# *A HOME FLU "KIT" TO EMPOWER INDIVIDUALS AND FAMILIES FOR PANDEMIC FLU*

*Stan Finkelstein, M.D.*

*Shiva Prakash*

*Karima Nigmatulina, Ph.D.*

*Richard Larson, Ph.D.*

*Center for Engineering Systems Fundamentals*

*Engineering Systems Division*

*Massachusetts Institute of Technology*

*& Harvard-MIT Division of Health Sciences & Technology*

*Cambridge, Massachusetts 02139 USA*

**ABSTRACT**

***Background***

When a flu pandemic occurs, it can overwhelm the capacities of our hospitals, clinics, nursing homes, and emergency services. Most of the stricken will have to be cared for at home, and there is strong evidence that in-home caregivers bear a disproportionate risk of becoming infected. We focus on simple steps that in-home caregivers can take to reduce the chances that they and other household members will become infected from the stricken individual being cared for in the home.

***Methods***

We examined the feasibility that a portfolio of non-pharmaceutical remedies, easily implemented in the home would reduce the local spread of illness.

***Results***

Personal hygiene, common masks, and technologies including air filters and ultraviolet light each offer incremental benefits, and in combination are expected to reduce some of the risk that caregivers and other household members become infected.

***Conclusions***

In pandemics and even seasonal epidemics, seemingly small steps could literally mean the difference between life and death, especially for in-home caregivers at high risk.

## INTRODUCTION

The World Health Organization declared in June 2009 a full-fledged pandemic of a novel strain of influenza whose genome included material of swine, avian and human origin, named A (H1N1). The number of cases had reached millions, worldwide. While no one knows how much sickness and loss of life might eventually result, we can be certain that a raging pandemic flu would rapidly overwhelm the capacities of hospitals, clinics, nursing homes, and emergency services.[1,2,3,4]

Most of the stricken will have to be cared for at home, by loved ones. This is an issue raised by the Agency for Healthcare Research and Quality: "In the event of an influenza pandemic, because of anticipated shortages of health care professionals and widespread implementation of social distancing techniques, it is expected that the large majority of individuals infected with the influenza virus will be cared for in the home by family members, friends, and other members of the community – not by trained health professionals."[5]

The risks to those living in the home but not yet infected with flu need to be recognized and mitigated. Two studies that examined data on deaths due to influenza concluded that spouses sharing the household of an infected spouse experience approximately twice the population-expected number of deaths due to infection, a relative risk ratio higher than that of any blood relatives.[6,7] That is, care-giving spouses are at great risk of becoming infected from their infected husbands or wives.

These are alarming statistics, and not well-known. The researchers in these studies focused on genetic predispositions to becoming infected, and did not emphasize these findings since wives and husbands are, by definition, genetically unrelated.

How can we reduce the risks to family members caring for those in their households who are ill with flu? It is a matter of educating the public and empowering them to adopt simple behavioral measures that can reduce the chance of becoming infected. The opportunity for

educating is now. But while many public health plans recognize that vaccines and antiviral drugs will be unavailable or insufficient, and some even outline various social distancing measures that could be implemented, far too many miss a huge opportunity to empower individuals and families to take steps that could greatly reduce the adverse impacts of a pandemic.

To be sure, many health authorities expect caring for influenza patients at home to be a substantial component of any response to pandemic influenza. But in some cases, such as documentation from the U.S. Centers for Disease Control, there is a focus on symptom recognition and care that addresses symptom relief through the use of over-the-counter medications.[8,9] There are, however, many other interventions that could be adopted for home use, all relatively low cost and most easy to implement. Ongoing compliance would require little effort beyond the initial installation.

Health authorities seem to ignore these interventions, perhaps because their effectiveness is difficult to study since they do not easily lend themselves to randomized trials or rigorous observational research. Nevertheless, for each of the non-pharmaceutical interventions we discuss, a highly plausible theory or mechanism exists to explain its benefits.

## HOW THE FLU VIRUS IS TRANSMITTED

The mechanism of virus transport from its release to when it infects a new host is still not well understood. A review of how the flu virus spreads helps emphasize the preventive value of non-pharmaceutical interventions.

Initially, the virus is spread by emissions of small particles from the nose and mouth of ill individuals when they cough, sneeze, or merely breathe; these may be aerosols that may be suspended in air for long periods and can be carried in the atmosphere directly to susceptible individuals.[10] Severely limited ventilation – so often found in enclosed spaces such as sickrooms and airplanes – makes it much easier for these aerosols to intensify, be inhaled, and directly

infect the tissues of others' lower respiratory tracts.

