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Melody Gretchen Miles February 21, 2011

Public Health Measures Implemented in Response to the 2009 H1N1 Pandemic

By

Melody Gretchen Miles

Master of Public Health

Global Health Department

____ [Chair's signature]
Saad Omer, MBBS, MPH, PhD

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By
Melody Gretchen Miles
B.S.
Westmont College
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Thesis Committee Chair: Saad Omer, MBBS, MPH, PhD

An abstract of a thesis submitted to the Faculty of the Rollins School of Public Health of Emory University in partial fulfillment of the requirements for the degree of Master of Public Health in Global Health
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Public Health Measures Implemented in Response to the 2009 H1N1 Pandemic

Background: The 2009 influenza A(H1N1) pandemic tested the capacity and flexibility of global response mechanisms to mitigate the transmission of an emergent virus. In the absence of available vaccine at the height of the pandemic, non-pharmaceutical public health measures including school closures, travel screenings, and isolation served as important tools to assuage morbidity and mortality. The World Health Organization Global Influenza Program identified a need to synthesize the extent these activities were implemented and lessons learned to inform future guidance. Results will contribute to the WHO technical workshop on public health measures.

Objective: To systematically review published literature documenting experiences and outcomes of public health measures implemented from April 25, 2009 – April 30, 2010 in response to the H1N1 2009 pandemic.

Methods: Peer and gray literature databases were systematically searched. Papers meeting inclusion criteria were abstracted for relevant information using a standardized assessment tool and rated based on methodological rigor.

Results: The search identified 1597 papers, of which 85 met inclusion criteria and thirty-one provided good quality evidence of impact. Among rigorously designed studies, hand washing and post-outbreak school closures showed evidence of reducing disease transmission. Isolation showed some positive impact in closed settings such as hospitals and universities. Travel screenings and restrictions were of none or very limited effect. Control measures taken at mass gatherings stymied any large-scale outbreaks. Qualitative analysis of author experiences identified consistent uncertainty on when to initiate measures. Overall, the scope and timing of each intervention was highly correlated with its impact.

Discussion: Robust empirical evidence on the impact of non-pharmaceutical public health measures implemented during the pandemic is limited. However, much was learned about the process of implementation and gaps in preparedness plans. Implementation and termination triggers described were largely qualitative, incomplete, and randomly applied. Response plans designed for a more virulent virus were of limited use and required rapid adaption by policy makers and program managers. A decision-making framework utilizing pre-established triggers to initiate a tiered structure of implementation is needed. Indicators should be standardized to allow for comparative analysis. Moving forward, efforts should be made to improve integration of decision making and coordinate communication across sectors. A strategy and supporting fund at the global level for impact studies (and monitoring) on public health measures should be put in place before the next pandemic.

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Contents

Informal Abstract

What is Already Known

Public health measures are prescribed in pandemic influenza plans as reasonable mitigation strategies. Evidence from past pandemics and quasi-experimental influenza trials suggests that hand washing is particularly effective; school closures and isolation have also demonstrated some effectiveness under controlled conditions.

What This Study Adds

Despite only mild symptoms, non-pharmaceutical public health measures slowed the transmission of the pandemic A (H1N1) influenza virus. The review found implementation triggers insufficiently calibrated for such a biologically weak virus forced policy makers to quickly adapt response plans. While literature on travel restrictions and thermal screening showed no strong evidence of impact, observational evaluations suggest hand hygiene, school closures, and isolation within controlled environments and specific outbreak settings positively contributed to the pandemic response.

Acronyms

ARI	Acute Respiratory Illness
BTC	Basic Training Cadets
DAT	Data Abstraction Tool
DOH	Department of Health
DQA	Data Quality Assessment
CDC	Centers for Disease Control and Prevention
CFR	Case Fatality Ratio
CI	Confidence Interval
ER	Emergency Room
ED	Emergency Department
GIP	Global Influenza Program
(H1N1)	Swine-origin Influenza A
H2H	Human-to-human transmission
HCW	Health Care Workers
Hong Kong SAR	Hong Kong Special Administrative Region
IHR	International Health Regulations (2005)
ILI	Influenza-like illness
MeSH	Medical Subject Headings
MOH	Ministry of Health
NPI	Non Pharmaceutical Interventions
NSW	New South Wales, Australia
NWGPP	National Working Group on Pandemic Planning (Serbia)
PAHO	Pan American Health Organization
PED	Pediatric Emergency Department
PHM	Public Health Measure
pH1N1	Pandemic H1N1
PPE	Personal Protective Equipment
PWR	PAHO/WHO country Representative (Office)
RCT	Randomized Controlled Trial
RT-PCR	Reverse transcription polymerase chain reaction
SAR	Special Administrative Region, Hong Kong
SARI	Severe Acute Respiratory Illness
S-OIV	Swine-Origin Influenza Virus
TLC	Targeted Layer Containment
UK	United Kingdom
UN	United Nations
USA	United States of America
WHO	World Health Organization

Chapter 1. Introduction

Influenza pandemics elicit global concern not only due to the high morbidity and mortality, but also the high societal costs. The evolutionary transformation of human-to human and animal-to-human influenza caused morbidity and mortality in the pandemics of 1918, 1957, and, most recently, in 2009 with the emergence of the novel influenza A (H1N1) virus [1]. Three types of influenza, type A, B, and C, continuously circulate in nature. Mutations in type A viruses occur most frequently and are classified by subtype on the basis of the surface proteins humaglutinin cksp (HA) and neuraminidase (NA). The influenza A virus is infectious to humans, birds, pigs, horses, seals, and whales; but wild birds function as their natural hosts. Three influenza pandemics occurred in the twentieth century (1918, 1957, and 1968) and 2009 marked the first pandemic of the twenty-first century.

Past Pandemics

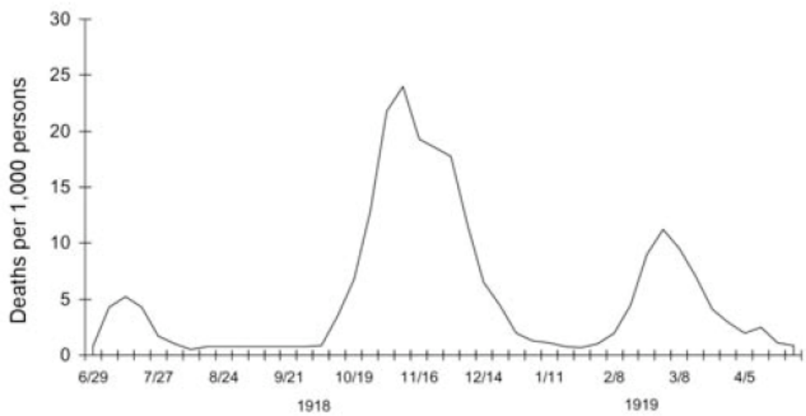
1918 Pandemic

To date, the influenza A pandemic of 1918-1919 exists as the most fatal in human history, causing 50-100 million deaths globally and infecting as many as one third of the world's population [2, 3]. Case fatalities rates were 5-20 times higher than any other influenza pandemic or epidemic (>2.5% rather than <0.1%) [2]. Patterson, et. al reports that the majority of people died not of influenza, but of secondary bacterial pneumonia infections [4].

While the exact geographical origin of the virus remains unknown, the first identification of cases occurred in the northern hemisphere and subsequently spread globally in three waves. The first wave, primarily concentrated in Europe, Asia, and North

America, began in the spring of 1918. The second and third waves followed in the fall and winter of 1918-1919 and resulted in higher fatality, with deaths among the young and healthy greater than 20 times previous years (Figure 1)[2]

Figure 1. Deaths per 1,000 persons attributed to the 1918-1919 Influenza Pandemic [2]



The high mortality of the 1918 Pandemic proved a frightening disease and changed the course of influenza circulation. Since 1918, all other influenza A viruses (including H1N1 and H5N1) have originated from descendants of the 1918 virus [2]. Although considerable post-hoc research has been conducted to explain the virulence in the 1918 virus, questions about its origins, unusual epidemiologic features, and the basis of its pathogenicity remain unanswered. Ultimately, the 1918 pandemic stamped in the human mind the reality that "We can only conclude that since it happened once, [it is possible] analogous conditions could lead to an equally devastating pandemic" [2].

1957 Pandemic

In 1957, influenza rapidly spread from the Asian continent across the northern and southern hemisphere [5]. The alert of a rising pandemic first emerged from Hong Kong news reports citing an epidemic of 250,000 people [3, 6]. The infecting H2N2 strain caused disease in over 25% of the USA population, localized attack rates as high as 40-60%, and disproportionately affected pregnant women and those with chronic underlying conditions [3, 5]. While disruptive, the virus elicited only mild symptoms in the majority of cases. However, a second wave in 1958 resulted in a cumulative two million deaths by the end of the pandemic, a reminder of the desultory and serious nature of an influenza virus [3].

1968 Pandemic & 1976 "Pandemic Alert"

Two smaller pandemics also appeared in recent years. The *Hong Kong (H3N2) Flu* of 1968 manifested variable regional impact and resulted in an estimated one million deaths globally [1]. In 1976 a novel influenza A H1N1 virus was detected in 230 Fort Dix, New Jersey soldiers, causing one death. This event catalyzed a national vaccination program in the US, an aggressive measure implemented in hopes of protecting against an experience similar to 1918. When no other cases of the novel virus were detected, the program was halted and lessons were gathered to inform for future guidance [3].

Global Response

No pandemic is the same. The rise of the novel influenza A (H1N1) virus tested the capacity, and flexibility, of global health systems to meet the vacillating public health needs of the emerging pandemic. Appearing in an era of global interconnectedness the 2009 pandemic required a closely coordinated response action between public health agencies and the travel, trade, private industry, education and information technology sectors. At an international level, the World Health Organization, acting on its mandate to provide governance on health and disease, published recommendations for disease mitigation throughout the pandemic [7]. At the national and sub-national levels, pre-established plans defining channels of communication and decision making processes across government branches served as a framework for coordinating the response between multiple sectors.

As events unfolded, global surveillance served a critical role in informing the response. Once a new virus was confirmed from Mexico, epidemiological indicators quantifying influenza like illness (ILI), acute respiratory illness (ARI), severe acute respiratory illness (SARI), laboratory confirmed H1N1 cases, and mortality were reported weekly by member countries to the World Health Organization (WHO) as mandated under the 2005 International Health Regulations (IHR) Article 6 [8]. Countries were encouraged to provide these data disaggregated by risk groups and age when possible. WHO also requested qualitative assessments from national IHR focal points on geographical spread, intensity, and health-system impact of the influenza A (H1N1) pandemic to help inform decision making [9]. This global surveillance network allowed WHO to track disease spread, measure pandemic severity, rapidly communicate data, and develop appropriate guidance for control and treatment. While the objectives of individual country surveillance systems varied according to the pandemic stage and laboratory capacity, the focus remained on disease epidemiology. No formal monitoring at the of national response activities, particularly non-pharmaceutical PHM, was coordinated by the WHO [10].

WHO also provided leadership in establishing a standard case definition. A confirmed novel influenza A (H1N1) case required real-time reverse transcription polymerase chain reaction (RT-PCR), viral culture, or a 4-fold rise in pandemic (H1N1) 2009 virus-specific antibodies [9]. Given the wide spectrum of surveillance capacities across countries, once community transmission was established, influenza like illness (ILI), defined as "a fever (temperature over 100°F) and a cough and/or sore throat in the absence of a known cause other than influenza" was accepted as the definition for diagnosis and reporting of cases [11] .

H1N1 2009 marks the first pandemic of the twenty first century. Contrary to predictions, it started in North America rather than South-East Asia. By August 2010, over 214 countries and territories reported laboratory confirmed cases, including over 18,000 deaths. Incoming case data from 23 April to 11 June 2009, first from Mexico and eventually from all six WHO regions[1], triggered WHO to raise the global pandemic alert from phase 3, to the highest possible level, phase 6. These alert phases are based upon the transmitability of the virus rather than the severity or virulence of the resulting infection. The WHO description of each phase is provided below (6). Incoming case data, first from Mexico and the USA and eventually from all six WHO regions[2], triggered WHO to raise its pandemic alert from phase 3, to the highest possible level, phase 6. (Of note, the WHO pandemic alert phases are based upon the transmitability of the virus in humans rather than the severity or virulence of the resulting infection.) The WHO description of each phase is provided below [12].

- **Phase 1:** No animal influenza virus circulating among animals has been reported to cause infection in humans
- **Phase 2:** An animal influenza virus circulating in domesticated or wild animals is known to have caused infection in humans and is therefore considered a specific potential pandemic threat.
- **Phase 3:** An animal or human-animal influenza reassortant virus has caused sporadic cases or small clusters of disease in people, but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks.
- **Phase 4:** Human-to-human (H2H) transmission of an animal or human-animal influenza reassortant virus able to sustain community-level outbreaks has been verified.
- **Phase 5:** The same identified virus has caused sustained community level outbreaks in two or more countries in one WHO region.

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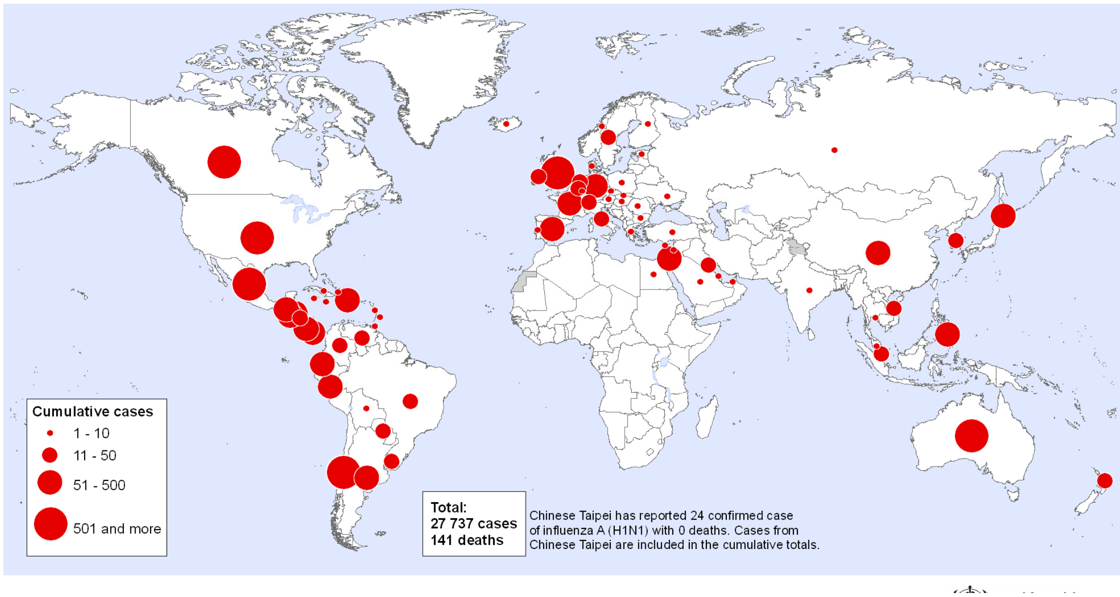
[1] All WHO Member States are grouped into six regions with an regional office. The six regions are: Africa, the Americas, South-East Asia, Europe, the Eastern Mediterranean, and the Western Pacific.

- **Phase 6:** In addition to the criteria defined in Phase 5, the same virus has caused sustained community level outbreaks in at least one other country in another WHO region.
- **Post-Pandemic Period:** Levels of pandemic influenza in most countries with adequate surveillance have dropped below peak levels.

Timeline of Events

Within three months after confirmation of a human H1N1 case in Mexico on 23 April 2009, a series of aggressive national and international actions unfolded. The first case of influenza A (H1N1) was confirmed on 23 April, 2009 from Mexico. By the next day, all schools in Mexico city were closed and on 25 April, the WHO declared influenza A(H1N1) a *Public Health Emergency of International Concern*, requiring every country to report cases to the agency as specified under the revised International Health Regulations [8]. Non-pharmaceutical public health measures served as the frontline defense for Mexico in the days immediately following the outbreak, as Mexico canceled all public events, recommended use of facemasks, and instituted a nationwide school closure by 27 April, 2009. Concurrently, cases were reported from the WHO European and Western Pacific Regions, prompting the WHO Director General to raise the pandemic alert from phase 3 to phase 5 in a one week period. The most aggressive PHM were launched by Mexico's government the week of 1-5 May, in which all non-essential economic activities were suspended. Subsequently, additional cases reporting from the Eastern Mediterranean Region and the first confirmed death from a 23 month old US toddler resulted in the declaration of pandemic phase 6 on 11 June. By this time 27,737 confirmed cases and 141 deaths attributable to H1N1 had been reported to WHO (Figure 2).

Figure 2. New Influenza A (H1N1), Number of laboratory confirmed cases as reported to WHO as of 10 June 2009 [13]



Ultimately, 32 countries reported influenza A(H1N1) cases to WHO within 1 month of the first initial case. Within 2 months, 76 countries reported cases. Table 1 provides the timeline of selective events during each pandemic phase [10, 14-16].

Table 1. Chronology of select global H1N1 pandemic reporting and response activities from 17 April to 16 June 2009 by WHO pandemic phase	
Phase 3	**17 April:** Mexico intensified national surveillance for acute respiratory illness and pneumonia. **23 April:** New influenza A (H1N1) virus confirmed from Mexico, marks the **first case reported to WHO from American Region** **23 April:** 7 cases in USA (Texas & California) **24 April:** WHO announces the outbreak of influenza A (H1N1) in Mexico and the USA **24 April:** Mexico City school closures are ordered **25 April: WHO declares A(H1N1) outbreak a Public Health Emergency of International Concern based on the revised International Health Regulations (2005)** **25 April:** Mexico City cancelation of public events **26 April:** Mexico advises people to wear face masks, avoid crowds **27 April:** Nationwide school closures in Mexico
Phase 4	**27 April:** WHO raises pandemic alert to Phase 4, indicating human-to-human transmission **27 April: First case reported to WHO from the WHO European Region** **28 April: First case reported to WHO from the WHO Western Pacific Region** **28 April:** First confirmed death in USA (23 month toddler) **29 April:** Mexico requires all public transportation drivers to wear masks
Phase 5	**29 April:** WHO raises pandemic alert to Phase 5, indicating sustained human-to-human infection in two or more countries in one WHO region **1 May:** First United Kingdom case of human-to-human transmission was reported **1-5 May:** All non-essential economic activities suspended in Mexico **3 June: First case reported to WHO from the WHO Eastern Mediterranean**
Phase 6	**11 June:** WHO declares Phase 6 **17 June:** Global cases reached approximately 35,000 in 74 countries with 163 deaths **18 June: First case reported to WHO from the WHO Africa Region**
Post Pandemic Period	**10 August 2010**

WHO Activity

A shift into Phase 5-6 requires national authorities to implement a series of actions following WHO recommendations in responding to the global situation. Priority areas of activity, outline in WHO's 2009 *Pandemic Influenza Preparedness and Response* are [17]:

- ***Planning and Coordination****:* Provide leadership and coordination to multi-sector resources to mitigate the societal and economic impacts.

- ***Situation Monitoring and Assessment:*** Actively monitor and assess the evolving pandemic and its impact and mitigation measures
- ***Communications:*** Continue providing updates to general public and all stakeholders on the state of pandemic and measures to mitigate risk
- ***Reducing the Spread of Disease:*** Evaluate the effectiveness of the measures used to update guidelines, protocols, and algorithms.
- ***Community of Health Care Provision:*** Implement contingency plans for health systems at all levels

Non-pharmaceutical Public Health Interventions

*Non-pharmaceutical inte*rventions (NPI) are defined as any public health strategy, excluding vaccines and antiviral medications, used to reduce or delay the transmission of an infectious virus [18]. The three main objectives of NPI responses are:

1) to delay the increase of incident cases
2) to decrease peak severity of epidemic
3) to reduce the total number of incident cases and hence reduce community morbidity and mortality.

Each objective helps mitigate the impact of disease on public health. A significant benefit of non-pharmaceutical public health interventions, is that they can be applied rapidly, prior to production of a vaccine. Timely, optimal implementation of such measures can aid in ameliorating many of the societal strains experienced during the peak stages of a pandemic.

On 11 June 2009 when influenza A (H1N1) was declared a global pandemic, WHO published a guidance document in the *Weekly Epidemiological Record* recommending public health measures (PHM) to control the outbreak [19]. The recommended interventions targeted individuals, households, communities and other situations where individuals may congregate. Governments were required to focus efforts "on mitigating the impacts on health and society through the appropriate care of ill people rather than on attempts to contain transmission of the disease"[19]. School closures and cancelation of mass gatherings were recommended only on a case-by-case basis with the objective of both reducing transmission and limiting, as much as possible, societal disruption [19].

Governments and civic institutions were required to execute sound public health judgments on when, and how best, to protect venues vulnerable to high transmission within their communities. As for travel, WHO recommended against closing borders and restricting international travel. However, it was considered prudent for ill people to delay international travel and for people developing symptoms following international travel to seek medical attention [20]. WHO also published a statement that citing screenings are "resource-intensive and will provide decreasing benefits as infections become more widespread", especially since many "asymptomatic or sub-clinical infections will not be detected" [21].

No explicit recommendations were made on isolation or quarantine beyond directives to the healthcare sector to prepare for capacity surges, ensure supply of medicines to treat ILI, and initiate appropriate trainings [20]. Countries were asked to communicate information to the public concerning pandemic activity and governmental actions. In accordance with the International Health Regulations, national authorities were responsible for making decision reducing public health risk [8]. Thus, national decision makers were required to weigh the benefits and barriers of each intervention strategy as the pandemic unfolded (Table 2)[18, 22].

Table 2. Benefits and barriers considered by decision makers in regards to implementation of non-pharmaceutical interventions during the 2009 H1N1 pandemic: evidence from literature review	
Benefits	**Barriers**
Reducing total number of cases Slowing epidemic Securing more time for vaccine production Reducing incidence of cases at peak of epidemic Limiting stress on the healthcare system Limiting school absenteeism Limiting absenteeism at places of work and in the general population Increasing community wide resistance	Community acceptance Uncoordinated messages Poor planning (lack of operational detail in how to execute plans and/or scale up interventions) Unclear lines of authority Individual stigma and fear Poorly designed and/or non specific screening questionnaires Poor linkages between screening an quarantine and/or treatment measures Difficulties with rapid, large scale implementation

Problem Statement

Non-pharmaceutical public health measures to mitigate against the A(H1N1) pandemic were implemented at various levels globally. The unpredictability of the virus and the emergence of new information for decision making at each phase of the epidemic resulted in a wide range of measures among countries, organizations, and institutions. Antidotal evidence and communication at WHO headquarters suggests wide variation in the objectives and rationale for "go-no-go" decisions for non-pharmaceutical public health measures. However, such experiences have not yet been synthesized in order to understand the impact of these interventions on both disease transmission and public perception.

Given the scant quantity and quality of evidence arising from previous pandemics, it is important to understand the scope, utility, and influence of non-pharmaceutical PHM in the

2009 H1N1 public health pandemic response. Ultimately, a mapping of what happened, where, what were the outcomes and lessons learned is critical in informing how best to implement public health measures in future.

Purpose Statement

The purpose of this thesis is to provide a comprehensive review of published literature on experiences from implementing public health measures during the influenza A (H1N1) 2009 pandemic from around the world. It will provide background data for the WHO technical workshop on public health measures (PHM) as well as contribute to the external WHO H1N1 Pandemic Response Evaluation ordered by the United Nations General Counsel.

Research Objectives

The objective of this project is to systematically review published literature in English, Spanish, and French on public health measures implemented by countries and or institutions/organizations during the 2009 influenza A(H1N1) pandemic. The review aims to focus on of five main venues and mechanisms for intervention:

1. Schools
2. Mass gatherings
3. Points of travel and trade
4. Individual and societal behavior change
5. Integration of measures to maximize impact

Significance Statement

On 10 August, 2010 the first pandemic of the twenty-first century came to a close. During the period of heightened alert, national governments and public health agencies initiated a wide spectrum of protection measures. Antidotal evidence among experts suggests many gaps in preparedness were identified during the implementation and surveillance processes. While naturally each countries response to the pandemic remains unique, there has been no systematic synthesis of lessons to share among stakeholders, promote future research, and guide policy revisions. The World Health Organization Global Influenza Program, which is responsible for producing international guidance on non-pharmaceutical public health measures during a pandemic, has requested a review of experiences to guide future planning. The significance of this work will be in the dissemination of its finding among representative countries at the WHO workshop, "Non-pharmaceutical public health measures implemented in response to the 2009 pandemic," to be held in Tunis, Tunisia.

Quality improvement and accountability remain essential components of public health emergency preparedness. However, new tools and sources of information are needed to guide this process, particularly given the rarity of pandemic influenza. Moving forward, it is important to consider what has already been done, what worked, and why. Thus, this research will serve public health professionals as a reference of key lessons learned emerging during the pandemic. Finally, it will offer the first known synthesis comparing experiences across developed and developing countries.

Definition of Terms

Public Health Emergency

A public health emergency is an event "[sic] who's scale, timing, or unpredictability threatens to overwhelm routine capabilities" [23]. Operationally, the definition directs public health scientists to focus on the potential health consequences of an event rather than its particular cause. The "routine capabilities" addressed in the definition speak towards the capability to "[1] detect, investigate, and identify health hazards; [2] deploy mitigation and countermeasures strategies; and [3] provide accurate and credible messages to the public during the crisis" [23]. A gap in any of these three response areas can trigger an emergency.

Colloquially, an emergency is any event that exceeds the ability of the response system to cope. Given this definition, an emergency must be measured on a relative basis; no number of infections or cases can define an emergency threshold: it depends on the response capacity in the nation or community at risk. For example, the capacity of a low resource country with a large population and an understaffed health system will likely be more quickly overwhelmed and pushed to the point of emergency as compared to a high resource country.

Public Health Emergency Preparedness

Public Health Emergency Preparedness

Public Health Emergency Preparedness (PHEP) is defined as "the capability of the public health and health care systems, communities, and individuals, to prevent, protect against, quickly respond to, and recover from health emergencies, particularly those whose scale, timing, or unpredictability threatens to overwhelm routine capabilities" [23]. The goal of PHEP should be to "build upon existing systems" and will require "deploying and adapting plans and resources to meet the emerging needs of the situation" [23].

Chapter 2. Background

Existing Evidence and Previous Reviews

The scientific base supporting non-pharmaceutical interventions (NPI) prior to the 2009 pandemic, consisted "primarily of historical and contemporary observations, rather than controlled scientific studies" [24].

The 1918 pandemic produced numerous reports that isolation and social distancing failed to prevent virus transmission [24, 25]. However, a recent review in 43 US cities of the weekly excess death rate during the 1918 pandemic showed that the combination of school closures and public gathering bans, lasting on average 4 weeks, was correlated with a lower excess death rate. Cities implementing measures closer to the start of the pandemic showed greater delays in reaching peak mortality ($r=-0.74$, $p<.001$) and lower total mortality ($r=0.31$, $p=.02$), results strongly supporting timely implementation of PHM [25, 26].

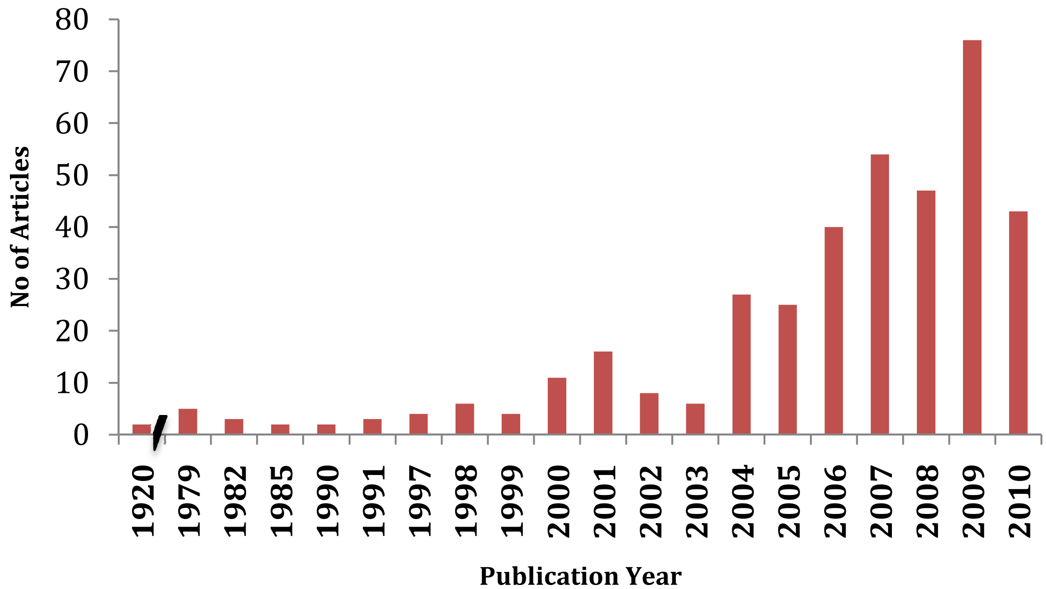
In contrast, PHM were used sparingly during the 1957 Asian influenza epidemic. Epidemiological surveillance reporting rapid spread of the novel virus, coupled with a low death rate, lead USA policy makers to conclude there was "...no practical advantage in the closing of schools or the curtailment of public gatherings as it relates to the spread of this disease" [5]. Nonetheless, an increase in school absenteeism to 20-30% above average in a sample of 25 USA schools suggests self-isolation was routinely practiced [5]. In France, a review of school closures in France found closure decision were local, lacked consistency, and overall judged ineffective [22].

