students • Probability (0.216 per ILI episode) and length (1.3 hours) of physician visits are average • Probability of antibiotic (0.088 per ILI episode) and antiviral (0.010 per ILI episode) use is low • Probability of hospitalization is low (0.000 per ILI episode) • Intervention is employed for 16 weeks of peak cold and influenza season • 15% of students on campus enroll in the program • Length of absenteeism is short (2.1 hours) • Productivity during presenteeism is high (87% of normal productivity) • QALDs during initial illness phase and recovery phase are high due to mild cases (0.79 and 1.00, respectively) • Staff support required for the program is low ($24,642 in salary and benefits, or 0.5 FTEs)	936,520	922,562
Moderate	ILI incidence and severity are moderate, but there is a high level of interest among the public: • Moderate cold and influenza season in which ILI incidence is average (0.031 episodes per person-week) • Student interest in the intervention is moderately high, leading to intervention effectiveness of 26% • Time spent on intervention site is high (9.2 minutes per week) owing to high level of interest among students • Probability (0.398 per ILI episode) of physician visits is high but length (1.3 hours) of physician visits is average because of moderate cases • Probability of antibiotic (0.296 per ILI episode) and antiviral (0.040 per ILI episode) use among those ill is high • Probability of hospitalization is average (0.004 per ILI episode) • Intervention is employed for 16 weeks of peak cold and influenza season • 40% of students on campus enroll in the program because of high level of interest in the program • Length of absenteeism is average (3.1 hours) • Productivity during presenteeism is average (83% of normal productivity) • QALDs during initial illness phase and recovery phase are average (0.61 and 0.79, respectively) • Staff support required for the program is average ($49,284 in salary and benefits, or 1.0 FTE)	20,160	13,376

Table 6 (cont). Scenario analysis.

Scenario	Description*	$ per QALY gained: C-E Ratio 1†	$ per QALY gained: C-E Ratio 2‡
Severe	ILI incidence is high, and illness is severe with a high level of interest among the public: • Severe cold and influenza season in which ILI incidence is high (0.034 episodes per person-week) • Student interest in the intervention is high, leading to intervention effectiveness of 55% • Time spent on intervention site is high (9.2 minutes per week) owing to high level of interest among students • Probability of physician visits is high (0.398 per ILI episode); physician visits are also longer (7.1 hours) because of long wait times from overloading of system, as well as complications related to illness • Probability of antibiotic (0.296 per ILI episode) and antiviral (0.040 per ILI episode) use among those ill is high • Probability of hospitalization is high (0.011 per ILI episode) • Intervention is employed for full 23 weeks of cold and influenza season • 50% of students on campus enroll in the program because of concerns about getting sick • Length of absenteeism is high (11.8 hours) • Productivity during presenteeism is low (79% of normal productivity) • QALDs during initial illness phase and recovery phase are low due to severe cases (0.25 and 0.61, respectively) • Staff support required for the program is high ($73,926 in salary and benefits, or 1.5 FTEs)	1,197	-8,825

Abbreviations: C-E, cost-effectiveness; FTE, full-time equivalent; ILI, influenza-like illness; QALD, quality-adjusted life day; QALY, quality-adjusted life year.

* Lower range, reference case, and upper range estimates were used based on whether variables were described as low, average, or high, respectively.

† Assumes productivity losses are implicit in QALDs estimate.

‡ Explicitly adds costs of absenteeism and presenteeism to estimate.

CHAPTER IV: AN EXPLORATORY QUALITATIVE ANALYSIS OF PANDEMIC PLAN COMPONENTS AND PLANNING CONSIDERATIONS IN THE PRIVATE SECTOR

Introduction

Business preparedness is an essential element of public health preparedness for pandemic influenza. Businesses are a major driver in any economy, and the health of communities is affected by the local economy (1, 2). Public health agencies would be remiss in their preparedness efforts if they did not effectively encourage businesses to participate in these efforts. On the employer side, the health of a business is directly related to the health of its employees. This is apparent from businesses' direct employee healthcare costs alone: U.S. businesses pay for 26% of the total $1.9 trillion annual expenditures on healthcare in the United States (3). Additionally, businesses are affected by indirect employee healthcare costs: productivity losses due to family and personal health problems cost U.S. businesses $225.8 billion per year (4). As a result, it is understandable that employers are concerned with employee health and productivity in general, and even more so during a pandemic.

Given this mutual concern about employer preparedness for a pandemic influenza event, public health efforts have included steps toward engaging businesses in preparedness efforts, such as promulgation of recommendations for businesses by federal, state, and local public health authorities (5-8). Tools to support business preparedness for pandemic influenza include information such as the U.S. Department of Health and Human Services' (HHS) Business Planning Checklist and information on business preparedness for the 2009 H1N1 influenza pandemic provided by the Centers for Disease Control and Prevention (CDC) (9, 10). For example, the HHS Checklist is a two-page document with general information for businesses initiating pandemic planning, including reminders to plan for the impact of a pandemic on their business, employees, and customers; establish policies and procedures for a pandemic; allocate resources to protect employees and customers; communicate to and educate employees; and coordinate with external organizations and the community (9).

Despite these collaborations and initial guidance from public health authorities, very few organizations have made their pandemic plan public, making it difficult to assess which components are most relevant or of the most concern to business continuity planning practitioners. As a result, the pandemic plan components identified by businesses themselves and those who advise businesses, including private consultants and public health and public sector planners, are unknown.

With the emergence of the novel influenza A(H1N1) in April 2009, business plans for pandemic preparedness were put to the test and many lessons were learned related to private sector preparedness, on both the public and private sector sides (11). These have not yet been captured systematically. In fact, while the HHS Business Planning Checklist is a useful and tangible tool for businesses, including a special version for organizations with overseas operations, the core checklist has not changed since 2005. Changes to the checklist based on experience with the 2009 H1N1 influenza pandemic could have significant implications in terms

of shaping employers' pandemic and infectious disease preparedness efforts going forward, as well as the efforts of the public sector in supporting employers' efforts.

Given these gaps in our understanding of employer preparedness for pandemic influenza, this research involved interviews with a range of key informants involved in preparedness efforts for the private sector, including private sector business continuity managers, consultants, and public sector planners. Specifically, the following research questions were explored: (1) What are the key components of employers' pandemic preparedness plans? Which of these do individuals identify as the most and least important components? (2) What lessons did organizations or individuals uncover as they engaged in pandemic influenza preparedness planning before and during the 2009 H1N1 influenza pandemic? (3) What 'model practices,' based on both successes and failures, emerged related to preparedness planning before and during the 2009 H1N1 influenza pandemic? This paper presents a descriptive analysis of participant input related to each of these questions. In addition to an in-depth analysis of key components of private sector plans, the results include suggestions to guide future cross-sector collaborations for pandemic or other public health events.

Methods

Key informant interviews were conducted with individuals involved in pandemic preparedness planning for the private sector. The interviews addressed several subject areas, including: plan components and lessons learned from preparedness activities (plan components, most and least important efforts, lessons learned, and model practices); how to engage organizations in preparedness planning (why they prepare, factors that encourage and discourage preparedness, and the role of uncertainty); how to gain executive support and build a business case for preparedness (support from executives and other key players and how to build a business case); and lessons concerning the role of public health agencies for private sector preparedness (defining the ideal role for a public health department and identifying resource-sharing opportunities between the private and public sectors). This analysis focuses on the first subject area – plan components and lessons learned; subsequent analyses will explore each of the other subject areas. The University of California, Berkeley Committee for the Protection of Human Subjects (CPHS) confirmed the study did not meet the threshold for "human subjects" research in June 2008. Based on adjustments to the interview guide after the first few interviews, CPHS further approved the study as an exempt research protocol in May 2009.

Study design and data collection methods

Study setting

Interviews were conducted from February 2009 to July 2009, with one additional interview conducted in October 2009. The novel influenza A(H1N1) virus emerged in April 2009, thus providing a unique opportunity to examine pandemic preparedness efforts before and during an influenza pandemic. Novel H1N1 was first recognized in two children in the United States in April 2009, with initial disease spread occurring predominantly in Mexico (11). The World Health Organization (WHO) escalated the pandemic alert phase over the next two months as the virus spread globally, declaring it a pandemic in June of that year (12). The escalation of the 2009 H1N1 influenza pandemic over time allowed a unique "natural history" of private sector efforts before and during an influenza pandemic to be captured. This included internal

private sector efforts, as well as the interaction of the private sector with the public sector and in particular, public health agencies.

Preparedness efforts vary regionally. Threats in different areas may vary according to what natural disasters (e.g., earthquakes, hurricanes, and floods) are of concern. During the 2009 H1N1 influenza pandemic, virus spread also varied regionally, resulting in variations in the actions taken in response. In order to account for these regional variations in preparedness efforts, interviews were conducted with organizations on both the east and west coasts of the United States.

Study population and eligibility criteria

The study population of interest was individuals with knowledge of or involvement in private sector business continuity planning efforts, including individuals in the public and private sectors, as well as consultants who advise the private sector in their efforts. Among individuals working in the private sector, those working at large organizations were primarily targeted because they tend to have more resources available for preparedness efforts and therefore were more likely to have developed and implemented pandemic plans.

In order to be eligible for participation, each individual had to have some interaction with the private sector around preparedness efforts, either from within a private sector organization, as a consultant to private sector organizations, or through his or her role in a public sector agency.

Sampling and recruitment

Purposive sampling was utilized, based on a snowball sampling mechanism initiated from contacts made at business preparedness organizations and conferences (13). Sampling of individuals on the west coast of the United States was initiated from existing contacts of the lead investigator established through pandemic and disaster preparedness conferences. Sampling of individuals on the east coast was initiated from a connection with a public health employee working on pandemic preparedness in a local health department on the east coast.

On the private sector side, individuals were sought from a range of industries to understand variation between industries and obtain a more comprehensive list of plan components. Consultants who work with private organizations on preparedness efforts were also sought to get a broader view of preparedness efforts from individuals who had worked with a range of organizations. Finally, representatives from public health and other emergency services agencies were sought to provide input on the public sector experience of working with the private sector on pandemic preparedness and response efforts. Individuals were targeted and recruited to participate via email, phone, and in-person discussions. Interviews were conducted until saturation related to the primary research questions was reached (14).

Retainment

Data gathering was conducted in one primary interview with each of the interviewees, in order to minimize time demands on participants. Most interviews lasted between one and 1.5 hours. Follow-up information was requested via email from a few individuals to clarify specific points. One interview was started in February 2009 but due to the participant's time constraints had to be stopped early and rescheduled for July 2009; this was the only individual interviewed more than once, and was counted as one interview for data reporting. Participants did not receive any compensation for their participation.

Data collection

Data collection was performed via a variety of sources of evidence, in keeping with rigorous qualitative data collection methodologies (15). Data collection occurred primarily via key informant interviews. Additional sources of evidence included documentation and direct observations of organizations' preparedness policies in practice. Examples of the types of sources of evidence used in this research are summarized in Table 1. Additionally, notes were recorded after each interview, including interviewee responses to questions and lead investigator observations. Memos reflecting on the interview were also created following each interview.

The lead investigator conducted all interviews.* Interviews were semi-structured, based on a general interview guide (see Appendix), which provided a list of open-ended questions that allowed for follow-up probes to explore and understand participant responses in greater detail (16, 17). The order of questions differed between interviews to solicit maximum potential variation in participant responses. In some cases, participants would address issues intended to be explored later in the interview; in these cases, the interviewer would follow that line of conversation and explore the issue raised so as to not interrupt the participant's current thought. Due to time constraints, not all questions were asked in all interviews. Rather, questions on the subject areas of interest were prioritized and explored first, followed by other questions on related subject areas.

Questions related to the following areas were most commonly used to solicit information on the subject areas of interest for this analysis: the current state of preparedness within organizations; pandemic plan components, including which components were considered to be most important and least important; preparedness activity over time, with special consideration of changes based on the 2009 H1N1 influenza pandemic; lessons learned and model practices related to preparedness efforts; changes organizations would make if starting their efforts over; advice for other businesses; the role of public health agencies in advising private sector pandemic preparedness efforts; and opportunities for resource sharing. Additionally, participants often mentioned plan components and reflections as part of responses to other lines of questioning. A comprehensive list of items was coded, rather than just those identified by participants in response to the particular questions identified above.

Given participants' various roles and organizations, questions were modified slightly for different types of interviewees. Each participant who was currently working or previously worked in a private sector organization was asked about his or her experiences with that organization in particular and/or any other organizations with which he or she was familiar. Both participants who were consultants were asked about his or her experiences with private sector organizations in general. Each participant who was a public sector planner was also asked about his or her experiences with private sector organizations in general, as well as his or her specific experience as a public sector employee interacting with those organizations.

All interviews were recorded using a digital voice recorder. All participants agreed to have their interviews recorded. Participants were told the recorder could be stopped at any time if they so chose; in a few interviews, participants did ask to stop the recorder to share sensitive anecdotes about organizational preparedness. None of the information from those comments is reflected in this analysis. Interviews were conducted in a location chosen by the participant, from individual offices to coffee shops or restaurants. Several interviews were conducted on the phone when the participant was unable to meet in person.

* I served as lead investigator for this research.

In addition to information collected regarding organizational preparedness, publicly available information regarding the industry and size (indicated by number of employees) of the organizations current business continuity managers worked for was collected.