Large emission particles are often launched by coughs or sneezes. Laden with virus they travel short distances and settle on surfaces, but can transmit disease for up to 48 hours, typically infecting upper respiratory tissues in the noses, mouths, and throats of healthy individuals who touch these surfaces and then touch their faces. Some of the moisture in large particles can evaporate, producing smaller particles called aerosol droplets that pose risks similar to those of other smaller particles that remain airborne or infect surfaces.[11]

Ambient conditions such as temperature and humidity affect the properties of both large and small particles and, presumably, their ability to produce disease. The virus-containing particles are potentially vulnerable to a number of non-pharmaceutical interventions that include disinfectants, mechanical barriers, negative air pressure, and others that can reduce the chances of infection.

## NON-PHARMACEUTICAL REMEDIES FOR THE HOME

### *Hand Hygiene*

Hands are the common intermediary between infected objects or surfaces and the entry points into the body. Hand hygiene, therefore, offers great potential for preventing infection. Empirical studies, particularly in hospitals, daycare centers, and schools, suggest that diligent washing and hand sanitizing can reduce infections by 20 to 95 percent.[12,13,14,15,16,17]

Evidence suggests that we remove more pathogens the more time we spend washing our hands; 30 seconds is suitable. Common detergent-based soaps work, but alcohol-based hand sanitizers can be highly effective disinfectants because alcohol denatures virus-associated proteins. One study showed that a 95-percent ethanol-based rub brought flu virus to undetectable levels after 30 seconds of use, by which time the hands would be completely dry.[18,19]

Hand soaps and sanitizers are inexpensive and pose minimal risks, but how many people

spend 30 seconds each time they use one? Only a massive public education campaign about hand hygiene will produce the widespread behavioral change needed to prevent flu transmission.

### *Surgical Masks*

The modest incremental benefits of home use of common surgical masks would be positive in pandemic influenza. While they probably do little to block aerosol transmission,[20] they may block some large virus particles emitted when a sick person sneezes or coughs. Some evidence suggests a mask worn by an infected person reduces the speed of air coming from the mouth or nose, limiting the distance large particles travel.[21] Conversely, a mask may block a healthy person from inhaling some large particles. Perhaps more significant is that a well person wearing a mask will find it much more difficult to transfer virus from the hands to the more vulnerable nose and mouth.[11]

Public health officials rarely, if ever, recommend wearing masks in the home. The practice, though, should be strongly encouraged: masks are inexpensive, widely available, and could reduce some of the risk that a healthy family member would contract the flu from another who is sick.[11]

### *Air Filtration and Ventilation*

Empirical observations show a strong correlation between increased rates of infection and poorly circulated or ventilated air, and evidence suggests the effectiveness of specialized air handling and ventilation – low-cost and easy to implement – in reducing potential aerosol transmission of influenza.[22]

Filtration efficiency rises with an increase in the rate of air circulation through a filter or the amount of new air entering the room from outside.[23] High Efficiency Particulate Air (HEPA) filters, typically costing $100 or less, work in most homes heated with forced air or other climate

control and ventilation systems and can remove nearly 98 percent of particles 0.3 microns or greater in size.[24] A portable air purifier with a HEPA filter can be used for circulation in homes heated in other manners, and can be purchased for $100 to $500 per unit.

Even a simple fan facing out the window of an enclosed patient care room can help remove the virus by creating a slight negative pressure differential compared to that in other rooms in the home. This is presumed to reduce the leakage of infected air when the sickroom door is opened to other parts of the home.[25] With that same door slightly ajar, an outward-facing fan would transport air from the rest of the home though the sickroom to the outside, this air-cleansing presumably lessening the density of any aerosol flu particles and thereby reducing the chance of infecting a caregiver in the sickroom.

***Ultraviolet Light***

The UV-C wavelength range of ultraviolet light has been found to be germicidal, with potential to disinfect air by inactivating virus-containing aerosols.[26] A study at a hospital found 2-and 19-percent rates of influenza in two comparable buildings with and without UV lights installed, respectively.[27] UV light – beginning at about $150 – could be particularly useful in the home, especially with extended exposure.[23,26]

Effectiveness can double when there is a continuous source of cold air at the ceiling level, which naturally moves downward as warmer air moves up and thus increases air circulation, creating greater exposure to the UV irradiation. A large room fan also supports this effect.[23] Combining an exhaust fan, as described above, with another in the room to promote circulation may be best.