During the SARS epidemic in Hong Kong, targeted layered containment[3] (TLC), including school closures, cancelation of sporting events and other public activities, disinfecting public places, use of face masks, frequent hand washing, and less social mixing was found to decrease laboratory diagnosed viral infections [27]. Thermal scanning of travelers was inefficient in detecting cases and no data were captured on individual school closure effectiveness [24].

However, lessons learned from past-pandemics were not quick to be published: they evolved over time. Publication trends from peer-reviewed literature on the 1918 pandemic show evidence was disseminated for decades following the pandemic and increased over time (Figure 3). Variability in research capacity, funding, public interest, and publication requirements in peer-reviewed journals all influence the timeliness of post-pandemic information. Additionally, the "ice-berg effect" of information never reaching publication limits public knowledge on community public health measures. While the 2009 H1N1 pandemic has arguably generated the largest quantity of pandemic data to date, a similar publication delay, to some extent, is likely.

[3] A set or package of interventions, including household isolation of identified cases, quarantine of household contacts, closure of schools, social distancing in the community, infection control measures, and travel restriction interventions combined and implemented as a single, targeted strategy (Halloran et alt 2008).

Figure 3. Peer reviewed articles published following 1918 pandemic[4]



Three formative reviews of non-pharmaceutical PHM were completed prior to the 2009 pandemic. Such evidence served as guidance for decision making, especially in the early stages of the pandemic when information regarding the severity of the H1N1 virus was still unknown. These papers include:

1. In 2009, a systematic review of 59 studies assessed the effectiveness of 14 different non-pharmaceutical interventions. While differences in study quality and design prohibited meta-analysis, results from the highest quality randomized controlled trials (RCT) showed good hygiene practices in children and household contacts of index cases elicited the greatest effect, reducing infection rates by 3-17%. Among the seven case control studies, barriers to transmission, isolation, and hygiene measures also proved effective [28].

2. An August 2009 review of pandemic school closures cited two historical accounts

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[4] Figure generated from Web of Science search using keywords “1918 influenza” “1918 epidemic” “1918 pandemic” “1918 flu”

where closures most likely slowed virus transmission, with reductions from 15% to 40% depending on the stage of pandemic intensity. However, in the case of the SARS outbreak in Hong Kong as well as in the 1957 French pandemic, no individual or ecologic evidence exists that school closures had any meaningful effect. Overall a failure to properly isolate children during school closures was shown to “substantially undermine” closure effectiveness. The authors conclude that the attack rate among children and the severity of the pandemic likely determines the impact of school closures on reducing disease spread [22].

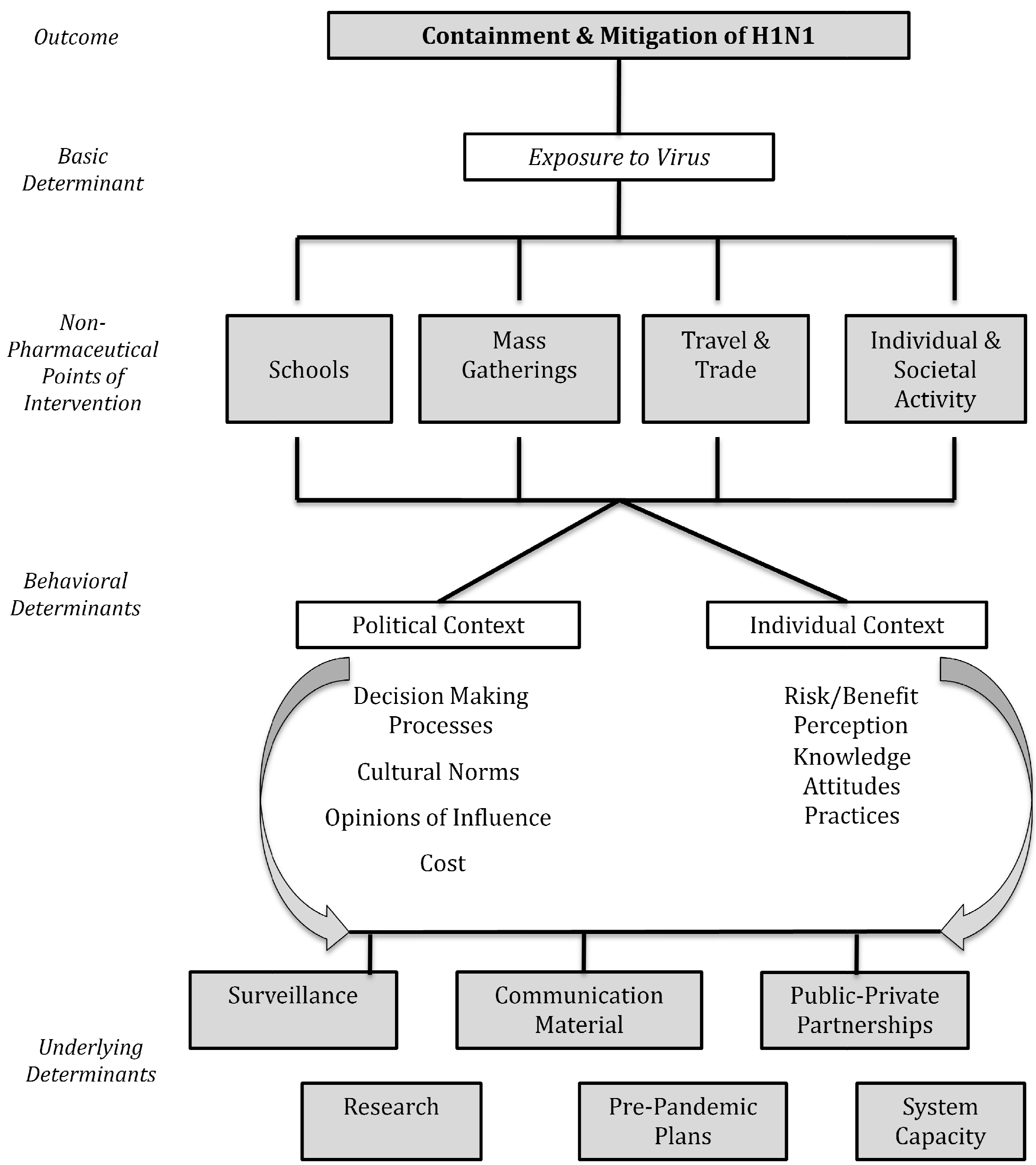
3. The CDC funded eleven projects from 2007-2009 to evaluate NPI during seasonal influenza outbreaks. The studies, while differing in methodologies and outcome measures, provide some evidence that facemasks, cough etiquette, hand hygiene, school closures, and reduced crowding can limit the spread of seasonal influenza; however insufficient sample sizes and underreporting limit the generalizability of these findings. Additionally, modeling procedures from these projects have provided theoretical evidence that targeted layered containment (TLC) strategies using PHM can reduce pandemic influenza transmission before a vaccine becomes available [29].

Social Science and Public Health Measures

Differences in attitudes and adherence practices to NPI often confound estimates of impact. For example, a randomized controlled trial testing the effectiveness of facemasks in reducing ILI during the 2006-2007 influenza season reported mixed results. While compliance to mask use significantly reduced the risk for ILI in households, less than 50% of participants reported wearing masks per protocol for the majority of the study period. Low adherence led the authors to conclude facemasks were ineffective in controlling the spread of seasonal ILI [30].

Conceptual Framework

Figure 4. Containment & Mitigation of the H1N1 2009 influenza A Pandemic



Global Matrix of PHM Implemented During the 2009 H1N1 Pandemic

Entering the twenty-first century, clear gaps exist in the evidence base for public health measures and pandemic preparedness. The background research described above, coupled with international recommendations from the WHO, served as a common platform for decision making during the H1N1 pandemic. However, responses varied across selected measures, levels of implementation, and impact. Each country implemented a unique package of PHM according to the local epidemiology, resource availability, public health capacity, and expert internal judgment. As a whole, such activities generated the highest quantity and, while still inadequate, quality of published literature on the impact and lessons learned from implementing PHM to date. Table 3 catalogs PHM implemented by WHO region and country. The purpose of the table is to capture what happened and where. It depicts all searched sources of published literature and thus provides an evidence-based starting point for generating lessons learned during the 2009 H1N1 pandemic.

Table 3. Global Matrix Framework and Category Definitions	
School Closures	Literature describing closure of any educational institution (kindergarten through university) for one plus days
Mass Gatherings	Literature describing protective actions taken, including but not limited to cancelation, at a large festival or gathering
Travel and Trade	Literature describing travel restrictions, travel screenings, protective measures at border crossings, restrictions to trade, and all travel related activities during the pandemic
Individual and Societal Measures	Literature describing protective measures at hospitals, points of interest, and public gatherings; Media campaigns, hygiene education, hand washing, and promotion of self-quarantine are also included in this category
Integrated-National Measures	Literature capturing a multi-disciplinary measures, typically at the national or district level
Bold Text Normal Text	**Peer reviewed literature** Gray literature

Table 4. Non-Pharmaceutical public health measures implemented from 24 April 2009 to 30 April 2010 in response to the influenza A (H1N1) 2009 pandemic (First Author's Last Name, E-Publication Month-Year)

Table 4.1 Americas Region

Country	Schools	Mass Gatherings	Travel& Trade	Individual& Societal Measures	Integrated National Measures
Argentina	**Orellane, Apr-10**				**Valente, Jul-09 US Gov, Jun-09**
Belize				PAHO, May-10	
Bolivia				PAHO, May-10	
Canada			PHA Canada, May-10		
Caribbean				PAHO, May-10	
Chile					
Costa Rica				PAHO, May-10	
Mexico				**Bourlon, Mar-10**	**Del Rio, Mar-10 Bell, Dec-09 Stern, Sep-09 Condon, Dec-09 Macias, Aug-09**
Caribbean				**PAHO, May-10**	
Chile					
Costa Rica				**PAHO, May-10**	
Mexico				**Bourlon, Mar-10**	**Del Rio, Mar-10 Bell, Dec-09 Stern, Sep-09 Condon, Dec-09 Macias, Aug-09**
Panama				PAHO, May-10	

All PAHO					Gorter, Dec-09
United States	**Cooper, Nov-09 Gift, Aug-10** USG, June-09	**Dill, Dec-09**		**Park, Jan-09 Boehm, Mar-10 Witkop, Oct-09,** US Dep. Defense, NA	**Bell, Dec-09**
Uruguay					**US Gov, June-09**

Table 4.2 Eastern Mediterranean Region

Country	Schools	Mass Gatherings	Travel& Trade	Individual & Societal Measures	Integrated National Measures
Afghanistan	**Reuters, Nov-09**				
Iraq	**IRIN, Oct-09**				
Saudi Arabia	**Ebrahim, Nov-09**				

Table 4.3 European Region

Country	Schools	Mass Gatherings	Travel& Trade	Individual & Societal Measures	Integrated – National Measures
Belgium			**Gutierrez, Aug-09**		
France	**Guinard, July-09 Carrillo, July-10**			**Fillenl, April 10** Connely, Sep-09	
Greece			**Lytras, Aug-09**		
Italy				**La Torre, Dec-09 Chironna, Jan-10**	
Russia			Shuster, Nov-09		
Serbia		**Loncarevic, Aug-09**			
Slovakia			Shuster, Nov-09		

Ukraine			Shuster, Nov-09		
United Kingdom				**O'Dowd, May-09 Rubin, July-10**	Hine, July-10

Table 4.4 Southeast Asia Region					
Country	**Schools**	**Mass Gatherings**	**Travel & Trade**	**Individual & Societal Measures**	**Integrated – National Measures**
India				**Kamate, Feb-10**	
Thailand	Apisarnthanarak, Jan-10		McConnell, Sep-09		
Vietnam			McConnell, Sep-09		

Table 4.5 Southeast Asia Region					
Country	**Schools**	**Mass Gatherings**	**Travel & Trade**	**Individual & Societal Measures**	**Integrated – National Measures**
Australia			**Bishop, Nov-09 Leggart, Nov-09**	**Kotsimbos, Feb-10 Corley, Dec-10 Eastwood, Sep-09 Hamilton, June-09 Van, Mar-10 Spokes, April-10**	**Smilth, Dec-09 Waterer, Mar-10 Appuhamy, Jan-10 US Gov, June-09**
Brunei Darussalam					Hamid, July-09
Japan	**Kawagucki, Oct-09**		**Shigemura, Sep-09**		**WHO, June-09**
Malaysia				The Star, April-10	
New Zealand			**Jennings, Aug-09**	**Kotsimbos, Feb-10**	**US Gov, June-09**
People's Republic of China	**Wu, Mar-10** Moy, Sep-10		**Shen, May-10 McConnell, Sep-09**	**Cheng, Jan-10 Lau, July-09 Chu, Aug-10**	**Ong, June-09** Jacobs, June-10
Singapore			**(Mukherjee, Dec-09) (Ang, Feb-10)**		**Ong, June-09 Tay, May-10**

Chapter 3. Research Methodology

A systematic search methodology was used to identify all published experiences from 24 April 2009 to 30 April 2010 on public health measures implemented during the pandemic A (H1N1). No human research was conducted and thus the study investigated was not required to submit to IRB for approval.

Search Strategy

The search strategy and process was guided by the *Meta-Analysis of Observational Studies in Epidemiology* (MOOSE) recommended guidelines [31]. Title and abstracts were reviewed based on the apriori selection criteria described below. Full text of papers appearing to meet criteria were retrieved and a final determination on relevance made by one primary reviewer (mgm). Reference lists of included articles were screened and WHO content area experts consulted for additional papers pertinent to the review. Endnote version X4 was used to catalog all articles and duplicate search results were deleted. Frequencies of titles and abstracts reviewed, full-text papers read, as well as included and excluded articles were recorded in Microsoft Excel.

Numerous categories could have been used to classify public health measures. Technical experts from the Global Influenza Program identified five categories paralleling the WHO pandemic preparedness organizational structure. The five categories were: schools, mass gatherings, travel and trade, individual and societal measures, and emerging ideas. Many papers provided information on multiple measures and thus a fifth category, integrated measures[5], was also defined. The primary reviewer made every effort to catalog

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[5] Integration of measures was defined as the "…*process where disease control activities are functionally merged or tightly coordinated*" in order to optimize impact (Unger et al)

each article according to original authors intended description, primary measure of interest, and overall best fit for informing programmatic decisions.

Peer Reviewed Literature

Articles published in peer-reviewed journals were searched using Ovid MEDLINE and Web of Science online databases. The medical subject heading (MeSH) "Influenza A Virus, H1N1 Subtype" was paired with nineteen other MeSH* terms and six non-MeSH terms: "schools*", "hand washing*", "travel*","mass screening*", "quarantine*", "patient isolation*", "Mexico/epidemiology*", "practice guidelines as topic*", "disease outbreaks/prevention & control*", "sanitation*", "sterilization*", "masks*", "mandatory programs*", "infection control*",, "gloves, protective*", "protective devices*", "hygiene*", "protective clothing*", "surge capacity*", "trade", "distancing", "disease notification", "gatherings", "border", and "personal protective equipment."

Gray Literature

Ministry of Health websites were search for the following developed and developing countries: Australia, United Kingdom, Canada, Singapore, Mexico, Brazil, Argentina, Afghanistan, South Africa, Tanzania, Uganda, Ghana, and Kenya. Additional searches were conducted within the European Commission for Public Health, WHO, and Pan American Health Organization (PAHO) online materials. For the United States, the US Department of Homeland Security, US Customs and Border Protection, US Department of Education, US Department of Defense, and US Centers for Disease Control and Prevention websites were searched for relevant publications. Google searches in English using the queries "H1N1 2009 pandemic AND public health measures" and "H1N1 2009 pandemic AND school closures" were also used, with approximately the first 1000 titles reviewed. Within all websites, pages coving "influenza", "H1N1 pandemic", "infectious disease control", and "publications" were read. Expert Opinion news articles on measures taken in nations and/or communities not otherwise represented in the peer-reviewed literature were accepted.

Selection/Exclusion Criteria

Articles from all 191 WHO countries across all six regions were eligible for inclusion. Acceptable study designs included experimental (randomized controlled trials [RCT], non-randomized controlled studies, time series), observational (cohort, case control, cross sectional, narrative reviews, case study) and "gray" literature (expert opinion, editorials, "newsy" narratives, commentaries, and digitally archived news articles). Each article was reviewed based on the following selection criteria:

1. Article included a description of a non-pharmaceutical public health measure implemented from 24 April 2009 to 30 April 2010 in response to the pandemic A (H1N1) 2009 influenza.

2. Article specified the type and objective of one or more of the following measures: school closures, mass gatherings, travel and trade, individual and societal measures, integrated measures, and emerging ideas.

3. Article was in English, French, or Spanish and available through Emory University library or the World Health Organization Headquarters office.

Articles were excluded if they described guidelines in national/organizational policy and/or pandemic response plans rather than retrospective documentation of implemented activities.

Data Abstraction and Analysis

A standardized data abstraction tool (DAT) was developed from two previous reviews on global health interventions [32][33]. Abstraction fields included background information (publication type, methodology, country), description of the public health measure (date, duration, objective, implementation and termination triggers), and outcome(s) (indicators, author stated success). Results were organized first based on measure categories and secondly by either proactive or reactive implementation, defined as:

Proactive Measures: intervening public health action taken prior to significant community influenza transmission.

Reactive Measure: intervening public health action taken within a community after an outbreak of influenza-like illness had already been identified [22].

Data Quality Assessment

Quality assessment of each article was completed using three data quality assessment (DQA) tools corresponding to observational, expert opinion, and gray literature. Each article was ranked *good*, *fair*, or *poor* based on the rigor of the measure description, clarity of objectives, methodology and sampling, appropriateness of target population, time frame for measuring impact, identification of confounders, and cited limitations (Annex 1-3). An overall study grade was assigned based on cumulative points for each category (good-2, fair-1, poor-0). The DQA scoring criteria for observational/expert opinion articles ranked ⩾ 20 points as "good", 15-19 points as "fair", and ≤ 14 points as "poor." The abbreviated gray DQA ranked ≥ 18 points as "good", 18-12 points as "fair", and ≤ 12 points as "poor". Good and fair quality papers are presented in the results tables, with poor quality articles mentioned and footnoted only when contributing new themes or implementation triggers to analysis.

Qualitative limitations in strength of evidence (methods, sample, sources of bias and confounding) and generalizability (context, parameters for implementation, and authors considerations), adapted from a previous review on public health interventions, were also considered and reported in the annotated bibliography (Annex 4-5) [33].

Characteristics of Excluded Abstracts

A dearth of literature exists related to the 2009 H1N1 pandemic. Some examples of common exclusions made by the author during the search process are:

1. Article described implementation and planning of a pharmaceutical or medicinal intervention

   Example: Veryard,C. Terrapinn's world influenza congress Europe 2009: Report from a meeting with vaccine manufactures to discuss the European Union's response to H1N1 pandemic; IDrugs. Feb 2010; 3(2):76-77. [34]

2. Article failed to document experiences on measure already implemented.

   Example: Kiely, P.M.; Lian, K.Y. et alt. Influenza A (H1N1) and infection control guidelines for optometrists. Journal of the Australian Optometrical Association: Clinical and Experimental Optometry. Sep; 92(6):490-94. [35]

3. Measure did not fall between 24 April 2009 to 30 April 2010

   Example: Cowling, Benjamin J. Facemasks and Hand Hygiene to Prevent Influenza Transmission in Households A Cluster Randomized Trial. Ann Intern Med. Oct; 151(7):437-46. [36]

4. Article summarized proposed guidelines rather than implemented measures

   Example: Poalio, F.E; Geiling, J, Jimenez, E.J. *Healthcare personnel and nosocomial transmission of pandemic 2009 influenza.* Critical Care Medicine. April; 38(4):e98-102. [37]

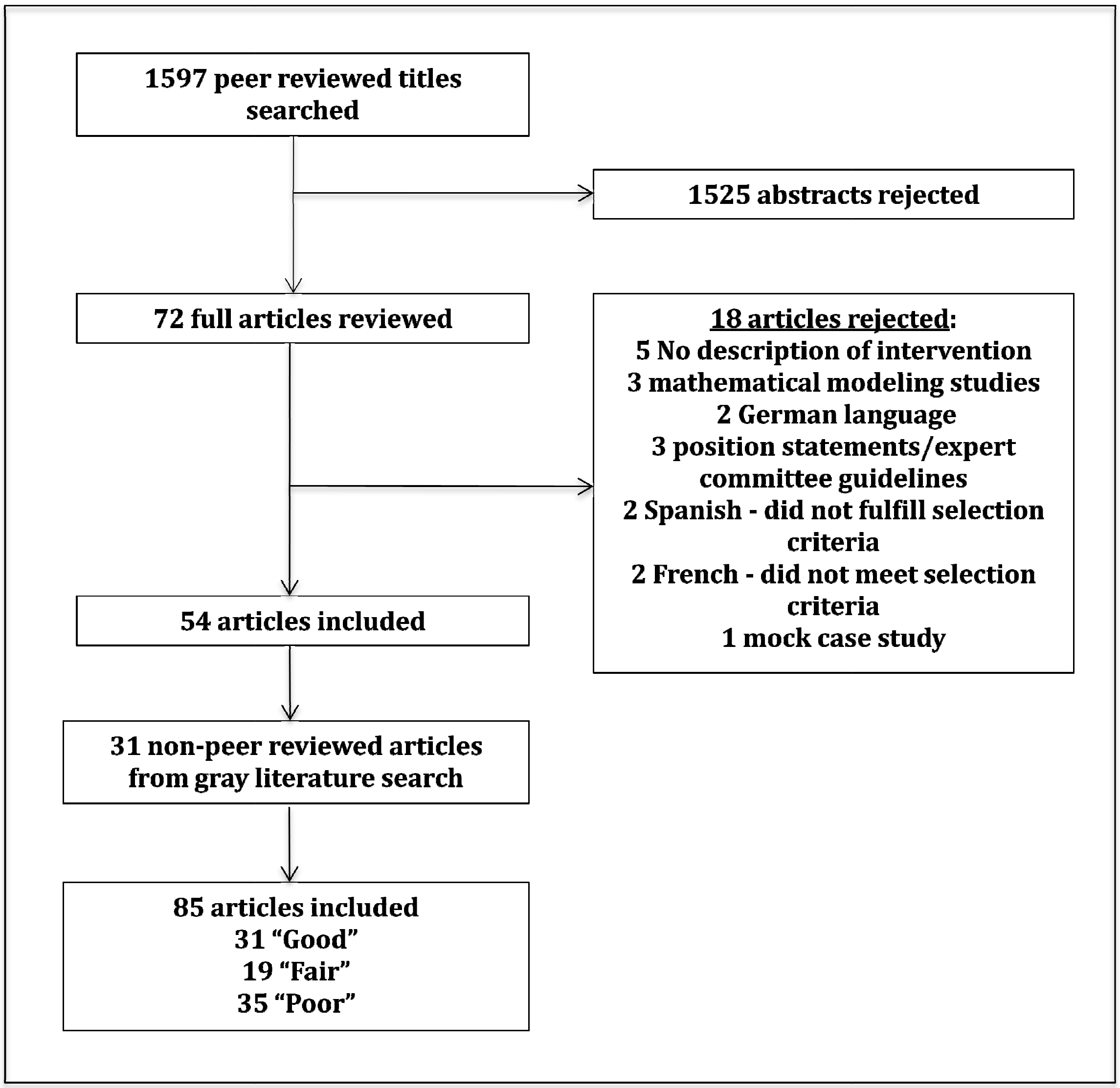
5. Article used mathematical models to describe an interventions outcome

Example: Tang, S, Xiao Y, et alt. Community-based measures for mitigating the 2009 H1N1 pandemic in China. PLOS One. Jun 18;5(6):e10911. [38]

Chapter 4. Results

Eighty-five articles were identified through the search process. Approximately one third of the articles (n=31) met the highest rigor of research standards ("good quality"), as identified by the article data quality assessment score. Nineteen articles received a "fair" rating and thirty-five, over forty percent of all papers, rated "poor" (Figure 5).

Figure 5. Flow diagram of process and results of literature search



Expert opinion papers, including news articles from gray web searches as well as peer-reviewed commentaries, represent an overwhelming majority of retrieved information.

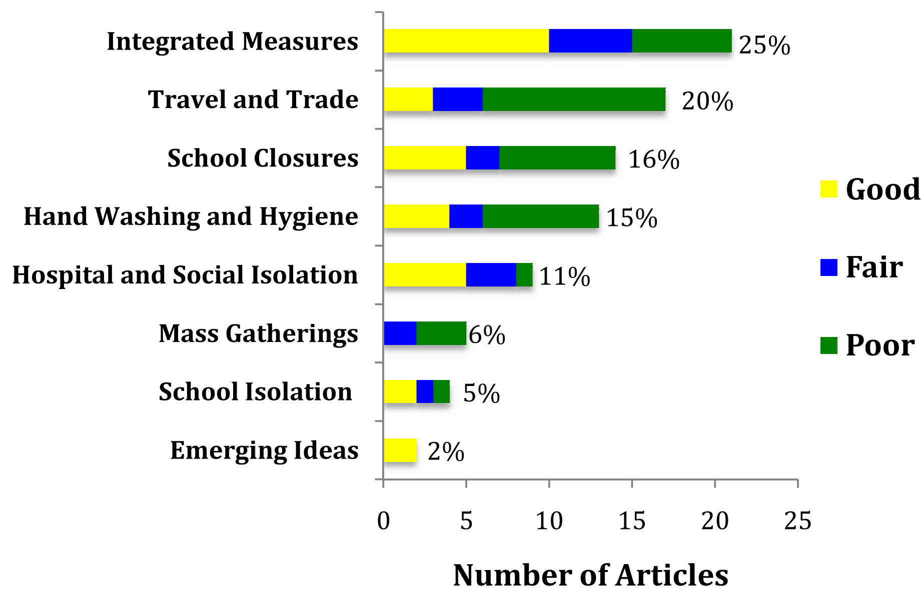
Eighteen articles were case reports, detailing measures enacted at the community level in response to a local outbreak. Only one experimental design study was published, an "emerging idea" paper pilot testing a drive through emergency department (ED) for rapid influenza assessment and treatment [39]. Qualitative research methods were only used in one study, limiting results available for understanding public perceptions and reactions to PHM employed (Table 5).

Table 5. Systematic literature search on published PHM implemented during the H1N1 pandemic by study design and data quality assessment score (N= 85 articles)

Study Design	Operational Definition	Good	Fair	Poor	Total
Experimental Designs					
RCT	Randomized prospectively at individual or group level	0	0	0	0
Non Randomized Controlled Study	Non-random methods used to select people into various intervention groups	1	0	0	1
Observational Designs					
Cohort	Retrospective or prospective; evaluation associations between PHM and a pre determined process or impact outcome	7	1	3	10
Case Control	Compares a population exposed and unexposed to a PHM with respect to process or impact outcome.	1	0	0	1
Cross Sectional	Results of a PHM at a single point in time	6	0	0	6
Time Series [Case Series]	A population is followed throughout the roll out of a PHM with outcomes measures a specific time intervals	2	0	0	2
Meta Analysis	Systematic synthesis of multiple studies	1	0	0	1
Narrative Review	Non-systematic synthesis of experiences reported by an expert in the field	3	4	1	8
Case Study or Case Report	Report detailing a specific institution, outbreak, or localized PHM and its implementation	6	4	8	18
Phenomenological	Qualitative focus groups or in-depth interviews	1	0	0	1
Expert Opinion	Editorials, commentaries, reflections, opinion, and "newsy" literature	3	10	23	36
Total		**31**	**19**	**35**	**85**

The majority of the studies described PHM initiated prior to the availability of well-developed information on the 2009 H1N1 epidemiology and virulence. Further, the intrinsically dynamic nature of the virus made it difficult to evaluate PHM effectiveness, especially within a package of interventions serving to confound any single estimate. Generally, articles suffered from incomplete descriptions and no process indicators, making it difficult to ascertain how and under what conditions the measures were implemented. Approximately half of all articles reported no outcome metrics (n=41). The lack of well-designed studies and standardized indicators made it difficult to draw comparisons and synthesize results. Among gray literature, little evaluative information was available beyond qualitative opinion. Overall, the global research capacity to design high quality studies within a time-sensitive pandemic environment proved weak (Figure 6).

