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Grishma A. Kharod Date

Effect of a joint incident management team response on health care providers' perceptions regarding the adequacy of pandemic H1N1 vaccination campaigns in Washington, USA, 2009

By

Grishma Kharod
MPH

Global Epidemiology

____
Saad B. Omer, MBBS, MPH, PhD
Committee Chair

____
Katherine Seib, MSPH
Committee Member

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By

Grishma Kharod

B.S., Medical Technology
Michigan State University
2009

Thesis Committee Chair: Saad B. Omer, MBBS, MPH, PhD

An abstract of
a thesis submitted to the Faculty of the
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Abstract

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In light of the H1N1 influenza spread, health care providers and departments implemented emergency preparedness and response plans and set up systems to efficiently allocate vaccines for prevention. Region 4 counties in the state of Washington executed a joint incident management team (IMT) system to respond to the pandemic. The objective of this study was to study the extent to which use of a joint IMT system affected health care providers' perceptions on the adequacy of the H1N1 pandemic vaccination campaigns. Health care providers (n=619) from the state of Washington who applied for H1N1 vaccine in 2009 from the state department of health were surveyed to determine their H1N1 pandemic response behaviors and perceptions. Zip codes and phone calls to regional lead health departments were used to determine which counties utilized the joint IMT systems. Logistic regression models were employed to assess associations between IMT use and health care providers' perceptions on vaccination campaign adequacy. Participants in a joint IMT system for H1N1 response were less likely to find information received from local health departments to be useful than practices that did not participate in joint IMT systems. Additionally, joint IMT participants were less likely than non-participants to be concerned about denying vaccine to low-priority groups. Results suggested better management of vaccination supplies and more effective management of vaccination campaigns with centralized responses, such as the IMT systems. The associations between joint IMT use and health care providers' perceptions of H1N1 vaccination campaign adequacy were adjusted for type of practice, number of physicians and pharmacists in practice, and staff participation in preparedness training drills and sessions. The findings from this study serve d as preliminary steps toward validating the effectiveness of joint IMT use, and can be used to implement centralized responses in more regions.

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List of acronyms and abbreviations

EOC	Emergency Operations Center
ICS	Incident Command System
IMT	Incident Management Team
PHA	Public Health Agency
WHO	World Health Organization

Chapter 1: Background and literature review

EMERGENCY PREPAREDNESS AND RESPONSE

Emergency preparedness and response strategies have been applied to a multitude of public health disaster-type events, ranging from bioterrorism attacks to natural disasters to infectious disease outbreaks. The nature of preparedness and response activities has evolved as time has progressed and events requiring the utilization of such procedures have transformed. Since the September 11, 2001 attacks, the United States government has invested heavily in the need for viable disaster preparedness and response plans. The effectiveness of such measures is reliant on several factors, including planning processes, communication and collaboration tactics, as well as management capabilities.

Planning

In order to have comprehensive public health emergency preparedness and response, programs must be able to prevent, mitigate and manage consequences of the disaster (1). Without planning strategies in place, it is difficult to gauge the level of risk and the amount of resources necessary to allay the threat. Health departments at every level need to possess the ability to cope with a variety of hazards and be adequately prepared to prevent and respond to emergencies with differing magnitudes of severity (2). According to Perry, et al., in a study outlining essential guidelines for the emergency planning process, one of the most important and least static strategies for successful preparedness was determined to be "pre-event" planning. In order to be considered ethical, planning processes should engage the public. This can be achieved not solely through participation in all stages of the planning process, but also through collaborative problem-solving and joint decision-making. Public involvement may lead to improved decisions and greater health impact within the community, as well as increased social capital and social efficacy (3). Planning should hold its basis in "accurate knowledge of the threat and of likely human responses", and should address surveillance, communications, community service maintenance, medical care and logistics of supply and delivery (4, 5). It should, in general, also take into account the effects of the potential hazards facing populations, in addition to previous investigations that have outlined how affected populations and emergency organizations have handled similar situations (4).

Communication and collaborative techniques

In another study on pandemic influenza management and planning, which aimed to create plans for county-wide pandemic influenza responses, Danforth, et al placed emphasis on the role of community-wide responses in program effectiveness (6). Such methods allowed for more consistency between jurisdictions and help in providing single, overriding messages to relay to the public, health care providers and health departments. In addition, it was important for everyone to receive the same information, so that responses would be more efficient and organized. In the Danforth article, this type of unified, detailed messaging approach was seen as being "essential to effective and efficient public health practices" (6). Too much communication may also be detrimental, since staff can feel inundated by the amount of information being presented, become overwhelmed, and less likely to respond.

Management

Because available resources vary widely among health departments, adequate management is necessary. This resource availability is dependent on a multitude of factors, such as: size of facility, population density, staffing and allocation of budget. Therefore, providers' abilities to plan and respond differ, as well. For instance, the incident command system (ICS) structure is usually not utilized outside of an emergency setting except for the military. Unfamiliarity with such a system on the health department side could result in implementation challenges. However, when an emergency is declared, additional funds become available for the health departments to use. ICS activation can, therefore, be a response to or precede these states of emergencies. If the jurisdictions have pre-planned and have made ICS collaboration possible, they can benefit by having "budget-ready" responses that can use funds from various sources. Still, resource allocation is essential to the management of a successful and efficient response program, especially when limited supplies are available. In addition, with infectious disease emergencies, proper identification of high-risk groups can help define medication and immunization prioritization guidelines. In a 2006 analysis by Uscher-Pines et al. on prioritization decisions in national preparedness plans of nations worldwide, results indicated that prioritization practices may have been helpful in curbing disease burden and disease-related morbidity and mortality (7). Though these results were from global studies, the findings can most likely be extrapolated to smaller-scale public health agencies (PHAs).

As discussed, the effectiveness of emergency preparedness and response measures is dependent on the levels of planning, collaborative efforts and types of management or command structure involved. These preparedness and response measures can be engaged in an array of events. For example, as the spread of H1N1 intensified and eventually reached pandemic status, public health agencies responded to the event. H1N1 preparedness and response measures may have required different techniques for control than preparedness and response measures for a bioterrorism attack, or even other communicable diseases. However, there were overarching commonalities that made such measures effective.

H1N1 AND THE IMPORTANCE OF VACCINATION CAMPAIGNS

In June 2009, the World Health Organization (WHO) declared the spread of H1N1 influenza a pandemic (8, 9). Pandemic H1N1 presented in two waves: the first of which was in June 2009 (largely in big cities in within the United States), and the second of which presented when students returned to school in August and September of that year (8). Because of the nature of the virus strain, the groups at highest risk included those younger than 25 years old, since they did not have any type of immune response to the evolved 1918 and 1978 pandemic influenza virus strains (8). Initially, hospitalization rates were highest among 0-4 year olds (8). These age groups were consistent with those affected around the world.

Common symptoms of H1N1 included fever, cough, sore throat, rhinorrhea, myalgia, vomiting and diarrhea (8). Risk factors for severe illness (and sometimes hospital admission or death) included pregnancy, chronic lung and heart disease, diabetes, and obesity (8). The reproductive number, R_0, was originally placed at 2.2 - 2.3 but later decreased to 1.7 - 1.8, which indicated lower levels of transmission than the 1918 influenza strain (R_0= 1.8 - 2.4).

Though the low reproductive number indicated less severe transmissibility, vaccination strategies were seen as interventions that had potential in slowing infection spread and diminishing the height of the epidemic peak, attack rate and mortality. With 50% coverage, it was estimated that an R_0 of 1.8 could be alleviated (10). Because of the usefulness of vaccinations in reducing disease burden due to H1N1, properly managed vaccination campaigns were vital. Effective preparedness and response programs throughout the nation, even at the local levels, were expected to help allocate resources to the most vulnerable populations in order to achieve successful vaccination campaigns. For this to ensue, adequate and effective preparedness and response programs were necessary.

PANDEMIC H1N1 PREPAREDNESS AND RESPONSE

Planning

As in emergency preparedness and response approaches for non-H1N1 events, planning was one of the key factors in putting effective programs into practice.