Analysis

This exploratory research aims to understand how pandemic planning is conceived and operationalized within the private sector. Analyses were approached using an inductive process, where themes were allowed to emerge from the data (18). Using this approach, interview data were analyzed to identify key themes within and between organizations, as described by individuals. The primary focus of this analysis was on identifying themes related to the following subject areas: components included in pandemic preparedness plans; identification of most and least important pandemic plan components or pandemic preparedness efforts; lessons learned from pandemic preparedness and response efforts before and during the 2009 H1N1 influenza pandemic, respectively; and model practices. Once themes were identified, a constant comparative method was employed (14). This constant comparative method involved comparing themes across interviews to identify consistencies and variations between individuals, modifying those themes to better fit the data, comparing the revised themes again across interviews, and ultimately developing broader conclusions through this iterative analytic process.

Transcription

All interviews were transcribed verbatim, supplemented by the interview notes recorded after the end of each interview. The lead investigator and a research assistant transcribed the interviews; the lead investigator reviewed and finalized each transcribed interview before analysis. The process of transcribing the interviews, coupled with post-interview notes and memos, led to an initial conception of the themes emerging from the data within each of the subject areas of interest. The process also allowed for reflections on potential connections between themes within and across interviews.

Coding

Once transcription was complete, each of the sources of evidence were reviewed electronically or on paper (for documentation provided from participants in paper format only) for an initial list of themes using an inductive process (18). Interview transcriptions were then loaded into Atlas.ti version 6.1.11 (Atlas.ti Scientific Software Development GmbH, Berlin, Germany) and this initial list of themes was coded. After all interview transcripts had been coded for the initial themes, transcripts were reviewed again to be sure no other potential plan components or planning considerations had been omitted from the codes developed. The amount of data associated with each theme at this point was enormous. Therefore, the initial themes were then examined in greater detail to identify and code sub-themes. Each quote was reviewed individually to determine and note the main point of the comment. These notes were then reviewed and grouped within each larger theme to determine sub-themes along which participants' comments were clustered. Participant quotes associated with each of these clustered sub-themes were reviewed to identify the best representative quotes, as well as to understand any variations in participant conceptions of issues in order to best characterize the range of responses given.

Memoing

Memos were created throughout the interview and coding process to reflect on major themes and ideas prompted by reading and coding the interview transcripts (19). Memos were used to reflect on themes, including points of agreement and disagreement between interviews. Memos were also used to reflect on connections between themes and synergies that emerged as themes were considered in more detail. These memos helped shape the development of this report by identifying options for organizing themes and sub-themes as presented here.

Validation

An important part of scientific analysis is ensuring validity. Therefore, this research was designed in such a way as to maximize validity using two different strategies. First, feedback on an initial set of plan components was solicited from individuals similar to participants (18, 19). In particular, an initial set of plan components was identified based on memos and post-interview notes, prior to coding the interview transcriptions. These were presented for feedback at a conference of private sector business continuity planners from a range of industries in the San Francisco Bay Area, as well as a few of their public sector counterparts, in August 2009. Attendees at the presentation were asked to complete a worksheet indicating whether each plan component was incorporated in their organization's plans. In addition, at the end of the presentation attendees were asked to write on an index card one thing they thought had been missed in terms of plan components or planning considerations. This information was used to critically assess the validity of data from the interviews.

Second, multiple forms and sources of evidence were used to triangulate findings (15, 18, 19). Forms of evidence included interview transcripts, investigator observations, participant-provided documentation, and investigator memos. Variation in sources was sought in terms of sectors represented by participants, and industries represented by private sector participants; area of the country in which participants were based; and time point in relation to the occurrence of a pandemic event (before versus during a pandemic event). This variation across types of evidence and participant viewpoints allowed for an opportunity to check results and better interpret the weight of different individual comments and suggestions.

Results

Study participants

Table 2 presents a description of the interview participants and organizations they represented. In total, seventeen interviews were conducted with nineteen participants. Two interviews included two individuals each; both sessions were counted as only one interview.

Participants varied in several ways. Approximately two-thirds of the interviews were conducted on the west coast and one-third on the east coast. This allowed for variation between perspectives to understand regional differences in what organizations prepare for. Similarly, approximately one-third of interviews were conducted before the emergence of the 2009 novel influenza A(H1N1) virus and two-thirds as H1N1 started to circulate, allowing for different results and insights from participants in relation to plans before and during a pandemic event. The participant sampling method achieved representation across sectors, with most emphasis by design on the private sector. All of the public sector participants were from local public health or emergency services agencies. Among those participants representing the private sector,

representation was achieved across a variety of industries. The highest frequency of interviews were with representatives of the banking and finance industry; this is in line with participants' comments that that industry tends to be most involved in preparedness activities because they are regulated to do so.

In terms of organization size, most private-sector organizations represented were very large, with 10,000 or more employees. In fact, one participant noted that some organizations are the size of communities.

> *I really consider this job, in a lot of ways, akin to what a local emergency manager deals with in a community. Any given day of the week, we're 20,000 people on this corporate campus. That's larger than a lot of communities in the area… I live in a town twenty miles [from] here that has a population of 10,000 people. So this organization is twice the size.*

Participants also noted that large organizations are more likely than small- and mid-sized organizations to have continuity planners on staff who are, in turn, more likely to be engaged in business continuity associations and networks. This often makes engaging large organizations around preparedness activities more straightforward because their planners can be easily identified and reached.

In terms of the participants themselves, most were current or former business continuity managers, but there was good representation from individuals in other roles, including consultants and public health or public sector planners.

Participant-identified plan components and planning considerations

Through the interviews, participants identified components to be included in pandemic preparedness plans as well as a range of considerations for organizations to take into account when developing pandemic preparedness plans. Components are defined briefly in Table 3 and planning considerations are defined in Table 4.

Tables 5 and 6 present how frequently each of the plan components or planning considerations was mentioned, respectively. The first column of data indicates the component or planning consideration in question was mentioned at some point during an interview. The next three columns of data are subsets of all the plan components and considerations mentioned and therefore frequency of mentions in those categories are often lower than the numbers of mentions for plan components in general. The column related to most important items was based on participant identification of the most important items the organization had worked on with respect to pandemic planning. For lessons learned, participants identified specific lessons they had learned preparing for or in response to the 2009 H1N1 influenza pandemic. Model practices represent those approaches to components or considerations that participants identified as items they currently thought were or would be the best approaches to different issues. As with any model practices, the ones identified related to pandemic influenza efforts will evolve and change over time, especially as organizations reflect back on their experience with the 2009 H1N1 influenza pandemic and identify improvements going forward.

Many of the plan components mentioned were identified by multiple participants, and were often subsequently identified as a most important action or as an area in which lessons were learned, or both. As shown in Table 5, three plan components were mentioned consistently

across interviews: general preparedness, communication, and employee education. These are described in more detail below.

In addition, several other items were mentioned as plan components in ten or more interviews. Establishing a response structure was the only component mentioned in ten or more interviews that was also identified by more than half of the participants who talked about it as a most important component and an area for lessons learned. Of the other components mentioned frequently, two were subsequently identified as one of the most important plan components by more than half of the people who mentioned them: general human resources (HR) policies and a general hygiene program. Note these represent the two general umbrella categories identified by participants.

Five plan components mentioned in ten or more interviews were subsequently identified as an area for lessons learned by more than half of the participants mentioning them: taking an all-hazards approach, response escalation triggers, absenteeism and sick leave, social distancing, and stockpiles. In contrast, many participants mentioned telecommuting policies and exercises as a plan component, but fewer than half of those mentioned either as a most important action or a component for which there were lessons learned.

There were also several components that received relatively few mentions (four or fewer interviews). These included budget, travel restrictions, case management, and recovery plans. Only one person identified a model practice in any of these areas, and that was related to recovery plans. At least half the people talking about each of these, though, talked about them as most important pandemic plan components, and many identified lessons learned in these areas.

Among the planning considerations identified, cross-sector collaboration was mentioned in fifteen interviews, fourteen of which included discussion of it as a most important item to consider. Additionally, ten identified a lesson learned related to cross-sector collaboration, and six identified a model practice in this area. Other considerations were mentioned less frequently. Half of the people who talked about information sources identified lessons learned; half of those who talked about the benefits of preparedness identified these benefits as one of the most important things to consider.

Description of most frequently mentioned plan components and planning considerations

Among the many plan components, three were mentioned by all (n=17) or all but one (n=16) of the participants: general preparedness, communication, and employee education. Therefore, each of these is explored in more detail here. Among the other considerations identified by participants, cross-sector collaboration was mentioned by fifteen participants, and of those, fourteen discussed it as one of the most important items to consider, therefore that issue is also reviewed in detail here.

General preparedness

General preparedness was mentioned in all interviews, and approximately three-quarters of participants mentioned it as one of the most important components of a pandemic plan. More than half mentioned a lesson learned related to general preparedness, and a few mentioned a model practice in this area. At the broadest level, participants talked about the fact that business continuity efforts are important and the process of planning is as important as the actual plan.

As might be expected, the importance of planning becomes most evident during an event but the efforts need to have been initiated well before that point. Businesses need to be prepared

to address employee concerns and answer questions when an event occurs. While participants noted that many large organizations had worked on pandemic influenza preparedness prior to the 2009 H1N1 influenza pandemic, the importance of these efforts was underscored during H1N1 and renewed interest in these efforts.

> *We have a draft plan that's pending internal review. We had had a draft plan for several years now, but it never got finalized, and after this last outbreak, we decided we needed to have it finalized, make it formal.*

Participants suggested that organizations that had not yet started their plans should leverage some of the information available from other organizations to determine components of interest and provide a good starting point for pandemic efforts. They also pointed out that in doing so, organizations should work to find strategies that fit their business culture specifically.

> *I think there's enough being done that nobody needs to be developing their own homegrown product. They need to go out there and review what's out there. And find what's going to fit, not just your own business environment, but literally your culture and all the cultures that you operate within. What's your business philosophy truly going to be?*

The importance of planning, not only to develop plans but also the process of planning, underscored the utility of business continuity efforts for pandemic preparedness. In fact, participants went on to describe the process of planning to be just as important as the plan developed through that process. A plan is never considered "complete," nor is planning ever finished. Rather, planning is an ongoing effort.

> *I don't really believe in plans. I believe in planning.*

Specific plans and components may not be used during an event as the situation unfolds, but the act of planning, through identifying and addressing the range of issues that may arise, makes an organization better able to respond. Part of this is because planning helps an organization know what questions to ask. Because events cannot be anticipated exactly, this may be more important than knowing the answers to questions in advance.

> *And I think one of the things we try to look at is, how do we take as much guesswork out of it when it happens. So you may not have all the answers ahead of time because you can't prepare for every contingency, but at least you can have the list of questions and the things you need to think about ahead of time so that that way you can prepare as much as possible.*

Another important part of planning is having debated and discussed potential responses to different situations before the event. Thinking about issues in advance facilitates the process so good decisions can be made in the moment.

Participants identified the importance of not starting "from scratch" during an event. That is, planning sets the stage and establishes relationships so that as new threats come to light, an organization is not starting from square one. One participant identified a lot of preparedness

efforts as planting seeds so that when an event happens, people have been primed and are more likely to act.

> *What we planners do, and the way we're trained to act is, when the window opens a crack, we go barreling through with both legs. Emails go out, things go in the newsletter, we talk it up, anybody in the elevator we buttonhole, and we prepare behind the scenes. We get our group of people that are like-minded, and we do what we can - without a lot of money usually - to plant seeds. A lot of it's seed-planting. And so that hand sanitizer thing had been run up the flagpole, had been dissed at the marketing level, and then just sort of went away. But everybody in that circle knew that that had been an option, and so when all this [H1N1] started to come down, it was like, "OK, well, get the stuff."*

Finally, planning is also important so people are ready and open to act when an event occurs. Engaging the team in advance allows them to come together more easily in an event. In fact, participants identified the fact that organizations that plan have a much higher chance of surviving an event as a reason for preparing.

> *And the more you have people prepared, and to understand who and how they should communicate when it does happen. Because you need to have good business resumption. There used to be, and I don't know if this is accurate still, but, the statistic out in my industry used to be that for every disaster that happens, only 50% of companies that are impacted by a disaster are able to resume business. And of those 50 that do resume business, within two years, 50% fail.*

In summary, participants across interviews noted the necessity of planning as a process and an outcome to help increase the likelihood of a business succeeding during and after an event.

Communication

Communication was mentioned most consistently across all metrics. All participants mentioned communication not only as a component of pandemic plans, but as one of the most important components. All but one participant subsequently identified a lesson learned related to communication plans. Communication as a component also had the highest percentage of participants identifying a model practice in this area.

Participants identified important aspects of a communications strategy specific to the private sector and aspects specific to the public sector, as well as cross-cutting issues. These cross-cutting issues included how to craft messages, how to deliver messages, when to deliver messages, and how to account for the role of the media when delivering messages.

Private sector communications. Communication is the lynchpin for a private organization's response during an event and recovery afterwards.

> *What it all boils down to is communication. It's up to us to do the preparedness and the documenting, to where it needs to be, and then you need to get the word out. And you need to continually get the word out. Because during any type of incident, I don't care if it's an infectious disease, or God forbid a bomb, or a*

> *hurricane. You need to have communications out there. And the more you have people prepared, and to understand who and how they should communicate when it does happen. Because you need to have good business resumption.*

That is, continued and consistent messaging is necessary for business resumption, which is the ultimate goal of any preparedness efforts. This messaging must be done before, during, and after any event. One important note on communication is that messages cannot be developed or communicated until HR policies have been discussed and decided. In fact, organizations' primary response for the 2009 H1N1 influenza pandemic was messaging and communication, but it required that decisions about policies had been made in advance.