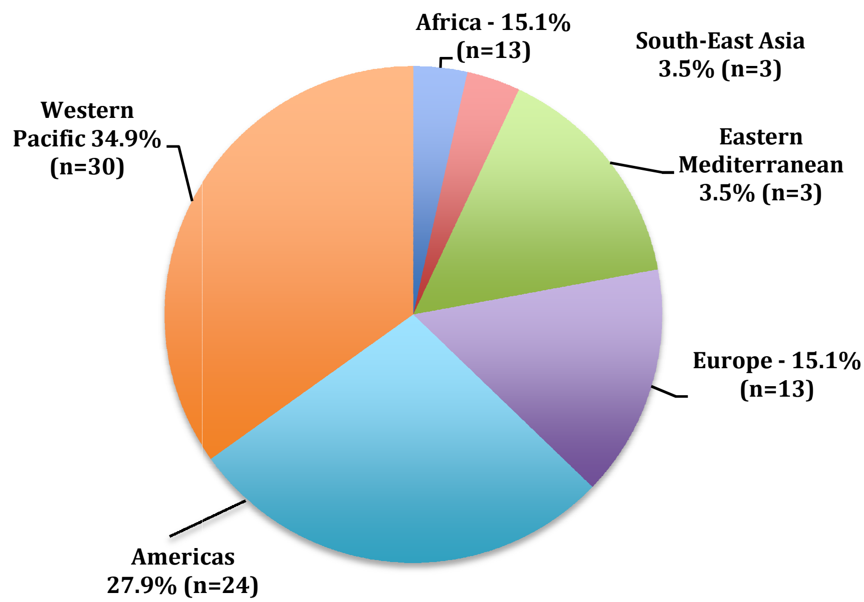
Figure 6. Quality and quantity of published non-pharmaceutical PHM experiences implemented in response to the H1N1 pandemic from 25 April, 2009 - 30 April, 2010 (N=85 articles)



Among articles meeting the selection criteria, the majority describe ***integrated measures*** (n=21), highlighting the trend of nations and/or organizations to link PHM together during a pandemic. The second most common PHM described was ***Travel and trade*** (n=17), which includes screenings at airports and border crossing along with quarantine of incoming cases. ***School closures*** (n=14), hand washing and hygiene communication (n=13), hospital and social isolation (n=9), mass gathering interventions (n=3), and emerging ideas (n=2) complete the PHM categories included in review results.

Stratified by WHO regions, 28% (n=24) of articles describe experiences in the Americas, 4% (n=3) from the Eastern Mediterranean, 15% (n=13) from Europe, 4% (n=3) from South-East Asia, and 35% (n=30) from the Western Pacific, and 15% (n=13) from the African region (Figure 7). Few good quality publications emerged from developing countries, probably reflecting competing priorities. Two studies reported experiences from multiple WHO regions.

Figure 7. Number of articles reporting non-pharmaceutical public health measures implemented in response to the H1N1 pandemic from 25 April, 2009 - 30 April, 2010 by WHO Region (N=86 articles) [6]



Proactive measures represent 57% (n=48) of included literature, while 38% (n=32) described reactively designed responses. Both proactive and reactive responses were reported in 4% (n=3) of studies (Figure 8)

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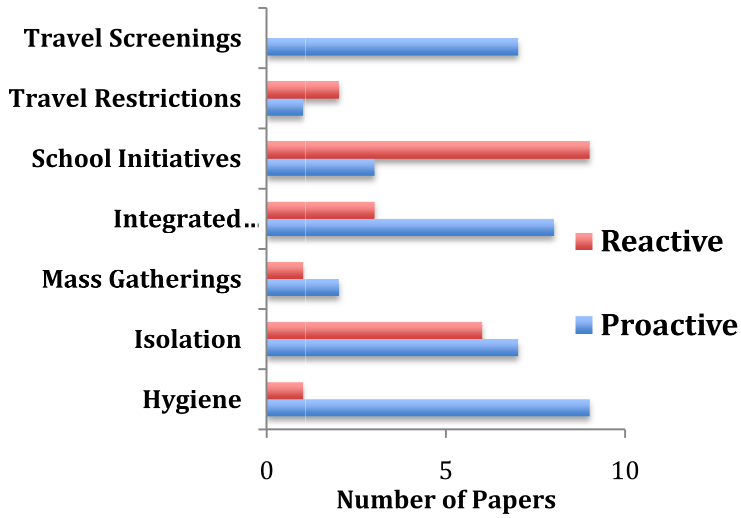
[6] One global systematic review not included in sample size. However, two articles describe measures implemented in multiple regions, increasing the total count to 86.

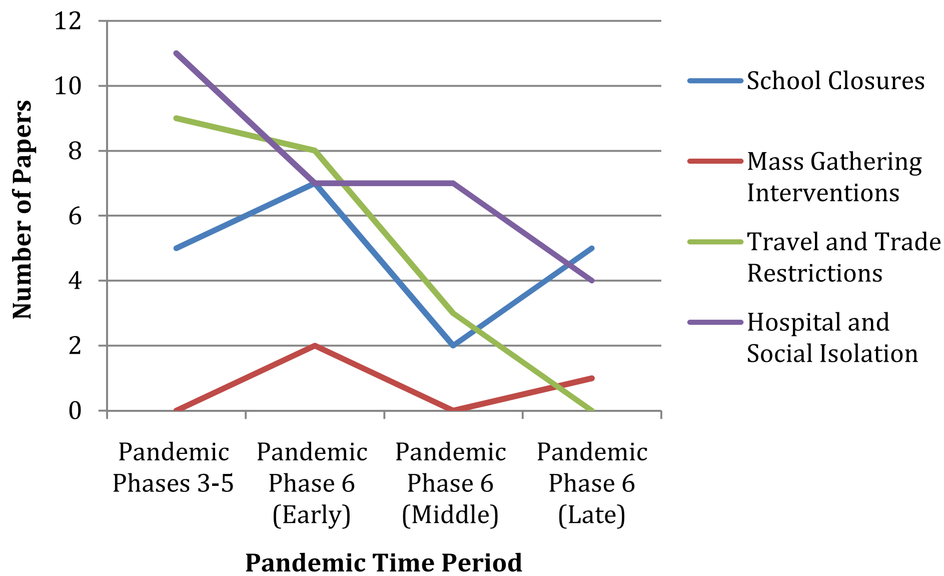
Figure 8. Proactive vs. Reactive Responses to the H1N1 2009 Pandemic Described in the Published Literature



Timeliness of PHM Implementation and H1N1 Epidemiology

The published literature describes a spectrum of implementation dates for PHM, ranging from as early as 24 April 2009 in Mexico to as late as 27 April 2010 in Malaysia and Ghana. Approximately one third of papers (n=25) included no information on the exact date or length of PHM implementation. Among literature with available implementation dates, PHM were quickly brought to scale within the first month of the pandemic (23 April -31 May). Such rapid activity corresponded with the global epidemic status of phases 3 -5 (Figure 8). Articles evaluating travel and trade as well as individual and society measures decreased from June 2009 into May, while PHM at mass gatherings and school increased through June and July 2009. By August 2009 implementation of all PHM were on the decline, with the exception of school closures in Africa as late as April 2010.

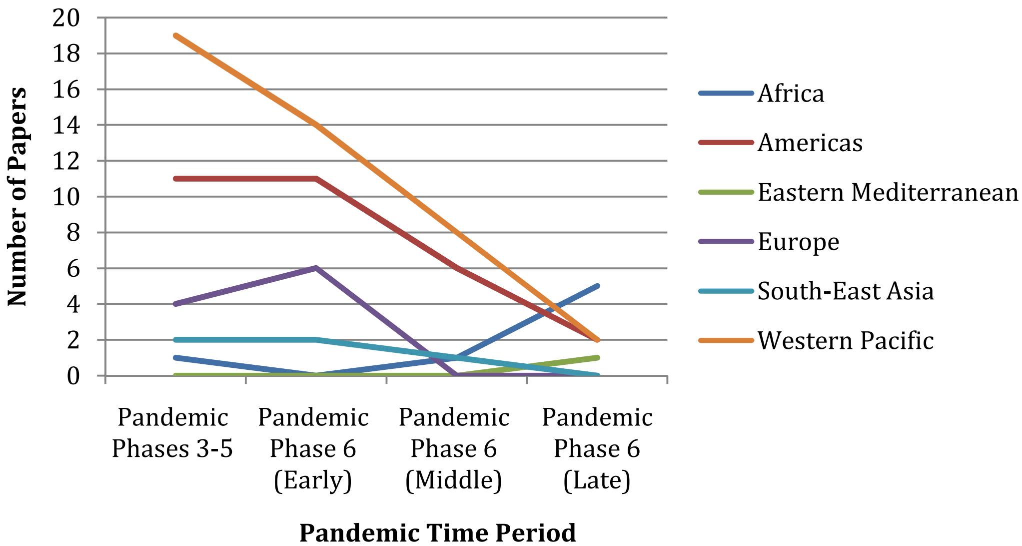
Figure 9. Non-pharmaceutical measures implemented in response to the H1N1 pandemic stratified by intervention: 24 April 2009 to 30 April 2010



Analysis based on the following date classifications:
Pandemic Phase 3-5 (17 April – 30 May), Phase 6 Early (1 June – 31 July), Phase 6 Middle (1 August – 30 September), Phase 6 Late (November– April 2009)

Corresponding to WHO Regions, the published literature depicts the Western Pacific as a rapid adopter of non-pharmasuetical PHM, with 19 articles. The Americas Region was also early to implement and evaluate measures, with 11 articles describing activity from 17 April-30 May. The European, South-East Asian, and African Regions published less than 5 articles during this early time period. All six regional clusters followed a downward trend, with PHM activity decreasing through June and July. Information is only available for Africa, the last region to report a local virus transmission, beginning in 1 Aug. – 30. Sep 2009. Reports of outbreaks and subsequent school closures in Africa as late as April 2010, mark the latest articles included in the review (Figure 9)

Figure 10. Non-pharmaceutical measures implemented in response to the H1N1 pandemic stratified by WHO Region: 17 April 2009 to 30 April 2010.



Analysis based on the following date classifications:
Pandemic Phase 3-5 (17 April – 30 May), Phase 6 Early (1 June – 31 July), Phase 6 Middle (1 August – 30 September), Phase 6 Late (November– April 2009)

School Closures

Fifteen articles were included on school closure initiatives. Twelve articles were reactive in nature, and two described proactively designed responses. Table 5 summarizes the parameters and outcomes of school PHM implemented during the pandemic A (H1N1) 2009 influenza.

Table 5 Summary of global parameters and outcomes of reactive school closures implemented from 25 April 2009 to 30 April 2010 in response to the pandemic A(H1N1) 2009 influenza (N=15 articles)

Location	*Ref.*	*Days (Date) of implementation*[a]	*Trigger*[b]	*Enabled by Legal Provision or Plan*	*Author Conclusions*[c]
Reactive					
Osaka, Japan[d]	*[40]*	*7 days (18 -24 May)*	*Multiple confirmed H1N1 cases in various Perfecture schools and cities*	*No*	*Yes – trends in transmission*
Prathumthani, Thailand [d]	*[41]*	*90 days (1 May - 31 July)*	*Not Described*	*No*	*Yes – pre-post impact measurements*
Pennsylvania, USA[d]	*[42]*	*7 days (Mid May)*	*Increase in student absenteeism and the confirmation H1N1 influenza in one student*	*No*	*Not Evaluated*
Tierra del Fuego, Argentina [d]	*[43]*	*35 days (1 July-4 Aug)*	*Not Described*	*No*	*Yes – reduced ILI incidence*
Paris, France [e]	*[44]*	*7 days (22 -28 Jun.)*	*Not Described*	*No*	*Yes*
New York City, USA [e]	*[45]*	*Spring 2009*	*Not Described*	*Yes*	*Not Evaluated*
Toulouse, France [f]	*[46]*	*7 days (15 -21 Jun.)*	*Detection of multiple H1N1 cases following absence of 11 students from a single class*	*No*	*Yes – no secondary cases observed after closure*
Baghdad/Kut/Thi Qar, Iraq [f]	*[47]*	*7 days (22 Oct.)*	*Triggered over panic of H1N1 after isolated outbreaks in 7 Baghdad schools*	*No*	*Not Evaluated*
Central Region, Ghana [f]	*[48]*	*14 days (5 Apr. 2010)*	*Two out of five suspected cases at Ayipe Primary and D/L school were tested positive for H1N1.*	*No*	*Not Evaluated*
Central Region, Ghana[f]	*[49]*	*Not Reported*	*individual school outbreaks*	*No*	*Not Evaluated*
Accra, Ghana[f]	*[50]*	*14 days (24 Mar. 2010)*	*Detection of 3 H1N1 cases at school*	*No*	*Not Evaluated*

Wan Chai, People's Republic of China [f]	*[51]*	*7 days (17 Mar. 2010)*	*School flu outbreak struck 35 students, with one needing hospital treatment*	*No*	*Not Evaluated*
Boston, United States	*[52]*	*99 days (1 April - 29 June 2009)*		*No*	*Not Evaluated*
Proactive					
China, Hong Kong SAR [d]	*[53]*	*30 days (10 Jun. -10 Jul.)*	*First reported local case not linked with outside travel*	*No*	*Yes –trends in transmission*
Afghanistan [f]	*[54]*	*21 days*	*Declaration of a health emergency by government authorities*	*Yes*	*Not Evaluated*

[a] 2009 dates if not otherwise noted [b] Description of what triggered the decision to implement measure [c] includes both evaluative and speculative conclusions made by authors
[d] Good DAQ score [e] Fair DAQ score [f] Poor DAQ score

Measures and Implementation Strategies

Schools serve as a common gathering place for children, a population particularly vulnerable to H1N1 infections. Published accounts of school closures were most frequently enacted for a period of 7 days in Osaka, Japan, Paris and Toulouse, France, Pennsylvania, USA, Baghdad, Kut, and Thi Qar, Iraq, and Wan Chai, People's Republic of China [40, 42, 44, 46, 51, 55, 56]. Additionally, schools closed for 14 days in Ghana [48], 30 days in China, Hong Kong SAR [53], 21 days in Afghanistan [54], 35 days in Tierra del Fuego, Argentina [43], 90 days in Prathumthani, Thailand [41] and intermittently throughout the April, May, and June 2009 in New York City, USA[45]. Closure decisions occurred at the school administrator and city levels in New York [45] and on a national and sub-national level in Japan, where the Osaka governor closed all 270 high schools and 526 junior high schools in the prefecture [40]. City Mayors, public health official, and national government authorities were documented as contributing and/or ordering the decision to close schools. Articles citing closures from New York City and Afghanistan specified policies or plans enabling such action.

Two common implementation strategies emerged from the literature: **"watch and wait"** and **"immediately activate".** Among the good quality articles describing reactions to confirmed school outbreaks, four [40, 42, 44, 45] immediately activated a school closure policy while two [41, 43] adapted a "watch and wait" strategy utilizing active and passive surveillance. For example the Ministry of Health Tierra de Fuego Argentina, initially only closed schools with detected cases. Approximately two weeks later all city schools were closed for five weeks [43]. All five articles identified "alert of the outbreak" by school surveillance as triggering a response, albeit variations in the responses magnitude described. However, among reactive school closure, three involved schools directly harboring cases. Only in Japan were widespread school closures launched in unaffected schools [40].

Triggers for Implementation and Termination

Reactive school closures were triggered by either the first confirmed case of H1N1[36, 40, 46, 53] or an increase in ILI [42, 44]. On-site school nurses, hospital case surveillance, and school-generated reports of ILI among students were relied upon as decision making tools. Delays in testing and poor surveillance in some areas stifled access to good quality data to justify local school closures. In Japan, anecdotal information on infections arising in siblings, groups of students sharing extracurricular activities, and parents of student cases served as a secondary confirmation for school closure [40]. Gray literature from Iraq cited public panic from exaggerated media attention as another trigger for implementation, but this claim was not quantified by any good quality research.

The literature also documented criteria-driven approaches to school closures. The Hawaii Department of Health reacted to a single school outbreak by distinguishing a set of triggers that if met, would result in school closures. These triggers were 1) student hospitalizations due to H1N1 increased or 2) school operations were severely affected (i.e. teachers and/or staff absent) or 3) there was an increase in student absenteeism [55]. In Queensland, Australia, schools and childcare centers were ordered to close for one week only if a person with confirmed disease had attended while infectious. In Hong Kong, secondary schools were mandated to close for 14 days only after a case was confirmed among the school's student population [53]. This criteria-driven approach resulted in the schools in Hawaii remaining open and in Queensland, only 2.8% of all schools and five childcare centers closing [57]. While such measures contain the benefit of minimized disruption, they sacrifice the synchronized and consistent communication a district, state, or nation wide plan can quickly bring to scale. Sensitive surveillance and diligence within the community to report school cases and act quickly is required.

Proactive school closures were triggered by macro level changes at the international and national levels: WHO raising the pandemic level to 6, the US declaring a public health emergency, and the unknown nature of the circulating virus [58]. In Afghanistan, a declaration of a health emergency by government authorities triggered closures while in Hong Kong SAR, the first reported local case not associated with outside travel triggered closures [53, 54].

Lack of information on triggers used to terminate school closure are described in the literature, suggesting schools lacked contingency plans on when to re-open in the necessary case of closure. Theoretically lifting of school closure mandates should include confirmation of herd immunity, either through natural infection or vaccination [22]. However without a vaccine early in the pandemic and lack of feasibility of sero-prevalence surveys left school administrators, public health experts, and government authorities to make decisions on an ad-hoc basis.

Outcomes and Potential Impact

Among the four good quality studies reporting impact outcomes, all reported positive results (Table 6)

Table 6. Impact outcomes of cohort studies evaluating school closures during the H1N1 2009 Pandemic from 24 April 2009 to 30 April 2010

Outcome Indicator	Ref.	Pre School Closure	Post School Closure
Newly reported H1N1 cases [a]	***[40]***	30 cases (17 May)	0 (25 May)
Newly reported H1N1 cases [a]	[53]	Reporting of cases declined to 5.2% from prior to school closure	
Incidence of ILI[a]	[43]	1679 cases	174 cases
Estimated effective Reproductive number [a]	[53]	1.7 (~11 June)	1.1 (July)
Newly reported H1N1 cases [b]	[46]	20 cases (14-June)	0 (22 June)

[a] "Good "DQA Score, [b] "Poor" DQA Score

Additionally, upon schools re-opening in Japan, absenteeism did not increase from pre-outbreak rates [40]. According to an evaluation of select southern hemisphere[7] country responses to the H1N1 pandemic, nationwide school closures in Argentina throughout the month of July were associated with a concurrent decrease in disease incidence. However, when schools reopened in August there were early indications of resurgence in ILI detected in a few outpatient settings in Buenos Aires [59].

A prospective case control study in central Thailand evaluated daily temperature screenings, enforcement of absenteeism, hygiene education and promotion in a private kindergarten; the schools associated primary classes served as the control group. The incidence of ILI was 7.1 cases per 1000 children-days in the intervention bundle compared with 14.9 cases per 1000 children-days among controls (rate ratio, 2.4; 95% confidence interval, 1.14–5.77; p.04). This study documents the viability of school based prevention measures, even without school closures, can effectively reduce influenza A (H1N1) transmission [41].

Household and Socio-Economic Impact

A pertinent question when considering school closure is the impact on families, incomes, and places of work. According to a cross sectional survey of 214 households affected by school closures in Pennsylvania, USA, home was found to be the most frequently cited location during closure for (77% of student-days) [42]. Still, 69% of all of students surveyed cited they visited locations outside the home during days the school was closed [42]. As for impact on parental work activities, "79% of households did not miss any

[7] Countries geographically located south of the equator

workdays" due to the school closure. However, among the households that did miss work, about 40% were absent the entire week [42]. When adjusted odds ratios were calculated, household income greater than or equal to median (calculated based on the median responses to the household income question) was a significant predictor for missing any workday at $p<0.05$ [42]. Overall, households in Pennsylvania, USA study population were only moderately affected by school closure.

Potential Impact

The timing of the epidemic onset in conjunction with lack of pre-existing evidence created a difficult scenario for quantifying and justifying the benefit of school closures prior to necessary action. However, publications printed early in the pandemic provided helpful insight into weighing the pros and cons of school closures. They include:

Predicted/Identified Benefits

- Reduced transmission among community contacts [53]

Predicted/Identified Risks

- Interruption to academic programs and extracurricular social functions [22, 60]
- Disruption of services provided at school such as free breakfast and lunch to children from low-income families and therapy for students with special needs [60]
- Parental work loss and the subsequent societal impact [60]
- Nurse absenteeism or other negative effects on healthcare system [61]
- Household economic loss [52]
- Possible loss of public trust due to "unwarranted" or "excessive reactions" [58]

Predicted/Identified Barriers

- Complexities of state, independent, and faith based schools systems and the need to communicate different policies in neighboring countries [22]

Implementation Tools

Summer holiday, scheduled to start on 10 July, was noted to influence school re-opening in China, Hong Kong SAR, [22]. Rather than accelerate re-opening, schools originally mandated to close for 14 days in June remain closed until the scheduled summer holiday, extending mitigation and utilizing the school calendar as a natural barrier against transmission. Declaration of a health emergency and the Pandemic and Response Plan in New York City, USA [45, 54] along with the legal parameters of an Infection Control Law in Japan were cited as supporting school's closure decisions and subsequent action steps [40].

Measures Sanctioned Under School Authorities

Many schools remained open during the pandemic, subsequently coordinating aggressive disease control and prevention strategies among students and staff. Table 7 describes individual measures sanctioned under the auspices of school administrators.

Table 7. Summary of global parameters and outcomes of measures sanctioned by school authorities and implemented from 25 April 2009 to 30 April 2010 in response to the pandemic A(H1N1) 2009 influenza (N=4 articles)

Location	Ref.	Days (Dates) of Implementation[a]	Trigger [b]	Enabled by Legal Provision or Plan	Author Stated Conclusions a success[c]
Reactive					
Northern China, People's Republic of China [d]	[62]	12 days (31 Aug.-12 Sep.)	Laboratory confirmed H1N1 cases in 6 students on 31 August.	Yes	Yes – low attack rate of suspected cases in quarantine
Colorado, USA [d]	[63]	7 days (7 July onward)	1) two cadets were identified as positive for influenza A by rapid antigen test 2) increase in diagnostic codes for respiratory illness as compared to the two previous years	No	Yes –reduction in reported cases
Hawaii, USA [e]	[55]	Not Listed	2 confirmed H1N1 cases at school	No	Not Evaluated
Reunion Island, France [f]	[64]	Not Listed	Detection of a H1N1 case on the island coupled with an increase in ILI	No	Not Evaluated

[a] 2009 dates if not otherwise noted [b] Description of what triggered the decision to implement measure [c] includes both evaluative and speculative conclusions made by authors [d] Good DAQ score [e] Fair DAQ score [f] Poor DAQ score

School authorities followed numerous approaches to either promote or enforce self-isolation among its students, most reactive in nature. These school-based isolation strategies fall into five categories:

- **Self quarantine after travel**

  In Australia, students returning from travel in Queensland and/or Victoria, regions reporting high community transmission, were asked not to return to school for seven days [58].

- **Daily temperature screens**

  In Thailand, children were screened daily before entering school by measurement of temperature and staff inquiry of any ILI symptoms [41].

- **Public announcements of the outbreak**

  In Hawaii, a letter was sent home with students informing parents of the school outbreak [55]. In France, school officials telephoned families of all class students following an outbreak and local health officials sent all students home with information [44]. Emergency call-in lines and websites were used by New York City Department of Education to communicate outbreak status and subsequent school closures across the city [45].

- **Recommendations of parental isolation**

  Beyond schools protecting children, schools in Japan issued guidance for parents of infected children to stay home for seven days [40]. Messages home to the parents and a health department press release requested children with ILI symptoms to stay home in Hawaii, USA [55]. In the French territory of Reunion Island, a campaign promoting absenteeism was launched in lieu of school closures [64]. In Boston, students with ILI were specifically asked to stay home for seven days if sick [52] and in Thailand, the absenteeism policy was strictly enforced [41].

- **Isolation in University Settings**

All United States Air Force Academy basic trainee cadets (BTC) with ILI and a fever of greater than 100.4 were isolated in a separate dorm; those with ILI symptoms but with a temperature of 99.0-100.4ºF were assigned to a second dorm for isolation. Upper- class cadets delivered meals and healthcare providers made daily rounds to the isolation dorms and approved release when a BTC had completed 7-days of isolation and had been not shown ILI symptoms for twenty four hours [63]. Following approximately two weeks of aggressive isolation and containment measures, totaling 228 people with ILI symptoms and fevers greater than 99.0 ° F, there were less than five confirmed H1N1 cases [63]. In a northern China university outbreak, six cases and 202 contacts were quarantined either in individual or shared rooms. The attack rate among initially virus–negative contacts significantly increased when persons were quarantined in the same room or used the same bathroom as a virus-positive contact ($p = 0.02$, 2-tailed Fisher exact test). However, single room quarantine of virus negative contacts failed to significantly decrease the attack rate among virus-negative contacts in comparison with quarantining two persons in a single room. The authors affirmed isolation as an effective measure in containing a secondary outbreak and demonstrated that quarantining two virus-negative contacts in single room remained effective, especially in situations with a large quantity of isolation candidates and limited space [62].

On May 29, the Chinese Ministry of Health required that each confirmed case and subsequent contacts be isolated and quarantined in a separate room to contain and permitted incomplete quarantine of contacts (e.g., quarantining more than one contact in a single room) [62].

Mass Gatherings

Five articles described experiences implementing PHM around mass gatherings, four of involving mitigation efforts and one describing cancelation of a mass gathering (Table 8). Two articles are of fair quality while three are of poor quality, stating actions taken but failing to report any rigorous measurements of impact.

Table 8. Summary of global parameters and outcomes of PHM implemented at mass gatherings from 25 April 2009 to 30 April 2010 in response to the pandemic A(H1N1) 2009 influenza (N=5 articles)

Location	Ref.	Days(Dates) of Implementation[a]	Trigger [b]	Enabled by Legal Provision or Plan	Author Stated Conclusions a success[c]
Reactive					
Accra, Ghana/Nigeria[f]	[65]	28 Mar. 2010	H1N1 swine flu detected at Achimota College, the planned host of the National Cricket Tour and Ghana team players	No	Not Evaluated
Belgium, France[f]	[66]	4 days (2-5 Jul.)	Detection of 12 confirmed H1N1 cases at large rock music festival	No	Yes – no outbreak after detection of index case
Proactive					
Tivaouane, Senegal[e]	[67]	Not Listed	First case of H1N1 in Senegal corresponded to time the small town (40,000 inhabitants) of Tivaouane was to host a mass gathering of two million pilgrims for a religious festival	No	Not Evaluated
Saudi Arabia[e]	[68]	Not Listed	Concern over heightened transmission of H1N1 virus during Hajj	Yes	Not Evaluated
Serbia[f]	[69]	12 days; 1-12 Jul	National plans to host two large international gatherings	No	Yes – no outbreak after detection of index case

[a] 2009 dates if not otherwise noted [b] Description of what triggered the decision to implement measure [c] includes both evaluative and speculative conclusions made by authors [d] Good DAQ score [e] Fair DAQ score [f] Poor DAQ score

Serbia: Music Festival and International Sporting Event

Two large national gatherings, the EXIT music festival (190,000 people) and the 25th Universiade (approximately 523,600 people), were planned for early July. Recognizing the potential for rapid viral transmission to occur onsite, proactive pre-event PHMs were added to the agenda of the Serbian National Working Group on Pandemic Planning (NWGPP). In the months preceding the event, national surveillance was scaled up to report confirmed cases each day. One month prior to event, the NWGPP issued criteria for cancelation of the Universiade gathering: "1% of the attending population was diagnosed with influenza A (H1N1), a case of acute respiratory distress, or a there was death in a confirmed case" [69].