One of the most significant aspects of the planning stage relates to preparation for the lack of vaccine supplies in the early phases of the pandemic. Pre-event planning can help capitalize on this course of preparation, and is a key component of effective preparedness. Public health agencies should replenish supplies for the dissemination of antivirals, masks and education materials for preventive measures (11). Vaccine deployment plans, for when the vaccines become available for use, are vital portions to the program that must be addressed (11). Epidemiologic patterns of the disease can be useful in prioritizing high-risk groups for these limited supplies. In a study exploring approaches to challenges that impact the effectiveness of public health response, however, findings indicated that planned tabletop exercises and groundwork did not completely prepare the community and public health agencies for vaccination campaigns (12). This could serve as an indication that planning may not be as beneficial towards program effectiveness on its own as it may if in collaboration with strong communicative and managerial practices.

Communication and collaborative techniques

A recent study from Pasco County, Florida focused on the creation of an emergency response plan for pandemic influenza through the utilization of public health and social science research methods. In this instance, a community-wide participatory approach was utilized by Pasco County to help determine factors that contributed to disease transmission, treatment, disparities in health and coping abilities (6). With vaccination being a significant means of prevention for H1N1, and initial vaccine supplies not quite reaching demand, coordinated community-wide responses were vital in assuaging pandemic impact (6, 13). Regional coordination may be essential in such situations, since disease can easily spread across neighboring jurisdictions. In the Pasco County study, communication and trust issues provided the most challenges on the effectiveness of vaccine campaigns organized by local health departments, and in order for local public health agencies to successfully implement preparedness and response, community collaboration must be a long-term goal (12). Additionally, another article on H1N1 influenza, health policy reform and preparedness mentioned that linkage of information on individuals' vaccination statuses and usage of health care services was challenging, but could benefit planning for more severe pandemics (14).

A study from the United Kingdom discussed a multi-agency regional response center, which was created from four emergency operations centers. Lessons from these experiences revealed that communications were difficult at times depending on the nature of the event, and with large volumes of information circulated, communications were hindered at times (15).

SINGLE IMT USE IN THE STATE OF WASHINGTON

As an alternative method to emergency response for the H1N1 pandemic, four county public health agencies and a tribal public health agency in the state of Washington combined forces to create a single incident management team (IMT), and provide a regional response to the 2009 H1N1 pandemic, by utilizing an incident command system (ICS) (16). This collaboration between public health agencies to form a joint IMT for public health response was the first of its kind. It was formulated for several reasons (16):

- To avoid exhaustion of local resources before response can be completed.

- To ensure that a single, consistent, common preparedness message was being delivered to the public.
- To solidify communication and coordination with the medical care delivery system and regional hospitals in the area.
- To adjust for personnel who may be less experienced in the field by consolidating leadership from each participating public health agency.
- To smooth the transition to a type 3 IMT, which is a "state of regional multiagency/multi-jurisdiction team used for extended incidents with increased complexity from a type 4 IMT" (16)

Prior to the pandemic, there were already plans for cross-jurisdictional coordination and collaboration to improve ICS capability and create a regional governing council (16). This may have made the transition to a single, joint IMT easier than had there been no plans in place, but there were still challenges faced during the execution of joint IMT response.

First of all, local health departments are not normally set up to run under an ICS outside of emergency settings, which could have made the integration more difficult (2). However, it is becoming increasingly common to activate emergency operations centers (EOC) or ICS during responses to emergencies. In the region 4 IMT process, many personnel served in dual role capacities, which were often seen as "difficult and as getting in the way of the response" (16). Meetings tended to take longer than necessary, which resulted in increased feelings of disengagement, disorganization and frustration (16). Certain directors served in the rotating role of incident commander for this joint IMT system. Therefore, the distribution of information between directors was uneven (16). Additionally, although one of the primary reasons for establishing a joint IMT was to avoid exhaustion of resources necessary for pandemic H1N1 response, there were instances in which available local resources were not being adequately applied (16). Maintenance of regional focus was an issue in terms of incident management team strategies. Cowlitz County's public health agency, which was the largest PHA, was also the location of the incident command post and contributor of the greatest amount of resources (16). Communication also proved to be a challenge. It was difficult to implement the single, overriding risk communication messages when deadlines and rules of local media were not completely known. Also, communication was regarded as a burden when contact with off-site members of a centralized IMT were required, especially when these members were not familiar with local culture and operations (16).

Aside from the challenges faced, this joint IMT employed many similar approaches that rendered previously-discussed emergency preparedness and response plans effective. After implementation of the single joint IMT response, the involved public health agencies stated that they were jointly able to manage a limited vaccine supply, cooperate effectively with school systems participating in vaccination campaigns and add surge capacity to their response measures. Public health officials partaking in the joint IMT process claimed that execution of such a plan was beneficial for H1N1 pandemic response.

Chapter 2: Manuscript

ABSTRACT

In light of the H1N1 influenza spread, health care providers and departments implemented emergency preparedness and response plans and set up systems to efficiently allocate vaccines for prevention. Region 4 counties in the state of Washington executed a joint incident management team (IMT) system to respond to the pandemic. The objective of this study was to study the extent to which use of a joint IMT system affected health care providers' perceptions on the adequacy of the H1N1 pandemic vaccination campaigns. Health care providers (n=619) from the state of Washington who applied for H1N1 vaccine in 2009 from the state department of health were surveyed to determine their H1N1 pandemic response behaviors and perceptions. Zip codes and phone calls to regional lead health departments were used to determine which counties utilized the joint IMT systems. Logistic regression models were employed to assess associations between IMT use and health care providers' perceptions on vaccination campaign adequacy. Participants in a joint IMT system for H1N1 response were less likely to find information received from local health departments to be useful than practices that did not participate in joint IMT systems. Additionally, joint IMT participants were less likely than non-participants to be concerned about denying vaccine to low-priority groups. Results suggested better management of vaccination supplies and more effective management of vaccination campaigns with centralized responses, such as the IMT systems. The associations between joint IMT use and health care providers' perceptions of H1N1 vaccination campaign adequacy were adjusted for type of practice, number of physicians and pharmacists in practice, and staff participation in preparedness training drills and sessions. The findings from this study serve d as preliminary steps toward validating the effectiveness of joint IMT use, and can be used to implement centralized responses in more regions.

KEYWORDS: joint IMT, vaccination, emergency, preparedness, response

INTRODUCTION

Emergency preparedness and response plans that can adequately utilize resources and manage public health situations of varying levels of severity are essential components of successful public health programs. During the 2009 H1N1 pandemic, health departments around the nation engaged emergency response plans to mitigate the effects of the pandemic. As a part of the responses, vaccination campaigns were also set up by public health agencies and health care providers to prevent infection.

Many public health agencies planned decentralized responses to this pandemic. However, as emergencies are characterized by chaos and require the exchange of information between numerous agencies and the at-large community, decentralized responses had the potential to provide challenges (17). As an alternative response plan, region four counties (Clark, Cowlitz, Wahkiakum and Skamania counties) in the state of Washington implemented a joint incident management team (IMT) to respond to the H1N1 pandemic, which consisted of regionally-coordinated communication strategies, vaccination campaigns and other response measures(16). This joint IMT system claimed to be effective at managing limited vaccine supplies, effectively cooperating with school systems and adding surge capacity to pandemic H1N1 response measures; nonetheless, these claims were based on empirical evidence (16).

As the only counties known to have used such a system to respond to the H1N1 pandemic, the extent to which the joint IMT was an efficient use of resources and helped improve perceptions about the adequacy of response campaigns is unknown. The aim of this study is to determine the extent to which the utilization of the joint IMT system was as effective as claimed, using health care providers' perceptions of the adequacy of the H1N1 pandemic vaccination campaigns as indicators of effectiveness.