> *And really what we did, basically, was inform the employees that we knew what was happening, that we didn't think it was a significant impact to [company] as of yet, but we were going to increase the availability of the hand sanitizers and bacterial wipes, and masks available to people, and gloves. So just the prophylactic stuff. But we weren't going to change any operational things. We might increase the janitorial cleaning of common surfaces, that was it.*

Executive support for messaging and communication around pandemic tended to be good because these are often inexpensive actions. In this way, communication was one of the most important actions taken during the 2009 H1N1 influenza pandemic, more so than any actual operational changes.

Participants identified multiple considerations for others to be aware of in developing their own communications plans, especially the need to develop communications plans in advance of an event so messages are ready when the event occurs. This is important in terms of being able to reach employees quickly and educate them. Additionally, participants found that talking about the pandemic threat before the 2009 novel influenza A(H1N1) virus emerged made it easier for groups such as corporate communications to come up to speed when the pandemic started. In terms of crafting messages, participants talked about the benefit of scripting messages in advance. One benefit was identifying what can and cannot be included in communications, with input from a range of internal departments, before an event happens. Further, pre-scripted messages can then be leveraged for other events and situations that may arise in the meantime. Pre-scripting messages also allows communications to be quickly rolled out during an event. In fact, one participant who was interviewed on the day the WHO formally declared the circulation of novel influenza A(H1N1) as a pandemic (June 11, 2009) provided copies of his organization's draft talking points that had already been developed to address questions about what this meant for all stakeholders. In contrast, several other participants noted that they were not able to get corporate communications on board to draft pandemic messages until the 2009 H1N1 influenza pandemic occurred, despite participants' recognition of the importance of crafting messages before an event.

> *So we had our plan, but I would say we still had some components in the plan that in my opinion, were somewhat incomplete. One of these was our communications piece, and it was because we had a difficult time persuading communications to pre-script any communications. They basically said, "Look, we'll have to see what the situation is, we'll have to see what messaging we're hearing from public*

> *health, before we can really figure out what messaging we want to put out." So I have to say with the H1N1 that was great in the respect that we got a lot of communications scripted rather quickly, and now we have them available should there be another situation.*

In this way, the 2009 H1N1 influenza pandemic offered an opportunity to move pandemic plans significantly forward, not the least of which related to further developing communications plans and messages.

Other considerations participants identified for private sector communications plans included: emphasizing first and foremost the importance of the welfare of employees in all messages; considering different messages for preparedness and response efforts; putting out messages before, during, and after an event; communicating continually during an event; planning for the time and effort required to have any messages cleared by corporate communications; avoiding words like "catastrophe" or "crisis" that might give the perception of escalation of an event; designating a press representative and making sure employees understand who that person is and his or her role; educating employees so they know how to communicate and with whom during an event; and thinking about the range of possibilities for emergency notification mechanisms, including text, telephone, email, sirens, and person-to-person communications.

Participants also identified a range of target audiences for private sector communications, including employees (with differentiation between essential and non-essential personnel); consultants and contractors, including groups such as housekeeping; departments within the organization; the pandemic task force or other core group in charge of pandemic activities; executives and other levels of management; investor analysts; government; suppliers; customers or clients; and community members.

> *…crisis communications, which historically was always thought of primarily as being media communications, but in reality it's a broad continuum. So it's communications in the area of identifying all of your key stakeholders, which could be from your employees all the way to your investor analysts, and board of directors, and government people. And all the tools that you use to communicate with them, which could be your website, it could be notification systems, it could be blast email, it could be whatever. And then that last thing is all the messaging that sort of is associated with those stakeholders.*

Those in the higher education sector noted additional special target audiences including faculty, alumni, students, and parents. Others mentioned children as a target audience, with one organization reaching out to area childcare centers and providing education to them about hygiene and influenza. One participant noted that communicating to the workforce is important not only for their own knowledge, but also in their role of communicating the organization's mission to others, such as customers and clients.

Consideration of the range of stakeholders should also include reflection on the diversity of individuals to be reached by these messages. One form of diversity occurs in terms of the different languages and cultures in different offices. Diversity also occurs from person to person in terms of the range of reactions people may have to an event or a message about an event.

Participants noted during the 2009 H1N1 influenza pandemic that individuals had a variety of responses to the same messages, and communications should account for this.

> *So we've been focusing this culture on preparedness, on outreach to different contingency audiences that have different concerns and viewpoints on these things… There's a lot of different contingency groups you have to think about relative to.*

The key here is to consistently communicate your core message despite adaptations for different groups. Above all, plans should entail connecting with target audiences in a way that makes sense for them.

Public health communications. Participants also discussed the importance of communication on the part of public health agencies. Similar to the private sector, communication is one of the most important parts of a public health department's response to an infectious disease event.

> *Risk communication for public health, I think, is the most important thing. You can talk about all the clinical medical aspects and things; that's a lot less important to me than the information you can put out.*

Participants noted above all that messaging needs to be consistent across public health and other public sector agencies in order to retain the public's trust. Participants identified this as one of the most important things the public sector needs to do in relation to communication efforts, and noted this as a lesson learned from the public sector response to Hurricane Katrina in New Orleans, as well as one of the strengths of the federal response to the 2009 H1N1 influenza pandemic in the United States.

Target audiences identified for public health communications included other public health agencies; other government agencies; community-based and non-governmental organizations; the community, including all age ranges and special needs populations; neighborhood associations; the media; and the private sector, including large, medium, and small businesses. As with any target group, communications need to be tailored to that group and the language they use. This is true for messages to the private sector as well. The private sector often uses different language and approaches than the public sector, and public sector messaging should account for such differences.

In terms of modes of outreach to the private sector, participants noted that communications mechanisms specific to the private sector would also be helpful. For example, business-specific guidance and conference calls during the 2009 H1N1 influenza pandemic were helpful for the private sector. Similarly, participants found hotlines helpful during the 2009 H1N1 influenza pandemic but wanted calls to be differentiated for different types of callers, such as business continuity professionals versus individual citizens. Finally, participants also identified social media as a powerful tool for the future, especially if they can be targeted and marketed specifically to the private sector. For example, one participant suggested public health agencies create a Twitter account targeted to businesses in particular.

Removing fear from messaging and framing preparedness for everyday benefits. Participants noted that many people do not prepare for events because the thought of different catastrophes can be overwhelming. This is especially true for public health issues, which one participant described as "particularly freaky" and another as "sci-fi-ish." Therefore, participants

talked about removing fear from messaging at both the individual and business entity levels by shifting messages away from the scary concept of a pandemic and to everyday benefits. At the individual level, this might include messaging around the utility of changing hygiene behaviors to lower risk of illness from a range of infectious diseases, with the simultaneous benefit of decreased risk of illness during a pandemic.

> *We need to find the way so [pandemic is] less intimidating. And that's why I'm saying we need to keep falling back to [messaging around] if you don't want to catch a cold, the things that you do not to catch a cold probably, hopefully are going to be helpful when something [like pandemic is] coming around.*

This type of messaging can also be done on an organizational level. An organization choosing to prepare is making a business decision like any other; justifying this based on fear is not effective on its own to encourage business investment. Rather, presenting facts and probabilities to executives will be more effective at getting them engaged with preparedness initiatives.

> *I think one mistake most companies make, particularly in terms of pandemic fatigue, is to just position it as just being about pandemics. Again, you've got to make it more general than that. Show them there can be an immediate advantage to doing this - there are all these other contagion-based threats, and this is why you should be concerned. Not because of pandemic, which may never happen is what they're thinking - history tells us it will, but the average person is thinking, "Not in my lifetime." So I think over-emphasizing pandemic as being the objective of this can really start to lose management support, the attention of your staff, and so forth. You've got to bring it down to what is the advantage to you today.*

For example, short-term benefits of a telecommuting policy for things like snow days could be a reason to develop a telecommuting program that is also necessary for a pandemic. Focusing on immediate benefits such as these will help both individuals and organizations get on board with pandemic preparedness.

Delivering the message. In addition to preparing communications messages, having a plan to deliver those messages to target groups is equally important. First, participants noted a range of potential delivery mechanisms, including telephone, text messages, email, and sirens. Call trees, as a low-tech option, are simple and effective. Utilizing the existing communication structure will often also be effective. This structure may include staff emails, weekly newsletters, periodic staff trainings, web-based trainings, communications networks used for other purposes (e.g., televisions in elevators), or internal employee websites. Participants also noted that practicing how to use each option is important to identify and fix any problems in advance.

Second, participants identified suggestions for how public health and private sector organizations might reach each other. These mechanisms must include a way to gather feedback from private business for public health and vice versa. Suggestions included holding conferences and/or conference calls between the public and private sectors; having business representatives in the emergency operations center who would then share information back to the business community; communication through business organizations, word of mouth and business networks; and using the internet, and social media such as blogs or Twitter, to push information

out. The suggestion to deliver messages to the private sector through business associations and organizations was raised by several participants, and is further explored below in the section on cross-sector collaboration. One document provided by a participant talked about notification protocols for coordination between a group of emergency response and healthcare agencies for any medical events in his community. This document highlighted three main points, which have relevance for any groups of organizations working together: (1) notification between agencies is important, even when the notification may be to let others know that no action is currently required; (2) organizations need to work ahead of time to develop protocols to help define who needs to be notified for different events, as well as timeframes and delivery mechanisms for when and how they will be reached, respectively; and (3) the person in charge of collecting and disseminating information has to be trained on his or her role and trusted across agencies.

Finally, in addition to continuous communications, messaging must also be consistent. Employees need to hear consistent messages from different individuals and groups throughout the organization.

> *But one of the things we try very hard to do is make sure we put out the same, consistent message to everybody. Because the most damaging thing we can do is to put counteracting information out there, things that are conflicting.*

Each of these considerations was identified in terms of developing ideal communications delivery mechanisms for both the public and private sectors.

Timing messages to capitalize on public interest. Timing of messages was a theme that was mentioned by several participants, especially around capitalizing on public interest in an event. Participants noted as an overarching lesson learned that interest increases during an event or if an individual has a personal experience with an event. The types of personal experiences identified ranged from executives talking to someone on a plane about a given risk to being affected personally by an event or feeling fear about an event. For example, participants noted that employees were more likely to pay attention to hygiene messages for pandemic influenza if they were at risk during SARS. Similarly, interest in influenza prevention messages increased quite a bit during the 2009 H1N1 influenza pandemic.

> *From a senior management perspective, from an employee perspective, I would say the interest has been low. We have an internal website, called [name of influenza prevention website], which is a site where we have a lot of pandemic-related information, healthy habits campaigns, things like that. I would probably say that site hadn't been hit, it was minimum clicks over the last couple years. But in the last couple months, it's getting a lot of traffic, we've driven people there for information, so the thing is completely flipped around.*

Given this increased interest during an event, participants in business continuity roles identified that their job is to prepare for events, so that once interest increases or an event occurs, the organization is poised to react with well thought-out plans and policies. This was identified as a model practice as well as one of the most important preparedness actions.

> *You have to deliver the message when people are ready to hear it. And unfortunately, most people are not ready to hear the message until something*

happens. So you need to be positioned so that you can deliver the message as soon as something happens. Because I can guarantee you if we had sent out a big thing on pandemic planning at [company] two weeks before the H1N1, nobody would read it. I mean we send out all kinds of stuff all the time and nobody reads it. But I guarantee you that week that H1N1 hit, everybody was asking us what our pandemic plans were. Not everybody, but, you know, there was just much more of an audience. So it was a good opportunity to review a lot of things.

In this way, planning requires a lot of advance work and laying foundations so when an event happens and interest increases, the organization is not starting from scratch in its efforts.

Role of the media. The role of the media for emergency events was an important lesson learned during the 2009 H1N1 influenza pandemic. In particular, participants noted that the media's portrayal of an event can lead to escalation of the event, especially by sensationalizations that cause fear in the public. While this was expected, the lesson learned was that organizations' communications have to adapt to how things are being handled in the media because that is likely where employees are getting most of their information.

You have to know what people are hearing from the media and how they are interpreting that and digesting it to make your message relevant.

While public health messages were good for general awareness around the pandemic in the general public, participants felt media coverage of the pandemic far overshadowed most messaging. This makes clear, consistent, and strong messages even more important from an organization and public health perspective as an event is occurring.

In summary, participants noted that communication is a key part of any pandemic plan for both the private and public sector and is especially important for a mild pandemic virus that does not require activation of more aggressive pandemic responses, such as that caused by the 2009 H1N1 influenza. Participants talked about crafting messages to minimize fear and emphasize everyday benefits of preparedness, how to deliver messages, the importance of timing messages to capitalize on public interest, and the role of the media in communications.

Employee education

Employee education was mentioned as a pandemic plan component in all but one interview, but only half of those who mentioned it said it was one of the most important components. Fewer than half of interviews included identification of a lesson learned related to employee education, and no one identified any model practices in this area.

Employee education was an area that many participants mentioned as an important plan component even before the 2009 H1N1 influenza pandemic. Given the mild nature of the 2009 H1N1 influenza virus, education and communication turned out to be two of the most important response activities identified for the pandemic. Participants talked about education to reinforce messages over time to make desired behaviors ingrained, especially focusing on hygiene and environmental sanitation. In addition to the content of education campaigns, participants talked about delivering messages to employees and lessons learned from the 2009 H1N1 influenza pandemic.

