Care4EveryBreath

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Contents

Executive Summary

1. Percentage of Increase in Incidence and Severity in Cold, Influenza, and Flu-like Illnesses Attributed to Climate Impact

Several studies have demonstrated a significant increase in the incidence and severity of respiratory illnesses, including colds, influenza, and flu-like illnesses, attributable to climate change and related factors such as air pollution:

- **Cold Incidence and Severity**:
  - Air pollution, specifically PM2.5 and PM10, has been linked to increased upper respiratory tract symptoms (URTS) in children, with increases of 10%, 9%, and 11% for runny nose, cough, and sneezing, respectively, in areas with higher pollution.Ratajczak, A et al. 2021
  - Lower temperatures and humidity levels are associated with a higher incidence of human rhinovirus infections, with an 8% increase in risk per 1°C decrease in temperature and a 13-20% increase per 0.5 g/m³ decrease in absolute humidity. Ikäheimo TM, et al., 2016. Residential exposures like mold and dampness increase respiratory tract infections by approximately 9-19% depending on the specific illness (common cold, influenza, etc.) (Groot J et al., 2024)
- **Influenza Incidence and Severity**:
  - Air pollution significantly contributes to the incidence and severity of influenza. A one-standard-deviation increase in the Air Quality Index is linked to a 35.7% increase in flu-related hospitalizations. (Zivin J et al.,2022)
  - Extreme weather events and climate variability (e.g., extreme precipitation)) are correlated with increased emergency room visits for influenza, particularly among children and adults.
    - **Influenza A and B virus** show positive correlation with rainfall (Smith G et al., 2017)
  - A reduction in relative humidity is associated with a higher risk of **influenza A** in the population (Yang J et al.,2022)
  - A 10 μg/m³ increase in PM2.5 and PM10 has been associated with a relative risk increase of 1.618 to 2.103 for **Flu-A**. (Ma P et al.,2023)

2. Awareness of Health Care Providers (HCPs) on Climate-Related Health Issues and Tailoring of Treatment or Care

HCPs are taking initiatives to increase awareness on climate-related health issue

- 72% of the surveyed physicians believe that they play a role in responding to climate change, 62% felt the need to inform patients on the health effects of climate change (Sarfaty M et al, 2015)

Role of HCP in protecting health from climate change

1. Recommend use of saline irrigation to remove pollutants and particulate matter. Doing a nasal saline irrigation once or twice daily can be extremely beneficial
2. Use respirator masks, air purifiers and HEPA filters to protect from the pollution (MultiCareVitals)
3. An N95 mask help block air pollutants.
4. Use quick-relief medications (BannerHealth)

Health care providers are increasingly recognizing the impact of climate change on respiratory illnesses. However, there is a gap in comprehensive knowledge and education:

- **HCP Awareness and Actions**:
  - A significant majority (86%) of HCPs feel responsible for informing the public about the health effects of climate change, and 90% believe in informing policymakers.Despite this awareness, 76% of HCPs indicate a need for continuing medical education on the topic. (Kotcher J et al.,2021),
  - HCPs are beginning to advise patients on mitigating measures to improve indoor air quality and reduce respiratory disease exacerbations, such as using air purifiers, proper ventilation, and evaluating household chemicals. (CCJM,2023).

3. Awareness of Patients/Consumers on Increased Severity or Incidence of Respiratory Illnesses Due to Climate Impact

The awareness among patients and the general public regarding the link between climate change and increased respiratory illnesses is varied and generally low:

  - 73% of Americans are aware that air pollution from the use of fossil fuels harms human health, However, only about half (55%) are able to name even one such health impact
  - The most frequently cited health impacts are general (e.g., breathing problems, respiratory illness) rather than specific (e.g., asthma) (Kotcher, J. et al., 2019).