DATA AND METHODS

Study population and study design

Health care providers from the state of Washington who requested H1N1 vaccine in 2009 from the state department of health formed the study population. The cross-sectional survey, designed to determine H1N1 pandemic response behaviors at the time of survey implementation, was made available to providers and practices in three ways. Participants could either complete the survey online or complete paper surveys (sent by mail and fax), and then return completed surveys via fax or postal mail. The research team utilized Feedback Server version 2008.1 to administer the online surveys (Data Illusion, Geneva, Switzerland). Participating health care providers were sent a pre-notice regarding the survey before the survey kits were disseminated via FedEx. Each kit included: a sheet of survey FAQs (informed consent for the research process), a hard copy of the entire survey, postage-paid return envelope, a $25 Target gift card as an incentive for completing the survey (funded by Emory through a CDC grant), and a pen. Fax reminders were sent two weeks after the initial survey mailing. Telephone callbacks, starting three weeks after initial mailing with two phone calls per health care provider (two direct contacts with people), served as post-survey kit dissemination reminders.

Customized letters with a second copy of the survey were sent to all non-responders, via fax, after eight weeks.

Sampling

Corrections facilities and women's health centers were oversampled with a probability of 1. Once those two groups had been sampled, those providers were subtracted from the originally-intended n=800 and the rest of the provider categories were proportionally sampled. All observations were weighted, and the weighting was determined by multiplying the inverse of the probability of selection with the inverse of the response rate for the respective observation.

Study variables

Utilization of the single, joint IMT system served as the main exposure of interest. Counties that participated in a joint IMT system were classified as "yes" for the exposure, while those that did not participate were classified as "no". These designations were based on zip codes corresponding to the counties that participated in the joint IMT (16). Region 4 counties (Clark, Cowlitz, Wahkiakum and Skamania) were determined to have utilized joint IMT systems (16) (figure 1). Phone calls to health departments for counties in region 2 were made to verify whether or not the region had employed a regional response or a joint IMT. Type of practice, practice size (designated by number of physicians and pharmacists at the practices), and participation of staff in preparedness training drills or sessions were all variables designated as potential confounders for the analysis. Practice type categories were collapsed into traditional family practices vs. non-traditional family care practices for the purpose of this analysis.

Study outcomes were defined as follows: usefulness of information received from state and local health departments, providers' abilities to adhere to priority group guidelines for immunization campaigns, concern regarding denial of vaccine to low-priority groups, and perceived capabilities of provider in responding to large-scale public health events. Perceptions on the usefulness of information received from both local and health departments were classified as being either "useful or very useful" or "somewhat useful or not useful/ineffective". Providers' abilities to adhere to the priority group guidelines for vaccination (at the beginning of the campaign when vaccines were in limited supply) were classified in terms of "easy" or "moderately difficult to hard". Responses to concerns about denying H1N1 influenza vaccine to those in lowest priority groups were classified as "yes" or "no/not applicable". Finally, the levels of agreement to the statement that the provider was capable of responding to large-scale public health events were split into "agree" or "disagree/neutral".

Analysis

Frequency distributions were employed to obtain descriptive statistics on the characteristics and perceptions of the study population. Logistic regression models were run to obtain crude odds ratios and adjusted odds ratios for multivariate regressions. Adjusted odds ratios were attained by controlling for type of practice, number of physicians in practice, number of pharmacists in practice and staff participation in preparedness training sessions or drills. Collinearity diagnostics for each of five multivariate regressions were performed with the utilization of an unpublished collinearity macro (18). Confounding was assessed with the all-possible subsets method of model selection and precision evaluation based on 95% confidence interval widths (19). All analyses were weighted as previously described, and alpha was set at a level of 0.05. The statistical analyses for this study were performed using SAS, version 9.2 (SAS Institute, Inc., Cary, North Carolina). This study was deemed exempt by the Emory University Institutional Review Board (IRB).

RESULTS

Of 765 surveys administered to health care providers in WA, 619 responses were received, resulting in a response rate of 80.91%. Table 1 describes the characteristics of the health care providers and practices from the state of Washington. The study population consisted of eight provider types: non-traditional medical specialists, under-25-year-old priority practices, pharmacies, government providers, hospitals/acute care centers, traditional family care practices, corrections facilities and women's health centers. Traditional family care practices made up the largest percentage (27.76%) of the study group. Participation in a joint incident management team system (IMT) was prevalent in just under 7% of the providers. Most providers had 1 to 3 physicians and no pharmacists in practice. Just over half of the practices reported that they were either unsure of staff participation in preparedness training sessions or drills or reported that there was no staff participation in these trainings.

Perceptions on the adequacy of the H1N1 vaccination campaign also varied across respondents, as depicted in table 2. Of all respondents, 71.07% stated that they found the information from the state health department to be useful or very useful, while 83.77% of respondents stated the same for information received from local health departments. Most health care providers found it relatively easy to adhere to priority group guidelines for vaccination campaigns, since the decisions on who should or should not receive vaccine were clearly delineated. Nearly 74% of providers expressed either no concern about denying H1N1 vaccine to lowest priority groups or found the concern to be inapplicable. Approximately 80% of providers agreed that they perceived their branch to be capable of responding to large-scale public health events.

We examined the associations between characteristics of health care providers and their perceptions on the adequacy of the vaccination campaigns, shown in table 3. Unadjusted associations between joint incident management team usage and providers' perceptions on vaccination campaign adequacy are represented in table 4. Respondents who participated in a joint incident management team for the pandemic H1N1 response were 43% less likely (unadjusted OR = 0.57, 95% CI: 0.40, 0.83) to find information received from local health departments to be useful in comparison to those who did not use the joint IMT. However, there was an insignificant association between participation in joint IMT and the perceived usefulness of information received from the state health department (unadjusted OR = 0.94, 95% CI: 0.67, 1.32). Practices that participated in the joint IMT system were found to be 11% more likely to have the ability to adhere to priority group guidelines (unadjusted OR = 1.11, 95% CI: 0.80, 1.53) and 25% less likely to be concerned about denying H1N1 vaccine to low-priority groups (unadjusted OR = 0.75, 95% CI: 0.52, 1.10) than those that did not use joint IMT. Joint IMT participants were also 11% less likely to have the perceived capability of responding to large-scale public health events (unadjusted OR = 0.89, 95% CI: 0.60, 1.31); however, these results were also insignificant.

Multivariate logistic regression models also tested the associations between participation in joint incident management teams for pandemic H1N1 response and health care providers' perceptions, while controlling for confounding (table 4). Health care providers who utilized joint IMT systems were approximately as likely as those who did not utilize joint IMT systems to find information received from the state health department to be useful (adjusted OR: 1.01, 95% CI: 0.70, 1.44), though this association was not significant. However, users of the joint IMT were 45% less likely to perceive information received from the local health departments to be useful (adjusted OR = 0.55, 95% CI: 0.37, 0.82). Additionally, providers who participated in joint IMTs were 41% less likely to be concerned about denying H1N1 vaccine to low-priority groups than those practices that did not participate in the joint IMT system (adjusted OR = 0.59, 95% CI: 0.39, 0.90). Finally, practices that participated in the joint IMT system were found to be 11% more likely than non-participants to have the ability to adhere to priority group guidelines (adjusted OR = 1.11, 95% CI: 0.79, 1.55), and were 24% less likely to have the perceived capability of responding to large-scale public health events (adjusted OR = 0.76, 95% CI: 0.51, 1.13), although these results were insignificant.

DISCUSSION AND CONCLUSION

The findings of this study revealed that health care providers who participated in a joint IMT system for H1N1 response had decreased concern about denying vaccination to low-priority groups (table 4). Priority group guidelines for vaccine administration were intended to target higher-risk groups, especially during times of low vaccine supply, and to maintain cost-effectiveness of vaccination campaigns. This diminished concern implied that health care providers participating in joint IMTs may not have even encountered shortage issues that would have required them to otherwise stringently restrict the dissemination of vaccines. The results supported empirical claims made in recent literature on region 4 counties in WA, which suggested that usage of a joint IMT system and regionalization of response measures allowed for more efficient management of vaccination campaigns (16). In terms of vaccine management, therefore, joint IMT usage may be a beneficial system to employ.