In proactively designing PHM for each event, the NWGPP's objectives were to ensure detection of first cases through good epidemiological monitoring and reduce virus spread. Prior to, and during the events, posters with information on symptoms and phone numbers of where to seek help, were posted at airports; mass media was used to communicate where to seek medical help, and 24/7 mobile epidemiology teams were available to respond to queries regarding suspected cases and to triage persons to be tested. Influenza-like illness patients reporting to event medical facilities were isolated until test results were confirmed. PHM were then implemented by Serbia's Military Medical Academy, institutes of public health and healthcare facilities in the districts where mass gathering sites were located.

Saudi Arabia: Hajj

The Hajj marks the Muslim's pilgrimage to Mecca and the world's largest movement of people. Concern among national public health authorities promoted the proactive design and implementation of control measure around this event. Specifically, thermal screening equipment was used to detect febrile individuals at Saudi Arabian airports. Airports designated space for triage of ILI symptomatic travelers and provided treatment as necessary. Further, private organizations in Saudi Arabia donated personal hygiene kits for each arriving pilgrim, which contained facemasks, hand sanitizers, and educational information. The Saudi Arabian Ministry of Health promoted cough etiquette and hand washing through media campaigns. Termination of all measures coincided with the end of the Hajj [68].

Belgium: “Rock Werchter” Festival

In contrast to the previous two proactive implementation strategies, public health control measures began after detection of 12 confirmed H1N1 case at the four-day Belgium rock music festival, with over 100,000 attendees. Mass media (press, internet, TV, radio) immediately publicized the cases and advised festival participants to contact a physician if fever or respiratory symptoms appeared. A similar message was posted on the festival website.

Senegal Religious Festival

The Senegalese Red Cross initiated proactive control measures after first confirmed national H1N1 case was identified immediately prior to the time the country was to host a mass gathering of two million pilgrims for a religious festival to celebrate the birth of the prophet Mohammad in the 40,000 resident town of Tivaouane. Measures associated with the gathering included a public campaign focused on good hygiene, hand washing, self-isolation, and disposal of waste. Three hundred and twenty volunteers were mobilized to go house-to-house distributing leaflets and personal protection kits which included gowns, gloves, masks, and disinfectant gels. Community leaders were asked to promote campaign messages. Additionally, information centers were established and hand-washing demonstrations provided to raise awareness on best practices in prevention of disease [67].

Outcomes and Potential Impact

Public health measures (PHM) appear to have adequately controlled the spread of H1N1 during the mass gatherings described in the literature. While confirmed cases of H1N1 had been detected prior to each gathering, no large-scale outbreaks were associated with the events. All authors concluded that the PHM implemented proved effective, most likely reducing the number of cases that would have occurred in the absence of such measures. While ethically no control group could be used statistically evaluate the effect of PHM on reducing transmission at mass gatherings, the following outcomes were cited:

- 62 confirmed cases and 32 probable cases associated with EXIT event [69]
- 6 confirmed cases and 22 suspected cases associated with Universiade event [69]
- 26 confirmed cases of H1N1 associated with the Hajj period; This was not an upsurge from expected among the > 2 million Hajj attendees [68]
- Communication measures quickly raised public awareness and slowed outbreak spread. After the information on the first case linked to the festival was published, subsequent cases were identified and treatment sought[66]

Travel and Trade

Human travel marks a major catalyst to the spread of infectious disease. Seventeen articles describe PHM implemented in the context of travel or trade activities, 3 which were of good quality, 3 of fair quality, and eleven of poor quality. Table 9 summarizes the parameters and outcomes of each article.

Table 9**. Summary of global parameters and outcomes of travel and trade PHM implemented from 25 April 2009 to 30 April 2010 in response to the pandemic A(H1N1) 2009 influenza (N= 17 articles)**

Location	Ref.	Days (Date) of implementation [a]	Trigger [b]	Enabled by Legal Provision or Plan	Author Stated Conclusions a Success[c]Success[c]Success[c]
Reactive					
Japan[e]	[70]	16 May onward	First case of local transmission reported and subsequent school outbreaks in Kobe/Osaka	Not Described	Not Evaluated
New Zealand[f]	[71]	20 Apr. onward	Return of a group of symptomatic school children from Mexico activated New Zealand's Influenza Pandemic Plan	Yes	Not Evaluated
Ukranie, Russia, Slovakia[f]	[72]	3 Nov. onward	Outbreak in western city of Ternopil, Ukraine	Not Described	Not Evaluated
US Navy Vessels, USA[f]	[73]	24 days (20 May-13 Jun.)	Increase in ILI cases reporting to vessel medical unit	Not Described	Partially(lower secondary attack rate)
Proactive					
Tan Tock Seng Hospital, Singapore[d]	[74]	128 days (25 Apr. - 31 Aug)	Singapore Ministry of Health activated its pandemic response plan	Yes	Yes (low incidence of H1N1)
Singapore[d]	[75]	71 days (17 Apr. - 27 Jun.)	Global reports of air travel as a major route of virus introduction	Not Described	Yes (case detection rate)
Global[d]	[76]	40 days (13 Jul. - 22 Aug.)	Not Described/meta-analysis	NA	No
Shanghi, China[e]	[77]	68 days (24 May - 31 Jul)	Release of pandemic guidelines by the Ministry of Health	Yes	Yes
Australia[e]	[78]	apx. 60 days (25 Apr. - Jun.)	WHO declaration of public health emergency	Not Described	Yes (epidemiologic trends & author's perception)
China, Viet Nam, Thailand[f]	[79]	apx. 123 days (May -Aug.)	Not Described	Not Described	Not Evaluated
Greece[f]	[80]	55 days (20 Apr. - 14 Jun.)	WHO declared of a public health emergency	Not Described	Not Evaluated
Australia[f]	[81]	Not Listed	Not Described	Not Described	Not Evaluated

Canada[f]	[82]	Not Listed	Not Described	Not Described	Not Evaluated
Zambia, Uganda, Ethiopia[f]	[83]	Not Listed	Not Described	Not Described	Not Evaluated
United Republic of Tanzania[f]	[84]	Not Listed	Not Described	Not Described	Not Evaluated
Uganda[f]	[85]	Not Listed	Not Described	Not Described	Yes (author's perception)
Ghana[f]	[86]	May	Global reports of H1N1 outbreak	Not Described	Not Evaluated

Measures and Implementation Strategies

Travel Restrictions

No good quality articles evaluating travel restrictions were found in the published literature. Of the documented travel restriction cases, Japan ordered scientists not to travel to Canada, Mexico, or the US and two international meetings scheduled for 22-24 May 2009 were canceled [70]. In Australia, high-risk groups (chronic respiratory conditions, pregnant women, morbid obesity, indigenous, and those with predisposing cardiac disease/renal failure/diabetes/etc) were asked to consider postponing travel if they had ILI symptoms. They were also requested to seek medical advice before international travel [81]. A poor quality news article reported Slovakia closing two of its five border crossings with Ukraine to control spread of infection. Additionally, the Russia Federation examined all travelers crossing the border from Ukraine and quarantined those with severe ILI symptoms. People were urged to "travel only when necessary and stay away from public places" [72]. In Zambia, doctors and epidemiologists were placed at border crossings and international airports [83].

Travel Screening

A common objective of travel screening emerged across all articles: to contain, at least temporarily, the spread of the virus. Early initiation, prior to widespread community transition, was cited as essential. International airports functioned as the venue for implementation, with local hospitals, such as the Tan Tock Seng Hospital or the Shanghai Public Health Clinical Center (SPHCC) in China, providing support in the form of patient isolation and testing. Only one article cited a parameter used to guide implementation of screenings: focusing on those most at risk [78]. A news report from Tanzania listed three possible actions taken by authorities for symptomatic or exposed persons: 1) allowed to proceed 2) put under surveillance or 3) put under isolation. However, no documentation of the decision making process was described. Table 10 shows the various travel screening measures implemented during the H1N1 pandemic.

Table 10. Travel screening measures implemented during the 2009 H1N1 pandemic

	Ref	Country
Thermal Screenings	[75, 77, 79, 87]	Singapore, China, Viet Nam, Greece
Health Declaration Cards	[76, 78, 88]	Australia, Uganda, Tanzania
Temperature checks prior to aircraft disembarkment	[82]	Global
Airport alert staff observing travelers for ILI	[86]	Canada, Ghana
Transport from airport to hospitals for suspected arriving cases	[75, 77, 86]	Singapore, China, Ghana
Isolation of suspected and/or confirmed H1N1 cases arriving into country	[75, 77]	Singapore, China, Uganda
Isolation of contacts of cases of cases arriving into country	[75, 77]	Singapore, China
Establishment of examination center and examination of reported H1N1 cases	[83]	Ethiopia, Uganda

Triggers for Implementation and Termination

Travel Restrictions

Two of the three published travel restriction experiences were reactive in nature. One activated in response to the first cases of local transmission and a school outbreak in Kobe, Osaka Japan [70]. The Ukrainian outbreak and deaths initiated the restriction put in place by neighboring countries [72]. No termination triggers were mentioned, but in Australia health declarations and thermal scanning diminished as the primary travel PHM as the virus became more widespread; Travel restrictions most likely followed a similar termination patter [81].

Travel Screening

At the time of implementation, most authors express a lack of information on the pandemic's extent and severity, making it difficult to properly select travel screening strategies. As shown in Table 11, travel measures described in the literature were triggered by international alerts. Early in the pandemic, authors cited difficulty obtaining accurate case-data for decision-making. However, in Shanghai, China, travel screenings were prompted based on hospital records showing 230 out of the first 237 H1N1 cases (97.0%) were imported from people traveling outside China [77].

Isolation and quarantine were used directly in the above literature and indirectly through travel screening articles and school closures. A selective quarantine process was noted in Japan, where all suspected cases arriving from Canada, Mexico, or the USA were isolated [70]. Quarantine personnel also entered planes and checked all passengers health status [70]. Table 11 captures the mechanism in place to support isolation during the 2009 H1N1 influenza. Termination was triggered by an increase in the number of influenza cases [77] and epidemiologic surveillance indicating sustained community spread [75, 80].

Table 11. Implement and termination triggers for isolation of cases and quarantine of contacts resulting from travel screening measures among good quality publications from 24 April 2009 to 30 April 2010.

Ref	Implementation Trigger	Termination Trigger	Authority Responsible
[89]	When it had "become apparent that the impact on the population was much lower than feared"	When it had "become apparent that the impact on the population was much lower than feared"	Australian Government Department of Health and Ageing Australia
[74]	Activation of Singapore's pandemic response plan	Change in national strategy from containment to mitigation	Singapore Ministry of Health Department chiefs and nursing mangers at Tan Tock Seng Hospital (TTSH) - designated screening and isolation facility. Hospital monitored activities.
[90]	Not Described	Not Described	Senior medical and nursing staff at a tertiary referral hospital in Brisbane, Australia.
[91]	Nosocomial H1N1 outbreak of eight cases in a pediatric oncology hospital ward	Cases completed 48 hours of isolation after disappearance of ILI symptoms	Not Described
[92]	Not Described	Not Described	Hospital administration, clinicians, and nursing colleagues at Queen Mary Hospital, Hong Kong
[63]	Not Described	Not Described	US Air Force Academy Physicians
[87]	First confirmed case of H1N1 from a traveler from Mexico (1 May 2009)	Not Described	Hong Kong Government Centre for Health Protection
[62]	Laboratory confirmation of 6 H1N1 cases in students on 31 August. Chinese Ministry of Health mandatory isolation policy (29 May - mid August 2009)	All quarantined persons were released by September 12	Chinese Ministry of Health

Outcomes and Potential Impact

Travel Restrictions

By 11 May 2009, only four H1N1 positive cases were detected at Japan's airport yet 214 additional quarantine health personnel were employed [70]. 1,598 school trips and 403 international trips were canceled, resulting in 360,000 hotel room cancelations and a $45 million USD economic loss [70]. Authors suggested exhaustive public media coverage and the cultural notion of "shimaguni konjo", a Japanese belief that "the 'outside' is considered 'impure' and is often covered-up, criticized, and avoided," contributed to heightened fear and preference for airport quarantine [70]. No focused evaluation of travel restrictions was completed in Australia. A travel consumer survey in New South Wales showed that 84% of resident's travel plans were not affected by the swine flu. However, short term visitor arrival decreased by 0.2% in April, 1.7% in May, 5.1% in June, and fell to 1.2% in July 2009 [81].

Travel Screening

Three studies evaluated the effectiveness of travel screening in detecting cases. Results depict detection rates from 4 - 54%. In Shanghai authors concluded that travel-screening measures identified a significant number of cases, increased early detection, and helped contain the pandemic [77]. However, in Singapore, authors concluded thermal scanners were of limited use, as travelers must be symptomatic and febrile, which was often not the case. Passengers from short haul flights developed symptoms after entry and thus were missed by the airport thermal scanners, limiting its effectiveness [75]. Tanzania reported that despite a pandemic H1N1 screening program, only 0.6% (4) out of the 649 total confirmed cases were identified at points of entries [84].

A narrative review from Australia speculated that travel screening measures most likely slowed the spread of the virus and provided public health agencies time to assess its natural history and epidemiology before it became widespread [78]. At best, "...entry screening can only prevent local spread for a short period of time... slowing the outbreak curve [76] . Informal news reports from Uganda cited measures "prevented public panic" in the country [85].

Delay in Local Transmission

The most comprehensive evaluation published as of August 2010 is a global systematic review of four travel screening measures: 1) checks of temperature prior to arrival 2) health declaration forms 3) airport alert staff observing travelers and 4) thermal scanners triggered in response to WHO pandemic alert level 5 found that implementation of any of the four measures, either alone or in combination, resulted in 7-12 additional days delay in local transmission [76]. However, a lower 95% confidence bound of no delay and upper bound of 20-30 day additional delay suggests entry screening does not cause significant delays in local transmission [76]. The authors comment that at best, entry-screening serves only to prevent local spread for a short period of time [76].

Case Detection

1. A study by Shen, Y et. al found that out of a total 230 imported cases detected during the Shanghai screening period, 124 (53.9%) were detected by airport measures[77]. Result led authors to conclude Shanghai's public health measures identified a significant number of cases, increased early detection, and helped contain the pandemic [77].

2. A study by Mukherjee et al. showed screening measures failed to detect 101 of the 116 confirmed imported cases detected during the screening period [75]. Thermal scanners detected only 14 (12%) cases and 15 (13%) cases were referred by Singapore Changi

International Airport doctors to the hospital for isolation [75]. 51 (44%) of the 116 confirmed cases self-reported to the airport screening center and 50 (43%) were referred by community doctors [75].

3. A study by McConnell et. al in China reported 49 million people were screened at airports [79]. During the intervention period 16,328 febrile patients were detected of which 698 H1N1 cases were confirmed (4.3%) [79]. In Viet Nam 1,793,460 travellers passed through national borders during the screening period, of which 1,301 suspected H1N1 cases and 182 cases confirmed were detected [79]. Hong Kong faced difficulties managing and storing the 300,000 health declaration forms received daily from entering travellers [79].

4. A study by Appuhamy, R.D. et al in showed thermal scanners and/or health declaration card measures in Queensland, Australia airports from 28 April- 21 May 2009 identified 780 travelers with 52 meeting the ILI case definition [57]. Referrals for testing among these 52 suspected cases resulted in only four positive H1N1 infections (7.7%) [57].

Implementation Tools

Travel Screening

Public authorities often operate travel crossings and thus serve as natural public health gatekeepers in the early stages of a pandemic. Unlike household-level measures such as school closures or hand hygiene promotion in which the literature describes only a paucity of legal provisions, the majority of the travel screening articles cited legal authorities involved in implementation. Even in the few cases where no legal plan existed, the close inter-sectoral relationships already established at travel crossing allowed for a more aggressive, coordinated response. Authorities included a mixture of national government and public health institutions, namely the Ministry of Health China, Shanghai Bureau of Health, Singapore Government, Chinese Centre for Disease Control and Prevention, National

Institute of Hygiene and Epidemiology China, Ministry of Public Health, Thailand, Hellenic Centre for Disease control and Prevention, and the Government of Canada.

Individual and Societal Measures

Governments, public health organizations, places of employment, community groups, health facilities, and media outlets worked both independently and in collaboration to mitigate the societal burden of H1N1. The published literature provides evaluations for only a small sample of such activities. Nonetheless, available results reflect a broad spectrum of what happened and lessons learned during the pandemic. Three main areas were found: hospital based measures, societal measures, and hand washing/hygiene.

Hospital and Community Isolation Measures

Seven articles described actions taken in the community or by hospitals to isolate cases, protect healthworkers, and prevent nosocomial infections. Table 12 depicts the parameters and outcomes of such measures.

Table 12. Summary of global parameters and outcomes of hospital and social isolation PHM implemented from 25 April 2009 to 30 April 2010 in response to the pandemic A(H1N1) 2009 influenza (N= 4 articles)

Location	Ref.	Days(Date) of implementation [a]	Trigger [b]	Enabled by Legal Provision or Plan	Author Stated Outcome a Success [c]
Reactive					
Bari, Italy [d]	[91]	apx. 60 days (Oct.-Nov.)	Nosocomial H1N1 outbreak of eight cases in a pediatric oncology hospital ward	Not Described	Not Evaluated
Proactive					
Australia [d]	[90]	Late Jul.	Not Described	Not Described	Not Evaluated
China, Hong Kong SAR [d]	[92]	100 days (1 May - 8 Aug.)	Not Described	Not Described	No
Florida, USA [f]	[93]	28 Apr.	Not Described	No	Yes (process evaluation)
Vitoria, Australia [d]	[58]	Late Jul.	Not Described	Not Described	Not Evaluated
China, Hong Kong SAR [d]	[87]	100 days (1 May - 8 Aug.)	Not Described	Not Described	Yes, secondary cases after exposure
New York City, USA [f]	[73]	28 Apr.	Not Described	No	Yes, process evaluation
Mexico City, Mexico	[61]	late March -31 September 2009	Mexico Surveillence Data	Hopital Influenza Commission and Influenza Contingency Plan	Yes- staff knowledge
Australia	[94]	Contain Phase (early May - 16 June) Protect Phase (17 June onward)	Not Described	No	Yes-Number of cases

[a] 2009 dates if not otherwise noted [b] Description of what triggered the decision to implement measure
[c] includes both evaluative and speculative conclusions made by authors
[d] Good DAQ score [e] Fair DAQ score [f] Poor DAQ score

Isolation of cases functioned as the primary tool employed by hospitals in response to the established transmission of H1N1 cases in the population. Specifically:

- A Brisbane, Australia ICU wing was designated an "isolation pod" and housed presumed and confirmed H1N1 cases. All entering persons were required to wash hands and use personal protective equipment [90].
- Visitor restrictions were in place to encourage isolation, including no children or pregnant women visitors [90].
- In Bari, Italy all symptomatic patients were isolated in a separate hospital ward until 48 hours following disappearance of symptoms. External visitors were restricted and no contact with other patients was allowed. Health care workers wore personal protective equipment [91].
- In China, Hong Kong SAR hospital isolation was implemented in a tiered manner based upon clinical presentations. All ILI suspected cases were admitted for single room isolation; Confirmed cases were hospitalized in cohort wards and contacts of confirmed cases were also quarantined. "Close contacts" was operationally defined as passengers' three rows in front or behind the confirmed cases or people from the same household [92].
- A "high-risk zone" was designated in a hospital to isolate suspected ILI cases and masks, gloves, and gowns were used in the care of patients [93].

Conflicting Literature from Australia

Descriptions from Australia and New Zealand cite problems with inconsistent implementation of isolation measures across state and local intensive care units (ICU) [89]. Kotsimbos et al. reported that isolation elicited a heavy burden on medical and public health staff with likely little return of reduced transmission, noting rapid viral dispersion was established only twenty days after Australia declared its quarantine policy on 28 April 2009 [89]. In contrast, Eastwood et al. considered isolation a success, citing that when Australia transitioned from mandatory isolation to a self-isolation policy (containment to mitigation phases), the number of confirmed cases doubled [94]. A case study from rural Australia depicts that many rural towns never reached sustained community transmission of the H1N1 virus. In these areas, general practitioners were enthusiastically engaged in isolation and even “reluctant to accept the relaxed measures” after the containment phase was lifted [94].

Facemasks and Hospital Isolation

Descriptions of isolation measures often highlighted the utility of facemasks and personal protective equipment. At Tan Tock Seng Hospital, a Singapore designated (A)H1N1 pandemic isolation facility, heightened control measures were taken for hospital staff. Despite switching from N95 respirators to facemasks, there were fewer hospital staff with acute respiratory illness (955) and pandemic H1N1 (15) in pandemic period three (*late mitigation*), when the staff wore facemasks, as compared to period two (*early mitigation*), when they wore N95 respirators (ARI:1065; pH1N1 no total listed) [74]. The study concluded that during the (A)H1N1 2009 pandemic surgical masks and N95 respirators provided equally efficacy in preventing secondary staff infections [74]. In China, Hong Kong SAR at Queen Mary Hospital, absence of wearing a surgical mask by the exposed persons during contact with the index cases (4/4 verses 264/832, P- 0.010) or vice versa (4/4 verses 300/832, P - 0.017, Fisher’s exact test) resulted in a significant risk factor for nosocomial infection of confirmed (A)H1N1 [92]. Both studies confirm that for hospital staff exposed to pandemic (A)H1N1 2009, facemasks serve as a protective barrier to prevent viral transmission.

Hospital Isolation and Referral Strategies: The Importance of Synergistic Action

The need to identify cases functions as a pre-requisite to a viable and effective quarantine program. Hospital isolation must act synergistically with aggressive surveillance, detection, and referral measures at all authoritative and social level in order to function properly. Among both good and fair quality literature, the following actions were taken to identify eligible people for isolation:

- Establishment of flu centers to assess ILI cases **[89]**
- Media campaigns promoting physician seeking for all symptomatic people [89, 94]
- Referral from airport travel screenings [74, 86]
- Temperature surveillance of medical staff working in open wards with confirmed H1N1 cases [92]
- Temperature screenings of current US Air Force Academy students on campus [63]
- Screening questioner among Air Force Academy students returning to campus after the university's holiday break [63]
- Circulation of information on H1N1 clinical symptoms and recognition among general practitioners [94]
- Placement of public health staff at all international airports [71]
- New patients were screen outside the pediatric emergency department entrance and those classified "high risk" were isolated in a separate outdoor waiting area [93].

Community Isolation Measures and Implementation Strategies

- The Metropark Hotel (China, Hong Kong SAR) was immediately closed after first the confirmed H1N1 case was identified in a traveler returning from Mexico. All 350 guests and staff were quarantined for one week [87].
- A "modified sustain alert" in Victoria, Australia allowed high risk groups to be targeted for testing, contacts traced, and those with confirmed disease isolated for three days[58].

Sea Vessels

While in port, one ILI case from the USS Roosevelt was sent to a local New York City hospital and placed into isolation. An additional two ILI cases from the USS Iwo Jima were sent to a nongovernment hospital and allowed to return back to the ship without precautionary isolation; subsequently an outbreak of 135 new ILI cases occurred. The authors hypothesized that the practice of immediate isolation might have prevented a similar outbreak on the USS Roosevelt. Ultimately, the end of the USS Iwo Jima outbreak coincided with the ability to get personnel off the ships for sick leave[8] [73].

Public Response to Isolation

While documented impact suggests, to some extent, isolation slowed the spread of illness, its implementation was described as carrying weighty personal, social, and economic implications [89]. "Developing messages that incorporated both the mild nature

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[8] Poor quality article

of the disease in most patients and the potential for severe disease in a minority" proved a quintessential challenge for rolling out large scale isolation measures [89].

Two articles studied the public response to isolation. First, a phenomological study using qualitative data captured the lived experiences of staff during the height of the H1N1 pandemic; Resulting themes included:

- The "isolation policy created additional work, confusion, and frustration" [90]
- There was a "lack of guidance on what personal protective equipment to wear" [90]
- Staff experienced "discomfort with wearing PPE for up to 12 h a day" [90]

The second study, a public opinion survey of 555 people in China, Hong Kong SAR, found 92.4% affirmed the isolation of all Metropark Hotel guests as either necessary or absolutely necessary [87]. Further, 98.4% would comply with quarantine measures if asked. The article concluded the public was "very supportive of the government and…willing to observe governmental policies/recommendations such as quarantine" [87].

Hand Washing/Hygiene Communication

Twelve hand washing/hygiene communication articles were retrieved from the literature review representing experiences from New Zealand, Italy, United Kingdom, Australia, South Africa, Canada, Malaysia, and multiple countries in South America (Table 14).

Table 14... Summary of global parameters and outcomes of hand washing and hygiene communication PHM implemented from 25 April 2009 to 30 April 2010 in response to the pandemic A(H1N1) 2009 influenza (N= 12 articles)

Location	Ref.	Days (Date) of implementation [a]	Trigger [b]	Enabled by Legal Provision or Plan	Author Stated Outcome a Success [c]
Proactive					
Australia, New Zealand [d]	[89]	Late Apr.	Not Described	Yes	Not Evaluated
Italy [d]	[95]	Not Listed	Not Described	Not Described	Yes (Knowledge, attitudes, and practices survey results)
United Kingdom [d]	[96]	17 days (1-17 May)	Not Described	Not Described	Yes (Behavioral survey results)
Sydney, Australia [d]	[97]	159 days (30 Apr. -30 Sep.)	Not Described	Not Described	No (Behavioral survey results)
Eastern Cape, South Africa [e]	[98]	1 day (19 Aug.)	High number of confirmed H1N1 cases in region	Not Described	Yes (author's perceptions; coverage indicators of program)
KwaZulu-Natal, South Africa [e]	[99]	Not Listed	Not Described	Not Described	Not Evaluated
United Kingdom [f]	[100]	7 days (29 Apr.)	Measures initiated immediately following WHO confirmation of 115 H1N1 deaths worldwide	Not Described	Not Evaluated
New South Wales, Australia [f]	[101]	156 days (27 Apr.-30 Sep.)	Not Described	Not Described	Not Evaluated
US Forces Korea [f]	[102]	Jun.-Dec.	Measures triggered after huge spike in confirmed weekly H1N1 cases the second week of November. (101 cases).	Not Described	Yes (virus epidemiology from confirmed cases)
Canada [f]	[103]	Not Listed	H1N1 pandemic confirmed by Canada	Not Described	Not Evaluated

Belize, Bolivia, Caribbean, Cuba, Costa Rica, Panama [f]	[104]	Not Listed	Not Described	Not Described	Not Evaluated
Kuala Lumpur/Putrajaya, Malaysia [f]	[105]	25 Apr. 2010	Not Described	Not Described	Not Evaluated
Guilvenec, Brittany, France	[106]	Nod Listed	Not Described	Not Evaluated	Not Evaluated

[a] 2009 dates if not otherwise noted [b] Description of what triggered the decision to implement measure [c] includes both evaluative and speculative conclusions made by authors [d] Good DAQ score [e] Fair DAQ score [f] Poor DAQ score

Measures and Implementation Strategies

Hygiene PHM employed during the (A)H1N1 2009 pandemic represented a diversity of basic educational and promotional practices as well as the use of some innovative media messaging (Table 15). One author suggested text messages campaigns with prevention messages should also be considered for use in the future, especially in developing countries (43).