Participants noted an ideal approach would be one in which employee education was done before an event with consistent messaging over time to reinforce desired behaviors and targeted at all levels of employees within the organization. This ongoing reinforcement of behaviors would ideally lead to hygiene behavior being ingrained for day-to-day activities. Participants noted the importance of this approach for two reasons. First, individuals will revert to familiar behaviors during an event, so if good hygiene has become a habit before the event, they are more likely to follow good hygiene behaviors when something happens.

> *How do we get it to be behavior that can be ingrained, as opposed to behavior you want to pull out when bad things happen. We don't want that because people won't do it.*

Second, as discussed above around removing fear from any communications, good hygiene on a day-to-day basis has short-term benefits in terms of reducing illness and absenteeism.

> *Well first of all, we want to mitigate that risk because, I mean what has been proven is when you come out with a program that deals with things like hygiene in the workplace, and you see hand sanitizer all over the place… it's been proven that if a company has a program like that, absenteeism during the seasonal flu season is reduced. So right off the top, you've got a good business case to do this.*

Private sector participants noted that in addition to protecting employees, educating employees has the added benefit of reinforcing that the company cares about them.

> *…turnover can be less if you treat your employees well and extend even just basic orientation and training around "here's some threats in your area."*

Despite these benefits, education campaigns can carry significant costs, from resources required to develop messages to costs of employee time required to learn about desired behaviors. These costs should be accounted for in planning efforts.

In terms of content, participants educated employees about influenza, organizational policies, hygiene behaviors, and sanitation and cleaning of the environment. Education around influenza included helping people understand not only what influenza is, but also what a pandemic is and the current influenza situation. Messages around organizational policies included understanding employee roles and how employee information is protected. For example, one participant described her organization's strict policy about employee anonymity and escalation procedures if an employee was sick with the 2009 novel influenza A(H1N1) virus, and how they prioritized sharing this policy with employees. This will help employees know what to expect and know that they are protected if they get sick. Hygiene messages included raising awareness of healthy habits in general, specifically focusing on hand hygiene (hand washing and use of hand sanitizers) (20, 21), respiratory hygiene/cough etiquette (covering coughs and sneezes) (21), and proper use of personal protective equipment (PPE), such as facemasks and gloves. In particular, participants expressed concern that incorrect use of facemasks and gloves renders them ineffective but may give people a false sense of security. Sanitation and cleaning of the environment was an important aspect of hygiene, including educating people about use of cleaning agents and how to clean their workspaces. Participants

also discussed the importance of educating employees about social distancing to reduce intensity in the workplace, by being aware of high-touch areas such as elevator buttons and doorknobs and limiting face-to-face interactions with others.

In terms of developing messages, hygiene campaigns developed by public health authorities that can be used directly in businesses were especially helpful; development of such materials was identified as one of the most important actions public health agencies can take to support businesses.

> *The whole package thing they put together for businesses… oh yeah, they did one for city agencies and for businesses. And we all are using that. We just pirated this stuff completely. It's so beautifully done.*

It is important to note that the development of education campaigns requires employee policies to be developed and fleshed out in advance.

> *Most important – well, I was going to say the education and awareness, but you've got to prepare the documents first.*

That is, working through HR policies is critical to preparing any employee education campaigns, as messaging will inherently address employee policies and questions. This messaging can't be done until decisions have been made and policies developed.

Finally, it is important to ensure that messaging and education are clear and reliable. For example, participants suggested that education should include clarification of any jargon for employees. They also noted that it is important to clarify that any information or advice is from a public health agency or other medical expert, and that the organization is simply passing that information on.

Similar to mechanisms for reaching employees with general communications about an event, participants identified the need to utilize a variety of mediums to reach employees for ongoing education efforts, including through regular employee outreach mechanisms, exercises, posters and other printed materials, web-based trainings, handouts, taglines in emails, and internal employee websites.

> *It's really important for our employees to understand it. So we're very excited to get this [web-based training program] rolled out. Now, I mentioned that we've also done email communications through our global marketing department. And we have something, a weekly [online] newsletter that goes out, they put blurbs in that. And, also there is a page dedicated to this on our internal website for employees, and with resource [websites] for them to go, like you know, we'll provide them to WHO, and CDC, and for the U.S., the government has that pandemic website, you know, pandemic.gov?*

One participant further suggested that those mediums that don't require person-to-person contact (e.g., emails, computer-based training, information sheets) are best for delivering these messages during an event in which exposure to illness is a concern.

Participants noted that their efforts were complemented by public health hygiene campaigns for the general public, which increased community awareness of the threat and reinforced hygiene messages employers were delivering to their employees.

Finally, participants noted several lessons learned from the 2009 H1N1 influenza pandemic around employee hygiene campaigns. First, while hygiene programs prepared for a more severe influenza strain, such as H5N1, had to be adapted, they were a useful starting place for 2009 H1N1 influenza pandemic efforts. Second, the focus of messaging for the 2009 H1N1 influenza pandemic was mostly around staying home when sick and practicing good hygiene in the workplace, more so than any more involved efforts.

> *Everyone knew from the work that they had done on developing plans for H5N1 that there were those good hygiene practices. And they knew to stick up posters. And amongst those were, "Don't come to work if you're sick."*

Third, social distancing and staying home when sick are particularly challenging in the United States because of the culture of coming to work despite illness and lack of paid sick leave for many workers. One participant noted that the focus on staying home when sick was further reinforced by other employee hygiene campaigns, as workplace campaigns created a sense of the importance of protective measures in the workplace, and subsequently led to group expectations and pressure to not come to work and infect co-workers if sick. Several participants also mentioned that hygiene education efforts among children could be effective because these tend to be reinforced in the home and lead to subsequent behavior change in the workplace. Additionally, one participant noted that managers need to be trained on when to send someone home, especially in terms of being careful not to discriminate against any employees.

Such a multi-pronged approach to education around behavior change reinforced messages among employees with the goal of making behaviors ingrained so as to decrease illness due to future pandemic and non-pandemic respiratory illness events.

Cross-sector collaboration

Cross-sector collaborations for emergency preparedness efforts can and should occur on a variety of levels, and the interaction between public health agencies and the private sector was one of the main topics of the interviews. Pandemic planning and the 2009 H1N1 influenza pandemic in particular offered an opportunity to exercise plans understand the gaps in public-private interactions. Participants from both groups identified lessons learned and suggestions for the future around these interactions, in order to optimize collaboration. Participants talked about the importance of engaging each other; establishing trust prior to an event; understanding how public health guidance is used in the private sector to guide efforts on both sides; establishing sustainable collaboration mechanisms; and exploring opportunities for resource-sharing.

First, participants talked about the importance of building relationships before an event. In terms of businesses reaching out to engage public health authorities, private sector participants noted that building relationships with public health and other public agencies is one of the most important actions to take in preparedness efforts. Participants felt these relationships could be critical in an event.

And the more you work with people and get to know them, the easier it is, when something happens, and there is a crisis, then they can pick up the phone and call. I know that sounds really small-town, but it's very helpful.

In contrast, however, while the public sector talked about building relationships prior to an event, they then noted that during an event they are not going to be available to answer specific questions and calls, regardless of a relationship.

A lot of businesses obviously are planning for the event, but in an emergency, they want to be able to pick up the phone and call us directly, and have sort of this open channel of communication. They want to know exactly what we are doing and when we're doing it, what the recommendations are. And sort of figuring out how we're going to communicate with them has been challenging, because they're used to getting information quickly, in a quick turnaround time, and the government is obviously slower. And in an emergency situation, they aren't necessarily the most important people. The person running the show isn't going to be answering the phone for them, or really many other people.

Despite this disconnect, participants on both sides recognized that information sharing and collaboration before and during an event is important, and that both sides need to initiate and build relationships to improve collaboration. They also noted that this can become quite complex on the private sector side as organizations grow in size and number of locations, making establishing and maintaining local relationships in each corporate office location much more difficult.

Second, participants talked about engaging businesses in advance as one of the most important actions public health agencies can do for pandemic or other infectious disease preparedness. This engagement is important to establish trust and give organizations a say in their involvement and role.

But you've got to sit at the table with them, and what it comes down to is a trust issue in the beginning. That's probably the most important thing is, I think both parties have to feel like they're getting a benefit out of whatever it is. If the private sector feels government's just going to approach them and ask for them to give, give, give and in return they're not getting anything other than regulation or requirements placed on them…

Several participants noted that the private sector's experience with government has typically been that government only provides regulations and "punishments," rather than guidance and collaboration. A collaborative approach of involving the private sector in advance will help change the perception of public-private interactions among the private sector and help public health authorities achieve meaningful participation from businesses. One public health participant talked about inviting the private sector to participate in an ongoing public sector pandemic preparedness call and how helpful this was, especially in terms of the energy and thoughtful participation businesses provided. This engagement will also help establish trust. For example, many organizations are concerned about liability around their involvement in response

to events. Proactive collaboration can help businesses be sure they are protected from a liability standpoint and are therefore able to contribute meaningfully during an event.

> *So we're trying to figure out a way that we can be a good corporate citizen. And I know a lot of large companies try to do that… So I think we need to look at - you need to help us help you. You need to safeguard my world so I'm not vulnerable because I tried to do the right thing. So some of the pandemic planning you see now is sort of based a little bit more on that. And I hope that that continues, and you'll see some Good Samaritan laws being changed, sort of increase the voice around corporate involvement and all that stuff, and I'm not saying that any of the companies wouldn't step up and do the right thing at the time of disaster, but we don't want to have to do that, right? We want to make sure that we're available to help and we're part of the planning, we're part of that community outreach for doing what we can before something bad happens.*

As suggested here, limiting private sector liability may involve changing things like Good Samaritan laws or, as other participants suggested, relaxing regulations during an event. One participant also suggested incentives like a tax break for business preparedness.

Third, an added benefit of these collaborations is that public health agencies can learn about the impact of their different actions and pieces of guidance on businesses. For example, one participant from a higher education institution noted that "shutting down" a university is very different from shutting down a K-12 school, because universities have students who live on campus and cannot necessarily just leave. This is especially important for international students. Therefore, they worked with local public health authorities before the 2009 H1N1 influenza pandemic to explain that impact. During the 2009 pandemic, that information helped public health authorities in their decisions around advising school closures and university closures.

The private sector also needs public health guidance, especially to justify or guide business actions internally. This can range from providing general guidance to answering specific business questions. However, businesses noted during the 2009 H1N1 influenza pandemic that they were most concerned that public health guidance be reasonable in terms of recommendations that have an impact on the private sector. Establishing two-way communication for both sectors to provide feedback to each other would allow public health authorities to understand how businesses use their guidance and the impact those recommendations have, so guidance can be developed to be optimally effective to achieve both public health and business goals.

Fourth, in addition to the importance of engaging businesses, participants also discussed how public health agencies might do so. Suggestions included proactively sharing information and summarizing the state of the knowledge; developing planning guides; developing hygiene plans and kits for businesses to use in their efforts to reach employees; holding forums, workshops, conferences, conference calls, and seminars for the private sector; providing consulting services to businesses around their plans; participating in private sector events and exercises; inviting private sector participation in public sector conferences and meetings; including a business representative in the emergency operations center (EOC) to share critical information through their business networks and thereby lessen the burden on public health agencies in an event; including the private sector in public sector exercises; and participating in and reaching out to businesses through business organizations and professional associations. In

particular, this last option of engaging businesses through associations was mentioned by multiple participants, from both public health and private sector perspectives. This approach is attractive because it allows public health departments to reach the maximum number of businesses through each interaction with businesses, not only through direct interaction in groups but also by businesses sharing information with others through their professional networks.

> *What I was able to do was take that information and distribute it to the larger corporations, to the people that I know, and get that word out for them. So just that one step, that one meeting, with one organization got [public health] exposure to every major corporation in the city.*

Resource limitations are such that without accessing businesses as groups, most public health departments would not be able to establish relationships with all the businesses in the community. While some, better resourced public health departments have adopted more intensive models, participants in this study thought the approach of accessing businesses in groups was a model practice for public health departments with limited resources.

> *We don't have enough people to go out to every single business and speak with them. So we really focused on speaking at different business organizations. Reaching out to more organizations where you have a lot of representatives from a lot of different businesses is the strategy that we took… We just had to make the decision that if we're going to communicate with businesses, it has to be in larger group settings or communicating with many people at once.*

This offers a more streamlined way for public health departments to reach a range of organizations at once with messages as well as a feedback mechanism for public health authorities to understand the impacts of its guidance on the business community.

One of the key lessons learned from the 2009 H1N1 influenza pandemic was the importance of planning locally based on the severity of an event in the local community. When talking about public health and private sector interactions, participants further noted that these groups should work together to better understand what severity means locally and what each sector can absorb in terms of "damages" during an event. This includes understanding and defining what losses would be acceptable in the community; those local thresholds will help define responses for that community.

Finally, participants also talked in detail about public-private collaborations related to stockpiling and resource sharing. Pandemic preparedness has raised a range of questions around stockpiling, including business access to points of distribution (PODs). Some private sector organizations are participating in discussions about dispensing and storage sites. For example, one participant described a program in which large private sector organizations are working directly with public health departments around distribution of stockpiles for employees, thus decreasing the burden on community-based PODs.