Furthermore, the study provided evidence that users of the joint IMT were less likely than non-users to find information received from local health departments to be useful (table 4). This may be a direct result of the fact that the IMT system was a centralized, joint response, and information from individual local health departments (de-centralized systems) was not necessary for the function of the regionalized response system.

The findings of this study necessitate some caution in interpretation, due to limitations. All associations between IMT use and perceptions of H1N1 vaccination campaign adequacy were adjusted for potential confounders. However, the possibility that study findings were confounded by other unmeasured factors still remains. Differential misclassification bias on exposure status may also be a contributor to limitations. In order to determine exposure status, zip codes of health care providers were used to match their locations to counties. If providers' zip codes were located within Clark, Cowlitz, Skamania or Wahkiakum counties, those practices were marked as 'yes' for joint IMT use. However, zip codes can cross county lines. If there were practices with a zip code designated as 'yes' for IMT use, but those practices' locations fell outside of county boundaries, they would have been falsely classified as exposed ('yes' for IMT). This could produce bias either away from or towards the null, depending on the magnitude of the observed odds ratios.

Health care providers who utilized a joint IMT system constituted only about 7% (n=42) of the study population. With such a small exposed population studied, it is difficult to draw conclusions on the extent of the effectiveness of joint IMT. Only four counties in the state of WA were known to have utilized the joint IMT. Phone calls to region 2 county health departments in WA revealed they had not utilized a full joint IMT response, but had regionalized portions of their response to the H1N1 pandemic. It is unknown whether or not other counties within the state participated in joint IMT responses for the H1N1 pandemic response. Moreover, since the exposure group in this study was isolated in one region of WA, results may not be generalizable to the rest of the state, or even the United States, as population characteristics and H1N1 transmission dynamics would vary.

In conclusion, the findings from this study served as preliminary steps toward validating the joint IMT effectiveness claims made in the literature. The lessened concern in denying vaccination to low-priority groups suggested that health care providers and practices perceived IMT use to be beneficial in vaccination campaign management. Further studies on IMT use and vaccination campaign adequacy can provide a more thorough understanding of the efficacy of joint IMT use as means of emergency response.

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TABLE 1. Characteristics of health care providers in the state of Washington

Characteristics		n	Weighted %
Participation in joint incident management team for pandemic H1N1 response			
	No	558	93.04
	Yes	42	6.96
Type of practice			
	Non-traditional family care	469	72.24
	Traditional family care	147	27.76
Number of physicians in practice			
	None	147	27.25
	1 to 3	249	38.87
	4 to 6	100	14.08
	7 to 9	48	6.90
	10 or more	70	12.90
Number of pharmacists in practice			
	None	411	62.95
	1 to 2	110	19.81
	3 to 4	59	11.12
	5 or more	33	6.12
Participation of staff in preparedness training sessions or drills			
	No or not sure	344	56.75
	Yes	268	43.25

TABLE 2. Perceptions of health care providers in the state of Washington, on the adequacy of the H1N1 vaccination campaign

Perceptions	n	Weighted %
Usefulness of information received from state health department		
Very useful or useful	437	71.07
Somewhat useful, not useful, or irrelevant	169	28.93
Usefulness of information received from local health department		
Very useful or useful	511	83.77
Somewhat useful, not useful, or irrelevant	89	16.23
Practice's ability to adhere to priority group guidelines		
Easy to adhere. The guidelines made it easy for our practice to make decisions on who should or should not receive vaccine.	379	61.90
Moderately difficult or difficult to adhere. The guidelines gave us general guidance-but we still had to make some case-by-case decisions that we were not sure were covered by the guidelines.	225	38.10
Concern about denying H1N1 vaccine to lowest priority group		
Yes	158	26.05
No or not applicable	450	73.95
Agreement to the statement that practice/pharmacy branch is capable of responding to large-scale public health events		
Agree	480	80.02
Disagree or neutral	121	19.98

TABLE 3. Associations between characteristics of health care providers and the providers' perceptions on the adequacy of the vaccination campaigns, unadjusted ORs and 95% CIs (n=619)

Characteristics	Perceptions				
	Usefulness of information received from state health department	Usefulness of information received from local health department	Practice's ability to adhere to priority group guidelines	Concern about denying H1N1 vaccine to lowest priority group	Capability of large-scale public health event response
	OR (95% CI)				
Type of practice					
Non-traditional family care	reference	reference	reference	reference	reference
Traditional family care	1.00 (0.83, 1.21)	1.40 (1.09, 1.80)*	0.72 (0.60, 0.86)*	1.10 (0.91, 1.34)	1.38 (1.09, 1.73)*
Number of physicians in practice					
None	reference	reference	reference	reference	reference
1 to 3	3.12 (2.51, 3.87)*	3.46 (2.62, 4.57)*	1.61 (1.31, 1.98)*	0.94 (0.75, 1.18)	0.79 (0.61, 1.01)
4 to 6	2.05 (1.55, 2.70)*	2.43 (1.70, 3.46)*	0.70 (0.54, 0.91)*	0.97 (0.72, 1.31)	0.94 (0.67, 1.31)
7 to 9	2.89 (1.94, 4.29)*	2.10 (1.33, 3.31)*	1.24 (0.87, 1.76)	1.70 (1.18, 2.43)*	1.97 (1.15, 3.39)*
10 or more	2.70 (2.00, 3.64)*	1.53 (1.10, 2.11)*	0.60 (0.46, 0.78)*	1.22 (0.91, 1.64)	0.71 (0.52, 0.99)*
Number of pharmacists in practice					
None	reference	reference	reference	reference	reference
1 to 2	0.66 (0.53, 0.83)*	0.33 (0.26, 0.43)*	1.01 (0.82, 1.24)	1.71 (1.37, 2.14)*	1.64 (1.25, 2.16)*
3 to 4	0.64 (0.49, 0.84)*	0.31 (0.22, 0.42)*	0.77 (0.59, 0.99)*	1.47 (1.10, 1.95) *	1.52 (1.08, 2.13)*
5 or more	0.40 (0.28, 0.56)*	0.50 (0.32, 0.77)*	0.73 (0.53, 1.02)	2.67 (1.90, 3.76)*	1.48 (0.94, 2.31)
Participation of staff in preparedness					
No or not sure	reference	reference	reference	reference	reference
Yes	1.92 (1.59, 2.30)*	1.77 (1.40, 2.22)*	0.92 (0.782, 1.09)	1.50 (1.26, 1.80)*	1.18 (0.96, 1.44)

*p<0.05

TABLE 4. Associations between participation of health care providers in joint incident management teams for H1N1 pandemic response and the providers' perceptions on the adequacy of the vaccination campaigns, unadjusted and adjusted ORs† and 95% CIs (n=619)

Characteristics		Perceptions				
		Usefulness of information received from state health department	Usefulness of information received from local health department	Practice's ability to adhere to priority group guidelines	Concern about denying H1N1 vaccine to lowest priority group	Capability of large-scale public health event response
				OR (95% CI)		
Participation in joint incident management team for pandemic H1N1 response (unadjusted)						
	No	reference	reference	reference	reference	reference
	Yes	0.94 (0.67, 1.32)	0.57 (0.40, 0.83)*	1.11 (0.80, 1.53)	0.75 (0.52, 1.10)	0.89 (0.60, 1.31)
Participation in joint incident management team for pandemic H1N1 response (adjusted)†						
	No	reference	reference	reference	reference	reference
	Yes	1.01 (0.70, 1.44)	0.55 (0.37, 0.82)*	1.11 (0.79, 1.55)	0.59 (0.39, 0.90)*	0.76 (0.51, 1.13)

*$p<0.05$
†ORs adjusted for type of practice, number of physicians in practice, number of pharmacists in practice, and participation of staff in preparedness training sessions or drills

FIGURE 1. Map of Region 4 counties in Washington, USA (20)

Source: smallfarms.wsu.edu/farms/images/wa-map-counties.gif

Chapter 3: Public health implications and future directions

Emergency preparedness and response plans are vital to the alleviation of public health threats. The employment of joint IMT responses has the potential to help national and international public health agencies in the case of a pandemic or public health emergency. Based on results from the quantitative analysis performed in this study, joint IMT usage appeared to be somewhat beneficial in terms of vaccine supply management and allocation of resources necessary for an immunization campaign to efficiently run. The results from this preliminary study serve to inform future formulations of innovative emergency response measures that could have the potential to mediate challenges associated with decentralized emergency responses.