- **Patient Awareness**:
  - Public health campaigns and HCP communications are crucial in increasing patient awareness. However, current levels of awareness are insufficient, as reflected in ongoing studies and health initiatives. (Kotcher, J. et al., 2019)

Studies/Surveys indicate that while the direct impact of climate change on health is scientifically established, public knowledge is lagging, necessitating more focused educational efforts and clearer communication from health professionals and public health authorities (Kotcher J et al.,2021)

Conclusion

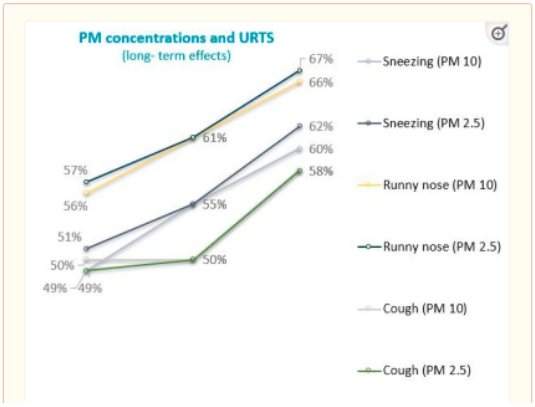
Climate change and air pollution have demonstrable impacts on the incidence and severity of cold, influenza, and flu-like illnesses. Although healthcare providers are increasingly aware of these impacts, there is a significant need for ongoing education and better communication strategies to inform both the medical community and the public. Enhancing awareness and adopting preventive measures could mitigate some of the adverse health outcomes associated with climate change.

Detailed Summary

Incidence and severity of cold: Percentage of increase in incidence and severity in cold

1. Air Pollution Increases the Incidence of Upper Respiratory Tract Symptoms among Polish Children
   Ratajczak, A et al. J Clin Med. 2021; 10(10): 2150.

A substantial proportion of airway disease's global burden is attributable to exposure to air pollution. This study aimed to investigate the association between air pollution, assessed as concentrations of particulate matter PM2.5 and PM10 on the upper respiratory tract symptoms (URTS) in children. A nation-wide, questionnaire-based study was conducted in Poland in winter 2018/2019 in a population of 1475 children, comparing URTS throughout the study period with publicly available data on airborne particulate matter. A general regression model was used to evaluate the lag effects between daily changes in PM10 and PM2.5 and the number of children reporting URTS and their severity. PM10 and PM2.5 in the single-pollutant models had significant effects on the number of children reporting URTS. The prevalence of URTS: "runny nose", "sneezing" and "cough" was positively associated with 12-week mean PM2.5 and PM10 concentrations. In the locations with the highest average concentration of PM, the symptoms of runny nose, cough and sneezing were increased by 10%, 9% and 11%, respectively, compared to the cities with the lowest PM concentrations. This study showed that moderate-term exposure (12 week observation period) to air pollution was associated with an increased risk of URTS among children aged 3–12 years in Poland. These findings may influence public debate and future policy at the national and international levels to improve air quality in cities and improve children's health.



2. Viral respiratory infections in a rapidly changing climate: the need to prepare for the next pandemic

   He Y et al , eBioMedicine. 2023 Jul; 93: 104593.

Viral respiratory infections (VRIs) cause seasonal epidemics and pandemics, with their transmission influenced by climate conditions. Despite the risks posed by novel VRIs, the relationships between

climate change and VRIs remain poorly understood. In this review, we synthesized existing literature to explore the connections between changes in meteorological conditions, extreme weather events, long-term climate warming, and seasonal outbreaks, epidemics, and pandemics of VRIs from an interdisciplinary perspective. We proposed a comprehensive conceptual framework highlighting the potential biological, socioeconomic, and ecological mechanisms underlying the impact of climate change on VRIs. Our findings suggested that climate change increases the risk of VRI emergence and transmission by affecting the biology of viruses, host susceptibility, human behavior, and environmental conditions of both society and ecosystems. Further interdisciplinary research is needed to address the dual challenge of climate change and pandemics.

3. Risk Factors for Respiratory Viral Infections: A Spotlight on Climate Change and Air Pollution Burbank AJ et al J Asthma Allergy. 2023; 16: 183–194.