Participants also identified opportunities for improved public-private resource sharing at a broader level. In particular, they noted that the private sector is willing and able to collaborate on preparedness efforts and inherently has many of the capabilities necessary for an effective response.

> *Yeah, well it is interesting because we were always so concerned as [the public sector] to be seen as the end-all, be-all, when A) it's not our role, and B) other people do it better. It's just the way of the world. If I am somebody that does logistics for a global company every day, I'm going to do that better than somebody that doesn't do that every day, and then has to do it under pressure during an emergency. You only do what you know.*

Given this, participants in the private sector talked about a model practice of engaging businesses around their core competencies by asking businesses to contribute those capabilities they already do and do well, rather than asking organizations to start to do things they don't do well. In particular, several private sector participants mentioned that one thing the private sector does not do and would prefer to not be responsible for is distributing drugs and vaccine. Leveraging private sector resources for many other components of response would ideally free some public sector resources to handle this portion of the response.

In summary, participants identified not only the importance of cross-sector collaboration, but also suggestions to improve the work already being done in this area. This included engaging in collaborations earlier and more often, especially to establish trust. Improving public health authorities' understanding of how the private sector utilizes guidance will ideally lead to more targeted and useful guidance over time. Utilizing existing business organizations and networks to streamline the demands on public health agencies is one suggestion identified to make collaborations sustainable from a resource perspective. Finally, opportunities for additional resource sharing were identified.

Least important actions

Participants also identified some plan components and actions taken that they thought were not helpful or were among the least important actions taken. Four were mentioned by two or more participants. Each of these is described below.

First, one of the public health participants talked about the fact that it is unhelpful for private sector organizations to not follow public health agencies' advice or be non-cooperative with public health authorities. For example, this individual described local high schools that closed during the initial 2009 H1N1 influenza outbreak per public health recommendations, but then continued to hold sporting events. The participant suggested it is much more effective to follow public health agencies' advice completely. Similarly, the lead investigator noticed during a different interview in a business building that people were sharing snacks in a common area, in the midst of the first wave of the 2009 H1N1 influenza pandemic. This was despite public health guidance around social distancing and precautionary hygiene measures. Again, this was not helpful from the standpoint of infection control efforts, which are in the best interest of employees and employers alike.

Second, two participants noted that it is not helpful when the public sector doesn't reach out effectively to collaborate with the private sector before and during an event. One participant noted this in terms of a lack of collaboration involving the private sector in response activities and leveraging private sector capabilities. The other participant talked about this in terms of the public sector trying to reach businesses through the Chamber of Commerce only, and that that is not an effective way to reach most businesses. In both cases, participants felt the efforts of the public sector to reach out to the private sector were limited and not as effective as other approaches might have been.

Third, four participants speculated that public health guidance that advised actions that weren't necessarily effective were not helpful actions. For example, one person noted that public health authorities advised use of facemasks early in the 2009 H1N1 influenza pandemic, despite a lack of evidence indicating that facemasks are useful in limiting the spread of influenza in the general population. Another concern was that some of the mitigation efforts adopted during the 2009 H1N1 influenza pandemic, especially related to social distancing, had unintended consequences and therefore were not necessarily helpful actions overall. For example, closing stores in Mexico led some to increase travel into the U.S. for shopping needs; closing schools led some students to meet in malls and other locales instead.

One final theme in participants' responses to what were the least important or helpful actions in pandemic response was that four participants indicated that nothing was unhelpful or unimportant with the exception of stockpiling some items. Rather, each of these participants suggested that all time and effort spent on pandemic preparedness is helpful and useful in some way, even though specific purchases and stockpiles may not have been useful.

> *Other than [procurement of N95 facemasks] … I think actually, most efforts where people have actually done something there's been value that I've seen.*

> *No [nothing was unhelpful]. I, honest to God, because I don't think you can do enough on this.*

> *Nothing that I know of… I think it would be related to purchases that they, if they felt there was something that was a waste. I don't think anybody would say that the time they spent in planning and - even though they're now going back and almost everybody is going back and amending their plans. From a business continuity standpoint that's expected.*

This lesson is especially important, as organizations need to consider justification of future pandemic planning efforts, to show that these efforts are not a waste of time and are beneficial to the company regardless of whether an event occurs.

Validation

Attendees at the August 2009 presentation of preliminary results were primarily business continuity managers from private industry, although at least one public sector representative was present. Approximately 50 individuals attended this presentation; of these, 30 provided feedback on the identified plan components and 19 provided input on potential gaps or areas to explore. Some of the attendees at this presentation were interview participants. However, input and feedback from presentation attendees was provided anonymously, and not all attendees filled out a worksheet or index card, so it is not possible to know if interview participants are represented in these responses.

Table 7 presents data provided by participants on their organizations' industry and size. Similar to study participants, the highest frequency of respondents were from organizations in the banking or finance industry. Industries represented by interview participants but not by conference attendees included professional services, real estate, and media. However, additional industries represented by conference attendees that were not represented in the interviews included insurance, transportation, healthcare/pharmaceuticals, and manufacturing.

In terms of organization size, conference respondents were most frequently from organizations with 1,000 to 9,999 employees. This is in contrast to interview participants, of whom none were from organizations with 1,000 to 9,999 employees; rather, the majority of organizations represented by interview participants had between 10,000 and 50,000 employees. Conference attendees therefore provided a broader representation of organizations of different sizes and industries.

Table 8 presents the frequency with which conference attendees confirmed having incorporated specific plan components into their organization's plans. Due to presentation time constraints, not all plan components represented by interviewees were presented. A comparison of component frequencies showed that responses between interview participants and conference attendees were generally similar. In particular, escalation procedures (triggers), definition of critical functions, absenteeism and sick leave policies, social distancing policies, telecommuting policies, employee education, and stockpiles were mentioned by at least half of the people in both groups. Similarly, budget and case management were mentioned by fewer than one-third of participants in both groups.

Three plan components were identified as part of an organization's plans among more than half of conference attendees, but not among interview participants. These were creating a pandemic task force, considering preparedness of supply and distribution chains, and developing travel restriction policies.

Conference attendees were also asked to identify any plan components they thought had been missed in this initial presentation. Several of these items had been included in the analysis but were not included in the presentation due to time constraints. For example, one attendee identified that telecommuting efforts need to be tested and refined; this is included in the considerations interviewees had identified. However, a few suggestions from conference attendees were covered in neither the presentation nor the interviews. First, one attendee wanted to know about how policies are actually implemented in organizations, which was outside the scope of the current research study. Two other questions related to understanding the corporate obligation to be prepared at a broader level, and exploring more about vendor interactions. The latter was touched upon in terms of supply and distribution chain considerations, but neither had been explored or mentioned in detail by interview participants.

Discussion

Variation in perspectives was achieved through recruitment of participants from a range of organizations and positions related to pandemic preparedness activities for the private sector. Good representation was achieved from both the public and private sectors, and within the private sector, across industries. In addition, interviewing people before and after the 2009 H1N1 influenza pandemic added a level of depth to the results in terms of lessons learned and practical use of policies and plans. This multi-faceted approach to variation allowed for a unique analysis. In addition, participants themselves identified three main sources of information for business planning efforts: public health experts, consultants, and other companies. The fact that participants represented each of these groups indicates that the analysis reflects many of the same sources those in the business continuity profession turn to for advice and guidance on their plans, potentially making these results even more useful for private sector preparedness going forward.

When examining the frequency with which various plan components were mentioned (Table 5), several items were highlighted based on how frequently they were mentioned. In

contrast, two items stand out for the fact that they were mentioned infrequently. First, one may have expected budget to be mentioned often because it seems like something that would be most important for any efforts to effectively start. However, budget may have been mentioned less frequently not because it wasn't necessary but because it was not one of the most pressing items for an event as mild as the 2009 H1N1 influenza pandemic. In fact, several participants noted that the budgetary needs for the 2009 H1N1 influenza pandemic efforts were low compared to the needs for other types of disaster preparedness and response efforts. Participants identified that the main response for the 2009 H1N1 influenza pandemic was communications and some provision of hygiene and cleaning supplies. In contrast, a more severe pandemic would potentially be much more expensive if, for example, large amounts of antiviral drugs needed to be purchased or employees took significant leave time.

Second, the relatively low emphasis on telecommuting as a central part of corporate pandemic plans may reflect that this is not a universal solution because of how many functions need to be done physically on site. The mild nature of the pandemic 2009 novel influenza A(H1N1) virus probably also contributed to this in that participants noted telecommuting was not a strategy that was activated on a large scale for most organizations during the event. Rather, hygiene at the workplace was given greater emphasis. This may explain why participants discussed telecommuting as a policy less frequently, and also why fewer lessons were learned around this component.

Examination of participants' comments on the importance of preparedness in general was possibly not surprising given that all of the participants were involved with preparedness efforts in some way through their jobs. However, the lessons learned about planning in general based on the 2009 H1N1 influenza pandemic experience are useful to help guide future private sector preparedness efforts. In particular, participants talked about looking to existing private sector plans as a starting place for organizations to initiate their planning. However, a gap existed in that participants also noted that very few organizations' plans had been made public. This analysis is one way to bridge that gap and provide information on what organizations did and what lessons they learned without violating any concerns about confidentiality. In fact, one participant suggested that such a "broker" role might be potentially useful for public health agencies to play going forward.

> *I like to share. I'm all over the place talking about one topic or another, almost never in reference to the bank, but in reference to the financial sector or something of that sort… I ran our pandemic plan past legal and said, "OK, I'm assuming to start out, this is a confidential internal document. But what would be your thoughts if we wanted to give it to clients who are asking about out pandemic preparedness? What would be your thoughts about if we wanted to give it out to the world as a whole? As just a model?" And they kind of stopped short of the last one, they didn't really say no, but they said there could be some risks. So, I mean obviously if we put out anything that appears to be advice, and somebody else does what we think they should do or what we would do and they feel it has harmed them in some way – we don't want to be putting ourselves in the position of saying we're experts in this, because we're not. No one is. But who is going to sue the CDC or WHO or whatever?*

This role for public health agencies to evaluate and provide de-identified plans back to the business community with their suggestions would help guide many organizations' efforts, especially by providing another form of benchmarking for organizations. This is of special note given the importance organizations place on benchmarking, but the disconnect between that need and organizations' reluctance to share actual plans highlights an opportunity for public health agencies to provide a necessary service to the private sector.

Participants uniformly identified communication as one of the most important components of a pandemic plan. This may be tied to the frequency with which people talked about employee education around hygiene and social distancing behaviors, which was noted as the crux of response efforts for the 2009 H1N1 influenza pandemic. In fact, communication and education are closely linked for an event such as a pandemic because much of the effort that is not about education in particular will still be about messaging to employees. In order to be effective, participants noted that a communications plan needs to be developed prior to an event so it can be deployed quickly when something happens. Development of a plan, however, requires consideration and decisions around almost all other pandemic plan components. In this way, the communications plan in some ways becomes a checkpoint to review pandemic efforts overall and identify any gaps.

Participants identified a range of target audiences that public and private sector communications plans need to reach. Participants also talked about the need to tailor messages to be meaningful for each target audience and in terms that are significant to the target audience. This includes public health communications targeted to the public sector. One suggestion for this, which would have impacts at both the individual and institutional levels, was framing messaging in terms of everyday benefits instead of in terms of risk and fear. At the individual level, this may motivate more people to follow advice; at the institutional level, this could help build a business case for preparedness efforts.

The focus on finding everyday benefits to behaviors to motivate behavior change was also reflected in terms of what participants talked about regarding employee education initiatives. Participants talked about how people revert to familiar behaviors during a crisis, and so making desired hygiene behaviors ingrained in daily life would help achieve the desired actions during a pandemic. From there, participants noted that campaigns would need to focus on daily benefits of these behaviors in order to encourage change. They also highlighted the need for culture change within local offices around behaviors such as staying home when sick, a major barrier within many U.S. offices. In general, employee education, often coupled with provision of materials necessary for compliance with desired hygiene behaviors, was among those plan components mentioned most frequently by participants.

Finally, this analysis explored participant reflections on cross-sector collaborations. One concept emphasized by participants from the private sector was that public health agencies need to work with businesses to understand how guidance will be implemented; this will help public health authorities develop more targeted and useful guidance for the private sector. One example of such a collaboration was highlighted by a participant from a higher education institution who described how local universities sat down with public health authorities prior to the 2009 H1N1 influenza pandemic to discuss the implications of "shutting down" a university. This helped guide public health authorities' recommendations for universities during the pandemic, and made universities more effective in mitigating the pandemic for their populations. This is the type of collaboration both sides have a responsibility to do. The key is to make this level of collaboration manageable resource-wise for public health agencies and the private sector alike, which is where

collaborations through groups of businesses are especially helpful. In fact, one concept emphasized by both public health and private sector participants was using business associations and networks as a more streamlined way for public health authorities to interact with a group of businesses at once, as well as using those networks as a conduit to push public health information to private sector organizations that may otherwise be difficult to reach.

