ENVIRONMENTAL HEALTH & ENGINEERING

HUMIDIFIERS AND INFLUENZA VIRUS

Humidifiers

AND

Influenza Virus

Summary

Peak influenza season in the Northern Hemisphere consistently occurs between November and March (Reichert, et al. 2004; Thompson, et al. 2006). In efforts to determine why influenza season occurs during the winter months when air temperature and indoor relative humidity (RH) are low, researchers have evaluated the impacts of air temperature and RH on influenza virus survival. These studies consistently demonstrate that influenza virus survives best at RH below 40% (Edward, et al. 1943; Loosli, et al. 1943; Lester 1948; Hemmes, et al. 1960; Harper 1961; Buckland and Tyrrell 1962; Hood 1963; Schaffer, et al. 1976). In un-humidified indoor environments, RH can fall below 40% during the winter heating season (Trechsel 1994). Therefore, research conducted over the last 70 years suggests that influenza survival could be reduced by using humidifiers in households, schools, and offices to create conditions where RH is between 40 and 60%.

Influenza

Influenza, commonly called the flu, is a respiratory infection caused by influenza viruses. Common symptoms associated with influenza infection are fever, headache, tiredness, dry cough, sore throat, runny or stuffy nose, muscle aches, and stomach symptoms. Illness typically last from 3 days to under two weeks (CDC 2009a).

In a typical flu season in the US, the US Centers for Disease Control and Prevention (CDC) estimates that an average 5% to 20% of the population gets seasonal influenza; with hundreds of thousands of hospitalizations and tens of thousands of influenza-related deaths (CDC 2009b).

How is the Influenza Virus Spread?

There are generally three identified exposure pathways for influenza to spread from person to person:

- Touching surfaces contaminated with influenza virus and subsequently exposing oneself by touching the mouth or nose
- Direct exposure from large droplets expelled by the sneeze or cough of an infectious person to the mouth or nose
- Inhalation of small particles formed by the evaporation of small droplets expelled from an infectious person

Relative Humidity Impacts Airborne Influenza Survival

Researchers, noting that influenza outbreaks occur when RH is low, have extensively evaluated the inactivation of aerosolized influenza virus as a function of RH and other environmental factors. The record of published literature begins in 1941, extending nearly 70 years with the most recent publication appearing in 2009.

The cyclical nature of influenza outbreaks, which typically occur from November to March in the Northern Hemisphere, are more pronounced in temperate regions and have been associated with environmental effects on the virus such as temperature and relative humidity (i.e., relative humidity is lower in the winter) (Reichert, et al. 2004; Thompson, et al. 2006). Other factors that may be tied to this seasonality, however, have not been ruled out (McLean 1961; Dushoff, et al. 2004; Lipsitch and Viboud 2009).

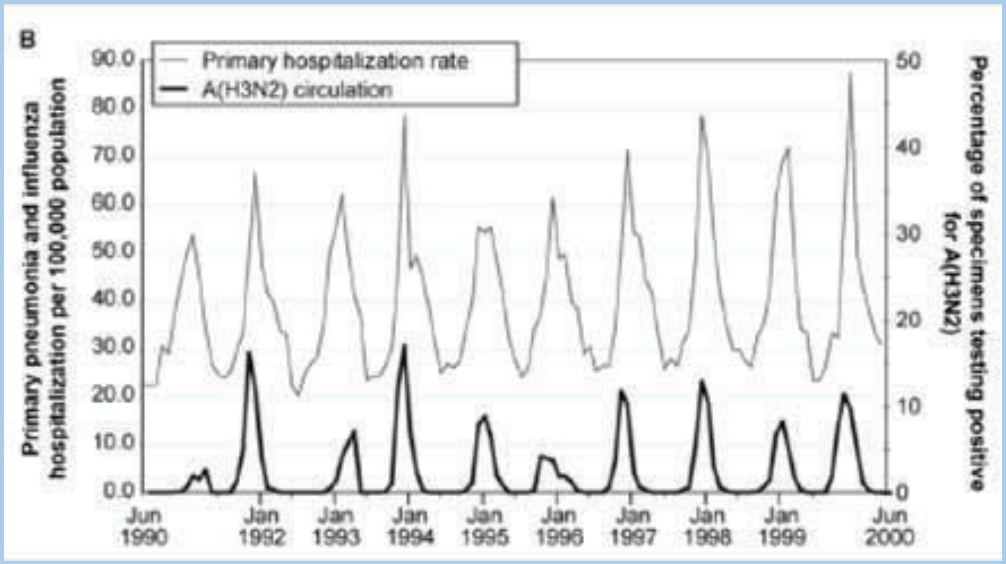

Figure 1 Cyclical Influenza Season Pattern in the U.S. Source: Thompson et al., 2006.