Climate change has both direct and indirect effects on human health, and some populations are more vulnerable to these effects than others. Viral respiratory infections are most common illnesses in humans, with estimated 17 billion incident infections globally in 2019. Anthropogenic drivers of climate change, chiefly the emission of greenhouse gases and toxic pollutants from burning of fossil fuels, and the consequential changes in temperature, precipitation, and frequency of extreme weather events have been linked with increased susceptibility to viral respiratory infections. Air pollutants like nitrogen dioxide, particulate matter, diesel exhaust particles, and ozone have been shown to impact susceptibility and immune responses to viral infections through various mechanisms, including exaggerated or impaired innate and adaptive immune responses, disruption of the airway epithelial barrier, altered cell surface receptor expression, and impaired cytotoxic function. An estimated 90% of the world's population is exposed to air pollution, making this a topic with high relevance to human health. This review summarizes the available epidemiologic and experimental evidence for an association between climate change, air pollution, and viral respiratory infection..More than 90% of the world's population is exposed to polluted air. Convincing epidemiologic data has linked air pollution exposure with increased incidence of viral respiratory infections like upper respiratory tract (URI) infections,bronchitis, and lower respiratory tract infections (LTRI) such as pneumonia and bronchiolitis. Similarly, temperature, humidity,and extreme weather events have also been directly and indirectly associated with respiratory infections. A US study found that warmer winters were associated with more severe epidemics of influenza A and B during the following winter season. Specifically, a mild winter was followed by a more severe than average influenza epidemic 72% of the time, and this epidemic had a growth rate 40% higher and peaking 11 days earlier than average. Among urban children <5 years of age in the Mekong Delta region of Vietnam, rates of hospital admissions for respiratory infections increased by 3.8% (95% CI 0.4, 7.2) for every 1°C increase in 2-day moving average temperature.Temperature variability was also linked to viral respiratory infection incidence. Greater temperature variability, day-to-day and within the same day, was positively associated with greater frequency of healthcare visits for acute bronchitis. A retrospective study from the Netherlands reported that exposure to floodwater and performing clean-up after flooding were associated with higher odds of acute respiratory infection (aOR 3.3, 95% CI 2.0, 5.4)

4. A Decrease in Temperature and Humidity Precedes Human Rhinovirus Infections in a Cold Climate
   Ikäheimo TM, et al. *Viruses*. 2016; 8(9):244.

Both temperature and humidity may independently or jointly contribute to the risk of human rhinovirus (HRV) infections, either through altered survival and spread of viruses in the environment or due to changes in host susceptibility. This study examined the relationship between short-term variations in temperature and humidity and the risk of HRV infections in a subarctic climate. We conducted a case-crossover study among conscripts (n = 892) seeking medical attention due to respiratory symptoms during their military training and identified 147 HRV cases by real-time PCR. An average temperature, a decline in daily ambient temperature and absolute humidity (AH) during the three preceding days of the onset (hazard period) and two reference periods (a week prior and after the onset) were obtained. The average daily temperature preceding HRV infections was −9.9 ± 4.9 °C and the average AH was 2.2 ± 0.9 g/m^3. An average (odds ratios (OR) 1.07 (95% confidence interval (CI) 1.00–1.15)) and maximal (OR 1.08 (1.01–1.17)) change in temperature increased the risk of HRV infections by 8% per 1 °C decrease. An average (OR 1.20 (CI 1.03–1.40)) and maximal decrease (OR 1.13 (CI 0.96–1.34)) in AH increased the risk of HRV infection by 13% and 20% per 0.5 g/m^3 decrease. A higher average temperature during the three preceding days was positively associated with HRV infections (OR 1.07 (CI 1.00–1.15)). A decrease rather than low temperature and humidity per se during the preceding few days increases the risk of HRV infections in a cold climate. The information is applicable to populations residing in cold climates for appropriate personal protection and prevention of adverse health effects.

Table 2. Onset of a human rhinovirus (HRV) infection (n = 146) and its association with mean values and declines in temperature (per 1 °C) and humidity (0.5 g/m^3).