Table 15. Hand hygiene measures implemented during the pandemic A (H1N1) 2009 influenza	**Ref.**	**Country**
Good/Fair Quality Articles		
Hygiene promotion through mass media campaign: posters, public messages, and distribution	[61]	Mexico
Distribution of hand sanitizers	[61]	Mexico
Hand washing enforced among patients in ED triage areas	[61]	Mexico
"Influenza Leaders" assigned to verify hand washing adherence and promote hygiene precautions among hospital staff	[61]	Mexico
Mass public education on use of tissues when sneezing and regular hand washing with soap	[107]	India
A "flu friends" network was encouraged amongst communities to support ill citizens.	[107]	India
Mass media communication campaign promoted good hand hygiene and tissue use	[96]	United Kingdom
Advertisements on precautionary behaviors were sent to every household in the country	[96]	United Kingdom
"Respiratory etiquette stations" were set up and stocked with hand sanitizer at entrance of emergency department	[108]	USA
Emails were sent to University staff and students containing health information of influenza transmission	[109]	Australia
Poor Quality Articles		
Public Health Nurses went to schools to provide hands on education on methods to limit viral spread	[102]	USA (Armed Forces Korea)
Water supplies were delivered to Indian communities to provide tangible assist to homes on reserves practicing preventative measures	{Aglukkaq, 2009 #109}	Canada
The insurance company AXA required employees to salute each other in place of a kiss or handshake. Other companies asked employees to follow a one-yard buffer zone between contacts. In Guivence, the mayor told teachers and students "not to kiss anymore."	[106]	France
"Fight H1N1, Stay Healthy" childhood education campaign was launched in primary schools to teach personal hygiene and proper handwashing.	[105]	Malaysia
"One day 'blitz' on H1N": Road show to educate community on prevention and distribute leaflets.	[98]	South Africa
Department of Health Public Servants disseminated information packets at taxi ranks, shopping malls, and airports across all national provinces. Community rallies were held at public schools to promote good hygiene.	[99]	South Africa

Triggers for Implementation and Termination

In general, there was a lack of information on triggers for implementation and termination. Literature reported hand hygiene PHM in both containment and mitigation phases, across all time periods, and during all points in the WHO pandemic phases. "Promoting beneficial behaviors in individuals for self protection" is part of the WHO recommended actions in pandemic phase 1-3 to control for seasonal influenza, and thus should be an ongoing activity throughout both northern and southern hemisphere flu season [17]. All good quality articles initiated hygiene measures before a detected surge in poor health outcomes. Seemingly once initial Information from the Mexican health authorities on the new human virus reached the world, implementation for hand hygiene PHM was streamlined [61]. Surveillance data was the only identified source of data for termination of hand washing/hygiene communication PHM [61].

Outcomes and Potential Impact

Outcomes were favorable across the literature, with most measuring effectiveness among small controlled samples, such as hospitals and universities.

Hand Washing

A case study in Mexico found the compliance index score for hand washing among hospital staff increased during the first two weeks of the outbreak from 35% to 87% compliance, an indicator of improved behaviors [61]. In China, Hong Kong SAR hospital staff regularly demonstrated compliance rates of 50% and 60% during hand hygiene audits. Nosocomial infections from hospitalized patients were two (0.43%) out of 466 exposed persons. Among hospital staff, the nosocomial infections were two (0.83%) out of 241 [92]. Among 1,960 Italian survey participants responding to an online questionnaire on influenza related behaviors, hand washing frequency increased; Both nurses (79.5%) and physicians (64.7%) reported washing their hands and/or using hand sanitizers more frequently in response to H1N1 2009 pandemic (p<0.001) [95]. A cross sectional knowledge, attitude, and practice survey conducted following H1N1 2009 pandemic PHM in Rajasthan, India, the sole article from India, shows 54.6% (432) of respondents washed their hands with soap and water more often than usual [107]. In China, compliance to personal protection and hygiene regulations remained good during a university outbreak and isolation activities [62].

Hygiene Communication

A study by Rubin G.J. et al in the United Kingdom found among 5,419 cross sectional survey participants, 33.1% reported carrying tissues, 9.5% bought sanitizing gel, 2.0% avoided public transport and 1.6% sought medical advice. Path analysis found exposure to either media announcements or advertising increased the number of people carrying tissues and buying hand-sanitizing gel while reducing avoidance of public transportation and unnecessary use of national medical services. An overwhelming majority had "heard a lot or a moderate amount about swine flu" (4,817, 92.9%), "felt they knew a lot or a moderate amount about swine flu" (3,808, 73.6%), and "were very or fairly satisfied with the amount of information available about swine flu" (4,462, 91.0%). However, 37% of respondents still "had one or more specific pieces of information that they wanted to know" [96]. In Australia, a study by Van, D et. al measuring hygiene communication (educational emails and posters) effectiveness among 2,882 university staff, general staff, and students found an overwhelming majority (75.9%, 2188/2882) had "not made any lifestyle changes", and 61.8% (1781/2882) had "not undertaken any specific health behaviors due to the pandemic." Only 20.8% (600/2882) reported purchasing hand hygiene products or face masks. Participants who had changed at least one recommended behavior were also significantly "more likely to be anxious about the pandemic" (OR 4.27; CI 1.61-11.10; p =0.002) [109]. The "on day blitz on H1N1", a road show in South Africa to provide information on H1N1 prevention, was reported to be well accepted and welcomed at the community level.

Implementation Tools

The literature listed no legal provisions or procedures supporting the implementation of hand washing/hygiene communication measures. Routine hospital hand washing audits, in place prior to the pandemic and continuing into the H1N1 2009 season, provided monitoring data on hand washing compliance [61]. In Italy, as survey first designed by Harvard School of Public Health on responses to the H1N1 2009 pandemic in the USA was adapted to the Italian situation and used in the form of an outline questionnaire for rapid monitoring and evaluation [95].

Integrated Measures (Targeted Layered Containment)

The review cataloged nineteen articles (6 "good", 9 "fair", and 4 "poor") describing integrated PHM, operationally defined as a set or package of measures applied together to synergistic increase the overall population level impact. "Targeted layer containment" was also frequently cited in the literature and similarly, refers to the coordination and linking of individual PHM implemented under the auspices of a central plan or strategy. Most articles retrieved in the review were oriented towards national level responses and their corresponding pandemic response plans (Table 16).

Table 16. Summary of global parameters and outcomes of integrated PHM implemented from 25 April 2009 to 30 April 2010 in response to the pandemic A(H1N1) 2009 influenza (N= 19 articles)

Location	Ref.	Days (Date) of implementation [a]	Trigger [b]	Enabled by Legal Provision or Plan	Author Stated Outcome a Success [c]
Reactive					
Kobe, Japan [d]	[20]	7 days - school closure (11-24 May)	Detection of H1N1 cases not linked to any imported cases.	Yes: Japanese Infectious Diseases Control Law	Not Evaluated
Mexico City, Mexico [d]	[14]	12 days (27 Apr. - 9 May)	Confirmation of a new A (H1N1) influenza virus was confirmed 23 April	Yes: Presidential degree	Mandatory status not effective
Buenos Aires, Argentina [e]	[110]	30 day school closure 10 day closure of theaters 14 day judicial recess	60 deaths due to H1N1	Not Described	Not Evaluated
Australia [f]	[111]	Not Listed	Not Described	Yes	No (author's perceptions)
Mbulu, Tanzania [f]	[38]	11 Oct.	40-year-old primary school teacher died of H1N1 at the local district hospital where she was admitted for treatment	No	Not evaluated
Proactive					
Mexico & USA [d]	[60]	23 April - Sep 2009	Not Described	Yes: Mexico's pandemic influenza preparedness plan invoked by the president of Mexico	Not Evaluated

Location	Ref.	Days (Date) of implementation [a]	Trigger [b]	Enabled by Legal Provision or Plan	Author Stated Outcome a Success [c]
Victoria, Australia [d]	[112]	20 May - early July 2009	First H1N1 case detected and increased influenza cases reporting to area hospitals	Yes: The Australian Health Management Plan for Pandemic Influenza	Not Evaluated
Singapore [d]	[113]	27 April - 30 August 2009	Not Described	Yes: National Influenza Pandemic Readiness and Response Plan and Infectious Diseases Act	Not Evaluated
Queensland, Australia [d]	[57]	28 April -22 June 2009	WHO declaration of a pandemic	Yes: Australian Health Management Plan for Pandemic Influenza	Not Evaluated
United Kingdom [d]	[16]	27 April - 2 July 2009	Not Described	Activation of the UK Civil Contingencies Committee (CCC) on 27 April 2009; National Framework	Not Evaluated
Mexico[e]	[114]	251 days (23 Apr.-3 Dec)	1st confirmed H1N1 case from national laboratory	Yes	Not Evaluated
Tanzania[e]	[84]	Not Listed	Not Described	Not Described	Not Evaluated
People's Republic of China[e]	[115]	Not Listed	Not Described	Not Described	Not Evaluated
Singapore & People's Republic of China[f]	[116]	Not Listed	Not Described	Not Described	Not Evaluated

Location	Ref.	Days (Date) of implementation [a]	Trigger [b]	Enabled by Legal Provision or Plan	Author Stated Outcome a Success [c]
TelBru, Brunei Darussalam[f]	[12]	27 April - 30 August 2009	Not Described	Not Described	Not Evaluated
Argentina, Australia, Chile, New Zealand, and Uruguay [d]	[117]	28 April -22 June 2009	WHO declaration of a pandemic Not Described	Not Described	Not Evaluated
[d]PAHO countries	[118]	27 April - 2 July 2009	Not Described	Not Described	Not Evaluated
Rajasthan, India [d]	[107]	None Listed	Not Described	Not Described	Not Evaluated
Mexico	[119]	24 April - early July 2009	Not Descirbed	Mexico's Constitution and General Health Law	Not Evaluated
Mexico City, Mexico	[120]	Not Listed	Concern of contracting influenza by hospital staff	Not Described	Yes- confirmed cases

a 2009 dates if not otherwise noted b Description of what triggered the decision to implement measure c Includes both evaluative and speculative conclusions made by authors d Good quality e Fair quality f poor quality

Measures and Implementation Strategies

The literature presented similar inter-country and between-country objectives for use of PHM, namely to prevent and control the spread of infections, “to delay the onset of an epidemic and decrease the total number of cases,” [60] to “slow the spread of influenza to reduce the surge on healthcare,” “to maintain essential services,” and “to limit social and economic disruption” [113]. A kaleidoscope of different PHM were packaged together and the literature provided little justification for the inclusion or exclusion of each measure. Integrated PHM were most often described in terms of containment and mitigation. Measures were integrated in the form of containment and mitigation strategies, according to the following definitions

Containment Strategies: public health measures selected as part of a national or institutional/organizations response plan prior to established community wide transmission

Mitigation Strategies: public health measures selected as part of a national or institutional/organizations response plan after local H1N1 had been established; community wide transmission

Integration of PHM was most consistent in the containment phase. Table 17 visually displays the diverse set of measures integrated by countries in their pandemic response plans. From frequency analysis of published integration experiences, school closing and travel screening were employed more often than isolation, cancelation of mass gatherings, and/or hand washing communication. Published literature on travel restrictions was only found for Singapore and Argentina.

Triggers for Implementation and Termination

The review found limited evidence of preemptive benchmarks triggering PHM implementation beyond the overarching declaration of influenza A (H1N1) 2009 pandemic. Inductive analysis of themes emerging from the literature showed (1) detection of the first case and (2) WHO pandemic declaration, as the main triggers for implementation (Table 16). Subsequently, most countries described activation of their legal plan or provision for pandemic control. Literature from Japan cited an Infectious Disease Control Law, which permitted hospital isolation of all confirmed cases, while in Mexico, a presidential decree sparked school closures across the country [60].

Termination of integrated PHM was typically synced with a phase transition in the national pandemic plan. A shift from the containment phase to the mitigation phase in Argentina, Australia, Chile, New Zealand, Uruguay, Singapore and Mexico was described as the trigger for termination of many PHM. Further, documentation that most H1N1 cases did not require hospitalization served as grounds for terminating aggressive integrated control strategies in Japan [20]. In Australia clinical evidence that the disease was not severe was used to justify shifting PHM away from containment towards protecting the most vulnerable [57]. In Singapore, transition from containment to mitigation occurred when newly diagnosed locally-acquired H1N1-2009 cases started to exceed the number of cases linked to international travel [113]. The listed authorities responsible for termination included National institutes of public health and national governments.

Meeting of Ministers to Establish Termination Triggers, United Kingdom:

An external evaluation of the United Kingdom's pandemic response described a 6 May meeting in which a consensus was reached between UK ministers that the containment phase would continue until one or more of the triggers were met [16]:

"Clear evidence of sustained community transmission"

"Robust scientific evidence that the disease was no worse than a seasonal flu";

"The number of confirmed cases was overwhelming operational and NHS resources"

Outcomes and Potential Impact

Quantitative process indicators, localized and national case surveillance data, qualitative descriptions, in-depth interviews, and on the ground knowledge from experts involved in implementation were used to evaluate the effectiveness of integrated measures. Most studies reported a limited number of outcomes compared to the package of measures described in the article, with substantially more "poor" quality articles speculating on potential impact. As of August 2010, a systematic evaluation of integrated PHM only exists for the United Kingdom and PAHO countries [16] [121]. While most measures were described in conjunction with a national pandemic response plan, there was little consistency of indicators for measuring outcomes. Indicators cited in the literature included economic loss, confirmed public cases, confirmed cases among first-response medical staff, school absenteeism rates, number of school closures meeting trigger criteria, facemask use, and number of travelers identified by border screening methods. No comprehensive, standardized indicators measuring the effectiveness of PHM outlined in pandemic response plans, especially during the containment period, was found through the literature review.

Economic Outcomes

The economic impact of pandemic (H1N1) 2009 virus in Mexico during the spring is estimated at over $2.3 billion (0.3% of gross domestic product) [60]. In Argentina, economic outcomes in the form of a July 2009 press release cited ski resorts, hotels, and restaurants as losing approximately US$150 million a week during containment (which included school closures and cancelation of flights from Mexico). However, the concurrent economic recession confounds these estimates. Also, in some Argentinean regions up to 40% of health care workers were absent from work during the height of the outbreak [59] and a news report cites business at schopping centers declined by half [110].

Legal Enforcement of facemasks in Mexico

In Mexico, facemask use mimicked the epidemiological rate of infections. Data from taxi/bus drivers shows mandatory mask requirements improved compliance, however the difference between mandatory and voluntary measures was not significant. Among metro passengers, females were found significantly more likely (1% significance level) than men to wear facemasks. Follow up informational interviews suggested mandatory rules were not enforced, with Mexico City police receiving bribes and threatening to seize taxis from non-compliers [14].

Expert Opinions of Integrated Strategies

Integration was most frequently described under large population level parameters. PAHO recently sanctioned an evaluation of PHM responses to the 2009 H1N1 pandemic and found:

- *Case-detection activities at borders were ineffective, but they helped boost the capacity at points of entry under the IHR (2005) and raise travelers' awareness of personal protection measures [122].*

- *Voluntary isolation measures were effective for patients but not for contacts. The establishment of triage mechanisms to prevent children, teachers, and other school personnel from going to school sick was effective. For example, a useful strategy was training school bus drivers to recognize sick students and send them home [122].*
- *Information provided to household contacts of patients to prevent transmission was useful. Teaching personal hygiene measures to children in schools was an effective strategy as children can act as disseminators of information at home. Promoting hand hygiene and respiratory etiquette (for example, covering a cough with tissue, coughing into one's sleeve) helped reduce the transmission of influenza and other diseases. In some countries, extending winter vacations helped minimize or delay transmission among school-aged children [122].*

Emerging Ideas

Two emerging ideas were tested and published in the United States during the H1N1 2009 pandemic: a drive through emergency room influenza clinic and an outdoor parking lot emergency department for ILI symptomatic patients.

In the first situation, at Stanford University Medical Center Emergency Medicine Department, patient automobiles were used as isolation compartments while waiting for clinical evaluation from healthcare providers. A mock simulation test found this drive-through influenza clinic could serve as a potential alternative to a traditional emergency department structure. Doctors identified 100% of those simulated patients who were admitted during their real ER visit in April 2009. No significant increase in carboxyhemoglobin , a carbon monoxide-hemoglobin complex that forms in red blood cells upon inhalation of carbon monoxide and in large quantities, can obstruct the delivery of oxygen to the body. The median waiting time was 26 min, which authors hypothesize could help alleviate the common delay inherent in hospital rooms turnover rate [39].

In the second case, at Texas Children's Hospital; Patients arriving to ER were screened outdoors for ILI symptoms and suspected cases sent to outdoor facility set up in adjacent parking lot. N95 respirators were available to staff and facemasks to incoming patients. The outdoor emergency department was constructed in 8 hours and took over 18% of the ED volume, which increased 50% over non-pandemic periods. Wait time in the department and total time in the department decreased. The additional operational costs were approximately $280,000 ($135,000 for supplemental staff pay and $113,000 for facility construction and additional laboratory supplies.) Overall the measure did not result in an overall savings for the decreased patient-time in the hospital [108].

Chapter 5. Discussion

As of 10 August 2010 many experts had contributed to the PHM knowledge base by publishing opinion and reflection articles on the H1N1 pandemic experience. However, only a limited number of articles retrieved provide good quality evidence towards the real-time effectiveness of PHM in the H1N1 2009 pandemic setting. Among the well-designed studies, hand washing and, to a lesser extent, post-outbreak school closures showed evidence of effectiveness. The literature on isolation remains inconclusive, with some effects documented in closed settings such as hospitals, universities, and military barracks. The larger impact of community and national isolation is not proven. Travel screenings and travel restrictions were most likely of none or limited effect, yet antidotal information attributed a reduced public fear from their implementation. Control measures taken at mass gatherings seemed to have limited virus spread while avoiding the need for cancelation (Table 17). A stochastic set of triggers was described in implementing PHM and many pandemic plans required major adaption. The literature was characterized by very little monitoring of process efficiencies, no standard outcome indicators, and unaddressed confounders.

Table 17. Strength of evidence among good quality studies for effectiveness and impact of non pharmaceutical PHMs during H1N1 2009 pandemic: outputs from the literature review

		Evidence of Impact	
Strength of Evidence	**Public Health Measure**	**Evidence in Support**	**Evidence Against**
HIGH: Likely effective	Hand washing/hygiene communication	[61, 95, 96, 107]	[97]
MEDIUM: Possibly effective	School Closures (post outbreak, preventative, post confirmed case)	[40, 41, 43, 53]	None
	Isolation or Quarantine	[62, 63, 74, 92]	None
LOW: Unlikely effective	Mass Gathering Cancelations	[14, 66, 68, 69]	None
	Travel Screening		[75, 76]

Summary of Published Experiences

Despite the lack of good quality evidence, the breath of accounts and expert opinions provide an opportunity for learning how to apply public health measures in mitigating the impacts of influenza outbreaks both locally and globally.

1. School Closures

Overall, in some settings and when implemented in a timely manner, school closures reduced virus transmission. However social costs, including loss of parental income and academic disruption, have not yet been adequately measured and deserves continued research in the post-pandemic phase.

When school closures did occur, the literature showed a gap between well-defined implementation and termination triggers. Schools need guidance based on standardized benchmarks to facilitate the decision making process, justify closure, and ensure appropriate timing of re-opening. A tiered trigger systems used in the "watch and wait" method described in the results might be an appropriate model to guide future planning. This strategy involves specifying a set of criteria, such as a daily school or community case count, which triggers one or more response (e.g. temperature screening, class dismissal, orschool closure). The criteria can be calibrated to the severity, not just the transmitability of the pandemic. Once the triggers are in place, communication of standards to parents and communities at large will be essential for a streamlined and synergistic response.

2. Mass Gatherings

While concern quickly generated over mass gatherings as places for heightened virus transmission, experiences from the published literature fail to document outbreaks at large events during the H1N1 2009 pandemic. In fact, control measures established for the Muslim Hajj pilgrimage, a series of sporting events and concerts across Europe, and even following a small outbreak at a Belgium rock festival all resulted in a relatively small number of confirmed cases [66, 68, 69]. The protective measures enacted in advance and during the gatherings appear to have effectively controlled transmission. Only one commentary from Australia hinted that the sanctioning of national school sporting events led to virus spread [111]. Proactive and aggressive measures should continue in the future, with the few published accounts from 2009 serving as a guide for sustaining public health control measures.

3. Travel and Trade

Travel Screening

Travel screening showed very little relative value, and no value when analyzed in terms of financial and logistical tradeoffs. The highest quality evaluations of travel screening reported case detection rates of only 4 – 54%. Further, a global meta-analysis of countries with and without screening found no significant difference in onset of transmission, with confidence estimates ranging from no delay to 20-30 day delay [123]. Any added benefit was likely counteracted by the extra financial and human resources required as well as the operational disruption during implementation.

Travel Restrictions

The literature review found no good quality evidence on the impact of travel restrictions during the influenza A (H1N1) 2009 pandemic. Experience from Japan, Australia, Russian, Slovakia, and the Ukraine described only the economic losses expected; formal evaluations were absent. A PAHO meeting report on responses and lessons to the 2009 pandemic shared that "no general consensus [was reached] among country representatives on interventions at points of entry, such as ports and airports" [122]. Many attendees stated that travel interventions elicited minimal benefit and consumed resources. In contrast, some experts believed that they helped "delay the spread of the epidemic to their country" [122].

4. Isolation

The published literature provides no evidence national mandatory isolation contributed to mitigation of influenza, either in terms of reducing the rate of virus transmission or its spread to close contacts. Whether this reflects a gap in research capacity or valid experience is unclear. An opinion article from Australia comments that two weeks after lifting the mandatory quarantine the number of cases doubled; another article speculates that isolation measures at borders appeared to contain community transmission through June [71, 94]. A high burden placed on medical staff posed a barrier to Australia's policy of case and contact isolation [112].

Partial evidence in support of isolation does exist in controlled environments. Isolation at the USA Air Force Academy [63] and onboard a USA navy ship [73] halted viral spread following an outbreak. In a Chinese University, placing exposed contacts together as opposing to in single rooms proved an equally efficacious isolation technique [62]. However, in China over 98% of people affirmed quarantine measures and the Metropark hotel isolation [87]. Less rigorous case studies in hospital emergency departments (ED) suggest isolation of patients immediately upon arrival slows transmission within the ED wards. In another time series study, surgical masks were found to be an equally viable tool in preventing hospital staff H1N1 [74]. Ultimately, the evidence supports a parsimonious approach to isolation measures.

5. Hand Washing/Hygiene Communication

Hand washing/hygiene communication served as a priority prevention measure during the influenza A (H1N1) 2009 pandemic [61]. The majority of articles, including a case-control study at a Thailand kindergarten, demonstrated hand washing and hygiene serve as effective mitigation tools during a pandemic. Nonetheless, it is noteworthy that the quality of hygiene communication influences its impact, as is seen in an Australian university survey where 62% of the 2,882 participants had “not undertaken any specific health behaviors due to the pandemic,” after receiving emails on influenza transmission [109].

In practice, convincing the public that the threat is real often remained an equally important task for public health agencies during the 2009-2010 influenza season, when "…many people believed that the Influenza A (H1N1) situation was exaggerated by health authorities and the media [107]. The study from the United Kingdom showed that when levels of worry are generally low, increasing the volume of mass media and advertising coverage is likely to increase the perceived efficacy of recommended behaviors, which, in turn, is likely to increase their uptake[107].

6. Integration

The published literature provides only a theoretical framework for integratation of response measures in an influenza pandemic. Almost all articles described a combination of prevention strategies, albeit limited quantifiable results of their *packaged effectiveness*. Triggers for selection of various measures and decision tools used to combine measures were not found in the search. Further, no formal operational research studies on the added benefits of integration beyond expert opinions and lessons learned have been published to date. Modeling studies have shown that under certain conditions, integration of PHM have a larger effect than the sum of the measure alone, but such results still need to be evaluated in practice [29]. Overall the decision framework for integration of PHM requires further research.

Lessons Learned

The beginning of the pandemic was galvanized by public fear and scientific uncertainties. As the nature of the virus unfolded, the international community was able to make more informed decisions and adjust public health responses accordingly. Literature on these experiences provides lessons for future action. Given non-pharmaceutical PHM serve as a good entryway into the health system, and can be activated far before vaccines are available, there value as a first line of defense should not be underestimated.

Table 18. Lessons learned during the 2009 H1N1 pandemic: results from systematic literature review of experiences
The Established Pandemic Response Plans were Too Stiff for the H1N1 Virus
Anticipate Decisions Making in Uncertainty
Improve Communication of Indecision
Link Decision Making Channels across Multiple Sectors
Improve Tools and Indicators for Decision-Making
Efficient, Targeted Communication is Essential to Success
A Standing Group of PHM Experts is Needed to Guide Research, Interpret Evidence, and Set Priorities
Invest in Preparedness and Surveillance Capacity in Developing Countries

The Established Pandemic Response Plans were Too Stiff for the H1N1 Virus

The literature highlighted numerous national and institutional pandemic response plans that guided the implementation of PHM. However, these plans were designed for a much more virulent virus, causing higher mortality than actually realized during the 2009 experience. In Australia, the variation in cases across regions made it difficult to implement a national policy for closing schools [78]. Sections of the pandemic influenza plan in Victoria were deemed inappropriate for the mild virus and government authorities essentially "choose which parts of the plan were relevant to the situation to implement" [112]. Published lessons learned from Singapore concur with Victoria's experience; when the color codes in the disease outbreak response framework were recognized as poorly applicable to the H1N1 virus, the "MOH and its stakeholders had to reframe and re-learn the context of public health control measures" [113]. An independent review of the United Kingdom's (UK) response revealed a similar frustration among UK authorities, affirming that for those involved, "…it was difficult to switch from the plan we had – predicated on a worse pandemic than that which emerged – to a more proportionate response" [16]. Further, qualitative results suggests a streamlined UK-wide approach, with explicit containment and treatment stages, actually hindered flexible management of the local, micro-level realities [16].

The collection of literature reviewed defends the position that the pandemic plans prior to the 2009 H1N1 pandemic were replaced, by the unexpected nature of viral evolution, with the sound judgment of those in charge. Such action resulted in inconsistent application of public health measures. A key lesson emerging from the documentation of such experiences is the need to develop flexible pandemic plans that "…allow for the turning on and off" of irrelevant parts based on the virus and corresponding relevance of each strategy [112].

Moving forward: Pandemic plans should define a clear, detailed command structure (i.e. who-talks-to-who) outlining what decisions need to be made, by whom, and when. These additions should replace many mandated action items, which may or may not be applicable to the virus' unique virulence. Updated plans should consider a wide range of possible response scenarios. Additionally, the pandemic phases, as currently defined by WHO, should be revised to correlate with the virus virulence as well as transmission.

Anticipate Decisions Making in Uncertainty

Uncertainty remains unavoidable in any pandemic. One of greatest lessons emerging from the 2009 experience might be that the world must never fail to anticipate and plan for its presence. Documentation from the 2009 pandemic affirms that recommendations must be in flux, evolving as new evidence becomes available [124]. Unfortunately, virulence cannot be tested in a lab and the virus must take its course in nature in order to know its severity. Thus, significant time was required for field investigations and epidemiological studies to determine the serial interval of infection, duration of symptoms, period of viral shedding, and mortality rate for the H1N1 virus. While valuable for informing PHM implementation, such as time symptomatic individuals should stay home if infected, such data was not available at the beginning of the pandemic when isolation and quarantine harnessed the greatest potential to contain its spread. Waiting for more data must be weighted against the costs and benefits of early implementation.

Whether shifts in geography, high-risk populations, or temporal spread, the epidemiology of the 2009 H1N1 virus proved to bring much uncertainty. First, the virus arose in North America, not Asia as anticipated. Secondly, counter many influenza plans which expected higher mortality among the elderly, excess mortality occurred primarily among age groups <65 years old and remained low for those >65 [125]. Additionally, the virus continued to circulate into the 2010 influenza season, with some regions experiencing the highest burden of disease in late spring 2010. Ultimately for decision makers, the challenge lies in appreciating the complexity of disease patterns and the need for more evidence, while still maintaining simple guidance [126].

Decision making under uncertainty also calls for recognition of the diverse objectives underlying public health measures. An August 2010 qualitative assessment of school closure decisions in the US captured the variations in justifications for decisions, noting five differing objectives: 1) reducing transmission of the virus in the community 2) stopping an outbreak of cases within a single school or class 3) protecting high risk populations 4) Adapting to staff shortages or high rates of school absenteeism due to illness for the pandemic virus and 5) reducing heighted fear and concern among parents [127]. These findings suggest implementation of PHM occurred to achieve differing goals and such variation much be appreciated and consider in the decision making process.

Moving forward: In the future, it will be important for decision makers to maintain a clear sense of 1) what they do and do not need to know in order to act and 2) how sure they need to be in their decisions. Pandemic plans with automatic triggers are needed to help target data collection activities to the highest priority items in which action can be taken. Multiple triggers and corresponding "go-no-go" decisions should be in place to allow for incremental steps in response intensity as needed. While more evidence is certainly necessary, too much information can be dangerous as well, taking attention away from the highest priority decisions [126]. Decision makers must pause and act responsibly, conscientious not to decide more or less than needed in each phase of the pandemic.

Improve Communication of Indecision

Close coordination between response agencies and frequent messages to the public were essential activities of the pandemic response. Yet it is important the pubic understands the limit of information available and the reality of decision makers who "can't do more until [they] know more" [128]. A lesson from the 2009 experience is the importance of providing information, even if it is of indecision among experts, to the public at all stages in the pandemic. As highlighted by the Minister of Health from Canada, a successful response must provide the public with "the information they need to make informed decisions to protect themselves and their families"[129]. Data reflecting uncertainty must not be discounted as information appropriate for public communication.