***Temperature and Humidity Control***

Recent studies in animal models suggest higher levels of both temperature and relative

humidity are associated with reduced virus flu transmission and are consistent with stronger and more effective host immune defenses, particularly in the early stages of developing an infection. The virus aerosols are less stable at higher humidity levels, and the larger particles absorb moisture, increase in size, and then settle out of the air.[28] In the home, room temperature can typically be regulated with the thermostat, while desired levels of humidity can be achieved by use of portable humidifiers available for $25 to $50. If these findings are accepted as valid, a decision would be required for the sickroom: whether to opt for air circulation with filters, negative air pressure, and UV light (the latter works better with low humidity[27]), or choose heat and high humidity.

***The Bathroom***

Transmission of disease from the bathroom has long been recognized as a substantial risk. These shared spaces tend to be used disproportionately by people who are not well and who can contaminate surfaces and ambient air.

Even flushing of toilets can cause significant numbers of virus particles to become aerosolized, increasing the risks.[29] While such virus particles are associated with intestinal disorders, SARS – a respiratory illness – was found in human feces, and toilet-flushing by a SARS-infected individual in a Hong Kong high-rise apartment building caused scores of other residents to become infected.[30,31] Novel H1N1 has caused vomiting and diarrhea in about 40 percent of those infected, and has been found in human intestines.[32] These are important issues to consider when someone suffering from influenza is cared for in the home.

Diligent behavior would suggest dedicating a single bathroom to the exclusive use of the sick person in homes with multiple bathrooms. Consistent with our earlier discussions, certain other protective measures that pose little cost or risk could be helpful. The bathroom window should be left partly, if not completely open. A ceiling exhaust fan, if present, should be kept in

continuous operation. Taking care to avoid infection by wearing gloves, and keeping air circulating outwards, the room should be wiped down with a virus-killing disinfectant at regular intervals to decontaminate surfaces.[6]

**DISCUSSION**

There is a growing consensus that rapidly moving epidemics would be susceptible to public health measures and individual behavioral changes, if implemented quickly and with vigilance. "An important component of the current pandemic planning strategies in the United States and many other countries is to keep ill persons out of the hospital and have large numbers of them cared for at home, with the idea of avoiding the amplification of infections in hospitals seen with SARS in 2003 and with a range of other modern epidemics."[33]

Each non-pharmaceutical intervention we have discussed could be a part of what we call "family-friendly" packages health officials at any level could develop and offer as examples of actions individuals can take on their own to prepare for a flu pandemic. These packages should include fact sheets written in plain language with details of how to employ each option in the set. Local print and electronic media could be enlisted to promote a public information campaign to announce and publicize the program. Establishing "auditing" organizations such as those that recommend ways to reduce energy consumption in private homes could go a long way towards assisting families in implementing these options. Perhaps subsidies could be arranged from prominent employers, local merchants, and even with some government funding to make these interventions can be accessible to families of lesser means.

Our proposal goes well beyond existing guides and checklists (such as those at pandemicflu.gov) that advise how to prepare for pandemics. An individual taking care of a sick loved one is performing a role similar to a professional health provider and, unless ameliorative steps are taken, faces significant risks of infection and would benefit from the same

precautionary measures as used in the hospital care setting. While some of our suggested interventions are standard measures within the healthcare/hospital setting, others could be considered within such settings (with obvious modification).

We would extend existing recommendations to incorporate a small set of hardware-embodied interventions. A suitable air filter and exhaust fan would be two of the components, along with ultraviolet light, which works best with low humidity. (We await further confirmation of the effects of heat and humidity in slowing the transmission of virus particles.) These interventions can be implemented in the home easily, and families could benefit passively after a modest initial investment of time and money (as low as $250; see Table 1).

Even if difficult to quantify, the potential benefits of these steps in reducing the spread of virus would turn out to be quite high. The environmental changes resulting from their implementation do not appear to pose measurable risks. Each measure has a plausible rationale to explain how it would help. The implementation costs are sufficiently low that even a modest level of incremental benefit makes them attractive for individuals and families.

Existing pandemic preparedness plans simply do not go far enough to encourage changes in individual behaviors to reduce the spread of disease. The common-sense measures we propose would help create an environment within the home that is less conducive to the spread of viral illness and would even help prevent commonly as well as seasonally occurring infectious diseases.