Public health agencies harboring concerns about vaccination campaign management should consider regionalization of emergency preparedness and response measures and implementation of joint IMTs to efficiently manage resources and allocate immunizations for the populations served by area health care providers. Setting up more joint IMT systems across regions may help ease vaccine supply and campaign organization concerns and pacify public panic during pandemics or other public health emergencies, resulting in smoother responses. However, this process will require strict pre-planning measures. Specific budgetary allocations should be accounted for, in order to regionalize response. Additionally, steps to identify and target priority groups for immunization will be essential to successful utilizing IMT responses.

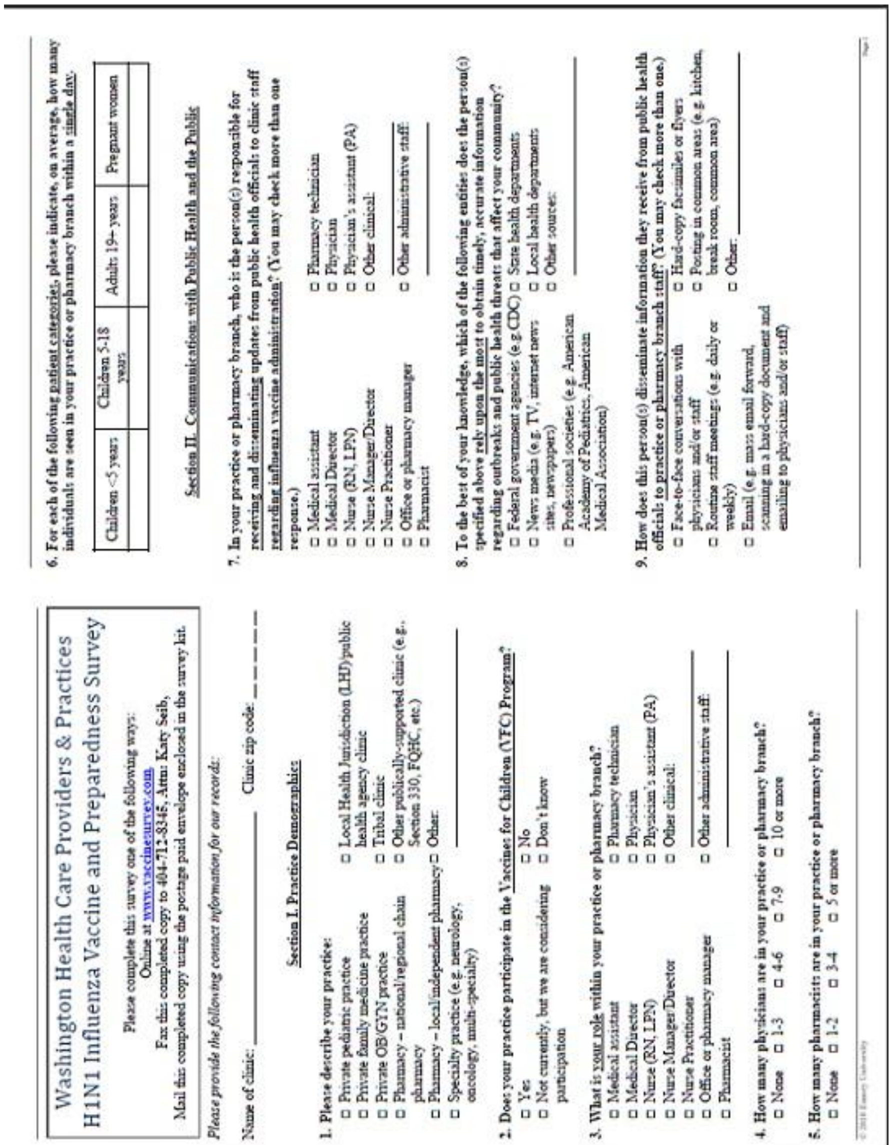
It is important to note that further studies will be necessary in order to obtain more comprehensive findings on the effects of joint IMT use, which will require an increased number of regions utilizing the IMT system. However, the current study focused only on the effects of joint IMT use on the perceived adequacy of vaccination campaigns for H1N1 pandemic response and not for other emergencies. Joint IMTs can be utilized in multiple emergency scenarios, and the effectiveness of the IMT responses in additional types of situations should be assessed. Studies involving joint IMT usage should also focus on the cost-effectiveness of engaging such response measures. The current study did not address the financial factors associated with the use of joint IMT emergency responses.

Furthermore, it will be essential to gauge whether or not other regions in the nation, with variations in population characteristics and health care provider structures, participated in joint IMT responses. The current study was centered on health care providers in four counties (Clark, Cowlitz, Wahkiakum and Skamania) in the state of Washington, which provided a very limited and homogeneous exposed population, making extrapolation of findings to larger populations difficult. Further studies should examine other regions to get a more comprehensive idea of the effect of joint IMT usage and how regional differences can influence effectiveness of these centralized response measures.

Appendices

APPENDIX I

Washington Health Care Providers & Practices:
Influenza Vaccine and Preparedness Survey



Washington Health Care Providers & Practices
H1N1 Influenza Vaccine and Preparedness Survey

Please complete this survey one of the following ways:
Online at www.vaccinesurvey.com
Fax this completed copy to 404-712-8345, Attn: Katy Seib,
Mail this completed copy using the postage paid envelope enclosed in the survey kit.

Please provide the following contact information for our records:

Name of clinic: ____________ Clinic zip code: _ _ _ _ _

Section I. Practice Demographics

1. Please describe your practice:
- □ Private pediatric practice
- □ Private family medicine practice
- □ Private OB/GYN practice
- □ Pharmacy – national/regional chain pharmacy
- □ Pharmacy – local/independent pharmacy
- □ Specialty practice (e.g. neurology, oncology, multi-specialty)
- □ Local Health Jurisdiction (LHJ)/public health agency clinic
- □ Tribal clinic
- □ Other publically-supported clinic (e.g., Section 330, FQHC, etc.)
- □ Other: ____________

2. Does your practice participate in the Vaccines for Children (VFC) Program?
- □ Yes
- □ Not currently, but we are considering participation
- □ No
- □ Don't know

3. What is your role within your practice or pharmacy branch?
- □ Medical assistant
- □ Medical Director
- □ Nurse (RN, LPN)
- □ Nurse Manager/Director
- □ Nurse Practitioner
- □ Office or pharmacy manager
- □ Pharmacist
- □ Pharmacy technician
- □ Physician
- □ Physician's assistant (PA)
- □ Other clinical: ____________
- □ Other administrative staff: ____________

4. How many physicians are in your practice or pharmacy branch?
□ None □ 1-3 □ 4-6 □ 7-9 □ 10 or more

5. How many pharmacists are in your practice or pharmacy branch?
□ None □ 1-2 □ 3-4 □ 5 or more

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6. For each of the following patient categories, please indicate, on average, how many individuals are seen in your practice or pharmacy branch within a single day.