In general, while many participants felt they had established good relationships with their private and public sector counterparts, they also identified opportunities for improved collaboration across sectors. One such suggestion focused on opportunities for resource sharing. Private sector participants noted that the main thing they were not comfortable taking responsibility for in their plans was delivering and administering vaccines and antiviral drugs to their employees; in contrast, public health participants noted this would be one of the best things the private sector could do to lessen the burden on public health agencies during a pandemic. This was probably the most significant point of disconnect between the two sectors, and participants identified opportunities to address this issue. One opportunity was finding ways to share other resources from the private sector that may alternatively lessen the burden on the public sector in an event and allow them greater availability for dealing with delivering and administering medications. This may also be an opportunity to work collaboratively at a broader level around defining the corporate obligation to employees in an event, which was one of the gaps noted by attendees at the August 2009 conference at which preliminary results were presented.

When asked about the least important pandemic preparedness steps taken, two responses in particular stood out. First, one theme was that the two sectors were not achieving the best practices identified for each other. The private sector was not following advice to the extent public health authorities wanted it followed; public health authorities in some cases were not reaching out to the private sector or providing "good" guidance from a private sector perspective. This further highlights the need for more and better collaboration going forward. Second, it was also interesting that multiple participants didn't identify anything as a least important action except stockpiling certain materials. This may have been partly self-protective, given participants' roles as continuity managers and their counterparts. However, participants also talked about the importance of planning as a process more than as an outcome throughout several interviews, which would support the response that "nothing" was a waste of time, because the process itself is always important, regardless of the outcome of that process.

The primary limitation of the research presented here is that almost all private sector participants were from large organizations that have already engaged in preparedness activities. The concerns of larger businesses may not fully reflect the concerns of smaller businesses or those businesses that have not yet engaged in any pandemic preparedness work. However, it is expected that in terms of plan components and lessons learned, these would be relevant for many organizations, regardless of size. Attendees at the August 2009 conference presentation represented organizations of all sizes, and results between interviews and conference participants were similar, indicating that these groups do in fact have similar concerns. Future studies should explore the concerns of small- and medium-sized businesses to understand the issues and concerns they have about pandemic preparedness activities specific to their size. In fact, there is a chance that providing information from actual businesses on what plans should incorporate could lead to encouraging more organizations to start their planning efforts given participants' input that benchmarking against other organizations is one of the ways that businesses justify and build momentum for this work.

One of the primary strengths of this research was the participation of individuals who represented a range of sectors, industries, and roles within organizations. In addition, this research benefits from data collection done before and during the initial 2009 H1N1 influenza outbreak, allowing for recognition of lessons learned over time during an actual pandemic. The unique timing of this research allows for a rare opportunity to understand organizational learning related to preparedness and response to public health events, which may be incorporated to further strengthen future efforts.

This research contributes significantly to the field of private sector efforts for pandemic influenza preparedness in several ways. First and foremost, from the employers' perspective, the results of this research will help inform their decisions regarding how to approach pandemic preparedness based on rigorous research from a range of organizations, consultants, and public health experts. In particular, this research provides information on acceptable and effective pandemic planning strategies and approaches currently utilized by the private sector, especially related to the most and least important pandemic planning activities, lessons learned based on efforts before and during the 2009 H1N1 influenza pandemic, and model practices. From the public health perspective, this study will help public health organizations identify opportunities for partnership with organizations, and help target technical assistance to best meet the needs of organizations in initiating and continuing their work in the area of pandemic influenza preparedness. Additionally, this study contributes to a more comprehensive picture of preparedness efforts within the private sector. It is expected that this study will not only guide private sector efforts but will also directly inform public health agencies in their role as advisors to employers for pandemic preparedness efforts.

In addition to the direct implications of these specific aims, this research lays the groundwork for many additional follow-up studies. In particular, further understanding of how to engage organizations in preparedness planning, how to gain executive support and build a business case for preparedness, and lessons around the role of public health agencies for private sector preparedness based on these interviews will provide an even more comprehensive and applied understanding of pandemic preparedness efforts within the private sector and its collaborations with the public sector.

This work lends itself to other follow-up studies, such as further exploration of barriers to preparedness, with special emphasis on small- and medium-sized businesses, businesses that have not yet initiated preparedness planning efforts, and businesses that lack the resources to initiate preparedness planning efforts. It is expected that the barriers for these organizations will be greater than those identified by the businesses participating in the current study. Another potential follow-up study would further examine lessons learned and plan components after the 2009 H1N1 influenza pandemic has subsided. Both of these potential follow-up studies would further develop the understanding of private sector preparedness work and help improve understanding and collaboration between the public and private sectors.

Conclusion

Business preparedness for pandemic influenza is a critical component of comprehensive and effective public health preparedness. While public health agencies have provided businesses with some recommendations around preparedness for an influenza pandemic, no analysis has yet examined the components in place within organizations, especially given the lessons learned and changes to those plans based on the emergence of the 2009 novel influenza A(H1N1) virus. This

research was started before the emergence of the 2009 novel influenza A(H1N1) virus and continued while the pandemic was occurring, allowing a unique understanding of the lessons learned over time before and during an actual pandemic. Of particular note are the plan components organizations had identified in anticipation of a potential pandemic as well as the components they found most and least helpful during their experience with the reality of the 2009 H1N1 influenza pandemic, including lessons they learned and model practices that emerged. This analysis looks at the components of private sector plans from a range of perspectives of those involved with private sector preparedness, from private sector business continuity managers to consultants and public sector planners. The input from people of varied perspectives provides a robust understanding of the general plan components of interest.

This exploratory research aims to provide a better understanding of the actions of the private sector and their public sector counterparts around pandemic influenza preparedness, with the goal of informing other private sector organizations' efforts and improving future cross-sector collaborations.

References

1. World Bank. 2007 World development indicators. U.S.A.; 2007.

2. Brenner MH. Mortality and the national economy. A review, and the experience of England and Wales, 1936-76. Lancet. 1979;2(8142):568-73.

3. Benjamin GC. Putting the public in public health: New approaches. Health Aff (Millwood). 2006 Jul-Aug;25(4):1040-3.

4. Stewart WF, Ricci JA, Chee E, Morganstein D. Lost productive work time costs from health conditions in the United States: Results from the American Productivity Audit. J Occup Environ Med. 2003 Dec;45(12):1234-46.

5. PandemicFlu.gov [homepage on the Internet]. U.S. Department of Health & Human Services. 2008 January 15 [cited 2008 January 16]. Available from: http://www.pandemicflu.gov/index.html.

6. CDC business home [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2009 October 15 [cited 2010 April 6]. Available from: http://www.cdc.gov/business/.

7. Be prepared California: Businesses [homepage on the Internet]. Richmond, CA: California Department of Public Health. 2008. Available from: http://bepreparedcalifornia.ca.gov/EPO/BePrepared/Businesses/Businesses.htm.

8. Pandemic flu - H1N1 influenza (swine flu): General information for employers [homepage on the Internet]. Seattle, WA: Seattle & King County Public Health. 2010 April 30 [cited 2010 May 1]. Available from: http://www.kingcounty.gov/healthservices/health/preparedness/pandemicflu/swineflu/employers.aspx.

9. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. Business pandemic influenza planning checklist. 2005 December 6, 2005:1-2.

10. Guidance for businesses and employers to plan and respond to the 2009 – 2010 influenza season [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2010 February 22 [cited 2010 April 2]. Available from: http://www.cdc.gov/h1n1flu/business/guidance/.

11. Centers for Disease Control and Prevention.
Swine influenza A (H1N1) infection in two children - Southern California, March-April 2009. MMWR Morb Mortal Wkly Rep. 2009 April 24;58(15):400-402.

12. World Health Organization. World now at the start of 2009 influenza pandemic. 2009 June 11.

13. Patton MQ. Qualitative evaluation and research methods. 2nd ed. Newbury Park, CA: Sage Publications; 1990.

14. Glaser BG, Strauss AL. The discovery of grounded theory: Strategies for qualitative research. New York: Aldine; 1967.

15. Yin RK. Case study research: Design and methods. 3rd ed. Thousand Oaks, CA: Sage Publications Inc; 2003.

16. Bernard HR. Research methods in anthropology: Qualitative and quantitative approaches. 4th ed. Lanham, MD: Altamira press; 2006.

17. Richards L, Morse J. README FIRST for a User's guide to qualitative research. 2nd ed. Thousand Oaks, CA: Sage Publishers; 2007.

18. Miles MB, Huberman AM. Qualitative data analysis. 2nd ed. Thousand Oaks, CA: Sage Publ.; 1994.

19. Maxwell JA. Qualitative research design: An interactive approach. 2nd ed. Thousand Oaks, CA: Sage; 2005.

20. OPRP - general information on hand hygiene [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention. 2009 July 20 [cited 2010 April 6]. Available from: http://www.cdc.gov/nceh/vsp/cruiselines/hand_hygiene_general.htm.

21. Respiratory hygiene/cough etiquette in healthcare settings [homepage on the Internet]. Atlanta, GA: Centers for Disease Control and Prevention Website. 2003 December 17 [cited 2009 May 14]. Available from: http://www.cdc.gov/flu/professionals/infectionControl/resphygiene.htm.

Table 1. Types of sources of evidence utilized.

Type	Sources
Interviews	Interviews with: • Leaders of planning efforts within organizations; • Consultants or others external to organizations but with knowledge of organizational policies; and/or • Public sector planners involved with pandemic efforts.
Documentation	Documentation provided by participants, such as: • Copies of employer information or updates shared with employees related to pandemic influenza planning efforts; and • Other documentation used for pandemic influenza preparedness efforts.
Direct observations	Direct observations of preparedness initiatives implemented within an organization, as much as they were observable during visits for interviews, such as: • Availability of hand sanitizer was observable, but • Changes to employee absenteeism and sick leave policies were not observable.

Table 2. Description of organizations and interviewees.

	n	% of category*
Number of interviews†	17	n/a
Location of interview		
West coast	11	65
East coast	6	35
Timeline‡		
Before emergence of 2009 novel influenza A(H1N1) virus (February 2009-March 2009)	6	33
After emergence of 2009 novel influenza A(H1N1) virus (April 2009-October 2009)	12	67
Sector		
Public	3	18
Private§	11	65
Other¶	3	18
Private-sector industry		
Banking/finance	3	27
Higher education	2	18
Retail	1	9
Professional services	1	9
Technology	1	9
Real estate	1	9
Media	1	9
Public utility	1	9
Private-sector organization size (number of employees)#		
< 1,000	1	11
1,000 to 9,999	0	0
10,000 to 50,000	5	56
> 50,000	3	33
Number of interviewees**	19	n/a
Interviewee Role		
Current business continuity manager	9	47
Former business continuity manager	2	11
Consultant	2	11
Public health/public sector planner	4	21
Other††	2	11

* Percentages may not total to 100 due to rounding.

† Due to time constraints, one individual was interviewed on two occasions; this was counted as one interview.

‡ One interview was started in February 2009, but due to participant time constraints, was ended early. A follow-up was done in July 2009. Therefore, this interview was counted as being both before and after the emergence of the 2009 novel influenza A(H1N1) virus.

§ Includes an individual from a public health agency who was interviewed based on a short-term project with a private organization and one individual responsible for business continuity for a public utility from an employer preparedness standpoint.

¶ Includes two consultants and one individual who worked at a non-profit foundation focused on preparedness.

[#] Counts for higher education institutions include students because planning efforts need to account for students as well as employees. Counts were not available for two institutions.

[**] Two interviews included two individuals each; each was counted as only one interview.

[††] One individual was interviewed in terms of her short-term role working on a private sector business continuity plan, but her broader career was based in public health. A second individual worked for a non-profit foundation focused on preparedness.

Table 3. Description of participant-identified pandemic plan components.

Plan Component	Description	Major Findings
General preparedness*	Pandemic preparedness in general, including determining what questions an organization will need to think about in an event and identifying key decision-makers to develop a response structure.	Preparedness is important, and the process of planning is just as important as the outcome. Individuals' interest will increase when an event occurs, and an organization needs to be poised to act when that happens.
All-hazards approach	Consideration of how pandemic influenza plans can be broadened to address all infectious diseases or how plans to mitigate the impacts of a pandemic can be incorporated into a business continuity plan for all potential hazards.	Focus planning efforts on potential impacts to the organization, rather than the causes of those impacts. Broaden plans beyond pandemic concerns to look at all infectious diseases or even all hazards to make plans more relevant for a range of situations.
Establishing response structure	Determining the people and roles who will be responsible for leading an organization's response efforts for a pandemic event, including decision-making as issues arise, and practicing the mobilization and use of this structure in advance.	One of the most valuable things about planning is establishing a response structure than can be activated in an event; in many ways, this is even more important than having a specific plan. Rather, knowing how questions will be approached and how decisions will be made in the moment is more important.
Executive support	Establishing and cultivating executive support for pandemic preparedness efforts before, during, and after an event.	Executive support needs to be cultivated before, during, and after an event. Without executive support preparedness efforts will not get far.
Pandemic task force	A group that is established before a pandemic to work through planning and policies; this will often be a primary part of the response structure during an event.	Organizations need to establish a task force with cross-departmental representation. The task force should be in touch regularly over time and should be activated early in an event.
Budget	Designated budget to support pandemic planning activities, including materials and resource time necessary to work on planning efforts.	A budget is necessary to support preparedness activities, especially in terms of dedicated resource time. Given that, though, efforts for the 2009 H1N1 influenza pandemic were relatively low budget compared to many other potential events.
Communication*	Communication plan for sharing information with all stakeholders before, during, and after an event.	A communications strategy is important for both the private and public sectors. Issues that affect both sectors include how to craft messages, how to deliver messages, when to deliver messages, and how to account for information coming from the media when delivering messages.
Escalation procedures (triggers)	Pandemic levels or other triggers that guide an organization related to implementing or removing different components or policies. For example, when absenteeism within an organization reaches a certain threshold, the organization may institute sick leave policies specific to a pandemic event.	Decouple plans and phases from the WHO pandemic phases; triggers should be based on local impacts instead. Triggers should include consideration of severity in addition to disease spread.