Parameter	OR (95% CI) [1]	Adjusted OR (95% CI) [2]
Absolute humidity (AH)		
mean of three prior days	0.94 (0.86–1.03)	0.97 (0.80–1.16)
maximum change during three prior days	1.09 (0.96–1.24)	1.20 (1.03–1.40)
mean change during three prior days	1.05 (0.91–1.21)	1.13 (0.96–1.34)
Temperature (°C)		
mean of three prior days	0.96 (0.92–1.00)	1.07 (1.00–1.15)
maximum change during three prior days	1.04 (0.98–1.10)	1.08 (1.01–1.17)
mean change during three prior days	1.04 (0.97–1.11)	1.08 (1.01–1.17)

[1] The odds ratios (OR, 95% confidence interval) were calculated per 1 °C temperature and per 0.5 g/m^3 absolute humidity decreases; [2] Adjusted for the initial level of the temperature and AH. The adjusted mean temperature and AH take into account seasonal variation, whereas the adjusted change in these parameters also considers that the potential for change in temperature and humidity depends on the level of the parameters. CI: confidence interval.

5. Residential exposure to mold, dampness, and indoor air pollution and risk of respiratory tract infections: a study among children ages 11 and 12 in the Danish National Birth Cohort
Groot J et al **European Journal of Epidemiology** 2024 **39:3** (299-311)

Background: The burden of respiratory tract infections (RTIs) is high in childhood. Several residential exposures may affect relative rates. Objectives: To determine risk of RTIs in children ages 11 and 12 by residential exposures. Methods: We included children in the Danish National Birth Cohort (DNBC) at ages 11 and 12. We estimated incidence risk ratios (IRR) and 95% confidence intervals (CI) for counts of RTIs within the last year by exposure to mold/dampness, gas stove usage, summer and winter candle-burning, fireplace usage, cats and dogs indoors, and farmhouse living. We also estimated IRR and 95% CI for RTIs for predicted scores of four extracted factors ('owned house', 'mold and dampness', 'candles', and 'density') from exploratory factor analyses (EFA). Results: We included 42 720 children with complete data. Mold/dampness was associated with all RTIs (common cold: IRR_{adj} 1.09[1.07, 1.12]; influenza: IRR_{adj} 1.10 [1.05, 1.15]; tonsillitis: IRR_{adj} 1.19 [1.10, 1.28]; conjunctivitis: IRR_{adj} 1.16 [1.02, 1.32]; and doctor-diagnosed pneumonia: IRR_{adj} 1.05 [0.90, 1.21]), as was the EFA factor 'mold/dampness' for several outcomes. Gas stove usage was associated with conjunctivitis (IRR_{adj} 1.25 [1.05, 1.49]) and with doctor-diagnosed pneumonia (IRR_{adj} 1.14 [0.93, 1.39]). Candle-burning during summer, but not winter, was associated with several RTIs, for tonsillitis in a dose-dependent fashion (increasing weekly frequencies vs. none: [IRR_{adj} 1.06 [0.98, 1.14], IRR_{adj} 1.16 [1.04, 1.30], IRR_{adj} 1.23 [1.06, 1.43], IRR_{adj} 1.29 [1.00, 1.67], and IRR_{adj} 1.41 [1.12, 1.78]). Conclusion: Residential exposures, in particular to mold and dampness and to a lesser degree to indoor combustion sources, are related to the occurrence of respiratory tract infections in children.

6. Effect of Air Pollution on the Cold Disease in Shanghai
Yang S.-X., *Huan jing ke xue= Huanjing kexue* 2018 39:4 (1552-1559)

This study discusses the changes in the daily average concentrations of the main air pollutants, such as PM10, PM2.5, O3, and NO2, in Shanghai, and the effects of air pollution on cold in Shanghai. For this study, data on air pollutants, meteorological factors, and the number of daily hospital visits from cold in Shanghai were collected from January 1, 2008 to December 31, 2010. Using the time series Poisson semi-parametric generalized additive model, and controlling for the long-term trend, "week" effect, and meteorological factors by smoothing the spline function, the exposure-response relationship between air pollution and human health in Shanghai was analyzed. The study sets up the model according to age, evaluating the impact and the lag effect of air pollution on the number of daily hospital visits. Results show that when PM10, NO2, O3, and PM2.5 increase by an IQR, the relative risk of cold disease is 1.0240 (1.0233-1.0246), 1.0206 (1.0201-1.0212), 0.9393 (0.9384-0.9402), and 1.0080 (1.0069-1.0086), and when PM10, NO2, O3, and PM2.5 increase by 10 μg·m-3, the daily hospital visits increase by 0.5%, 1.0%, -2.0%, and 0.2%. In the multi-polluted model, the results of NO2 and PM2.5 are basically lower compared to the results of the single-pollutant model, the results of PM10 and O3are higher. Air pollution in Shanghai has an impact on the incidence of cold disease.