Moving forward: In a pandemic eliciting high public health concern, public health agencies must transition from scientists being the sole consumers of evidence to transparently sharing that evidence with the public. Additionally, communication specialists should be added to pandemic response units to improve preparedness of simple, easy to understand messages of risk. Evaluation plans for pandemic response effectiveness must include indicators of public perception of information and risk.

Link Decision Making Channels across Multiple Sectors

A clear lesson emerging from implementation of PHM during the 2009 pandemic, particularly school closures, is that school and community officials should be linked more closely with public health agencies and involved in decision making [126]. In the United States, variability in decisions on when to close schools has been attributed to unclear variation in the ultimate legal authority. State and district pandemic plans were often vague about whether the school district or health department had the authority to make the decision. Further, competing incentives and priorities were in play for each group. US school districts often needed to consider laws requiring a certain number of days of school attendance in order to receive state funds. For example Rhode Island, New York, and Tennessee all evoked laws authorizing waivers of this requirement for closure due to 2009 H1N1. However, in Connecticut and Alabama, the state legislature required re-scheduling missed days in order to receive complete funding [127].

Improve Tools and Indicators for Decision-Making

Given the innate uncertainties in a pandemic, the quality of the response depends on the public health capacity to gather data quickly [124]. Process indicators for PHM decision making included in the published literature were diverse and fragmented. Coincidental events, such as pre-planned holidays and summer leave, facilitated decisions to delay or accelerate school closures in some instances. A weakness in surveillance and laboratory capacity at the start of the pandemic severed authorities reliance on typical decision making tools, forcing the use of expert judgment in other scenarios. Despite little documentation in the published literature on why certain PHM decisions occurred, the following sources were cited as useful in the decision making process: hospital data, national surveillance data, global surveillance data, global epidemiology reports, lessons learned from past pandemics and/or outbreaks, established national and/or institutional pandemic response plan. Expert opinion or political judgment was often inferred as triggers behind PHM implementation in the studies reviewed.

A lesson from the US was that mortality estimates, a key indicator for decision making scripted in the pre-2009 pandemic plan, was inherently delayed and unavailable for use during important decision periods. The biological course of the disease had to progress before the data was available, which retrospectively resulted in a median 15-day delay between illness onset and death [124]. Documentation of the death and transmission of the information to the CDC further delayed the utility of information. In light of this limitation, supplementary indicators, such as suspected and confirmed cases, were used to inform and justify decision making [124]. Overall, the US experience gives credence to the principal that while mortality data remains helpful for validating decisions and guiding long-term planning, a more rapid assessment of pandemic severity is needed.

Additionally, the variability in tools for decision making cited in the literature appeared geographically clustered. In developed countries, surveillance systems on suspected and confirmed cases served as the best sources of data on pandemic severity. However, many less resourced countries maintain poorly functional or sensitive surveillance, limiting their capacity for evidence based decision-making. Nonetheless, in Chicago, Illinois a community-based survey was conducted following a school outbreak, with results demonstrating such methods as a valid and accurate means of assessing influenza burden during a pandemic [130]. Developing countries should consider using household surveys as a means for providing data for making "go-no-go" decisions to implement interventions during a pandemic.

Moving Forward: Properly calibrated tools are needed to facilitate decision making during the pandemic. Public health planners must anticipate both the types of decisions needed along with what types of quantitative and qualitative evidence will be needed to make those decisions. Epidemiologic studies should set reasonable objectives and consider design constraints, time frame, and available staff. With this framework in mind, accepted standards on what decision makers should consider "good", "fair", and "poor" quality of evidence should be adopted by an international PHM group of experts.

Efficient, Targeted Communication Targeted Communication is Essential to Success

Whether correspondence between policy makers, mass media campaigns informing the public on proper cough etiquette, or announcing school closures, communication activities were described in almost all articles. However, communication activities faced many barriers. On a macro-level, "The layers of national, state, and local bureaucracy" among PAHO countries posed significant problems [111]. Heightened media attention might have caused unnecessary fear among the public and some people became complacent thinking the PHM were excessive. Such perceptions might result in loss of public confidence in the management of services related to the pandemic [111].

Communication problems between state health authorities in Victoria, Australia were cited as why cruisers aboard the Pacific Dawn, including ILI symptomatic and high risk people, were not isolated [111]. This failure led to widespread dissemination of the virus in Victoria [111]. Published expert opinion also claims communication gaps in Australia resulted in inconsistent procedures at border crossings. During school closures, parents were not always provided information on the importance of reducing contact with other children. During a school outbreak in France, decisions had to be made rapidly and authors cited "good communication and cooperation among the different people involved" of essential importance [46]. Conflicting massages were also received by health care workers in Victoria regarding whether or not to come to work with ILI [111]. A qualitative study on experiences of healthcare workers during the pandemic found feelings of "fear of the virus as a new phenomenon"; with staff stating more information and communication would have been helpful [90] (73). Additionally, a UK cross sectional telephone survey of public behavior change in response to the swine flu found ethnicity as the greatest predictor of any behavior change (odds ration 3.2, 95% CI 2.0 to 5.3) [96]. Targeting communication to specific minority groups might be beneficial in future pandemics.

PAHO countries also defined a communication barrier in conflicting international recommendations and national policies. At times PAHO/WHO country representatives issued advice counteracting the implementation of several interventions used in PAHO countries. When countries decided to implement such interventions against the technical recommendations, the PAHO/WHO Representative (PWR) was "…sometimes placed in the awkward position of appearing to validate these interventions when they were announced in the presence of the PWR by the MoH" [121]. Ultimately, the establishment of a cohesive, communication policy, with clear goals and objectives is essential in future pandemics.

A Standing Group of PHM Experts is Needed to Guide Research, Interpret Evidence, and Set Priorities

Currently the evidence based for non-pharmaceutical PHM relies more on inferential and experiential reports rather than rigorously designed observational studies. This is a both a product of the emergent setting in which they are implemented as well as the overlapping and often secondary nature of PHM during a pandemic. A study from New Zealand emphasizes that "had a research capacity been identified in advance, optimal use of the collected case history, epidemiological, surveillance and virological data could have been made more widely available" for planning PHM response actions [71]. Yet without a clear research agenda, controversy arose around recommendations and many authors cited international guidance as vague and of little utility.

This review supports the claim that no consistent pattern was seen when implementing PHM during the 2009 H1N1 pandemic. It also serves to synthesize the voice of policy makers and researchers calling for a more standardized, evidence based process for recommending NP PHM. In order to improve the effective use of PHM in future pandemics, a prioritized research agenda is needed.

Moving Forward: The standing group of experts should build upon the decision frameworks tested and used for pandemic influenza vaccination programs. For example, "The CDC's Advisory Committee on Immunization Practices (ACIP) and DHHS's National Vaccine Advisory Committee reviewed evidence on the disease burden and risk factors for influenza and its complications and produced a framework for prioritizing scarce supplies of pandemic vaccines" [124]. Refined over multiple pandemics, such frameworks could serve as a template for building a body (such as the ACIP) to guide global decision-making on non-pharmaceutical interventions. Emphasis should be place on realistic data to collect for rapid decision-making in the early pandemic stages.

Given the uncertainty of decision making during a pandemic, it is important to acknowledge and communicate the appropriate goal hoped to be achieved in that decision.

Invest in Preparedness and Surveillance Capacity in Developing Countries

The unfolding of the 2009 influenza A H1N1 response validated concerns documented in the literature that low resourced countries will have limited access to antivirals and vaccines during a pandemic. Limited pharmaceutical supplies and increased HIV-coinfections place developing countries at heightened risk of increased mortality compared to high income countries [131]. A transmission model simulation using data from a hypothetical developing country population during the 2009 pandemic showed a 50% reduction in mortality with the availability of contact reduction and anti-virals as compared to a no intervention senario [132]. Such results validate the claim that lower resource countries represent a highly vulnerable population during a pandemic.

Decisions weighting the risks and benefits of non-pharmaceutical interventions are particularly important in such settings. The review returned little information on impact or process outcomes of PHM in developing countries. More operational research and post-hoc qualitative assessments of the response in such settings is needed to guide future preparedness plans. However, public health principals should be used to guide future preparedness and can be based off the work of Oshitani et al, who proposes five activities for developing countries to meet the challenges of influenza preparedness [131]. The first step is to improve planning processes. Currently, most of the preparedness plans are based off of plans adapted from industrial countries. A template for developing nations should be designed, specifying points of non-pharmaceutical action and how low-resourced hospitals can prepare. Secondly, countries should improve systems for providing medical care and public health, include training on basic infection control. Thirdly, countries should be encouraged to expand the use of non-pharmaceutical interventions. Fourth, countries should strengthened core capacities for seasonal influenza surveillance and vaccination, including establishing a yearly seasonal flu prevention program to build capacity for the next pandemic. Finally, investments should be made to strengthen international collaboration and sharing of virus strains for expedited vaccine development [131].

Moving Forward: It is important to note that antiviral and vaccine capacity is not the only benchmark for pandemic preparedness. In low-resourced countries, creation of culturally appropriate and locally tailored preparedness plans, along with the establishment of strong influenza surveillance systems, should be set as medium-term development goals. The international community should allocate funds and hold countries responsible to achieving these goals. Attentions should be given to the integration of influenza surveillance with other infectious disease surveillance systems. Finally, developing countries should leverage pandemic preparedness as a means to strengthen capacity of health systems in accoradance with the WHO health system building blocks [133].

Public Health Implications

This thesis highlights that what influenza needs, above all, is more evidence. Given the high costs of PHM in the form of lost work or school time, suspension of industry, and disruption of community gatherings, both the public and decision makers are justified in calling for evidence of the resulting benefits. This report provides an answer to the question "where is the evidence now" and suggests mechanisms for strengthening the global capacity for collecting, utilizing, and disseminating evidence moving forward.

Collectively, the PHM experiences documented in the year following the pandemic depict a wide spectrum of utilization and effectiveness. Prior to implementation, decision-making triggers were poorly defined. Once measures were implemented, few formal systems were in place to monitor effectiveness. Within the scientific discipline of pandemic preparedness, great potential exists to improve the quality of the non-pharmaceutical decision making through creation of a global monitoring and evaluation framework. This will also require supporting a feedback loop of PHM knowledge to the public, which under the rare occasion of a pandemic, must not be neglected as important consumers of such evidence.

If indeed a scale up of resources and technical expertise for PHM is adopted, it will require a shift from the current pharmaceutical-based frameworks to a horizontal, systems approach. Increased collaboration will be needed between schools, airports, industry, and civic organizations. New indicators which account for the interconnected implementation actors and integration of various community protection measures will need to be developed. While many of the public health success stories, such as smallpox eradication, salt iodinization, and food fortification, were based on silo interventions, successful pandemic responses necessitate a far more holistic approach. This is both a challenge and an opportunity for system strengthening. It is a call to connect decision makers, narrow objectives, focus on achievable goals and identify realistic data collection activities.

The recommendations proposed in this thesis, if wisely considered and implemented, will result in a more coordinated and directed response to the next pandemic. While the 2009 pandemic is not without multiple success stories, much of the capacity for documenting such successes lies within the realm pharmaceutical and surveillance activities. There is a need to uncover the successes of PHM. The next big step in pandemic preparedness is to align PHM as a more central and valuable intervention strategy. This requires investing in learning activities on strategies to capitalize PHM effectiveness. Paralleling globalization and the predicted increased frequency of small pandemics, evidence-based utilization of PHM will be significant public health tool in future pandemics.

This thesis, as a call for more evidence, has already served an important role in moving the PHM agenda forward. Distributed as a WHO report and orally presented to open international discussion on the issue at the WHO workshop “Public Health Measures Implemented in Response to the 2009 Pandemic”, this work has stimulated international thinking on a set of triggers and indicator necessary to improve decision making in the next pandemic. Further, authorities at the international level are considering the feasibility of a strategy and supporting fund for impact studies on public health measures.

Recommendations for Future Research

Despite the window of opportunity the H1N1 2009 pandemic presented to enhance evidence for PHM, wide gaps in knowledge remain. The world needs

> *"real-time, targeted, public health operational research to determine the effectiveness of specific public health policies and control measures. To obtain such knowledge, we need to plan ahead so that the research manpower and resources may be activated during an outbreak" [113].*

Some areas needing urgent study include:

1. To what extent can specific PHM measures such as school closings, be applied in resource-limited settings as found in parts of Africa, Asia, and Latin America, where formal structure such as classes may not exist.

2. Literature shows inconsistency in implementation of PHM even within countries or regions, with varying success. There is need to develop better ways of measuring implementation coverage and impact for each PHM

3. To what extent nation, district, and city school closures slowed transmission beyond localized school outbreak sites.

4. The extent self-identification for isolation succeeded in isolating a majority of cases and quarantining close contacts and hence slow or delay viral transmission.

5. Need to define triggers used for implementation and termination of measures in different setups.

6. The utility of monitoring or evaluation systems in triggering implementation or termination of measures.

7. The cost effectiveness of travel screening.

8. The extent integration of PHM was coordinated between policy makers and public health professionals at various levels of implementation

9. The impact of different combinations of measures on viral spread.

Table 19. Recommendations for improving evaluation of public health measures during a pandemic

Research Category	Goal	Research Activities
OPERATIONS AND IMPLEMENTATION	**Improve understanding of implementation processes; increase implementation efficiency**	• Develop a decision matrix for timing of school closures based on available evidence • Develop national, sub-national, and local decision tools for triggering and terminating PHM • Assess compliance of PHM among various population groups and pilot test strategies to increase compliance • Test methods to improve efficiency of PHM implementation • Test innovative, nuanced implementation strategies • Pilot test mechanisms for adjusting PHM up or down based on the severity of the pandemic • Conduct focus groups and define a theoretical framework for barriers to PHM implementation • Conduct detailed case studies on implementation processes • Test methods for improving linkages between airport screening and isolation measures (linkages between other measures?) • Evaluate incentives for PHM behavior change and PHM compliance • Establish proposals for operational research activities for future pandemics

MONITORING AND EVALUATION	**Increase capacity, at all planning levels, to adjust PHM strategies quickly and synergistically during a pandemic**	• Convene expert meeting, establish standard process indicators for implementation of PHM during a pandemic; (base indicators off simple process measures communities can collect) • Communicate indicators to proper networks and authorities • Develop expanded monitoring tools and rapid feedback mechanisms for coordinated measure implementation between entities
POLICY AND PLANNING	**Improve flexibility of pandemic response plans; add details of action required for implementation**	• Synchronize plans between neighboring countries • Design clear, coordinated integration strategies within national plans; include benchmarks for planning which strategies to implement, where, and when • Revise plans based on lessons learned from 2009 pandemic • Complete a literature review on communication experiences and functionality of response plans during the 2009 pandemic • Conduct qualitative case studies into factors for implementation of travel restrictions • Test tools for data sharing and integrated data management
IMPACT ANALYSIS	**Improve evidence for the effectiveness of PHM both individually and in combination**	• Convene research agenda, define a set of outcomes variables to use in future impact studies; focus on improving comparability of outcomes; streamline and disseminate recommendations widely • Measure the window of effectiveness for individual PHM in a pandemic setting • Measure effectiveness at different level of response (within national, sub-national, city, and household samples) • Determine the impact of targeting high risk groups; assess potential for increased benefit amongst specific populations (i.e. socially disadvantaged and minorities) • Evaluate impact of measures in rural vs. urban areas • Evaluate age specific effectiveness and compliance with interventions • Measurements impact within concurrent interventions • Measure societal costs, such as parent work time loss, economic loss, and academic disruption

METHODS FOR DISCOVERY	**Reducing bias and confounding of impact estimates; build evidence base; improve the generalizability of results**	• Increase sample sizes in RCT and cohort studies • When appropriate, consider the use control groups (or control countries) to compare measures • Conduct time series studies; determine thresholds in the epidemic where PHM are most critical and when they loose efficacy • Improve statistical methods for reducing confounding; report results of sensitivity analysis; discuss confounders in detail in publications • Update mathematical models based on 2009 evidence

Limitations

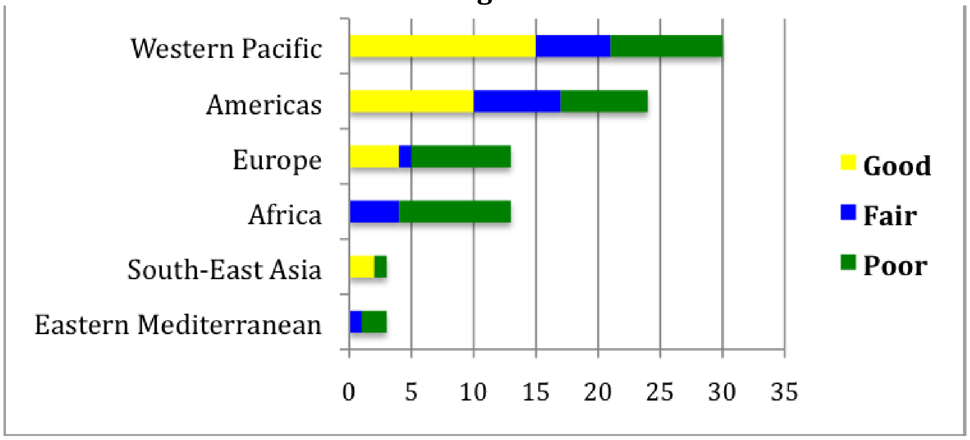
While the literature search retrieved plenty of antidotal and expert opinions on PHM implemented during the influenza A (H1N1) pandemic, there was negligible quantitative evidence of the decision tools, triggers, and effectiveness of each strategy. 30 articles were of good quality, 13 of fair quality, and 23 of the articles evaluated of poor quality. Additionaly, a single reviewer abstracted data from all papers. Most reports summarized the status of the situation in general terms but provided truncated descriptions of each PHM. This was mostly likely due to the timing of publication earlier in the pandemic and the felt urgency to report upon the present experience, albeit the quality of data available was insufficient. Also, most of the institutions, organizations, and even governments involved in implementing PHM were overwhelmed by the response demands, leaving little time for formal reporting or systematic documentation and or implementing an experimental research study. Such realities made it essential for the review to include informal reports and press releases whenever possible.

Most likely, far more experiences were measured than what exists in the published literature. Without such data, this review provides only a partial framework for discussion; it is clearly incomplete in terms of the frequencies of implemented measures and the ratio of successful verses unsuccessful outcomes.

Geographic Bias

The review is geographically biased towards Australia (n=11), the United States of America (n=10), China (n=5), Singapore (n=4), and the United Kingdom (n=3). Evidence is not available or sparse for three out of the six WHO regions (Africa, Eastern Mediterranean, and South East Asia) limiting cross-regional generalizability of review findings (Figure 6).

Figure 6. Regional distribution and quality of published articles reflecting inherent bias in literature review findings.



Limited Time Frame

The review only includes articles published within a 12-month time period following introduction of the virus (25 April 2009 – 30 April 2010). Given the time required for data analysis, writing, academic peer-review, and publication often takes more than a year to complete, the highest quality evidence is expected to be forthcoming. Thus, results present only a narrow sample of the full quantity of evidence anticipated to emerge from the pandemic. The review will require updating as further articles are published.

Strength of Evidence

A consistent finding across the published literature on the H1N1 experience was the strikingly poor quality of outcomes measured. Heterogeneous indicators and failing to control for potential and known confounders (i.e. concurrent measures, level of implementation, context) leaves room for speculation. Compliance was another major issues not addressed in the studies. Previous literature on hand washing/hygiene communication and self-quarantine suggest protective behaviors are adapted at varying levels across different populations. Compliance to such tasks, if mentioned, were qualitative in nature: no quantitative adjustments were made for variations in compliance.

Generalizability of Evidence

The authors very rarely generalized their own findings. The lack of mention of generalizability limits the extent one can justify using this evidence beyond its original context. This highlights the fact that it is difficult to generalize PHM, given the diversity of populations (socio-economic), belief systems, geographical spread, resource availability, policies, and general understanding of principles, to mention a few.

Completeness of Evidence

The lack of good quality observational studies is evident. The capacity of national research centers to respond quickly to the pandemic and to conduct PHM studies to inform future planning needs to be enhances. Overall it appears the practical and programmatic demands overshadowed PHM research activities during the height of the 2009 pandemic, with only a small body of good quality evidence available as of 10 August 2010.

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Appendix

Appendix 1: Observational Study Data Quality Assessment Form

Author:_________________________ **Year:** ________
Title: ______________________________________
Journal: _____________________________________
Study Method:__________________________________

	Excellent Good/Yes	**Fair/ Poor**	**Very Poor/No**	
I. Public Health Measure(s) Description				
Measures are fully described?				
Justifications for measures are described?				
II. Strategy for Implementing Measure				
Objectives of measure(s) clearly defined?				
Methods used to determine how/when measure(s) were implemented included?				
Description of procedures (legal or other) used to apply measure(s) included?				
IV Method & Results: Sampling & Analysis				
Description of Target Population?				
Measure(s) were evaluated?				
Statistical methods for analyzing effect of measure(s) appropriate and sufficient given nature of data				
Outcome/outputs are clearly defined?				
Outcome variables are reliable measures of the outcome of interest?				
V. Discussion/Conclusion Sections: Confounders & Comparisons				
Confounders are Identified				
Confounders are considered in how they affect results				
Study Timeframe is defined				
Sufficient timeframe for measuring impact of intervention				
Limitations of strategy identified				
Results were compared with similar studies				
Total:				

Appendix 2: Expert Opinion Data Quality Assessment Form

Author:____________________________________ **Year:** __________

Title: ____

Journal: ____

Study Method: ____

	Excellent/Good/Yes	**Fair/Poor**	**Very Poor/No**	
I. Public Health Measure(s) Description				
Measures are fully described?				
Justifications for measures are described?				
II. Strategy for Implementing Measure				
Objectives of measure(s) clearly defined?				
Methods used to determine how/when measure(s) were implemented included?				
Description of procedures (legal or other) used to apply measure(s) included?				
IV Method & Results: Sampling & Analysis				
Description of Target Population?				
Measure(s) were evaluated?				
Statistical methods for analyzing effect of measure(s) appropriate and sufficient given nature of data				
Outcome/outputs are clearly defined?				
Outcome variables are reliable measures of the outcome of interest?				
V. Discussion/Conclusion Sections: Confounders & Comparisons				
Confounders are Identified				
Confounders are considered in how they affect results				
Study Timeframe is defined				
Sufficient timeframe for measuring impact of intervention				
Limitations of strategy identified				
Results were compared with similar studies				
Total:				

Appendix 3: Gray Literature Data Quality Assessment Form

Citation Information

Author:______________________________ **Publication Date:** ___________

Title: ____

Source: __________________________ **Date Accessed:** _________________

Study Method: __________________ **Publication Type:** __________________

	Excellent/Good/Yes	Fair/ Poor	Very Poor/No	
I. Public Health Measure(s) Description				
Measures are fully described?				
Justifications for measures are described?				
II. Strategy for Implementing Measure				
Objectives of measure(s) clearly defined?				
Methods used to determine how/when measure(s) were implemented included?				
Description of procedures (legal or other) used to apply measure(s) included?				
IV Method & Results: Sampling & Analysis				
Description of Target Population?				
Measure(s) were evaluated?				
Outcome variables are reliable measures of the outcome of interest?				
V. Discussion/Conclusions				
Study Timeframe is defined				
Sufficient timeframe for describing impact of intervention				
Limitations of strategy identified				
Results or implementation experiences were compared with similar studies				
Total:				

Grade: /24

Appendix 4: Qualitative Rating Categories for Strength of Evidence

Possible Limitations

1. Methods:

No measurement of intervention
Inadequate measurement of intervention
Partial measurement of intervention

2.1 Sample:

Unknown study sample/Unclear study sample
Population inadequately defined

2.2 Sources of Bias:

Unknown measurement bias/confounding
Unknown confounding (concurrent measures and level of implementation)
Unknown confounding (unclear the interaction btw the two measures)
Present confounding (existence of concurrent interventions)
Present confounding (questionable adherence to interventions)
Inadequate precision of the results
Latent period not considered/measured
Partial follow-up
Inadequate follow-up

Appendix 5: Qualitative Rating Categories for Generalizability

Possible Limitations

1. Context:

Inadequate description of the measure/context
Partial description of the measure/context

2. Parameters for implementation:

Inadequate description of parameters used in determining how measure implemented and/or terminated
Partial description of parameters used in determining how measure implemented and/or terminated

3. Authors Considerations:

No consideration for generalizability
Inadequate authors' consideration for generalizability
Partial authors' consideration for generalizability

Appendix 6: Data Abstraction Fields

Data Abstraction Fields	
Background	**Implementation Processes**
Author Title Publication Type (Peer/Gray) Study Methodology Publication Category WHO Region Country Measure Category DQA Score Article Quality	Parameters in Determining Implementation Target Population Involved Institutions M&E Tools M&E Analysis
Measures Description Measure 1 Measure 2 Measure 3 Proactive/Reactive Responsible Authority Date of Implementation Duration of Implementation Measure Objective Implementation Triggered Termination Trigger Legal Provision (if any) Procedures (if any)	**Outcomes** Outcome(s) Measures (Y/N) Outcome Indicators Results Measure Successful (Y/N)

Appendix 7: Annotated Appendix of Literature

1. School Closures

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: Measure triggered by multiple H1N1 infections confirmed at schools • Osaka Governor closed all 270 high schools and 526 junior high schools in Prefecture. • National radio/television campaign recommend facemasks and hand washing, and for parents of infected children to stay home for seven days. No subsequent reports of school outbreaks occurred after 1 week closure and schools re-opened.	41	18 May – 24 May 2009 (7 days)	Japan Osaka Perfecture Governor of Osaka Perfecture	The number of newly reported cases declined from 30 cases on 17 May to none by 25 May, after one week of school closure. Authors believe school closure measure effective in controlling virus transmission.	**Good** Case Study *Partial follow-up* *Unmeasured bias/confounding*	*Inadequate description of parameters used in determining how measure implemented and terminated* *Inadequate authors' consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive • Hand washing education was provided to preschool children, parents, and teachers; workshops were convened to demonstrate impact of measure on infection rates • Children were screened daily before entering school by measurement of temperature and inquiry of any ILI symptoms • The school's absenteeism policy was enforced	42	1 May – 31 July 2009 (31 days)	Thailand Pratumthani	Reported cases were verified using RT-PCR test. The intervention group experienced 7.1 cases per 1000 children-days while the control group had 14.9 cases per 1000-children days. (Rate ratio, 2.4; 95% confidence interval, 1.14–5.77; p .04). Author suggests simple preventative measures such as hand washing and enforced absenteeism policies could effectively stymie transmission without the need for school closures.	**Good** Case-Control Unmeasured confounding (concurrent interventions and various levels of implementatio n) Inadequate precision of the results Latent period not measured	Inadequate description of community context Inadequate description of parameters used in determining how measure implemented and terminated Partial authors' consideration for generalizability
Reactive: measure triggered by spike in absenteeism due to ILI and subsequent confirmation of H1N1 virus in 1 student A Pennsylvania primary school serving kindergarten – 4th grade closed for 1 week	43	Mid May 2009 (7 days)	United States of America Pennsylvania Pennsylvania Department of Health	Among the 214 school households responding to the survey, 77% of the all student-days (number of students at each type of venue multiplied by the number of days spent there) were spent at home. However, Sixty-nine percent of students visited other venues at least once during the school closure. Among household caregivers, 79% reported zero missed workdays; Yet of the remaining households in which work was missed, ≈40% missed work during all 5 days of school closure. Logistic regression and the corresponding adjusted ORs showed household's with income greater than or equal to median were significantly more likely to miss any workday ($p<0.05$).	**Good** Cross Sectional No impact measurement of intervention Inadequate precision of results	Inadequate description of parameters used in determining how measure terminated Partial authors' consideration for generalizability