Some of the earliest published studies that address the effect of RH on virus infectivity were published in the 1940's. (Edward, et al. 1943; Loosli, et al. 1943; Lester 1948). In these initial experiments, influenza virus aerosols were mechanically atomized at different RH levels and mice were either exposed directly to the aerosol or the air containing the virus was sampled using a device that collected the aerosols into a liquid; the mice were then exposed to the virus containing liquid. Results from these studies demonstrated that aerosolized influenza virus survives longer in low RH.

By 1950, laboratory methods had been developed to measure influenza virus using eggs as opposed to using laboratory animals (Shechmeister 1950; Hemmes, et al. 1960; Harper 1961; Hood 1963). While each of these investigations had

slightly different methodologies, each study mechanically atomized influenza virus, collected aerosol samples into a liquid, inoculated the liquid sample into chicken eggs or egg membranes, and evaluated the presence of virus after incubation. If the liquid sample contained infectious virus, the virus would replicate in the eggs. Again, results of these studies consistently showed that influenza virus survives better at low RH. The following figure illustrates differences in virus survival for both low and high RH.

> ***"...relative humidity indoors, is considered as an important environmental factor contributing to the seasonal fluctuations of the morbidity of (influenza)..."***
>
> ***(Hemmes, et al. 1960)***

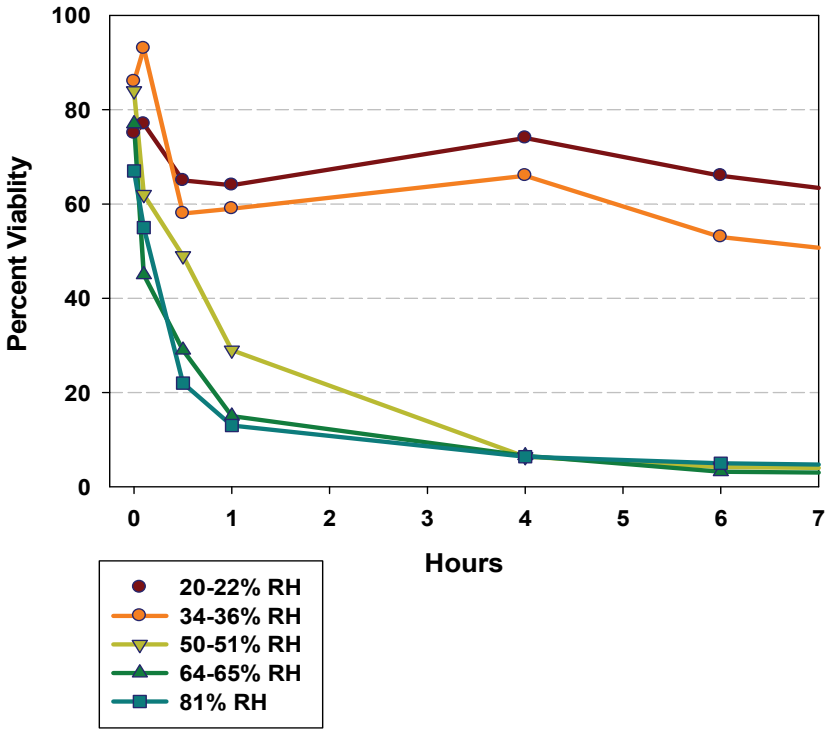

Figure 2 Influenza Virus Viability at 20.5 to 24C° and Five Relative Humidity Levels. Source: Harper 1961.

By the 1970s, methods had been developed that allowed for the analysis of influenza survival in cell culture. Researchers from the University of California

used these methods to test influenza aerosol samples aged from 1-30 minutes in environments with RHs ranging from 20 – 75% RH. Results of this research showed maximum survival at low RH (<30%), minimum survival at medium RH (30 – 60%), and moderate survival at high RH (>60%) (Schaffer, et al. 1976).

Although not as vigorously investigated as the effects of RH on aerosol survival, studies on the effects of RH on survival of influenza on surfaces have reached similar conclusions as the aerosol studies. For example, investigators evaluated room temperature surface inactivation of influenza virus by depositing virus suspensions on glass slides, allowing the virus to dry and then exposing the slides to either 20 or 84% RH for two and a half hours. The study found much less infectious virus at the higher humidity, indicating that the virus survived longer at 20% RH (Buckland and Tyrrell 1962).

