Review

Effectiveness of personal protective measures in reducing pandemic influenza transmission: A systematic review and meta-analysis

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ABSTRACT

The goal of this review was to examine the effectiveness of personal protective measures in preventing pandemic influenza transmission in human populations.

We collected primary studies from Medline, Embase, PubMed, Cochrane Library, CINAHL and grey literature. Where appropriate, random effects meta-analyses were conducted using inverse variance statistical calculations.

Meta-analyses suggest that regular hand hygiene provided a significant protective effect (OR = 0.62; 95% CI 0.52–0.73; $I^2 = 0\%$), and facemask use provided a non-significant protective effect (OR = 0.53; 95% CI 0.16–1.71; $I^2 = 48\%$) against 2009 pandemic influenza infection. These interventions may therefore be effective at limiting transmission during future pandemics.

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1. Introduction

Influenza pandemics may arise from antigenic shifts, when reassortment between different viral strains results in the emergence of a novel influenza virus to which most individuals are immunologically naïve (Zambon, 1999). If this new pathogen causes clinical illness in humans and is able to transmit effectively between humans, a global pandemic may occur. This has happened four times in the past one hundred years: the 1918 Spanish flu, the 1957 Asian flu, the 1968 Hong Kong flu and the 2009 Swine flu. Together these events have resulted in millions of cases of illness, hospitalization and death, as well as a significant social and economic burden (Humphries, 2013; Henderson et al., 2009; Guan et al., 2010; Simonsen et al., 2013). The Spanish flu demonstrates the catastrophic potential of such events, having caused between 20 and 50 million deaths globally (Humphries, 2013; Jordan, 1927; Patterson and Pyle, 1991; Johnson and Mueller, 2002). Advances in medicine and public health render such dramatic consequences unlikely today (Saunders-Hastings and Krewski, 2016). The emergence of antivirals, vaccines and mechanical ventilators should help protect from such a catastrophic pandemic in the future, and pandemic-attributable mortality has decreased in the three influenza pandemics since the Spanish flu[9]. However, the unpredictable nature of influenza pandemics, coupled with increasing opportunities for viral reassortment, necessitate further studies of appropriate mechanisms to respond to such events and mitigate their impact.

The irregular cycle of influenza pandemics makes them difficult to study, with most of the available, scientifically rigorous data deriving from the recent 2009 pandemic. This is problematic given that the 2009 pandemic strain — A(H1N1)pdm09 — is known to have been quite mild, with hospitalization and death rates similar to recent seasonal influenza (Henderson et al., 2009). The disease characteristics of future pandemics may differ substantially from those in the past. Little is known about the effectiveness of a suite of potential interventions to interrupt pandemic influenza infection. This is especially true of non-pharmaceutical measures such as social distancing (school closure, patient quarantine) and personal protective measures (PPMs). Pharmaceutical measures such as pandemic vaccination are effective (Breteler et al., 2013; Demicheli et al., 2014; Manzoli et al., 2009; Yin et al., 2012; Saunders-Hastings et al., 2016), but may not be available in the early stages of a pandemic influenza outbreak (Madhav, 2013; Longini et al., 2004). Social distancing policies, meanwhile, are of uncertain effectiveness, and are often expensive, unpopular and difficult to implement (Isfeld-Kiely and Moghadas, 2014; Perez Velasco et al., 2012; Borse et al., 2011). Consequently, patient quarantine has not been broadly implemented since the 1918 pandemic (Markel et al., 2006), while uncertainty regarding the effectiveness of school closure has limited its implementation over the course of the past three pandemics (Trotter et al., 1959; Earn et al., 2012). However, PPMs such as respiratory etiquette, hand hygiene and the use of facemasks are inexpensive and easy to implement, and are commonly recommended and undertaken during influenza outbreaks (Aledort et al., 2007; Aiello et al., 2010a; van der Weerd et al., 2011).

The primary objective of this review and meta-analysis is to quantify the effectiveness of PPMs in reducing the risk of human-to-human pandemic influenza infection. A secondary objective is to assess the relative effectiveness of these interventions. This is currently an important knowledge gap: a search for existing systematic reviews evaluating pandemic influenza interventions found only a single systematic review (Wong et al., 2014) on the effectiveness of PPMs in preventing pandemic influenza infection; focusing specifically on hand hygiene in the community, the review found only one study that was conducted during an influenza pandemic (Suess et al., 2011). However, the authors only included randomized control trials (RCTs) in their analysis, potentially missing important insights from observational studies. Given the important role PPMs may play in the early stages of a future pandemic, this review provides an important and timely assessment of the state of PPM literature and, where possible, quantification of pooled estimates of PPM effectiveness in interrupting pandemic influenza transmission.

2. Methods

2.1. Overview

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to guide the development of the systematic review methodology (Appendix A) (Moher et al., 2009). A protocol was developed a priori a registered in the National Institute for Health Research International Prospective Register of Systematic Reviews (PROSPERO) (Saunders-Hastings et al., 2016).

2.2. Search strategy

The literature search was conducted by PSH on June 30, 2016, with no language or date restrictions. Searches were conducted across five databases: PubMed (all dates), Medline via Ovid (1946-June 30, 2016), Embase via Ovid (1947-June 30, 2016), Cochrane Library via Ovid (all dates) and the Cumulative Index to Nursing and Allied Health (CINAHL; all dates). Database-specific variations are included in Appendix B. To supplement these searches, researchers conducted searches of the reference lists of included studies, and of the grey literature using Google Scholar.

2.3. Eligibility criteria and study inclusion

In this review, investigators sought to assess the effectiveness of commonly recommended PPMs in reducing the risk of pandemic influenza infection in humans. Personal protective measures included any form of hand hygiene, use of facemasks or respiratory etiquette (covering mouth during coughing and sneezing). Interventions more commonly recommended for healthcare staff, and less likely to be implemented in community settings, were not considered. These interventions include the use of goggles, gowns and gloves to prevent influenza transmission. Table 1 lists the relevant eligibility criteria developed a priori and applied throughout the screening process.

All citations were imported into the web-based systematic review software DistillerSR (Evidence Partners Incorporated, Ottawa, Canada). Following deduplication, two independent, blind reviewers conducted title and abstract screening using a pilot-tested DistillerSR screening form that reflected the eligibility criteria. An assenting response from at least one reviewer resulted in article inclusion for full review, where articles were again subjected to blind review by two independent reviewers using a piloted DistillerSR form. At this stage, disagreements were resolved by consensus; third-party arbitration was implemented as necessary.

2.4. Data extraction

Two independent reviewers (PSH, JC) extracted data from included studies using an adapted data collection form developed by The Cochrane Collaboration (Anon., 2013). The form collected information on study population(s), methods, intervention(s), outcome measure(s) and results.