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: measures triggered by first confirmed local H1N1 case All kindergarten and primary schools were closed for 1 month; secondary schools with ≥ 1 confirmed case were closed for 14 days. Containment phase policies, namely hospital isolation of all confirmed cases were maintained until 27 June. Contacts of cases were quarantined and provided prophylaxis. Measure terminated by start of summer vacation 10 July 2009	53	10 June – 10 July 2009 (30 days)	China Hong Kong Special Administrative Region Hong Kong Government	Data from confirmed H1N1 cases collected by the Hong Kong Hospital Authority and Centre for Health Protection (e-fl u database) was used to estimate the effect of school closures. Prior to school closure, the reproductive number was 1.7 for children <13 years of age. The reproductive number was 1.5 between 11 June and 10 July and 1.1 for the rest of the summer. Study results estimate a "70% reduction in intra–age-group transmission concurrent with school closures." Identified cases declined to 5.2% of the initial rate by the middle of the school closure period. Author suggests school closures could be effective in reducing transmission of H1N1	**Good** Cohort Unknown measurement bias/confounding	Partial description of parameters used in determining how measure implemented and terminated Partial authors' consideration for generalizability
Reactive: in response to first reported case in Province Initially, schools where cases had been detected closed on 13 June (Ushuaia) and 19 June (Rio Grande). On 1 July all 161 schools in both cities were closed for five weeks. Voluntary isolation of suspected cases was encouraged	44	1 July 2009 (35 days)	Argentina Tierra del Fuego Ministry of Health - Tierra del Fuego	The incidence of ILI before and after the school closings was measured as a proxy for school closure effectiveness. Prior to school closure, 6,901 cases of ILI and 281 confirmed H1N1 cases had been detected. Two weeks following closure there were nearly 10 times fewer cases. Study results indicate that school closure resulted in a significantly lower incidence of ILI.	**Good** Cohort Present confounding (existence of concurrent interventions) Partial follow-up	Inadequate description of parameters used to determining how measure terminated Inadequate authors' consideration for generalizability

Public Health Measure(s)	Ref.	Time Period	**CONTEXT** *Country Location Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured Potential Impact*	**Strength of evidence** *Type of study Major limitations*	**Generalizability** *Major limitations*
Reactive: measure triggered in response to a school outbreak Schools of two schools associated with the outbreak were closed for five days. The City Council of Paris canceled a school party planned for Saturday 20 June and a meeting for parents was held that day at the school. Upon re-opening the following week, local health authorities were present to answer parents' questions.	45	22 -29 June 2009 (7days)	France Paris City Council, Paris	No evaluation of measure effectiveness reported.	**Fair** Case Study No measure of intervention	Partial description of parameters used in determining how measure terminated No consideration for generalizability
Reactive: closure triggered when on-site school nurses reported spike in the number of students with an influenza-like illness (ILI). The Department of Education and Mayor made all final closure decisions. 54 public schools and 6 private and/or charter schools were closed for no more than five days. 33,000 students were affected.	46	Spring 2009 (5 days)	United States of America New York City Department of Health and Mental Hygiene Department of Education New York City Mayor .	No evaluation of measure effectiveness reported.	**Fair** Expert Opinion No measure of intervention	No consideration for generalizability

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country Location Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured Potential Impact*	**Strength of evidence** *Type of study Major limitations*	**Generalizability** *Major limitations*
Reactive 1 week school closure 2 days following detection of a confirmed H1N1 cases	47	15 June – 20 June 2009 (7 days)	France Toulouse, South Western France Secondary school administration	No secondary confirmed cases were observed after school closure. Authors conclude isolation of school closure effective in limiting transmission within the school community.	**Poor** Cohort Inadequate measurement of intervention Unknown measurement bias/confounding	Inadequate description of parameters used in determining how measure implemented and terminated Inadequate consideration for generalizability
Proactive: To prevent and control viral spread. Twenty Boston, Massachusetts (USA) schools were temporarily closed and those schools remaining open asked students with ILI to stay home for 7 days. City residents were asked to practice good hand hygiene; Boston Medical Center Pediatric Emergency Department opened a second triage room to accommodate increased caseload and improve isolation of ILI patients.	24	1 April – June 2009	United States of America Boston, Massachusetts	The weekly volume of patients increased significantly for a 7-week period during the H1N1 pandemic, peaking at 865 patients. Many concerned parents arrived in the PED because they feared their child had been exposed, and others requested clearance to return their child to school because they could not afford the economic impact of the 7-day work/school absence.	**Fair** Case Study No measurement of intervention Poor follow-up	Inadequate description of parameters used in determining how measure implemented and terminated Partial authors' consideration for generalizability

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: Measure triggered over outbreak of H1N1 cases in seven Baghdad schools. Over 2,500 Iraq schools closed. Infected persons were quarantined and the school sterilized.	48	21-22 October 2009 (5-10 days)	Iraq Baghdad, Kut, Thi Qar Ministry of Health Ministry of Education	According to the Minster of Health, schools were to close only if a teacher and 2-3 students had influenza. Seven Baghdad schools with confirmed outbreaks were authorization for closure. Out of exaggerated media attention and panic ~950 in Kut and 1,477 Thi Qar schools subsequently closed for 5 and 10 day periods respectively. Minister of Education, Al-Khuzaie, hypothesized overcrowding in schools served as an increase risk factor.	**Poor** Expert Opinion (News Article) *No measurement of intervention*	*Partial description of specific measures, context, and parameters used in determining implemented and termination.* *No authors' consideration for generalizability.*
All schools and kindergartens were ordered to close for three weeks. A public awareness was also launched across the country.	55	Date Not Specified (21 days)	Afghanistan National Authorities	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (News Article) *No measurement of intervention*	*Partial description of specific measures, context, and parameters used in determining implemented and termination.* *No authors' consideration for generalizability.*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: sparked by laboratory confirmation of 3 H1N1 cases at school. Report also cites multiple schools across Accra as previously “hit by the swine flu.” Initially doctors were brought in to education and treat students on H1N1. Following close monitoring and external criticism Achimota Basic school was closed for 2 weeks.	51	(14 days)	Ghana Achimota Basic School Director of Basic Education at the Ministry of Health	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (News Article) *No Measurement of intervention*	*No consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: two out of five suspected cases at Ayipe Primary and D/L school were tested positive for H1N1. Ten out of eleven cases from Mfantsipim Senior had also tested positive. Two week school closure at Ayipe. Mfantsipim remained open with limited visitation.	50	April 2010 (14 days)	Ghana Ayipe Primary and D/L School Asikuma-Odoben-Brakwa District Central Region, Accra Regional Health Directorate; Ghana Health Service; Director of Basic Education at Ministry of Health	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (News Article) *No Measurement of intervention*	*No consideration for generalizability*
Reactive: measures taken following outbreaks in individual schools. Numerous Accra schools closed. Specifically, student at Mfantsipim school underwent screening and the junior high school was closed for 2 weeks.	49	(14 days)	Ghana Accra schools Ghana Health Service	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (News Article) *No Measurement of intervention*	*No consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: primary school outbreak of flu struck 35 students, with one needing hospital treatment. One week school closure. School staff were educated on control of infection and the school was put under medical surveillance.	52	Week of 17 March 2010 (7 days)	People's Republic of China Wan Chai Health Department	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (News Article) *No Measurement of intervention*	*No consideration for generalizability*

2. Mass Gatherings

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Measures triggered in preparation for events. National surveillance was scaled up to report confirmed cases each day. 1 month prior to event, the Serbian National Working Group on Pandemic Planning issued criteria for cancelation of the Universiade gathering: "1% of the attending population was diagnosed with influenza A(H1N1)v, a case of acute respiratory distress, or a there was death in a confirmed case." Preventative measures taken prior or during the events included: • Posters with information on symptoms and phone numbers of where to seek help at airports • Use of mass media to communicate where to seek medical help • 24/7 mobile epidemiology teams available to respond to queries re: suspected cases and triage persons to be tested • Isolation of ILI patients at medical facilities until confirmed test results	70	1 July – 12 July (12 days) 2009	Serbia • EXIT music festival • 25th Universiade (international sporting event for young university athletes; 53 sites in 9 locations) • Events totaled > 700,000 people Serbian National Institute of Public Health Serbian Ministry of Health	62 confirmed cases and 32 probable cases associated with EXIT event 6 confirmed cases and 22 suspected cases associated with Universiade event	**Poor** Cohort *Inadequate measurement of intervention* *Unknown study sample/* *Population inadequately defined* *Poor follow-up*	*Partial description of parameters used in determining how measure implemented and terminated* *Inadequate authors' consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: Measures triggered after detection of 12 confirmed H1N1 case at a large rock music festival in Belgium Mass media (press, internet, TV, radio) publicized the detected H1N1 cases at the event and advised festival participants to contact a physician if fever or respiratory symptoms appeared. A similar message was posted on the festival website.	67	2-5 July (4 days) 2009	Belgium "Rock Werchter" festival, Werchter	No formal evaluation of measures conducted. Authors speculate that communication measures quickly raised public awareness and slowed outbreak spread. After the information on the first case linked to the festival was published, subsequent cases were identified and treatment sought.	**Poor** Cohort *No measurement of intervention*	*Inadequate description of parameters used in determining how measure implemented* *Inadequate consideration for generalizability*
Reactive: H1N1(2009) outbreak at Achimota College, planned host of National Cricket Tour and home of the majority of Ghana national team players Cancelation of National Vanguard Cricket Tour	66	28 March 2010	Ghana, Nigeria Chairman of the Ghana Cricket Association	No evaluation of measure effectiveness reported.	**Poor** **Expert Opinion (News Article)** ***No Measurement of intervention***	*No consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Measures triggered from strong concern from international public health agencies. Thermal screening equipment was used to detect febrile passengers in Saudi Arabian airport terminals receiving pilgrims; Airports designated space for triage of ILI symptomatic travellers and provided treatment as necessary. Private organizations in Saudi Arabia donated personal hygiene kits for each arriving pilgrim which contained facemasks, hand sanitizers, and educational information. The Saudi Arabian Ministry of Health promoted cough etiquette and hand washing. Measures Terminated at the end of Hajj.	69	Non Specified	Saudi Arabia Ministry of Health Ministry of Civil Defence	Only 26 cases of H1N1 were confirmed during the period of Hajj, which did not indicate an upsurge from what was expected among more the > 2 million Hajj attendees.	**Fair** Expert Opinion *No measurement of intervention* *Population inadequately defined* *Inadequate follow-up*	*Partial description of parameters used in determining how measure implemented and terminated* *No consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: First case of H1N1 in Senegal corresponded to time the small town (40,000 inhabitants) of Tivaouane was to host a mass gathering of two million pilgrims for a religious festival. Health prevention messages and hygiene kits distributed during gathering.	68	Not Listed	Tivaoune, Senegal	Author stated outcome: "Our success in this campaign also increased our credibility among community partners. When we talk about preparedness with the government, they now listen because it costs less to prepare than to respond without any preparation in place. The main challenge for us now is how to maintain this level of preparedness on a consistent basis."	**Fair** Expert Opinion *No measurement of intervention* *Population inadequately defined* *Inadequate follow-up*	*Partial description of parameters used in determining how measure implemented and terminated* *No consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: Measures triggered after detection of 12 confirmed H1N1 case at a large rock music festival in Belgium Mass media (press, internet, TV, radio) publicized the detected H1N1 cases at the event and advised festival participants to contact a physician if fever or respiratory symptoms appeared. A similar message was posted on the festival website.	67	2-5 July (4 days) 2009	Belgium "Rock Werchter" festival, Werchter	No formal evaluation of measures conducted. Authors speculate that communication measures quickly raised public awareness and slowed outbreak spread. After the information on the first case linked to the festival was published, subsequent cases were identified and treatment sought.	**Poor** Cohort *No measurement of intervention*	*Inadequate description of parameters used in determining how measure implemented* *Inadequate consideration for generalizability*
Reactive: H1N1(2009) outbreak at Achimota College, planned host of National Cricket Tour and home of the majority of Ghana national team players Cancelation of National Vanguard Cricket Tour	66	28 March 2010	Ghana, Nigeria Chairman of the Ghana Cricket Association	No evaluation of measure effectiveness reported.	**Poor** **Expert Opinion (News Article)** ***No Measurement of intervention***	*No consideration for generalizability*

3. Travel and Trade

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Measures triggered in response to WHO pandemic alert level 5 Four broad entry screening measures were systematically reviewed and evaluated: 1) Checks of temperature prior to dismemberment of aircrafts 2) Health declaration forms filled out and collected from all travellers 3) Airport alert staff observed travellers for influenza symptoms (i.e. cough) 4) Thermal scanners were used to detect elevated body temperatures in travellers	77	13 July – 22 August 2009 (40 days)	Global Airport Travellers arriving in 35 countries with >100 confirmed H1N1 cases.	The time frame between first confirmed imported and local case was used to indicate entry screening effectiveness. Implementation of any of the four tools, either alone or in combination, compared with countries not initiating entry screenings, resulted in 7-12 additional days delay in local transmission. However, a lower 95% confidence bound of no delay and upper bound of 20-30 day additional delays suggests entry screening does not cause significant delays in local transmission. The authors comment that at best, entry screen serves only to prevent local spread for a short period of time.	**Good** Meta-Analysis *Present Confounding (variations in interpretation of first cases, inaccurate information from internet search)* *Unknown confounding (concurrent measures, size of regional epidemics)*	*Inadequate authors' consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Measures triggered based on international evidence of air travel was increasingly becoming a major transmission route of • Airport thermal scanners • Health advisors at airport symptomatic travellers encouraged with influenza-like symptoms • Ambulance were assigned to transport suspected cases to hospitals • Infected case-patients and exposed persons were isolated Measures terminated 27 June after surveillance sustained community spread of disease	75	27 April – 27 June 2009 (61 days)	Singapore Singapore National Government Tan Tock Seng Hospital (TTSH)	During implementation of measure, 116 of the 152 patients with confirmed H1N1 fulfilled criteria for having an imported case. Doctors at Singapore's Changi International Airport referred 15 (12.9%) of the 116 patients to the hospital for isolation; thermal scanners detected fever in 14 of these patients. Of the 101 cases not detected during entry screening, "51 (44%) self-reported to the screening center at TTSH and 50 (43%) were referred by doctors in the community." Thermal scanners are limited in that a traveller must be symptomatic with a high enough fever for detection in order to identify suspect cases. Author's recommend considering scanners as a short-term measure for slowing the outbreak curve.	**Good** *Cohort* *Measurement bias (using reported cases from only one Singapore hospital)* *Latent period not considered*	*Inadequate authors' consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Measures triggered by release of national guidelines for H1N1 responses. Thermal scanners were installed in all airports to detect fevers and health questionnaires were administered to travellers. All asymptomatic contacts with suspected and confirmed H1N1 were quarantined for 7 days. Ambulances were made available to transport suspected cases from airports to hospitals for isolation until PCR test confirmation. After evidence of increased influenza cases, Shanghi lifted isolation policy on 1 August, 2009.	78	24 May – 31 July 2009 (67 days)	China Shanghi Shanghai Bureau of Health , Shanghai airports, Shanghai Center for Disease Control and Prevention, Shanghai Public Health Clinical Center	230 (97.0%) of the 237 H1N1 cases indentified in Shanghi were from imported (i.e. confirmed case in person who had recently travelled outside mainland China and had onset of illness within 7 days after arrival). Of 230 imported cases, detection of 124 (53.9%) occurred in airports during the screen period. The authors postulate the Shanghi public health measures identified a significant number of cases, increased early detection, and helped contain the pandemic.	**Fair** Cohort *Inadequate measurement of intervention* *Inadequate follow-up* *Unknown measurement bias/confounding* *Inadequate precision of results*	*Inadequate authors' consideration for generalizability*

Public Health Measure(s)	Ref.	Time Period	**CONTEXT** *Country Location Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured Potential Impact*	**Strength of evidence** *Type of study Major limitations*	**Generalizability** *Major limitations*
Proactive: Measures in response to WHO alert. All incoming travellers were required to declare the presence of ILI symptoms or contact with symptomatic person(s). All contacts of positive persons contacts were traced. Public messages for self-quarantine and reduction of droplet spread were also used. National Pandemic Plan terminology, including "Delay," "Contain," and "Protect," were incorporated into public messaging.	79	25 April - June 2009 (apx. 35 days)	Australia Government of Australia	Author's speculate that border control measures provided public health agencies time to assess the natural history and epidemiology of the new virus before it became widespread. Absenteeism rates from work and school were similar to those seen in 2007, Australia's worst influenza season. The Australian health system was stressed, there was spare capacity of ECMO equipment, hospital beds, and ICU beds.	**Fair** Narrative Review *Inadequate measurement of intervention* *Inadequate precision of results* *Inadequate follow up*	*Inadequate description of measure/context* *Inadequate authors' consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities* *Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: Measures implemented after first cases of local transmission reported and subsequent school outbreak in Kobe/Osaka. • Scientists were ordered not to travel to Canada, Mexico, or the US • Mass gatherings, school trips, and two international scientific meetings scheduled for 22-24 May were canceled • Quarantine personnel entered planes, checked all passengers' health status, and performed influenza A tests among suspected cases • Quarantine of all suspected cases arriving from Canada, Mexico, and the USA	71	May 2009 onward (end time not specified)	Japan	Only four H1N1 positive cases were detected at the airport by 11 May. 214 additional quarantine health personnel were employed. 1,598 school trips and 403 international trips were canceled, resulting in 360,000 hotel room cancelations and a $45 million USD economic loss. Authors suggested exhaustive public media coverage and the religious notion of "shimaguni konjo" contributed to heightened fear and preference for airport quarantine.	**Fair** Expert Opinion *Inadequate measurement of intervention* *Unknown confounding* *Unknown follow-up*	*Inadequate authors' consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities* *Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive **China**: thermal screening at airports **Viet Nam**: thermal screening at airports	80	May – August 2009 (apx. 92days)	China, Viet Nam, Thailand Chinese Centre for Disease Control and Prevention National Institute of Hygiene and Epidemiology, Ministry of Public Health, Thailand	**China**: 49 million screened, 16, 328 febrile, and 698 confirmed H1N1 cases were detected. Hong Kong faced difficulties managing and storing the 300,000 health declaration forms received daily from entering travellers. **Viet Nam**: 1,793,460 travellers passed through national borders (mid April -mid August), 1301 suspected H1N1 cases detected, and 182 cases confirmed. **Thailand**: recommended against thermal screening citing the public's ability to cheat the system as a major hindrance of measures effectiveness.	**Poor** Expert Opinion *Inadequate measurement of intervention* *Unknown confounding* *Unknown follow-up*	*Inadequate description of measure/context* *Inadequate description of parameters used in determining how measure implemented* *Inadequate consideration for generalizability*
Reactive: Measures specified in New Zealand's Influenza Pandemic Action Plan were activated after a group of school children with symptoms of influenza returned from Mexico on 25 April. • Isolation/Quarantine of all symptomatic international travellers and their immediate contacts • Clearly identifiable public health staff stationed at all international airports	72	30 April 2009 End time not specified	New Zealand	No formal evaluation of measure effectiveness reported. Authors speculated that isolation measures at borders seemed to contain community transmission through May and into June.	**Poor** Expert Opinion *No measurement of intervention*	*Inadequate description of measures and parameters of termination* *Inadequate authors' considerations for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities* *Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: measures triggered by increase in ILI cases reporting to medical unit At Port: One ILI patient put on sick leave and sent off ship to local New York hospital for isolation At Sea: Isolation of all suspected cases in medical and ICU units. No visitors were allowed in ward.	74	20 May -13 June 2009 (24 days)	United States of America New York City US Navy VA New York Harbor Healthcare System	While in port 1 ILI case from the USS Roosevelt was sent to a local New York city hospital and placed into isolation. 2 ILI cases from the USS Iwo Jima were sent to a nongovernment hospital and allowed to return back to the ship. Subsequently and outbreak of 135 new ILI cases occurred on the USS Iwo Jima. Authors hypothesize that the practice of immediate isolation could have prevented an outbreak on the USS Roosevelt. The absolute end of the USS Iwo Jima coincided with the ability to get personnel off the ships for sick leave	**Poor** Case Study *Inadequate measurement of intervention* *Measurement bias* *Unknown confounding* *Latent period inadequately considered*	*Inadequate description parameters of measure implementation* *Inadequate authors' considerations for generalizability*
Proactive • Quarantine Officers assessed ill travelers at airports and provide advice and direction when treatment was required • A travel health advisory was issued, informing Canadians of recommended precautions to take when travelling outside of North America. Information was distributed at airports and border crossings.	83	Not Listed	Canada Government of Canada	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (New Article) *No measurement of intervention*	*Inadequate description of measure, context, parameters for implementation or termination* *No consideration of generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: Measures triggered in response to Ukraine influenza outbreak and subsequent deaths. **Slovakia:** closed two of its five border crossings with Ukraine to control spread of infection. **Russia Federation:** examined all travelers crossing the border from Ukraine and quarantine those with severe ILI symptoms. **Ukraine:** schools and universities across the country closed. People were urged to "travel only when necessary and stay away from public places." Cafes, cinemas and theaters were closed in Lviv. Patients arriving at the emergency ward of the Lviv central hospital were quarantined.	73	Week of 3 November 2009 (7 Days)	Russia Federation, Slovakia, Ukraine	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (New Article) *No measurement of intervention*	*Partial description of measure, context, and parameters used in determining implementation and termination*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Zambia: Doctors and epidemiologists were placed at border check-points and international airports. Uganda: examination of reported H1N1 cases at airports and border posts Ethiopia: examination center and quarantine unit at main international	84	Not Listed	Zambia, Uganda, Ethiopia Ministry of Health	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (New Article) *No measurement of intervention*	*Inadequate description of measure, context, parameters for implementation or termination* *No consideration of generalizability*
Proactive • Surveillance desk established at international airport • Arriving travelers filled out surveillance cards • Isolation facilities set up at Entebee hospital • Mass media messages to sensitize public on H1N1	86	Not Listed	Uganda Entebbee Uganda Ministry of Health, in partnership with WHO, AFNET	No formal evaluation of measure effectiveness reported. Author speculates Measures "prevented public panic in the country"	**Poor** Expert Opinion (New Article) *No measurement of intervention*	

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: initiated based on global reports of outbreaks Staff at immigration ports and Kotoka International Airport were staffed with surveillance personal and information desks to educate travelers. Ill passengers arriving at airport were immediately transported to military hospital for treatment. Isolation wards were established at regional hospitals. Press releases and media campaigns communicated health education to the public	86	May 2009 onward	Ghana Ghana Health Services	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (New Article) *No measurement of intervention*	*Inadequate description of measure, context, parameters for implementation or termination* *No consideration of generalizability*
Health declaration form for travellers arriving from or had disembarked at infected areas with influenza A (H1N1). For symptomatic or exposed persons three possible actions are listed: • Allowed to proceed • Put under surveillance • Put under isolation	85	Not Listed	Tanzania Ministry of Health and Social Welfare	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (Entry Form)	*Not Applicable*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive Victoria and Queensland schools were closed for variable time periods. Students returning back to Queensland from Victoria were requested not to return to school for 7 days.	79	Not Clear; Approximately May – June 2009 (apx. 61 days)	Global Australia Victoria Queensland Australian Government	No formal evaluation of measure effectiveness reported. The author notes “school closures and social isolation can be beneficial.” However, given H1N1 influenza had caused no deaths at time of publication, “school closures may well turn out to have been unwarranted…[and] the practice of quarantining children returning from Melbourne is probably an excessive reaction.”	**Fair** Narrative Review *No measurement of intervention*	*Inadequate description of specific measures and the local context* *Unclear description of sequence of events and parameters used in determining how measures were implemented*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country Location Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured Potential Impact*	**Strength of evidence** *Type of study Major limitations*	**Generalizability** *Major limitations*
Proactive: Triggered by WHO declaration of a public health emergency and advisement to increase influenza surveillance activities • Thermal imaging cameras were installed at airports • Information on H1N1 was disseminated by internet, posters, and leaflets at international points of entry	81	20 April – 14 June 2009 (55 days)	Greece Hellenic Centre for Disease Control and Prevention	No formal evaluation of measure effectiveness reported. Epidemiological data showed most identified cases within the first two and a half months (containment phase) emerged from travelers. Antidotal evidence from several tourist who were unwilling to delay their trip even though ill suggests media messages advising against traveling when ill were not entirely effective.	**Poor** Case Study *No systematic measure of intervention*	*Inadequate description of measure/context* *Inadequate description of parameters used in determining how measure implemented* *Inadequate consideration for generalizability*
Proactive High risk groups (chronic respiratory conditions, pregnant women, morbid obsess, indigenous, and those with predisposing cardiac disease/renal failure/diabetes/etc) were asked to consider postponing travel if they had ILI symptoms. They were also requested to seek medical advice before international travel. Hand hygiene and cough etiquette were encouraged for those who did travel.	82	Not Specified	Australia Australian Government	No focused evaluation of travel restriction recommendations. A travel consumer survey in New South Wales showed that 84% of resident's travel plans were not affected by the swine flu. However, short term visitor arrival decrease by 0.2% in April, 1.7% in May, 5.1% in June, and 1.2% in July 2009.	Poor **Narrative Review** *Inadequate measurement of intervention* *Unknown confounding* *Unknown follow-up*	*Inadequate description of context* *Inadequate description of parameters used in determining how measure implemented or terminated.* *No consideration for generalizability*

4. Individual and Societal Measures

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country Location Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured Potential Impact*	**Strength of evidence** *Type of study Major limitations*	**Generalizability** *Major limitations*
Reactive: Measures implemented following detection of a nosocomial outbreak of confirmed H1N1 cases. All symptomatic patients were isolated in a separate hospital ward until 48 hours following disappearance of symptoms. External visitors were restricted and no contact with other patients was allowed. Health care workers wore personal protective equipment.	92	October – November 2009 (61 days)	Italy Bari	An asymptomatic health care worker is suspected to be the source of the nosocomial outbreak. During the study period, the attack rate was 50% for suspected and 35% for confirmed H1N1 influenza cases.	**Good** Cohort *Inadequate measurement of intervention*	*Partial description of measures* *Inadequate description of parameters used in determining how measure terminated* *No consideration for generalizability*
Proactive • One ICU wing was designated an "isolation pod" and housed presumed and confirmed H1N1 cases. All entering persons were required to wash hands and use personal protective equipment. Patients were treated in a "reverse barrier manner." • Visitor Restrictions were in place, including no children or pregnant women.	91	Late July 2009 (unknown termination)	Australia Brisbane Senior medical & nursing staff; tertiary referral hospital	Qualitative data analysis documented the lived experiences of staff during the height of the H1N1 pandemic. Themes included: • The isolation policy created additional work, confusion, and frustration • A perceived lack of guidance on what personal protective equipment (PPE) to wear. • A general discomfort with wearing PPE for up to 12 h a day	**Good** *Phenomeno-logical*	*Partial authors' consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities* *Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Measures implemented to contain and mitigate emerging pandemic • Phase 1: all ILI patients were admitted for isolation. Close Contacts of confirmed cases were also quarantined. • Phase 2: confirmed cases were hospitalized in cohort wards Exposed hospital patients and staff underwent temperature surveillance for 7 days post-exposure. All sick workers were required to take a 7-day sick leave. Surgical masks were provided to hospital visitors and hand hygiene of staff was audited periodically during the study period. Educational forms on infection control were also provided to staff.	93	1 May – 8 August 2009 (100 days)	China, Hong Kong Special Administrative Region Queen Mary Hospital	Hospital staff regularly demonstrated compliance rates of 50 and 60% during hand hygiene audits. Nosocomial infections from hospitalised patients was two (0.43%) out of 466 exposed persons. Among hospital staff, the nosocmial infections were two (0.83%) out of 241. Absence of wearing a surgical mask by the exposed persons during contact with the index cases (4/4 vs 264/832, P ¼ 0.010) or vice versa (4/4 vs. 300/832, P ¼ 0.017, Fisher's exact test) resulted in a significant risk factor for nosocomial infection of confirmed H1N1.	**Good** Cohort *Inadequate measurement of intervention*	

Public Health Measure(s)	Ref.	Time Period	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Measures in response to the declared public health H1N1 emergency A "high-risk zone" was designated inside the department and masks, gloves, and gowns were used in the care of patients	94	28 April 2009	United States of America Florida Administrative team at Memorial Regional Hospital/Joe DiMaggio Children's Hospital	No cases of patient cross-contamination were reported; a second triage area appears to stymie the transmission of H1N1 within this hospital paediatric department	**Poor** Case-Study *Inadequate measurement of intervention* *Inadequate precision of results*	*Partial description of parameters used in determining how measure implemented* *Inadequate authors' consideration for generalizability*