Table 3 (cont). Description of participant-identified pandemic plan components.

Plan Component	Description	Major Findings
Human resources policies (general)	Range of human resources policies that need to be adapted in a pandemic.	Much of pandemic efforts will come down to human resources policies.
Absenteeism and sick leave	Policies around employee sick leave during a pandemic event; employees may be absent for a range of reasons, including illness or fear of illness, caring for an ill family member, or caring for a child whose school was closed due to the pandemic.	Sick leave and absenteeism were identified as important new considerations for business continuity planning based on pandemic efforts. During the 2009 H1N1 influenza pandemic, absenteeism was most impacted by school closures rather than employee illness. Organizations need to look at creating supportive policies around sick leave and changing offices cultures so employees do not come to work when sick.
Social distancing	Initiatives to reduce intensity of person-to-person exposure in the workplace, including things such as staggered work hours and alternate work locations.	Sick leave policies directly impacted whether or not social distancing efforts were effective, with people returning to work when they or their child was sick if their sick leave policies were not flexible enough. Programs to increase the distance between people in the workplace were successful overall.
Travel restrictions	Limitations or changes to policies around employee business travel and in some cases, personal travel, to limit employee travel to areas where a novel influenza virus is circulating.	Travel restrictions were not as straightforward as anticipated, with some policies having surprising consequences. For example, at the beginning of the 2009 H1N1 influenza outbreak, one company told employees returning to the U.S. from Mexico to not come to work and quickly learned that many of their employees in U.S. locations near the Mexico border were actually living in Mexico, which made this policy difficult to enforce long-term.
Telecommuting	Policies and infrastructure to support remote work or work-from-home programs for employees.	This is an important component of a plan but is not the answer for everything. Those planning to use it need to practice it in advance and may find it to be a cost-saving option for an organization overall.
Case management	Tracking potential employee exposures and illness related to a novel influenza virus, and understanding others who may have been exposed to the virus due to interaction with that employee.	Organizations trying to track and manage employee cases found it quickly became overwhelming at the beginning of the 2009 H1N1 influenza outbreak. Case definitions were not clear-cut, especially because very few people actually got tested for the 2009 novel influenza A(H1N1) virus.

Table 3 (cont). Description of participant-identified pandemic plan components.

Plan Component	Description	Major Findings
Hygiene program (general)	Workplace-based program to educate and reinforce use of interventions against influenza, including hand and respiratory hygiene/cough etiquette, facemask use, and surface disinfection.	Participants identified two aspects of hygiene: individual hygiene such as hand washing and use of personal protective equipment, and sanitation and cleaning in the business environment. Most hygiene concerns focused on stockpiling necessary materials and educating employees.
Employee education*	Education component of a hygiene program aimed at all employees across an organization with the goal of individual behavior change.	Employee education was one of the critical components of organizations' responses to the 2009 H1N1 influenza pandemic. Education efforts should focus on making desired behaviors ingrained. Content should include hygiene messages as well as information on employee policies in a pandemic event. Organizations should use a range of mediums to deliver education messages.
Stockpiles	Buying and storing materials needed for a hygiene program that can be made available in an event, such as hand sanitizer, facemasks, and cleaning agents. Some organizations may also consider stockpiling antiviral drugs such as Tamiflu.	Stockpiling hygiene agents (hand sanitizer, tissues, cleaning supplies) was considered helpful but supplies ran out much faster during the 2009 H1N1 influenza pandemic than expected, and replenishing supplies was very difficult if not impossible. Participants had varied opinions of whether stockpiling antiviral drugs was helpful.
Preparedness of supply and distribution chain	Examining and working with other businesses in an organization's supply and distribution chain to confirm preparedness of all groups that may impact an organization's functions.	Organizations need to think about working with vendors and partners along their supply and distribution chains. This includes large and small vendors alike.
Recovery plans	Consideration of programs related to long-term recovery of an organization and/or their community in addition to short-term response efforts.	Organizations need to look at long-term recovery as well as short-term response. Recovery will often involve the community and surrounding areas, as this impacts employees and whether they will stay in a given area.
Exercises	Drills to practice a plan for an event. These can range from tabletop discussions to staged events.	Exercises help find gaps in plans and practice the response structure. They also offer an opportunity to build trust amongst executives.

* This component is explored in detail in the results section.

Table 4. Description of participant-identified pandemic planning considerations.

Item for Consideration	Description	Major Findings
Cross-sector collaboration*	Communication and collaborative work between public and private sectors around pandemic influenza preparedness.	Opportunities to improve cross-sector collaboration included engaging in collaborations earlier and more often, improving public health authorities' understanding of how the private sector uses guidance, utilizing existing business organizations and networks to streamline the demands on public health agencies, and considering opportunities for additional resource sharing.
Information sources for preparedness activities	Utilization of a range of information sources for pandemic preparedness efforts.	Three types of information sources were emphasized: public health or other subject matter experts, external consultants, and benchmarking against other organizations.
Barriers	Issues with and resistance to pandemic preparedness efforts.	There are many barriers to pandemic planning efforts. For example, pandemic preparedness is particularly difficult to sell internally to employees because the thought of a pandemic is overwhelming to a lot of people.
Benefits	Opportunities and advantages that result from pandemic preparedness efforts in addition to readiness for a potential pandemic.	Planning offers an opportunity to identify and fix potential inefficiencies in processes, as well as to document processes that may not otherwise be formally captured in the organization.

* This consideration is explored in detail in the results section.

Table 5. Number of interviews that mentioned specific pandemic plan components.

Plan Component	Mentioned as a general plan component	Mentioned as one of the most important components	Mentioned a lesson learned related to this component	Mentioned a model practice related to this component
General preparedness	17	13	9	3
All-hazards approach	11	4	9	3
Establishing response structure	12	7	9	3
Executive support	5	4	2	1
Pandemic task force	7	5	2	1
Budget	3	2	0	0
Communication	17	17	16	7
Escalation procedures (triggers)	11	5	9	0
Definition of critical functions	9	4	1	0
Human resources policies (general)	11	7	5	1
Absenteeism and sick leave	12	5	9	0
Social distancing	10	2	5	0
Travel restrictions	4	2	3	0
Telecommuting	11	2	2	0
Case management	2	1	2	0
Hygiene program (general)	11	9	3	0
Employee education	16	8	6	0
Stockpiles	13	4	7	2
Preparedness of supply and distribution chain	5	5	0	0
Recovery plans	4	2	2	1
Exercises	13	6	2	0

Table 6. Number of interviews that mentioned other pandemic planning considerations.

Item for Consideration	Mentioned as a general item to consider	Mentioned as one of the most important items to consider	Mentioned a lesson learned to consider	Mentioned a model practice to consider
Cross-sector collaboration	15	14	10	6
Information sources for preparedness activities	10	1	5	0
Barriers	3	0	2	0
Benefits	6	3	1	1

Table 7. Description of conference attendees.

	n	%*
Total responses	30	100
Private-sector industry		
Banking/finance	7	23
Higher education	2	7
Retail	3	10
Professional services	0	0
Technology	6	20
Real estate	0	0
Media	0	0
Public utility	1	3
Insurance	2	7
Transportation	1	3
Healthcare/pharmaceuticals	3	10
Manufacturing	1	3
Other†	3	10
Decline to answer	1	3
Private-sector organization size (number of employees)		
< 1,000	3	10
1,000 to 9,999	13	43
10,000 to 50,000	9	30
> 50,000	3	10
Decline to answer	2	7

* Percentages may not total to 100 due to rounding.

† Other category includes respondent answers of "Staffing," "Restoration - Emergency Cleanup," and "Preparedness Supplies."

Table 8. Presentation attendee feedback on plan components.

Item	My organization has incorporated this in our plans (n=30)
Pandemic task force	19
Budget	9
Escalation procedures (triggers)	20
Definition of critical functions	15
Absenteeism and sick leave	15
Social distancing	16
Travel restrictions	15
Telecommuting	18
Case management	6
Employee education	17
Stockpiles*	21
Preparedness of supply and distribution chain	16

* Defined as including any of the following: hand sanitizer, facemasks, disinfecting wipes, and janitorial supplies; vaccines, antiviral drugs, and antibiotics; and plans for distribution of materials.

CHAPTER V: CONCLUSION

The three studies presented in this dissertation together contribute to the field of knowledge around preparedness for pandemic and other public health disasters. The papers are described here first in terms of the major findings for each individually, and are subsequently examined together in terms of how they inform the overarching hypothesis of this dissertation.

The first paper, "Barriers to and Predictors of Changes in Hand and Respiratory Hygiene and Social Distancing Behaviors among University Students Enrolled in a Longitudinal Study," describes predictors of individual changes in hand and respiratory hygiene behaviors during the course of an interpandemic cold and influenza season. This study is based on an observational analysis of a prospective, longitudinal cohort of 1,463 individuals. Participants demonstrated varying levels of adherence to hand and respiratory hygiene and social distancing behaviors in response to different situations and based on different individual characteristics. In particular, participants who were ill, whose household and/or close contacts were ill, or who were living in group situations such as dormitories reported higher adherence to behaviors during the 2007-2008 cold and influenza season. These results may help public health authorities better target future interventions, for example by focusing interventions on those who are currently sick or those who have a higher level of exposure to illness, either through contact with ill household members and close contacts or through increased contact with others via group living situations. Similarly, participants who reported being concerned about getting sick with a respiratory illness had higher behavior adherence scores, which may reinforce the importance of raising awareness about the impacts of respiratory illnesses.

Of these findings, perhaps one of the most interesting and significant in terms of shaping future interventions is that participants who perceived that their peers had expectations concerning adherence to hand and respiratory hygiene behaviors had higher behavior adherence scores over the course of a cold and influenza season. This finding is supported in a workplace setting, where Robins and Klitzman found that employees were more likely to adhere to recommended procedures for workplace hazard prevention if they reported a change in their direct supervisor's attitude to the same procedures (1). This result suggests that public health authorities or others delivering hygiene messages should target those messages at a group-level instead of at an individual-level, including in the workplace, in order to help create a collective understanding of desired behaviors. This approach might help create peer expectations and thereby improve behavior adherence overall.

The second paper, "Cost-Effectiveness of a Hand and Respiratory Hygiene Intervention in Reducing Influenza-like Illness among University Students," complements the first study by examining next whether it can be cost-effective to invest resources in interventions to change individual hand and respiratory hygiene behaviors during an interpandemic cold and influenza season. Decreased illness is expected to save costs of illness, as well as time lost from productive activities among those who otherwise may have become ill. Among university students, productive activities include time at school as well as time at paying jobs and at volunteer opportunities. The intervention examined in the cost-effectiveness analysis was based on individual change without any attention to group effects. While this approach did not show effectiveness, two similar interventions among university students at other universities that focused on interventions at the dormitory level were both effective in reducing the incidence of respiratory illness among students (2, 3). By focusing those interventions at the dormitory level,

the studies may have inherently created the sense of peer pressure that the first study suggests would lead to increased adherence to desired behaviors.

Using effectiveness estimates from the published literature that are slightly more conservative than those from the dormitory-based studies, these results indicate that an intervention that provided education and the materials necessary for compliance with hand and respiratory hygiene behaviors during an interpandemic cold and influenza season would be cost-effective at thresholds typically used in the United States. This was especially true in moderate or severe cold and influenza season scenarios. Such scenarios are characterized by moderate to high levels of several factors, including incidence of influenza-like illness; disease severity, which also impacts utilization of healthcare resources and productivity losses due to illness; interest in interventions among the target population; and staff support needs for an intervention program. In contrast, such interventions would not be expected to meet cost-effectiveness thresholds used in the United States in a mild cold and influenza season.

Finally, the third paper, "An Exploratory Qualitative Analysis of Pandemic Plan Components and Planning Considerations in the Private Sector," examines pandemic preparedness activities within the private sector in particular. This includes the components of pandemic plans that private organizations included in their preparedness efforts leading up to and during the 2009 H1N1 influenza pandemic, as well as broader considerations organizations took into account related to their pandemic preparedness efforts. Information on plan components and considerations was gathered from individuals with a range of perspectives, including private sector business continuity managers, consultants who advise the private sector, and public sector planners who interact with the private sector. The three most commonly mentioned components across the interviews were the importance of preparedness in general; that communication before, during, and after an event is important for business resumption; and that employee education on hygiene behaviors was one of the primary components of pandemic preparedness and response efforts. In fact, participants noted employee education coupled with provision of materials necessary for compliance with behaviors as an important component of their pandemic plans before the emergence of the 2009 H1N1 pandemic influenza virus, and even more so during the event. Some organizations also identified advantages of implementing these efforts before a pandemic occurs, from the benefits of reduced employee illness in the short-term to the opportunity to make desired hygiene behaviors ingrained before an event occurs so they become a natural reaction during a pandemic.