7. Ambient particulate matter and oxides of nitrogen are associated with an increased incidence of copd exacerbations with symptoms of infective etiology
   Donaldson G.C., American Journal of Respiratory and Critical Care Medicine **2018** 197:Meeting Abstracts

Background: The healthcare burden from air pollution is a major public health concern. Previous studies of associations between ambient pollution and COPD exacerbations have found heterogeneous effects despite mechanistic studies indicating a multitude of harmful actions of pollutants. Methods: We examined exacerbations defined by respiratory symptoms recorded by patients on daily diary cards, and the subset involving healthcare utilization (HCUexacerbations), detected in the London COPD cohort between 1996-2015. We investigated whether preceding ambient particulate matter (PM10) and oxides of nitrogen (NOx) altered the incidence of exacerbations with random-effects logistic regression models adjusted for temperature, seasonality and long-term trend. Pollution was recorded at a central London background monitoring station. Results: 4173 exacerbations occurred in 440 COPD patients over 20 years. An increased incidence of exacerbations and HCU-exacerbations involving 'cold' symptoms, suggestive of viral-etiology, was evident at 3 days lag after higher ambient NOx (odds ratio = 1.0014 per 1μg/m^3 increase NOx (p=0.026); for HCU-exacerbations 1.0018 per 1μg/m^3 increase (p=0.022)). Exacerbations with symptoms of 'cold' and increased sputum purulence or volume suggestive of co-bacterial infection, were increased with higher same-day PM-173;10 levels (odds ratio = 1.0050 per 1μg/m^3 increase PM-173;10 (p=0.025); for HCU-exacerbations 1.0052 per 1μg/m^3 increase (p=0.049)). Exacerbation recovery was 1.29 (95% CI 1-17-1.42; P<0.001) times longer with viral-type HCU-exacerbations of onset 3 days after above versus below median ambient NOx. No consistent effect of air pollution on the incidence of exacerbations without symptoms suggestive of infectious etiology was evident. Conclusions: These findings indicate that air pollution increases susceptibility to, and severity of, respiratory infection in COPD. Similar effects in the general population would add considerably to the economic burden of pollution. Further research is urgently needed on strategies to ameliorate the pathological effect of air pollution on immunological responses to respiratory tract infections. (Figure Presented).

8. Presence of Household Mold, Children's Respiratory Health, and School Absenteeism: Cause for Concern
   Polyzoi E., Polyzois D. *Journal of environmental health* 2017 79:7 (28-35)

A study examining the relationship between housing conditions, respiratory health, and school absenteeism was conducted in the city of Winnipeg in Manitoba, Canada. As part of this study, a survey was completed by 3,424 parents of children in grades 3 and 4 to determine the a) relationship between self-reported visible mold in homes and tested airborne mold; b) relationships of self-reported visible mold, tested airborne mold, and asthma and/or persistent colds; c) school absenteeism rates due to asthma and/or persistent colds; and d) children's socioeconomic status (SES) and incidence of asthma and/or persistent colds. In addition, a complete inspection of a subset of 715 homes was conducted, including the collection of over 1,400 indoor and 500 outdoor air samples for mold analysis. Results indicate a significant association between self-reported visible mold and airborne mold. Additionally, a significant association was found between Cladosporium levels from air samples (the most common genus type found) and children's asthma in combination with persistent colds. Children with persistent colds in combination with asthma miss significantly more school than children who have only asthma or only persistent colds. Children from poorer families reported more

persistent colds than children from high-income families. No association was found between income and asthma. Furthermore, SES was not a significant factor for number of school days missed.