The risks to in-home caregivers – often spouses of the ill – must not be underestimated. As the authors of the Utah study we cited earlier wrote of the spousal risks they uncovered in 100 years of flu statistics from that state, "The significantly elevated RRs (Relative Risks) observed in spouses must be assigned entirely as resulting from shared exposure and/or environment, because spouses in an outbred population typically do not share common genetics."[7] Similarly, the Iceland researchers, who focused exclusively on the 1918 Great

Influenza, concluded that "the spouses of victims, often the only genetically unrelated member of the household, were paradoxically at the highest risk."[6]

When each flu pandemic occurs, we will need every incremental benefit that can be accrued. Seemingly small steps could mean the difference between life and death.[34]

**Table 1. Suggested Home Care Flu Kit**

| **Things to get:** | **Typical Cost** |
|---|---|
| Detergent-based soap | $10 |
| Alcohol-based hand sanitizer | $10 |
| Window fan | $40 |
| Ultraviolet light unit (some with HEPA filters) | $180 -$370 |
| High Efficiency Particulate Air (HEPA) filter system | $0 -$600 |
| Tissues | $5 |
| Face masks (25) | $10 |
| | APPROXIMATE TOTAL **$250 -$1,000** |

***Things to do and not to do:***

- Don't shake hands with people. Cough into your elbow or into a tissue.
- Wash hands frequently with hot soap and water for at least 30 seconds, and dry.
- Try not to touch your face with your hands.
- Practice careful bathroom etiquette.
- Avoid direct hand contact with surfaces that are likely to be contaminated.
- Hold meetings via telephone and email when possible.
- Read and study http://www.ifh-homehygiene.org/2003/index.html.

***References***


1 Kimery AL. Hospital flu admissions highlights national "surge" deficit. *Homeland Security Today*, http://www.hstoday.us/content/view/2188/149/ (accessed July 30, 2009).

2 Lam C, Waldhorn R, Toner E, Inglesby TV and O'Toole T. The prospect of using alternative medical care facilities in an influenza pandemic. *Biosecurity and Bioterrorism* 2006; 4(4):384-90.

3 Centers for Disease Control and Prevention. Long-term care and other residential facilities pandemic influenza planning checklist. http://www.pandemicflu.gov/plan/healthcare/longtermcarechecklist.html (accessed June 10, 2008).

4 Avery GH, Lawley M, Garrett S, et al. Planning for pandemic influenza: lessons from the experiences of thirteen Indiana counties. *Journal of Homeland Security and Emergency Managemen*t 2008; 5(1):1-24.

5 Knebel A and Phillips SJ (eds.). Agency for Healthcare Research and Quality. Home Health Care During an Influenza Pandemic: Issues and Resources. AHRQ Publication No. 08-0018. Rockville, MD: Agency for Healthcare Research and Quality; August 2008.

6 Gottfredsson M, Halldórsson BV, Jónsson S, et. al. Lessons from the past: familial aggregation analysis of fatal pandemic influenza (Spanish flu) in Iceland in 1918. *Proc. Natl. Acad. Sci USA* 2008; 105:1303-8.

7 Albright FS, Orlando P, Pavia AT, Jackson GG and Cannon Albright LA. Evidence for heritable predisposition to death due to influenza. *J. Infect. Dis.* 2008; 197:18-24.

8 Centers for Disease Control and Prevention. Home care guidance: physician directions to patient/parent. http://www.cdc.gov/h1n1flu/guidance_homecare_directions.htm (accessed July 16, 2009).

9 Centers for Disease Control and Prevention. Interim guidance for novel H1N1 flu (swine flu): taking care of a sick person in your home. http://www.cdc.gov/h1n1flu/guidance_homecare.htm (accessed July 29, 2009).

10 Morawska L. Droplet fate in indoor environments, or can we prevent the spread of infection. *Indoor Air* 2006; 16(5):335-47.

11 Collignon PJ and Carnie JA. Infection control and pandemic influenza. *Medical Journal of Australia* 2006; 185:S54-7.

12 Luby SP, Agboatwalla M, Feikin DR, et al. Effect of handwashing on child health: a randomized controlled trial. *The Lancet* 2005; 366:225-33.

13 Roberts L, Smith W, Jorm L, et al. Effect of infection control measures on the frequency of upper respiratory infection in child care: a randomized, controlled trial. *Pediatrics* 2000; 105:738-42.

14 Falsey AR, Criddle MM, Kolassa JE, et al. Evaluation of a handwashing intervention to reduce respiratory illness rates in senior day-care centers. *Infection Control and Hospital Epidemiology* 1999; 20:200-2.

15 Rabie T and Curtis V. Handwashing and risk of respiratory infections: a quantitative systematic review. *Tropical Medicine and International Health* 2006; 11:258-67.

16 St. Sauver J, Khurana M, Kao A, et al. Hygenic practices and acute respiratory illness in family and group day care homes. *Public Health Reports* 1998; 113:544-51.

17 World Health Organization Writing Group. Nonpharmaceutical interventions for pandemic influenza, national and community measures. *Emerging Infectious Disease* [serial online]. 2006; 12(1). http://www.cdc.gov/ncidod/EID/vol12no01/051371_app2.htm (accessed July 15, 2008).