Other key findings from the key informant interviews were the importance of cross-sector collaboration for public health events and the need to identify new ways to accomplish and improve such collaboration. First, participants suggested that public-private collaboration through business associations or groups would help streamline public health authorities' interactions with the private sector and leverage existing networks of connections between businesses. Second, participants noted that opportunities for better resource sharing between sectors exist. One suggestion was that utilizing existing private sector resources (e.g., call centers, shipping and distribution networks) rather than trying to re-create them for the public sector during an event would lessen the burden on public health departments in their response efforts. Ideally, this approach would make more public health resources available to help deliver the vaccines and antiviral drugs for which the private sector most relies on public health authorities.

Together the three studies also inform and provide a basis for the overall hypothesis of this dissertation, which is that an opportunity exists to shift the discussion of private sector

preparedness for public health events from one of insurance (protecting against uncertain future threats) to one of investment (finding short-term benefits to justify business expenditures). In particular, key informant interview participants talked about preparedness activities related to workplace hygiene as an investment strategy instead of an insurance strategy, and the results of the other two studies provide further justification for this approach.

In addition to the key findings from each study outlined above, several more are highlighted here in terms of the additional justification they provide as a basis for this hypothesis. Specifically, workplace-based interventions may be particularly effective in reducing illness because they easily lend themselves to group-level interventions that create peer expectations around individual hygiene behaviors. Additionally, the costs of absenteeism and presenteeism in the workplace are of particular interest to employers; therefore, the cost-effectiveness estimates incorporating productivity losses would be the most relevant estimates for a workplace setting. If productivity losses are included in the cost-effectiveness model, interventions have the potential to become cost-saving in a severe cold and influenza season. Further, while the cost-effectiveness analysis used quality-adjusted life years to value an episode of illness, employers may be interested in monetizing the outcome by assigning a dollar value to each avoided illness. If, as these results suggest, the approach may already be cost-saving in a severe cold and influenza season, then further monetizing the benefits would make this strategy even more desirable from an employer's perspective by adding additional value to each episode of illness averted. Finally, participants in the key informant interviews talked about the benefits of changing hygiene behaviors for seasonal respiratory illnesses as a business case for pandemic preparedness activities. The possibility of short-term benefits for pandemic activities provides an additional incentive in the private sector to engage in such efforts.

Therefore, the results presented here suggest that preparedness activities for public health events such as pandemic influenza can be effective and cost-effective during an interpandemic cold and influenza season, as well as acceptable to the private sector in terms of justifying preparedness as a short-term investment rather than simply as insurance against uncertain threats. Future research should further examine the business case being used by private sector organizations to justify preparedness activities, and identify any additional benefits organizations have realized through proactive implementation of such strategies. Additionally, implementation of interventions in a workplace during an interpandemic cold and influenza season, targeted at a group level so as to introduce peer expectations around hygiene behaviors, would provide further evidence for potential benefits of preparedness activities as a business investment strategy. Finally, opportunities for improved cross-sector collaboration were identified through the key informant interviews, and further exploration of how to operationalize those recommendations would be beneficial to public health authorities and the private sector alike.

Businesses are a major driver in any local economy and the health of communities is affected by the health of that economy. Therefore, private sector preparedness is critical to public health preparedness for events such as pandemic influenza. However, despite initial efforts by public health authorities to engage businesses in pandemic influenza preparedness efforts by pointing out the potentially devastating effects of a pandemic on their organization, only some of businesses initiated pandemic preparedness efforts. A novel approach of encouraging business preparedness by focusing on short-term benefits that can improve business functions on a day-to-day basis has the potential to engage a broader group of businesses. This research provides evidence to support such an approach. Public health authorities have the opportunity to test this approach and improve public health preparedness efforts across the board.

References

1. Robins TG, Klitzman S. Hazard communication in a large U.S. manufacturing firm: The ecology of health education in the workplace. Health Educ Q. 1988 Winter;15(4):451-72.

2. Aiello AE, Murray GF, Perez V, Coulborn RM, Davis BM, Uddin M, et al. Mask use, hand hygiene, and seasonal influenza−like illness among young adults: A randomized intervention trial. J Infect Dis. 2010;201:491-8.

3. White C, Kolble R, Carlson R, Lipson N. The impact of a health campaign on hand hygiene and upper respiratory illness among college students living in residence halls. J Am Coll Health. 2005;53(4):175-81.

APPENDIX: INTERVIEW GUIDE

Employer Preparedness for Pandemic Influenza (Flu) Interview

Introduction

Thank you for your time today. I have a series of questions I am going to ask you, and before we finish you'll have an opportunity to tell me anything you think I've missed. You can skip any questions you do not want to answer. You can also stop the interview at any time. Please answer the questions from the perspective of your current organization or other organizations you have worked with or observed.

General Preparedness

I'd like to start with some questions about preparedness in general – not specific to pandemic flu.

1) How does the organization think about preparedness in general?
    a. Probe: What does "preparedness" mean to the organization?
    b. Probe: What words do people use when referring to preparedness? (E.g., developing plans to avert disasters, exercises and drills for disaster situations)
    c. Probe: What types of disasters does the organization prepare for? (E.g., seasonal flu/expected annual diseases, pandemic flu/disease outbreaks, earthquakes, internal financial issues, market-wide financial issues) How is preparedness similar/different for each type?

2) What are the reasons organizations prepare for disasters in general? (E.g., regulatory requirements, reputation, commitment to employees, competitors)

3) What are the reasons organizations prepare for pandemic flu in particular?

4) What are the reasons organizations might NOT prepare for disasters?
    a. Probe: What about for pandemic flu in particular?

Current State of Preparedness

5) Can you describe where the organization currently is in its preparedness efforts?
    a. Probe: What are the factors that affect how prepared the organization is?
    b. Probe: Is preparedness progress uniform across the organization?

6) Where was the organization just before swine flu occurred?

7) What are the 5 most important things your organization has done or areas you've worked on related to pandemic preparedness?

8) What are 3 things your organization has done or areas you've tried to plan for that were not helpful?

Internal Resource demands

Now I'd like to ask you some questions about the resources your organization has dedicated to pandemic planning internally.

9) Who are the key players involved with pandemic preparedness at the organization?
    a. Probe: Where do they sit within the organization?
    b. Probe: How much time do they devote to pandemic preparedness work? Is this dedicated time for them, or is it in addition to their other organizational work?
    c. Probe: How is their time for pandemic planning spent? In meetings? Doing other work?

10) (If the organization has a planning committee): Describe the planning committee – who is on it, what it does, how often it meets, who it reports to, and who it communicates to.
    a. Probe: How were people identified to participate on the committee?
    b. Probe: Does the committee have other responsibilities?
    c. Probe: Was the committee formed specifically for pandemic planning?

11) What other resources have been dedicated to pandemic planning within the organization? (E.g., other personnel, money, space, time)

12) Has there been any resistance within the organization to pandemic work because of these resource demands?
    a. Probe: What challenges did each type of resources present for the organization? Are they similarly easy or difficult to access? What are the reasons they are easy or difficult to access?

External Resource demands

Now I'd like to ask you some questions about the resources private organizations (such as yours or ones you've worked with) might bring to the table to assist with the public response to a pandemic.

13) Imagine that your organization could choose to be responsible for one aspect of the public response to a flu pandemic, utilizing a capacity it currently has and does well, such as a call center, shipping capabilities, mass communications, etc. What expertise could the organization bring to the table?
    a. Probe: What might other organizations bring to the table?

14) What capabilities that your organization has currently planned to take on during a pandemic would it prefer to not be responsible for? (E.g., dispensing antiviral drugs)

Experiences with Preparedness

Now I'm going to ask some questions about your organization's experiences with pandemic flu preparedness in particular.

15) Can you describe your organization's pandemic planning activity over time?
    a. Probe: What was the starting date? How did the efforts start? Did the efforts take off right away? What barriers came up? Who was involved? When did you become involved with the efforts?
    b. Probe: Who were the key players (corporate champion) at each point?
    c. Probe: Were there any turning points? Please describe them. What happened? Who was involved? How did they affect change? What evidence was there that things were changing?

16) What has the organization done recently in light of the current threat of swine influenza?

17) What went well during the initial phases (or during your initial involvement)?
    a. Probe: What things worked as designed (expected successes)?
    b. Probe: What things did not work as designed but were still successful (unexpected successes)?
    c. Probe: Repeat questions for current situation. Since those initial phases, what has gone well? Expected successes? Unexpected successes?

18) What went poorly during the initial phases (or during your initial involvement)?
    a. Probe: What things did not work as designed?
    b. Probe: What things worked as designed but were still not successful?
    c. Probe: Were there any anticipated failures?
    d. Probe: Repeat questions for current situation. Since those initial phases, what has gone poorly?

19) Describe the level of executive support over the course of the planning efforts. What corporate champions have emerged for this program at different points?
    a. Probe: What did executive support look like at the beginning?
    b. Probe: What does it look like now?
    c. Probe: What prompted those changes?
    d. Probe: How was executive support gained?

20) Complete the following sentence: Our organization is better off for planning for pandemic flu because…

Facilitators and Barriers to Planning

Now I'm going to ask some questions about the organization's facilitators and barriers to pandemic flu planning.

21) When the organization was deciding to start preparing for pandemic flu, what factors helped move the process along?
    a. Probes:
        i. Financial considerations
        ii. Legal considerations
        iii. Insurance considerations
        iv. Executive support

b. Probe: How did those factors change in light of the current threat of swine influenza?

22) When the organization was deciding to start preparing for pandemic flu, what factors acted as barriers to the process?
    a. Probes:
        i. Financial considerations
        ii. Legal considerations
        iii. Insurance considerations
        iv. Executive support
    b. Probe: How did those factors change in light of the current threat of swine influenza?
    c. Probe: How did ROI concerns impact the decision-making process? Was return-on-investment (ROI) an issue in terms of uncertainties around pandemics?

23) What barriers still exist for the organization?
    a. Probe: Have they changed in any way? What about with regards to the current threat of swine flu?

24) How did uncertainty affect the preparedness process?
    a. (If not already mentioned)
        - Whether/when a pandemic is going to occur;
        - The severity of a pandemic if one occurs; and
        - Whether a pandemic would actually impact your organization.
    b. Probe: How did the organization resolve these issues? What discussions occurred related to these issues?
    c. Probe: What evidence was used to inform discussions?
    d. Probe: What levels of uncertainty were addressed with the introduction of swine flu? What impact did that have?

25) What would your organization do differently if it could go back in time and start over?
    a. Probe: If the organization could go back in time and correct course at any point in its planning efforts, what point would that be? What are your reasons for your answer?
    b. Probe: Has the organization learned from that? What is the organization doing differently now as they proceed with their pandemic planning efforts?

Adjustments to plans during implementation

Now I would like to ask you about how the plans your organization had prepared have been adapted to address the current real-time situation of swine flu.

26) What parts of the organization's plans have been implemented exactly as designed?

27) What parts of the organization's plans have been changed during implementation?

28) What parts of the organization's plans have not been implemented yet?

a. Probe: What changes do you anticipate for those sections of the plans, if they need to be implemented for the current swine flu epidemic?

29) Describe the level of executive support as the swine flu threat developed. What corporate champions emerged?
    a. Probe: What does executive support look like now?
    b. Probe: How permanent do you expect this executive support to be?

30) What changes or adjustments will be made to the organization's plans going forward for future threats?

Proactive Implementation of preparedness plans

Next I'm going to ask you about any plans the organization implemented in the pre-pandemic period.

31) Some organizations started to implement some of their preparedness initiatives proactively to address seasonal flu and other respiratory health concerns. Is this a business strategy your organization considered?

    If yes:

    a. Probe: Describe what happened with these initiatives.
    b. Probe: How did this impact your organization's response to the current swine flu threat?

    If no:

    c. Probe: Is this something the organization might consider? What factors would have to be addressed to make this an opportunity your organization would consider?
    d. Probe: What would your organization need to know from other organizations or experts, to similarly consider such an approach?

Role of Public Health

32) Public health is responsible for pandemic flu planning in a general sense. Describe the ideal public health department for supporting your organization in this role. What support would it give? How would it give it? To whom, and how often?
    a. Probe: What could public health do differently to better facilitate pandemic planning among the business community?
    b. Probe: What would be the ideal role for public health in this process?

Information Sources

Now I'd like to ask you about the information sources your organization has used to inform its pandemic planning efforts and implementation during the current swine flu threat.

33) What sources does your organization reference?
    a. Probes:
        i. Books
        ii. Internet
        iii. People/Experts

iv. Past experience

34) If you could rank those sources, which are the most important? Which are least important?
    a. Probe: Which of these did your organization rely on most heavily during the swine flu threat? What are the reasons it relied on that one?

Preparedness Scale

35) Consider a "preparedness" scale of 1 to 10, with 1 indicating organizations that are completely reactive to responding to disasters (e.g., no plans in place, response is "on the fly"), and 10 indicating organizations that are completely proactive about responding to disasters (e.g., complete plans in place and disasters averted). Where is your organization?
    a. Probe: Was the organization always at that point? Was there movement? Who or what spurred the change?
    b. Probe: Who or what are the factors pushing the organization toward the reactive end of the scale? What about toward the proactive end of the scale?

Closing

36) To finish up, if your organization could give advice to other businesses looking to start their pandemic flu planning, what would it tell them?
    a. Probe: What would your organization wished it had known before it started its own pandemic planning efforts?
    b. Probe: What would your organization wished it had thought about or known before swine flu?
    c. Probe: What best practices would it highlight?
    d. Probe: What would it warn them about?
    e. Probe: What experiences would it share?

37) Is there anything else I should know about pandemic planning at your organization or in general?

Thank you for your time.