Children <5 years	Children 5-18 years	Adults 19+ years	Pregnant women

Section II. Communications with Public Health and the Public

7. In your practice or pharmacy branch, who is the person(s) responsible for receiving and disseminating updates from public health officials to clinic staff regarding influenza vaccine administration? (You may check more than one response.)
- □ Medical assistant
- □ Medical Director
- □ Nurse (RN, LPN)
- □ Nurse Manager/Director
- □ Nurse Practitioner
- □ Office or pharmacy manager
- □ Pharmacist
- □ Pharmacy technician
- □ Physician
- □ Physician's assistant (PA)
- □ Other clinical: ____________
- □ Other administrative staff: ____________

8. To the best of your knowledge, which of the following entities does the person(s) specified above rely upon the most to obtain timely, accurate information regarding outbreaks and public health threats that affect your community?
- □ Federal government agencies (e.g. CDC)
- □ News media (e.g. TV, internet news sites, newspapers)
- □ Professional societies (e.g. American Academy of Pediatrics, American Medical Association)
- □ State health departments
- □ Local health departments
- □ Other sources: ____________

9. How does this person(s) disseminate information they receive from public health officials to practice or pharmacy branch staff? (You may check more than one.)
- □ Face-to-face conversations with physicians and/or staff
- □ Routine staff meetings (e.g. daily or weekly)
- □ Email (e.g. mass email forward, scanning in a hard-copy document and emailing to physicians and/or staff)
- □ Hard-copy facsimiles or flyers
- □ Posting in common areas (e.g. kitchen, break room, common area)
- □ Other: ____________

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10. In the matrix below, please indicate the MOST EFFECTIVE ways for public health departments to communicate information to your practice or pharmacy branch about the following public health emergencies. (You may check more than one communication method for each type of emergency.)

	Community outbreaks	Vaccine shortages for routine immunization	Pandemic influenza vaccine supply (e.g. H1N1 vaccine)
Blast faxes	□	□	□
Email	□	□	□
In person visits to provider offices	□	□	□
Newsletters	□	□	□
Notifications by postal mail	□	□	□
Phone calls	□	□	□
Press releases	□	□	□
Posting information to WA's Immunization Information System (CHILD Profile)	□	□	□
Posting information on general health department website	□	□	□
Notifications through the Health Alert Network (HAN/SECURES)	□	□	□
Sponsored conference calls	□	□	□
Text message alerts	□	□	□
Twitter feeds	□	□	□

11. Regarding preparedness for the 2009 H1N1 influenza vaccination campaign, how would you characterize the usefulness of information or guidance you received from the <u>health department</u>?

	Very Useful	Useful	Somewhat Useful	Not Useful	Irrelevant	I cannot recall
State Health Department	□	□	□	□	□	□
Local Health Department	□	□	□	□	□	□

12. In terms of communicating information on seasonal or H1N1 influenza vaccination to your practice or pharmacy branch:

a. What could your <u>state health department</u> have done better?

____

____

b. What could your <u>local health department</u> have done better?

____

____

<u>Section III. 2009 H1N1 Vaccination Administration</u>

13. <u>At the beginning of the H1N1 vaccination campaign when vaccine was limited,</u> please describe your practice's ability to adhere to the priority group guidelines:

□ Easy	The guidelines made it easy for our practice to make decisions on who should or should not receive the vaccine.
□ Moderate	The guidelines gave us general guidance, but we still had to make some case-by-case decisions that we were not sure were covered by the guidelines.
□ Hard	In most cases, the guidelines were not specific enough to help our practice make decisions on who should receive vaccine.

14. How did your practice communicate information about H1N1 vaccine prioritization and availability <u>with your patients or customers</u>? (Check all that apply.)

- □ Email notifications
- □ Face to face during patient/customer visits
- □ Flyers distributed to patients/customers visiting the practice
- □ Phone calls to patients/customers
- □ Postcards/mailings
- □ Posters in exam rooms
- □ Posters in waiting rooms/restrooms
- □ Postings on our practice's website
- □ Hotline or recorded message on phone answering service
- □ Text message alerts
- □ Twitter feeds
- □ Other (please specify): ____________

15. Were you or was anyone else in your practice concerned about <u>denying</u> H1N1 influenza vaccine to those in the lowest priority group (i.e. healthy adults and adults over the age of 65)?

- □ Yes, please describe: ____________________
- □ No
- □ N/A – we are a pediatric practice

Comment:____________________________________

____

16. In what ways did your practice or pharmacy branch <u>extend services</u> to vaccinate additional patients or customers against H1N1 influenza? (Check all that apply.)

- □ Hired additional staff to help vaccinate
- □ We extended our Monday – Friday business hours beyond our normal hours
- □ We opened on weekends when we do not normally open on weekends
- □ We extended our normal weekday and weekend hours
- □ We participated in mass vaccination clinics
- □ We did not extend our services
- □ Other
- □ I don't know

Comment:______________________________

17. What <u>barriers</u> did your practice or pharmacy branch have to storing and administering H1N1 vaccine? (Check all that apply.)

- □ Limited storage space for vaccine
- □ Limited storage space for ancillary supplies
- □ Lack of staff capacity to administer additional vaccines
- □ We did not have any storage or staff barriers
- □ Other (please specify): ____________

Comment:______________________________

18. Which prioritized groups benefitted most from off-site mass vaccination clinics (check all that apply)?

- □ Children under 18 years old
- □ Healthy young adults 18-24
- □ Adults with underlying conditions
- □ Healthcare workers
- □ Pregnant women
- □ Persons 65+
- □ Uninsured or underinsured populations
- □ Minority populations
- □ Healthy adults age 24+

19. Did your practice or pharmacy branch <u>offer</u> seasonal and H1N1 vaccines <u>to your staff</u>?

- □ Yes, we offered both vaccines to staff
- □ We only offered seasonal influenza vaccine to our staff
- □ We only offered H1N1 influenza vaccine to staff
- □ No, we offered neither vaccine to staff
- □ Don't know

20. Did your practice <u>require</u> that your staff be vaccinated with seasonal influenza vaccine and/or H1N1 influenza vaccine?

- □ Yes, both vaccinations were required of staff
- □ Only seasonal influenza vaccine was required of staff
- □ Only H1N1 influenza vaccine was required of staff
- □ No, neither vaccine was required of staff

Comment:______________________________

21. During the 2009 influenza season, approximately what percentage of your staff received each vaccine?

Seasonal Influenza Vaccine: _________% of our staff received this vaccine during the 2009 Flu Season

H1N1 Influenza Vaccine: _________% of our staff received this vaccine during the 2009 Flu Season

22. Did your practice vaccinate any patient or customer in an H1N1 vaccine target group, <u>regardless of their capacity to pay</u>?

- □ Yes, we vaccinated any patient or customer within a priority group, and waived any fees if they were unable to pay
- □ No, but we referred patients or customers who could not pay to alternate vaccination locations
- □ Other (please specify): ____________

23. Did your practice vaccinate individuals within H1N1 vaccine target groups that <u>were not established patients or customers</u> of your practice or pharmacy?

- □ Yes, we provided vaccine to anyone who fell within an H1N1 target group
- □ No, we did not vaccinate individuals who were not our patients or customers
- □ Other (please specify): ____________

24. Did you provide H1N1 vaccine to all patients or customers in target groups <u>regardless of whether they thought they already had H1N1 influenza</u> or influenza like illness in 2009?

- □ Yes, we vaccinated all patients or customers in target priority groups
- □ No, we only vaccinated those who did not already have H1N1 influenza
- □ Other (please specify):____________

25. For your practice, what measures worked best to get children to <u>return for their second dose</u> of H1N1 vaccine?

____

26. What lessons learned from previous vaccine shortages were <u>most useful</u> for helping your practice plan for and manage the vaccination campaigns for 2009 seasonal and H1N1 influenza vaccines?