18 Boyce JM and Pittet D. Guideline for hand hygiene in healthcare settings: recommendations of the healthcare infection control practices advisory committee and the HICPAC/SHEA/APIC/IDSA hand hygiene task force. *MMWR* 2002; 51:[51(RR16):1-44]. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5116a1.htm (accessed October 25, 2002).

19 Schurman W and Eggers H. Antiviral activity of an alcoholic hand disinfectant: comparison of in vitro suspension test with in vivo experiments on hands and on individual fingertips. *Antiviral Res* 1983; 3:25-41.

20 U.S. Department of Health and Human Services. Interim public health guidance for the use of facemasks and respirators in non-occupational community settings during an influenza pandemic. http://www.pandemicflu.gov/plan (accessed July 15, 2008).

21 Inouye S, Matsudaira Y and Sugihara Y. Masks for influenza patients: measurements of airflow from the mouth. *Japanese Journal of Infectious Disease* 2006; 59:179-81.

22 Li Y, Leung GM, Tang JW, et al. Role of ventilation in airborne transmission of infectious agents in the built environment – a multidisciplinary systematic review. *Indoor Air* 2007; 17:2-18.

23 Spendlove JC and Fannin KF. Source, significance and control of indoor microbial aerosols: human health aspects. *Public Health Reports* 1983; 98:229-44.

24 Sehulster LM, Chinn RYW, Arduino MJ, et al. Guidelines for environmental infection control in health care facilities. Recommendations from CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Chicago Il.: American Society for Healthcare Engineering/American Hospital Association, 2004.

25 Centers for Disease Control and Prevention. Interim recommendations for infection control in health-care facilities caring for patients with known or suspected avian influenza. http://www.cdc.gov/flu/avian/professional/pdf/infectcontrol.pdf (accessed May 21, 2004).

26 Weiss MM, Weiss PD, Weiss DE, et al. Disrupting the transmission of influenza A: face masks and ultraviolet light as control measures. *American Journal of Public Health* 2007; 97:S32-6.

27 Tellier R. Review of aerosol transmission of Influenza A virus. *Emerging Infectious Diseases* [serial online] November 2006. http://www.cdc.gov/ncidod/EID/vol12no11/06-0426.htm (accessed July 15, 2007).

28 Lowen AC, Mubareka S, Steel J, et al. Influenza virus transmission is dependent on relative humidity and temperature. *PLoS Pathog* 2007 3(10):e151. Doi:10.1371/journal.ppat.0030151.

29 Morawska L. Droplet fate in indoor environments, or can we prevent the spread of infection? *Indoor Air* 2006; 16:335-47.

30 SARS Mutates – Now Hitting Intestines, Too, News24.com - South Africa. http://www.rense.com/general37/hitting.htm (accessed April 22, 2003).

31 SARS mutating, becoming more virulent: new warning. http://www.smh.com.au/articles/2003/04/22/1050777253672.html (accessed April 23, 2003).

32 Starts like regular flu, then lungs stop functioning. A/H1N1 Influenza Outbreak Timeline. http://trancy.net/2009/07/08/july-8-starts-like-regular-flu-then-lungs-stop-functioning/ (accessed July 8, 2009).

33 Dowell SF and Bresee JS. Pandemic Lessons from Iceland, *PNAS* 2008; 105(4):1109-10.

34 Aledort JE, Lurie N, Wasserman J and Bozzette SA. Non-pharmaceutical public health interventions for pandemic influenza: an evaluation of the evidence base**.** *BMC Public Health* 7:208. http://www.biomedcentral.com/content/pdf/1471-24587-208.pdf (accessed August 15, 2007).

### *Conflict of Interest Statement*

The authors have no known conflicts of interest.

### *Acknowledgments*

Work on this manuscript was supported by the Sloan Foundation of New York under a grant entitled, "*Decision-Oriented Analysis of Pandemic Flu Preparedness & Response*," and under a cooperative agreement with the U.S. Centers for Disease Control and Prevention (CDC), grant number 1 PO1 TP000307-01, "LAMPS (Linking Assessment and Measurement to Performance in PHEP Systems), awarded to the Harvard School of Public Health Center for Public Health Preparedness (HSPHCPHP) and the Massachusetts Institute of Technology (MIT), Center for Engineering Systems Fundamentals (CESF). The discussion and conclusions in this chapter are those of the authors and do not necessarily represent the views of the Sloan Foundation, the CDC, the U.S. Department of Health and Human Services, Harvard or MIT. We gratefully acknowledge the editorial assistance of Scott Cooper in the preparation of this manuscript.