Public Health Measure(s)	Ref.	Time Period	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Hospital initiated Influenza contingency plan 9 hours after government of Mexico informed public of new human flu virus. • Hand washing/hygiene was promoted through posters, public messages, and distribution of hand sanitizers • Triage outside hospital entrance screened patients • Patients in triage area asked to wash hands and ILI presenters were asked to wear face masks; waiting rooms divided into two areas • influenza leaders assigned to verify adherence and promote hygiene precautions. Surveillance data showing end of epidemic triggered termination of measures	15	Late March – 15 Sep 2009 (apx. 168 days)	Mexico Mexico City National Institute of Medical Sciences and Nutrition Tertiary Care Center	• The compliance index score for hand washing among hospital staff increased during the first 2 weeks of the outbreak from 35 to 87% compliance. • Triage at hospital entrances effectively filter patients; From April-May 2009 44,225 visitors went through the triage stations while only1503 (3.3%) reached the ER. • Five months into the epidemic, 70 hospital influenza leaders were functionary • Despite precautionary measures, four patients contracted hospital acquired influenza, 467 workers had with respiratory symptoms suggestive of influenza (16% of our staff), and 96 workers with confirmed novel influenza A (3% of our staff)" • Authors commented that the closure of day cares and schools lead to nurse absenteeism, which presented a problem to the hospital. Also adherence to hand hygiene and behavioural conditioning was recommended as a priority prevention measure in control of influenza, especially in settings where other resources are not readily available.	**Good** Case Study *Inadequate measure of intervention* *Population inadequately defined/unclear sample*	*Inadequate description of parameters used in determining how measure implemented* *Partial authors' consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive • Quarantine of patients with ILI • Establishment of flu centers to assess ILI patients • Media campaign and release of control guidelines • Website providing resources for health professionals and business (included kit for workplace management of pandemic influenza).	90	Late April 2009	Australia, New Zealand Australian Government Department of Health and Ageing.	Quarantine measures were dealt with differently across the states and individual intensive care units (ICU's). The authors felt these activities created a heavy burden on individuals and likely did not impact transmission, as the virus showed rapid dispersal only 20 days after Australia declared it quarantinable on April 28. Further, "unbalanced, sensationalist" media reports is thought to have galvanized unnecessary panic.	**Good** *Expert Opinion* *No controlled measurement of interventions*	*Inadequate description of measures* *Partial description of parameters used in determining how measure implemented* *Inadequate authors' consideration for generalizability*
Proactive Emails were sent to University staff and students containing health information of influenza transmission. Posters promoted good hand hygiene and cough/sneeze etiquette.	98	30 April – 30 September 2009 (156 days)	Australia Commonwealth Department of Health and Ageing University of New South Wales	Among 2,882 survey respondents, an overwhelming majority (75.9%, 2188/2882) had "not made any lifestyle changes", and 61.8% (1781/2882) had "not undertaken any specific health behaviors due to the pandemic." Only 20.8% (600/2882) reported purchasing hand hygiene products or face masks. Participants who had changed at least one recommended behavior were also significantly "more likely to be anxious about the pandemic" (OR, 4.27 [CI, 1.61-11.10]; p = 0.002). Overall, the authors concluded "most respondents had not made any lifestyle changes or undertaken any specific behavior change despite receiving information from the University."	**Good** Cross Sectional *Unmeasured confounding (concurrent measures and level of implementation)*	*Inadequate description of parameters used to determine how measure implemented and terminated*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country Location Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured Potential Impact*	**Strength of evidence** *Type of study Major limitations*	**Generalizability** *Major limitations*
Proactive Mass media communication campaign promoted good hand hygiene and tissue use. Advertisements were sent to every household in the country. Messages also encouraged self isolation among those returning from an affected country or those with ILI symptoms.	97	1 May – 17 May 2009 (17 days)	United Kingdom National Health Services (NHS)	Of the 5,419 survey participants, 33.1% reported carrying tissues, 9.5% bought sanitizing gel, 2.0% avoided public transport and 1.6% sought medical advice. Additional path analysis found exposure to either media announcements or advertising increased those carrying tissues and buying hand-sanitizing gel while reducing avoidance of public transportation and unnecessary use of NHS services. An overwhelming majority had “heard a lot or a moderate amount about swine flu” (4,817, 92.9%), “felt they knew a lot or a moderate amount about swine flu” (3,808, 73.6%), and “were very or fairly satisfied with the amount of information available about swine flu” (4,462, 91.0%). However, 37% of respondents still “had one or more specific pieces of information that they wanted to know.” Overall, authors conclude that both early advertising and media coverage improved recommended behaviors to prevent infection during the 2009 H1N1 influenza outbreak.	**Good** Cross Sectional *Unknown measurement bias/confounding (concurrent measures)* *No follow-up*	*Partial description of measure implementation*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: triggered by first confirmed case from a traveller returning from Mexico Metropark Hotel was immediately closed on 1 May 2009. All 350 guests and staff were quarantined until 8 May.		1 May – 8 May 2009 (7 days)	China, Hong Kong SAR Centre for Health Protection Metropark Hotel	Of the 555 survey participants, 92.4% affirmed the Metropark Hotel isolation as either necessary or absolutely necessary. Further, 98.4% would comply with quarantine measures if asked.	**Good** Cross Sectional *Inadequate measurement of intervention*	*Inadequate description parameters of measure termination*
Proactive All public health units (PHU) were order to actively find cases and begin home isolation/containment of both cases and their high risk contacts. The media assisted in promoting physician seeking for all symptomatic people.		Early May onward 2009	Australia Australian Commonwealth's Department of Health and Ageing	Two weeks after moving form the containment/isolation phase into a "Protect Phase" without enforcing isolation, the number of confirmed cases in doubled. The authors consider isolation as having successfully delayed the spread of the pandemic. **Rural success**: remote parts of Australia were spared in a large extend from H1N1 transmission. General Practitioners from country areas "were enthusiastically engaged in active case ascertainment and assisted public health authorities with the implementation of control measures. Many were reluctant to accept the relaxed measures" of non-isolation.	**Fair** Expert Opinion *Inadequate measurement of intervention* *Unknown measurement bias/confounding*	*Partial description of measures and parameters of termination* *Partial authors' considerations for generalizability*

Public Health Measure(s)	Ref.	Time Period	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Measures initiated immediately following WHO confirmation of 115 H1N1 deaths worldwide. Information on "swine flu" and preventative behaviours was sent to all households in the United Kingdom DOH increased stockpile of facemasks	101	29 April, 2009	United Kingdom Department of Health Health Protection Agency	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion	*Inadequate description of measure* *Inadequate authors' consideration for generalizability*
Proactive Isolation of suspected cases Home isolation packs with information sheets, surgical masks, antibacterial hand wash, and tissues were provided to cases. St John Ambulance assembled and delivered packs to Public Health Units for community distribution. Welfare assistance, which included food, medical assistance/supplies, financial or accommodation assistance, was also provided for some people in home quarantine.	102	27 April – 30 September 2009 (156 days)	Australia New South Wales Public Health Emergency Operations Centre New South Wales Department of Health	No formal evaluation of measure effectiveness reported. However, at the peak of measure implementation approximately 1,200 people were in isolation in New South Wales.	**Poor** Expert Opinion *No measurement of intervention*	

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country Location Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured Potential Impact*	**Strength of evidence** *Type of study Major limitations*	**Generalizability** *Major limitations*
Proactive: measure targeted the area with the highest confirmed cases One day "blitz" on H1N1: Road show through Mdantsane educated community on H1N1 signs and prevention measures. Health department staff also distributed informational leaflets and posters.	99	19 August 2009 (one day blitz)	South Africa Eastern Cape Province, Mdantsane Area Health Department	No formal evaluation of measure effectiveness reported. Press release notes the measures were well accepted by the community.	**Fair** Expert Opinion *No measurement of intervention*	*No consideration for generalizability*
Proactive: National Public Education Campaign: Department of Health Public servants will go out in the field to educate communities about H1N1. Information packets will be handed out at taxi ranks, shopping malls, and airports. Community rallies will be held at Public Schools. Print media will run advertisements and press conferences will be held.	100	19 August 2009 onward (length not specified)	South Africa All National Provinces	No evaluation of measure effectiveness reported.	**Fair** Expert Opinion *No measurement of intervention*	*Inadequate description of parameters used in determining how measures implemented and terminated*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: Measure triggered after 6 student returning from Singapore reported laboratory confirmed H1N1 On 29 May Chinese Ministry of Health required cases and contact isolation. Following the university outbreak the 6 cases and 202 contacts were quarantined with either one or two contacts in each bedroom. Disinfecting each room, wearing mask, and washing hands were also strictly enforced. Isolation terminated on 12 September when all suspected cases had no temperature of ILI symptoms.	88	31 August- 12 September 2009 (12 days)	China Northern China Ministry of Health	The attack rate among initially virus–negative contacts significantly increased when persons were quarantined in the same room or used the same bathroom as a virus-positive contact ($p = 0.02$, 2-tailed Fisher exact test). However, single room quarantine of virus negative contacts failed to significantly decrease the attack rate among virus-negative contacts in comparison with quarantining 2 persons in 1 room. Compliance to personal protection and hygiene regulations remained good.	**Good** Cohort *Inadequate precision of results due to no laboratory RT-PCR virus testing* *Unmeasured Confounding (concurrent hygiene measures and level of implementation)*	*Partial description of parameters used in determining measure termination* *Partial authors'considerations for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: Measures triggered after huge spike in confirmed weekly H1N1 cases the second week of November. (101 cases). Public messages promoted good hygiene practices and hand sanitizers were made easily available. School nurses and Army Public Health Nurses went to Department of Defense schools to provide hands on education in methods to limit viral spread.	60	November 2009	United States of America United States Forces Korea	After H1N1 infections rapidly dropped to from 1010 to 2-3 cases per week immediately following mid November vaccination. However, hand hygiene measures were concurrently initiated in response to the outbreak and authors propose such activities also contributed to a drop in cases.	**Poor** Case Study (News Article) *No accurate measurement of intervention* *Unclear study sample* *Present confounding (concurrent interventions)*	
Proactive: Measures triggered in response to H1N1 pandemic confirmed in Canada. Hygiene campaign with print media, websites, posters, and adds at points of transit was launched. The Minister of Health held daily new conferences. Water supplies were delivered to Indian communities to assist with preventative measures in homes on reserves. Daily new conferences transitioned into weekly updates when severity of outbreak deemed much milder than expected.	61	Not Specified	Canada Canadian Parliament Minister of Health Chief Public Health Officer	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion *No measurement of intervention*	

Public Health Measure(s)	Ref.	Time Period	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive People were advised to avoid face-to-face interactions. The insurance company AXA required employees to salute each other in place of a kiss or handshake. Other companies asked employees to follow a one-yard buffer zone between contacts. In Guivence, the mayor told teachers and students "not to kiss anymore."		Not Specified	France Guilvenec, Brittany City Mayor Ministry of Health	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (News Article) *No measurement of intervention*	
Proactive [Country reports to PAHO] All countries listed described hand washing education or hand washing communication as part of their media strategy during the pandemic.	105	Not Listed	Belize, Caribbean, Cuba, Costa Rica, Panama, Bolivia National Authorities Ministry of Health	No evaluation of measure effectiveness reported.	**Poor** Case Study *No measurement of intervention*	

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: H1N1 virus active in community "Fight H1N1, Stay Healthy" childhood education campaign launched in primary schools. Students taught personal hygiene, proper handwashing.	106	April 2010	Malaysia Kuala Lumpur Putrajaya Health Department	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (News Article) No measurement of intervention	Inadequate description of measure, context, parameters for implementation or termination No consideration of generalizability
Reactive: initiated after the death of a Mbulu primary school teacher due to the H1N1 virus two days after hospital admission. Quarantine of > 50 people in district hospital (dispensaries) isolation wards Heightened surveillance at border entry points coupled with transport to hospital for screening and treatment Health declaration form required for all outside entry from H1N1 infected areas Isolation wards set up in district hospitals	85	Initiated 11 October 2009 (No end date specified)	Tanzania Mbulu, Northern District Ministry of Health	No formal evaluation of measure effectiveness reported. CDC Tanzania noted that "Despite huge investments on screening of travelers at port-of-entries, it was not very effective in detecting incoming travelers"	**Poor** Expert Opinion (News Article) No measurement of intervention	Inadequate description of measure, context, parameters for implementation or termination No consideration of generalizability

5. Integrated Measures

Public Health Measure(s)	Ref.	Time Period	**CONTEXT** *Country* *Location* *Authorities* *Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: Measures initiated following the 16 May detection of H1N1 infection in 3 students of which none were epidemiologically linked to any imported cases. • > 1400 schools closed for 7 days • A major city festival and planned parade, expected to gather ~1 million people, was cancelled • Suspected and confirmed cases were isolated in the hospital according to the Japanese Infectious Diseases Control Law Measures terminated upon recognition of the mild intensity of illness on 18 May, 2009	20	11 - 18 May 2009 (7 days)	Japan Kobe City Osaka Prefecture National Institute of Infectious Diseases	As of 25 May 2009 49 laboratory confirmed cases associated with the Kobe City school outbreak were hospitalized. When schools re-opened, absenteeism did not increase through the coming weeks.	**Good** Case Study *Unclear study sample* *Present confounding (concurrent measures and level of influence)* *Partial follow-up*	*No consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Mexico: Media campaign of hygiene and social isolation practices. Cancelation of large gatherings, public facilities, restaurants, and schools. Masks were provided for bus drivers and passengers. Alcohol disinfectants were available at all public facilities; Thermal screening of international travelers . New York: A large media campaign of hygiene and social isolation practices was launched. Frequent conference calls and an electronic health alert network communicated public measured to healthcare providers. School closures were reactive and conducted on an individual basis.	14	Late March – 15 Sep 2009 (apx 167 days)	Mexico, United States of America Mexico New York City Ministry of Health State Department of Health	Overall, authors concluded "preparation paid off" in both megacities pandemic responses. Mexico: Authors concluded hygiene recommendations were followed. Closure of schools and business resulted in an estimated >2.3 billion (0.3% of GDP) loss to the Mexican economy. Laboratory capacity proved insufficient and the Ministry of Health quickly scaled up its network to now include 28 PCR molecular diagnostic sites across the country. Procedures existed to close schools but lack of reopening criteria resulted in problems. New York City: Authors depicted issues in communicating objectives and measuring cost-benefit of school closures. Also, coordination with the private sector to assist in pandemic response could be improved. Authors also note a text message campaign alerting public to pandemic prevention measures could be useful in developing countries.	**Good** Case Study *No measurement of intervention*	*Partial description of parameters used in determining how measure implemented* *Partial authors' consideration for generalizability*

Public Health Measure(s)	Ref.	Time Period	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive Containment Phase (27 April -8 July) • Thermal screening, temperature checks and health declaration cards • Temporary visas for Mexican nationals and 7-day quarantine for all travellers arriving from Mexico • Isolation of suspected and confirmed cases and close contacts • Temperature screenings at work places, school closures, and cancelation of mass gatherings • Public hygiene education campaign Gradual Phasing into… Mitigation Phase (9 July – 30 August) • Thermal scanning and mandatory isolation discontinued • Suspected cases given medical leave for self-quarantine	114	27 April – 30 August 2009 (125 days)	Singapore Homefront Crisis Ministerial Committee for Influenza Minister for Home Affairs Homefront Crisis Executive Committee H1N1	No systematic evaluation of effectiveness. In-depth interviews and focus group discussions. Authors commented that “thermal scanning was not foolproof” and reported estimates that border thermal scanning only detected about 25% of imported confirmed cases. Scanners were thought to be most effective at the airport than at land checkpoints.	**Good** Narrative Review *No formal measurement of intervention* *Unknown Confounding*	*Partial consideration for generalizability*

Public Health Measure(s)	Ref.	Time Period	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: ~ 35% of all Australian H1N1 influenza cases in the beginning pandemic phases occurred in the state of Victoria. • Paramedics were given PPE (N95 masks) and patients surgical masks; stockpiles of both were increased and employees provided with communication messages on their importance. • 7 day bans from attending school if students had just returned from travel in Victoria were instituted in some Australian states • Singapore issued a statement advising against travel to Victoria	113	20 May – early July 2009 (apx. 16-20 days)	Australia Victoria and Tasmani Department of Human Services State Minister of Health Ambulance Victoria	Only 1 paramedic among the entire company had H1N1 influenza. In Tasmani, staffing issues posed a problem due to the number of paramedics in quarantine due to infection. Employee compliance with PPE was a constant concern. The Victoria pandemic influenza plan failed to provide appropriate guidelines given the mild form of illness; the paramedic company selected the sections of the plan they felt were relevant to the situation to implement.	**Good** Expert Opinion *Inadequate Measurement of Intervention* *Unclear study sample* *Present confounding (infections originating from multiple transmission routes)*	*Inadequate description of parameters used in determining how measures terminated* *Inadequate consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive **Delay Phase (28 April – 21 May)** Passenger health declaration cards, positive pratique, and thermal scanners used at international airports to detect cases. **Contain Phase (22 May – 21 June)** If a confirmed case had attended school while infections, schools and childcare centers were closed for one week. Close contacts were quarantined for 7 days. Children were asked to stay home if they had just returned from and area with sustained transmission. Closure policy terminated when evidence confirmed the disease was not severe. **Protect Phase (22 June onward)**	58	28 April – 22 June 2009 (61 days)	Australia Queensland	780 travellers at Queensland airport were identified and screened by border nurses. 52 met the case definition and were sent for testing and follow up; four tested positive for H1N1 influenza infection. 48 schools (2.8% of all Queensland schools) and five childcare centres were closed.	**Good** Narrative Review	*Inadequate description of parameters used in determining how measures terminated* *Inadequate consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: National Pandemic Plan activated, by presidential degree, immediately following classification of novel H1N1 virus 23 April. Facemasks recommended for all public transportation riders and distributed by Mexican Army at subway stations and bus lines. Facemasks were mandatory for bus and taxi drivers; non-compliance resulted in a fine of ~$USD 150 (around 40 times minimum wage). Concurrent Measures included closures of schools, suspension of mass gatherings, and isolation of suspected and confirmed cases.	115	Study evaluated facemask measures from 27 April – 9 May 2009 (12 days)	Mexico Mexico City Mexico Federal Government	Observational data from public transportation riders and taxi/bus drivers shows mandatory mask requirements improve compliance, however the difference between mandatory and voluntary measures was not significant. From 26 -30 April the bus/taxi driver behavior did not significantly change (1% significance level) but from 1-6 May, an significant increase in facemask use was seen. Among metro passengers, females were significantly more likely (1% significance level) than men to wear facemasks. Informational interviews suggest mandatory rules were not enforced, with Mexico city police receiving bribes and threatening to seize taxis for 5 days from non-compliers. A retrospective comparison with H1N1 infection data shows the increase and decrease use of facemask mimicked the rate of infections.	**Good** Case Study *Inadequate precision of results* *Unknown measurement bias* *Non random sampling* *Unclear study population*	*Inadequate description of parameters used in determining how and when measures terminated* *Partial; consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities* *Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Argentina: school closures for most of July, furlough of high risk government employees, cancelation of flights from Mexico (before cases detected in country) **Chile:** thermal screening, recommended against non-essential travel to the USA or Mexico, required cruise ship passengers and flights to complete health questionnaires **New Zealand:** brief school closures **Australia:** school closures, thermal scanners, border screeningMeasured mostly all terminated when government transitioned from a containment to a mitigation phase.	118	1 May – 24 August 2009 (85 days)	Argentina, Australia, Chile, New Zealand, Uruguay	**Argentina**: Following Argentina's school closures there was a decrease in the incidence of ILI; When schools reopened in August indications of resurgence were detected in a few places in Buenos Aires. Economic outcomes in the form of a July 2009 press release cited ski resorts, hotels, and restaurants as losing approximately US$150 million a week during containment. However, the concurrent economic recession confounds these estimates. In some Argentinean regions up to 40% of health care workers were absent from work during the height of the outbreak.	**Good** Case Study (Report) *Partial measurement of interventions*	

Reactive • 24 April all schools closed in Mexico city • 27 April restaurants, sporting events closed • Personal hygiene messages broadcast on national TV and widely distributed via pamphlets.	61	24 April – early June 2009 (apx. 42-50 days)	Mexico Health Secretary Health Promotion Department	Mexico's health secretary delivered consist informational updates on the situation. However, limited technology for surveillance resulted in an early gross overestimation of case-fatality rates. Outcome measurements based on confirmed cases was difficult due to insufficient lab capacity. Results from Mexico's Health Promotion department survey found sneeze etiquette poor and hygiene recommendations missing teenagers.	**Fair** Expert Opinion No statistically valid measurement of intervention Inadequate follow up	*Inadequate description of measures and termination plan Partial consideration for generalizability*

Public Health Measure(s)	Ref.	Time Period	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive: Measures triggered immediately after detection of first confirmed case by Mexico labs: • Hygiene/handwashing promotion through risk Communication Program and use of face masks, gowns, and gloves. • Social distancing via closures of schools, theatres, churches, stadiums and other social gathering centers.	115	23 April – 3 December 2009 (224 days)	Mexico Mexico State Authorities Secretary of Health	No outcomes were reported. However, the outbreak and subsequent national control measures resulted in an estimated economic cost of 0.33% of Mexico's annual gross national product (GNP). The authors recommended initiating an international economic insurance fund accessible to countries after an emerging pandemic is identified to ensure countries do not hide an outbreak for concern of financial repercussions (i.e. travel avoidance).	**Fair** Expert Opinion *No measurement of intervention*	*Partial description of measures* *Partial description of parameters used in determining how measure implemented*
• School closures • Cancellation of arriving flights from affected countries such as Mexico, Canada and the USA • Refusal of docking or disembarking permits to a cruise ship with ILI cases on board • Thermal scanners and passenger questionnaires); • [In the case of Mexico] a general closure of most public spaces	119	Not Specified	Pan American Health Organization (PAHO) Countries National Government Authorities	"Although the PAHO/WHO country Representative (PWR) office often provided advice against the implementation of several interventions used by different countries, this advice and the recommendations of the national scientific advisory bodies were often overridden. [….] In summary, while countries sometimes implemented dubious interventions, often against or without PAHO/WHO technical advice, the PWR was sometimes placed in the awkward position of appearing to validate these interventions when they were announced in the presence of the PWR by the MoH." – pg. 22	**Fair** Expert Opinion (Report) *Partial measurement of interventions*	*Does not provide details on country specific measures or context*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country Location Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured Potential Impact*	**Strength of evidence** *Type of study Major limitations*	**Generalizability** *Major limitations*
Proactive Personal protective equipment (PPE) available; Surveillance hospitals established in different parts of county. A screening program was designed for incoming travellers at all major points of entry. Laboratory confirmed cases were placed in isolation wards for 5 days. Healthworkers were training in influenza surveillance and use of available resources (PPE, Tamiflu).	85	July-December 2009 (apx.184 days)	Tanzania Ministry of Health	95.3% of the 537 local Tanzanians identified as H1N1 cases had no travel history outside the country. Only 0.6% (4/649) of the total cases were identified at point-of-entries. The author concluded that despite resource-intensive investments in travel screenings, it was not effective in detecting cases. Private health clinics served as the primary detection site for foreign-born cases.	Fair Case Study (ppt)	*Partial description of parameters used in determining how measure implemented and terminated* *Inadequate authors' consideration for generalizability*
• School closures • Hospital isolation measures and staff fever clinics • Hygiene public messaging • Twice daily bulletins and situation reports through the National Incidence Room during height of pandemic	58	Not Specified	Australia Department of Health and Ageing State Health Departments	No formal evaluation of measure effectiveness reported. Authors speculated that failing to isolate passengers on board the cruise ship *Pacific Dawn*, which had confirmed H1N1 cases, contributed to virus dissemination in Victoria. Poor communications between national, state, and local authorities was also hypothesized to weaken pandemic responses. Authors noted parents were not informed of avoiding social contacts during school closures, border procedures were not uniform, and health professionals were receiving conflicting messages about working while symptomatic.	Poor Expert Opinion *No measurement of intervention Unknown confounding*	*Inadequate descriptions of measures* *Inadequate description of parameters used in determining how measures implemented and terminated* *Inadequate consideration for generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Reactive: 60 deaths due to H1N1 as of 8 July 2009 • Public and private schools closed from 8 July – 31 July, extending winter vacation • Move theatres closed for ten days • Gyms, cybercafés, and swimming pools closed in many places • Self-isolation recommended • Public employees with children < 14 allowed to take leave • Argentina congress took prolonged recess • Winter judicial recess extended two weeks	111	July 2009 (23 days)	Argentina Buenos Aires Argentina Ministry of Health	No formal evaluation of measure effectiveness reported. Antidotal information cites business at shopping centers declined by half.	**Fair** Expert Opinon (News Article) *No measurement of intervention*	*Partial description of measure, context, parameters for implementation or termination* *No consideration of generalizability*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country Location Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured Potential Impact*	**Strength of evidence** *Type of study Major limitations*	**Generalizability** *Major limitations*
Proactive **China**: Canadian and Mexican nationals quarantined; Hong Kong hotel sealed off and placed in quarantine after first case of H1N1 detected in a Mexican guest. **Singapore**: overseas travel restricted for hospital employees. Travelers returning from Mexico were quarantined for 7 days. Temperature monitoring was enforced for all students along with public hand hygiene communication campaigns.	114	28 April – 7 May 2009 (10 days)	China, Singapore	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion *No Measurement of Intervention*	*Partial descriptions of measures* *Inadequate description of parameters used in determining how measures implemented and terminated* *Inadequate consideration for generalizability*
Proactive • Full or cohort isolation of ILI cases • Staff triage to identify ILI symptoms and send home if necessary • Hand washing education drills • Behaviour conditioning on avoiding touching eyes, nose or mouth • Distribution of hand sanitizer bottles • Provision of facemasks and N95 respirators to staff	115	Not Listed	Mexico Mexico City National Institute of Medical Sciences	During the first month of the epidemic, 22 hospital workers (0.8% of the 2,900 total employees) contracted H1N1 influenza. Out of 19 specimens from hands and environmental surfaces of isolated patients taken 2-17 days after diagnosis, 10 were found to have influenza A virus and 4 confirmed H1N1. Given the environmental detection of the virus in the environment, authors conclude facemasks remain of "doubtful efficacy" and priority should be placed on hand hygiene for prevention.	**Poor** Case Study *Inadequate measure intervention* *Population inadequately defined* *Inadequate precision of results*	*Inadequate description of parameters used in determining how and when measures implemented and terminated*

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive People were screened for fever before entering its premises and facemasks were provided to each individual. Telbru staff were alerted to practice good hygiene and hand-washing. Hand sanitizer was provided to curb viral spread.	12	Not Listed	Brunei Darussalam TelBru Broadband Company	No evaluation of measure effectiveness reported.	**Poor** Expert Opinion (News Article) *No measurement of intervention*	*Inadequate description of measure, context, parameters for implementation or termination* *No consideration of generalizability*

5. Emerging Ideas

Public Health Measure(s)	**Ref.**	**Time Period**	**CONTEXT** *Country* *Location* *Authorities Responsible*	**EFFECTIVENESS** *Country Outcomes Measured* *Potential Impact*	**Strength of evidence** *Type of study* *Major limitations*	**Generalizability** *Major limitations*
Proactive Drive through emergency room influenza clinic Patient automobiles were used as an isolation compartment while waiting for clinical evaluation from healthcare providers	21	3 hour simulation (1 day)	United States of America Stanford University Medical Center, Emergency Medicine Department	Simulation results depict a drive-through influenza clinic could serve as a potential alternative to a traditional emergency department structure. Doctors identified 100% of those simulated patients who were admitted during their real ER visit in April 2009. No significant increase in carboxyhemoglobin was found in participants. The median waiting time was 26 min, which authors hypothesize could help alleviate the common delay inherent in turning over hospital rooms.	**Good** Mock Case-Study *No measure of actual intervention impact*	
Reactive: Measure in response to increased Emergency Department Patient Visits and 27 April, 2009 death of young child in hospital due to H1N1. Patients arriving to ER were screened outdoors for ILI symptoms and suspected cases sent to outdoor facility set up in adjacent parking lot. N95 respirators were available to staff and facemasks to incoming patients. "Respiratory etiquette stations" were set up and stocked with hand	25	1 -7 May 2009 (7 days)	United States of America Houston, Texas Texas Children's Hospital	The outdoor emergency department was constructed in 8 hours and took over 18% of the ED volume, which increased 50% over non-pandemic periods. Wait time in the department and total time in the department decreased. The additional operational costs were approximately $280,000 ($135,000 for supplemental staff pay and $113,000 for facility construction and additional laboratory supplies.) Overall the measure did not result in an overall savings for the decreased patient-time in the hospital.	**Good** Case Study *Unknown confounding (level of implementation)* *Inadequate follow-up time*	

sanitizer. Symptomatic staff was asked to stay home for 7 days. 3 area schools were closed.						