Figure 3 A transmission electron micrograph of an influenza virus. Influenza virus is about 120 nanometers—about one tenth thousandth of a millimeter in diameter. *Photo credit: CDC / Dr. Erskine L. Palmer; Dr. M. L. Martin.*

While there are understandable differences between the results of the individual studies (many of which were discussed above), the data are remarkably consistent and confirm that survival of influenza is reduced in environments with RH at approximately 40 – 60% (See figure 4). While some studies suggest that RH above 60% is also protective of influenza virus survival and transmission,

elevated RH indoors can lead to other unwanted conditions such as mold and dust mite growth.

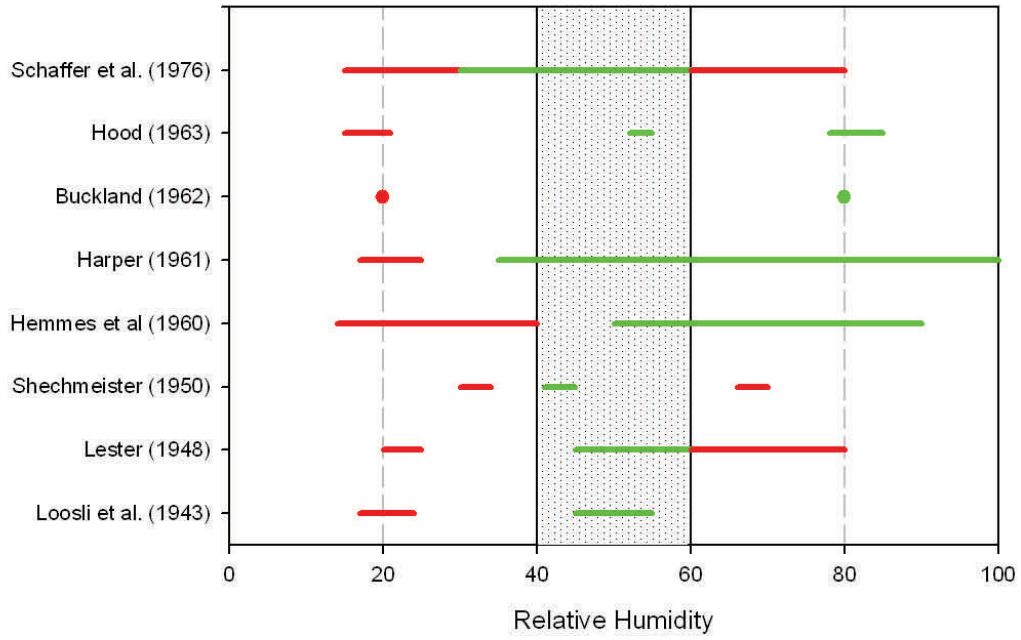

Figure 4 Summary of Influenza Virus Survival Studies. Red bars indicate areas of high influenza survival, green bars indicate areas of low influenza survival.

Controlling Influenza at Home

Controlling exposure to influenza virus at home is important, as households are a significant location for spreading the flu. Several studies, for example, have detected secondary attack rates among family members near 40% (Hayden, et al. 1989; Carrat, et al. 2002). The best strategy to control the spread of influenza is to vaccinate against flu, and use of a humidifier is no substitute for vaccination. However, humidification has been shown to reduce the numbers of infectious influenza viruses in the air and on surfaces, and therefore, humidifiers can assist in controlling influenza in the home.

To calculate the increase in RH expected from the use of a Vicks® portable humidifier in a home, we used the methodology outlined in the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE 2009).

Utilizing typical household characteristics, moisture generation data from Vicks® portable humidifiers, and a conservative estimate for outdoor vapor pressure (i.e., outdoor air is cold with very little moisture), we estimate that using a Vicks® portable humidifier would raise the indoor RH from near 20% to within the 40-60% RH range. Based on these results, we expect that under normal conditions and when used as directed, using a Vicks® portable humidifier in the home will increase the RH to levels that have been demonstrated to reduce influenza virus survival.

Figure 5 Vicks® GermFree (Model V3900) Portable Humidifier. Vicks® is a registered trademark of The Procter & Gamble Company.

The Bottom Line

Studies consistently demonstrate that influenza virus survives best at RH below 40% (Edward, et al. 1943; Loosli, et al. 1943; Lester 1948; Hemmes, et al. 1960; Harper 1961; Buckland and Tyrrell 1962; Hood 1963; Schaffer, et al. 1976). In un-humidified indoor environments RH is typically below 40% during the winter heating season. Therefore, research conducted over the last 70 years suggests that influenza in the air and on hard surfaces could be reduced by using humidifiers in households, schools, and offices to create conditions where RH is between 40 and 60%.

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