____

____

27. For each of the following statements, please indicate your <u>level of agreement or disagreement</u>:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Using the Vaccines for Children (VFC) Program distribution model for the 2009 H1N1 vaccine <u>made sense</u> for our practice/pharmacy branch.	□	□	□	□	□
The H1N1 vaccination campaign illustrated that our practice/pharmacy branch <u>is capable of responding to large scale public health events</u>.	□	□	□	□	□
Our practice/pharmacy branch is willing to work with local and state health departments should another <u>vaccine-related public health emergency</u> arise.	□	□	□	□	□
Our practice/pharmacy branch is willing to work with public health in the future to distribute <u>non-vaccine countermeasures</u> (e.g. antivirals, masks, antibiotics) in the event of an emergency.	□	□	□	□	□
Our practice/pharmacy branch believes staying in regular communication with local public health departments is important to prepare for any future large scale public health emergencies.	□	□	□	□	□

<u>Section IV. Staff Participation in Public Health Preparedness Activities</u>

28. In the past 5 years, have any members of your practice or pharmacy branch (e.g. doctors, nurses, pharmacists, physicians' assistants, administrative staff) participated in any <u>training sessions or preparedness drills</u> in response to <u>large-scale public health disasters</u> (e.g. hurricanes, earthquakes, pandemics, or terrorist events)?

□ Yes □ No □ Not sure

29. If "YES" to the above question, please indicate which types of individuals have participated in disaster response training sessions (Check all that apply):

- □ Medical assistant
- □ Medical Director
- □ Nurse (RN, LPN)
- □ Nurse Manager/Director
- □ Nurse Practitioner
- □ Office or pharmacy manager
- □ Pharmacist
- □ Pharmacy technician
- □ Physician
- □ Physician's assistant (PA)
- □ Other clinical: ________________
- □ Other administrative staff: ________________

30. Has anyone in your practice ever participated in an <u>actual response</u> to a <u>large-scale public health disaster</u> (e.g. flood, hurricane, earthquake, terrorist event)?

- □ Yes, please describe: ____________________
- □ No
- □ Not sure

Comment: ____

31. Are any physicians, nurses, pharmacists, or physicians' assistants in your practice currently involved in any <u>medical surge capacity initiatives</u> (e.g. Medical Reserve Corps or volunteer advanced registration program for health professionals)?

- □ Yes, please describe: ____________________
- □ No
- □ Not sure

Comment: ____

<u>Section V. Immunization Information System – CHILD Profile</u>

32. Did your practice submit data to CHILD Profile, WA's Immunization Information System (IIS) vaccine registry, for <u>H1N1 vaccine administration</u>?

□ Yes □ No □ Not sure

Comment:____

33. For which of your patients or customers did your practice or pharmacy branch submit H1N1 administration data to CHILD Profile?

□ All 0-18 year olds
□ Only VFC patients 0-18 years old
□ All adult patients
□ Some adult patients (i.e. healthcare workers or parents of pediatric patients)
□ Not sure

34. For your practice or pharmacy branch, how easy was it to upload H1N1 vaccine administration data to CHILD Profile within <u>7 days of administration</u>?

□ Very Easy
□ Easy
□ Neutral
□ Difficult
□ Very Difficult
□ N/A - we did not upload data to CHILD Profile

35. What <u>method</u> did your practice or pharmacy branch use to submit H1N1 influenza vaccination data to the CHILD Profile system?

□ Electronic transfer into CHILD Profile through existing submission method
□ Internet based entry directly into CHILD Profile
□ Not sure

Comment:____

36. Did your practice or pharmacy branch use the CHILD Profile website to <u>check the vaccination status</u> of patients coming in for influenza (seasonal and/or H1N1) vaccine this season?

□ Yes □ No □ Not sure

Comment:____

37. What is the most significant <u>barrier</u> to your practice's or branch's efficient use of Child Profile?

38. What is the most significant <u>facilitator</u> to your practice's or branch's efficient use of Child Profile?

39. What were the <u>greatest concerns</u> among members of your practice or pharmacy branch regarding vaccine administration for the 2009 – 2010 influenza season?

This is the end of the survey. Thank you for your participation!
Please provide any additional comments about the survey or about the survey material that you would like us to know:

APPENDIX II

Collinearity macro for SAS, version 9.2 (Dr. David Kleinbaum)

```
/***********************************************************************
***********************
Program:    collinearity_macro.sas
Date:       Sometime before 2005
Authors:    Mathew Zack (MZ, original author), Jim Singleton (JS),
            Catherine Satterwhite (CS)
Purpose:    Generate collinearity diagnostics from the variance-
covariance matrix produced in
            nonlinear regression based on output generated from PHREG,
LOGISTIC, or GENMOD.
            Reference:
                DAVIS CE, HYDE JE, BANGDIWALA SI, NELSON JJ. AN EXAMPLE
OF DEPENDENCIES AMONG
                VARIABLES IN A CONDITIONAL LOGISTIC REGRESSION.  IN:
MOOLGAVKAR SH,
                PRENTICE RL, EDS.  MODERN STATISTICAL METHODS IN
CHRONIC DISEASE
                EPIDEMIOLOGY.  NEW YORK:JOHN WILEY & SONS, INC.,
1986:140-7.

Input:      Output (captured in datasets) from PHREG, LOGISTIC, or
GENMOD.  See below
            for instructions.  Macro must be included in code before
calling.
Output:     Collinearity diagnostic matrix (and supporting output)

Change History:
04/26/2005  JS  Modified to handle covariates included in class
statement
                (name of file: collingenmodv9c.sas)
04/21/2009  CS  Increased length of PARNUM in datastep NEXT_1 to $25,
PARM to $25 in
                datastep NEXT_1A, and _NAME_ to $25 in datastep NEXT_4
to increase display
                length of variable name in PROC GENMOD output
                Added code to increase number of parameters that can be
used in PROC GENMOD
                (previously limited to 9, now can have up to 20)--this
becomes important
                when a class variable with multiple levels is used in
the model
                Added additional information to explain macro and
detailed call instructions
***********************************************************************
**********************/

/***********************************************************************
***********************
To use this macro with PROC GENMOD:
    -If the REPEATED statement is not used, add:
        *COVB to the model statement as an option (model x=y/covb)
        *MAKE 'PARMINFO' OUT=<DATASETNAME1>;
```

```
        *MAKE 'COV'      OUT=<DATASETNAME2>;
    -If the REPEATED statement is used (correlated data analysis-
cluster identification), add:
        *COVB to the MODEL statement as an option (model x=y/covb)
        *COVB to the REPEATED statement as an option (repeated/covb)
        *MAKE 'PARMINFO' OUT=<DATASETNAME1>;
        *MAKE 'GEERCOV'  OUT=<DATASETNAME2>;

Macro call:
    %COLLIN(COVDSN=<DATASETNAME2>, PROCDR=GENMOD,
PARMINFO=<DATASETNAME1>)

Example:
%include 'E:\collinearity_macro.sas';
proc genmod data=five;
    class facility_id region;
    model total_positive/total_tests=year prop_15to20 prop_black
prop_naat region
                                     year*prop_15to20 year*prop_black
                                     year*prop_naat/dist=bin link=logit
covb;
    repeated subject=facility_id/type=exch covb;
    make 'PARMINFO'   out=set1;
    make 'GEERCOV'    out=set2;
    title Collinearity assessment, full model;
run;

%collin (covdsn=set2, procdr=genmod, parminfo=set1);
run;
**********************************************************************
**********************/

/*********************************************************************
***********************
To use this macro with PROC LOGISTIC or PROC PHREG:
    -Add:
        *COVOUT to the proc statement as an option (...data=xx covout)
        *OUTEST=<DATASETNAME2> to the proc statement as an option
(...data=xx outest=set2)
        *COVB to the MODEL statement as an option (model x=y/covb)
        *FREQ COUNT;

Macro call (only need to pass first parameter value):
    %COLLIN(COVDSN=<DATASETNAME2>, PROCDR=, PARMINFO=)
    -or-
    %COLLIN(COVDSN=<DATASETNAME2>)

Example:
%include 'E:\collinearity_macro.sas';
proc logistic data=one desc covout outest=set2;
    model brc=smk ses age smk*ses smk*age/covb;
    freq count;
    title Homework 4, Question 2, part i;
run;

%collin (covdsn=set2);
run;
```

```
*********************************************************************
*********************/

/********************************************************************
**********************
In GENMOD, SAS does not record the variable names in the output
variance-covariance dataset.
The next section of code replaces the parm variable with the actual
names of the variables
and renames parm to _name_ to conform to the output datasets generated
by LOGISTIC and
PHREG.

If there are more than 20 variables in the model statement (including
all class levels if
the class statement is used) SAS will stop processing and the final
collinearity matrix
will not be produced.  To allow more parameters, add corresponding code
lines to data next_1
and data next_1_a within the GENMOD do-loop, which makes GENMOD
covariance output similar
to LOGISTIC and PHREG.  In some output variance-covariance matrices,
there will be a record
for scale; this is deleted in the next_3 datastep.  A dummy record for
ESTIMATE is inserted
in datastep next_4 to simulate output from LOGISTIC and PHREG.
*********************************************************************
*********************/

options mprint symbolgen mlogic;

%macro collin(covdsn=, procdr=, parminfo=);

%if %upcase(&procdr)=GENMOD %then %do;
data next_1;
    set &parminfo;
    attrib parnum format=$25.;
    parnum=parameter;
    if parnum='Prm1' then parnum='Prm01';
    if parnum='Prm2' then parnum='Prm02';
    if parnum='Prm3' then parnum='Prm03';
    if parnum='Prm4' then parnum='Prm04';
    if parnum='Prm5' then parnum='Prm05';
    if parnum='Prm6' then parnum='Prm06';
    if parnum='Prm7' then parnum='Prm07';
    if parnum='Prm8' then parnum='Prm08';
    if parnum='Prm9' then parnum='Prm09';
    if parnum='Prm10' then parnum='Prm10';
    if parnum='Prm11' then parnum='Prm11';
    if parnum='Prm12' then parnum='Prm12';
    if parnum='Prm13' then parnum='Prm13';
    if parnum='Prm14' then parnum='Prm14';
    if parnum='Prm15' then parnum='Prm15';
    if parnum='Prm16' then parnum='Prm16';
    if parnum='Prm17' then parnum='Prm17';
    if parnum='Prm18' then parnum='Prm18';
    if parnum='Prm19' then parnum='Prm19';
```

```
    if parnum='Prm20' then parnum='Prm20';
    rename parnum=parm;
run;

proc sort data=next_1;
    by parm;
run;

data next_1a;
    set &covdsn;
    attrib parm format=$25.;
    parm=rowname;
    if parm='Prm1' then parm='Prm01';
    if parm='Prm2' then parm='Prm02';
    if parm='Prm3' then parm='Prm03';
    if parm='Prm4' then parm='Prm04';
    if parm='Prm5' then parm='Prm05';
    if parm='Prm6' then parm='Prm06';
    if parm='Prm7' then parm='Prm07';
    if parm='Prm8' then parm='Prm08';
    if parm='Prm9' then parm='Prm09';
    if parm='Prm10' then parm='Prm10';
    if parm='Prm11' then parm='Prm11';
    if parm='Prm12' then parm='Prm12';
    if parm='Prm13' then parm='Prm13';
    if parm='Prm14' then parm='Prm14';
    if parm='Prm15' then parm='Prm15';
    if parm='Prm16' then parm='Prm16';
    if parm='Prm17' then parm='Prm17';
    if parm='Prm18' then parm='Prm18';
    if parm='Prm19' then parm='Prm19';
    if parm='Prm20' then parm='Prm20';
run;

proc sort data=next_1a;
    by parm;
run;

data next_2(drop=effect);
    merge next_1a( in=in1a)
          next_1  (in=in1);
    by parm;
    if in1a;
    parm=effect;
    rename parm=_name_;
run;

data next_3;
    set next_2;
    if _name_='SCALE' then delete;
run;

data next_4;
   length _name_ $25;
    _name_= 'ESTIMATE';
    output;
run;
```

```
data next_5;
    set next_4
        next_3;
run;

proc print data=next_5;
    title Input dataset--GENMOD;
run;
%end;

%else %do;
data next_5;
    set &covdsn;
run;

proc print data=next_5;
    title Input dataset--LOGISTIC/PHREG;
run;
%end;

%if (next_5 ne ) %then %do;

%let __stop=0;

proc iml;
    use next_5;
    read all var {_name_} into _varname;

    _nrvname=nrow(_varname);

    if (_nrvname>1) then do;
        _varnam2=_varname(|2:_nrvname, |);
        nmissing=j(nrow(_varnam2),1,.);
        labels={"EIGENVAL","CONDINDX","        "};
        _varnam2=labels//_varnam2;
        free _varname labels;
        read all var _num_ into varcov(|colname=_nvname|);
        _nrcvc=ncol(varcov);
        lastvnam=_nvname(|1,_nrcvc|);
        if (lastvnam="_LNLIKE_") then
varcov2=varcov(|2:_nrvname,1:_nrcvc-1|);
        if (lastvnam^="_LNLIKE_") then varcov2=varcov(|2:_nrvname,|);

%* If the covariance matrix is from GENMOD using the repeated measured
design, ;
%* then the lower diagonal will have the correlations and the upper
diagonal will have;
%* the covariances. The next section of code replaces the lower
diagonal with the upper;
%* diagonal to make a symmetric matrix.  If the matrix is symmetrical
already, then the;
%* next section of code will not affect anything.;

        vc2_c=ncol(varcov2);
        vc2_r=nrow(varcov2);
        do cl=1 to vc2_c;
            do rw=1 to vc2_r;
```

```
                varcov2(|rw,cl|) = varcov2(|cl,rw|);
            end;
        end;

        print varcov2;

        free varcov _nrcvc lastvnam vc2_c vc2_r cl;
        covbinv=inv(varcov2);
        scale=inv(sqrt(diag(covbinv)));
        r=scale*covbinv*scale;
        free covbinv scale;
        call eigen(musqr,v,r);
        free r;
        srootmus=sqrt(musqr);
        ci=1/(srootmus/max(srootmus));
        phi=(v##2)*diag(musqr##(-1));
        sumphi=phi(|,+|);
        pi=phi#(sumphi##(-1));
        free phi sumphi srootmus v;
        final=(musqr||ci||nmissing||pi`)`;
        free pi musqr ci nmissing;
        _ncfinal=ncol(final);
        _nrfinal=nrow(final);
        final2=j(_nrfinal,_ncfinal,0);
        _ncfp1=_ncfinal+1;
        __vdp="VDP";
        do i=1 to _ncfinal;
            final2(|,_ncfp1-i|)=final(|,i|);
            x=char(i,3);
            y=compress(concat(__vdp,x));
            if i=1 then _vdpname=y;
                else _vdpname=_vdpname||y;
        end;
        free final _nrfinal _ncfinal i x y;
        create final2 from final2(|rowname=_varnam2 colname=_vdpname|);
        append from final2(|rowname=_varnam2|);
        free _varnam2 _vdpname final2;
    end;
    if (_nrvname=1) then do;
        x="1";
        call symput("__stop",left(x));
        print " ";
        print
"************************************************************";
        print "You need to specify the covout option";
        print "in either proc logistic or proc phreg.";
        print "This program will not calculate collinearity
diagnostics.";
        print
"************************************************************";
        print " ";
    end;
    quit;
run;

%if (&__stop eq 0) %then %do;
proc print data=final2 label noobs;
```

```
    id _varnam2;
    title8 "Collinearity diagnostics for nonlinear models using";
    title9 "the information matrix:  Eigenvalues, Condition Indexes,";
    title10 "and Variance Decomposition Proportions (VDPs)";
    label _varnam2="VARIABLE";
run;
%end;

%end;
%else %do;
   %put;
   %put "********************************************************";
   %put "When you invoke this macro, you have to specify the name";
   %put "of a SAS data set that contains the variance-covariance";
   %put "matrix from LOGISTIC, PHREG, or GENMOD.";
   %put;
   %put "For more information, see the macro code (comments";
   %put "are included with instructions.";
   %put "********************************************************";
   %put;
%end;

proc datasets;
    delete next_1 next_1a next_2 next_3 next_4 next_5;
run;
quit;

%mend collin;
```

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