9. Clinical studies and epidemiology of recurrent wheezy infants and young children. Part I. A study on air pollution and epidemiology of wheezy young children - the study in children aged two years old in Fuji City
   Ohtani T. *Tokyo Jikeikai Medical Journal* 1979 94:4 (730-737)

The influence of air pollution and epidemiology was studied in wheezy children disclosed by the two years old health examination (3283 cases) in Fuji city, Shizuoka prefecture. The results obtained were as follows. The incidence of the children who had wheezy attack within one year was 14.5%. Morbidity of asthmatic bronchitis was 16.0% in strongly polluted area, 13.0% in moderately polluted area, and 10.1% in a little polluted area on the basis of sulphur dioxide concentration. A ratio of male to female in children with asthmatic bronchitis was 1.86 : 1. Allergic diasthesis in family member was observed in 63% in children with asthmatic bronchitis, and 34% in non-wheezy children. In blood examination in 46 cases of children with asthmatic bronchitis, eosinophilia was observed in 24%, mean value of serum IgE was 196u/ml and positive skin test was observed in 52%. According to the questionnaire, major provocating factors of wheezy attack were respiratory infections, common cold (85%) and pneumonia (13%). Mycoplasma or viral infection were detected serologically in 60%. From these results, as a predisposing factor to wheezy attack, the combination of air pollution, respiratory infection and allergic diasthesis should be strong.

10. A study on respiratory diseases in relation to air pollution in Kita Kyushu City (Japanese)
    Nakagawa S et al.,.*Japanese Journal of Allergology* 1974 23:8(554-60+581-82)

An epidemiological survey of respiratory diseases, especially related to air pollution, was carried out in Kita Kyushu City, one of the heavily industrialized areas of Japan. The population consisted of 7,856 workers from 108 industries located and distributed in a variety of polluted areas of the city. The results are summarized as follows: The incidences of bronchial asthma were 4.98% in the most heavily polluted areas, 3.67% and 4.00% in the second and third pollution areas, and 2.99% in the lightly polluted area. The incidence of bronchial asthma among workers directly exposed to occupational pollution was higher than among those not directly exposed. The smoking group, especially the aged patients, showed a significantly higher incidence of asthma than the non-smoking group. According to the results, the effects of air pollution increased gradually in the higher age groups. Psychosomatic investigation indicates that asthmatic patients in this survey had such difficulties as the inability to express their feelings, introversion and hypochondrial tendencies. Air pollution was a factor aggravating or causing rhinitis, bronchitis and a susceptibility to the common cold or respiratory infections.

11. Flooding and excessive rainfall risk respiratory health
    The Lancet Respiratory Medicine, 2024 Feb;12(2):89

2023 has been described as a turning point in the climate crisis. The 2023 United Nations Climate Change Conference (COP28) closed with an agreement signalling "the beginning of the end" of the fossil fuel era. While this agreement is a cause for some optimism, this sense of hope has been coupled with a year of historically high temperatures, extreme rainfall and flooding, drought, and

forest fires. Lung health can be seen as a key indicator of the health of our planet and its air quality. Our respiratory health bears the brunt of many climate-change related phenomena, such as extreme heat and cold, disturbed and extended seasonal virus fluctuations, smoke inhalation after forest fires, increases in newly emerging zoonotic respiratory viruses, and air pollution. Although lung health research often focuses on air quality due to the immediately apparent effects on common respiratory conditions, the impact of flooding and excessive rainfall on respiratory health can be overlooked. Given that floods are the "most frequent type of natural disaster" and with current trajectories signalling increasing likelihood of floods in the future, we cannot afford to underestimate the potential harms, especially regarding lung health. Flooding increases the risk of respiratory harms both directly and indirectly. Urban pluvial flooding has been shown to be contaminated with respiratory pathogens. Flooding can worsen respiratory harms due to housing damage and compromised health systems and emergency services, which increases both exposure and vulnerability to viral respiratory infections. Another respiratory danger after flooding is mould growth in damp environments. Research indicates that a damp indoor environment can result in asthma onset or flare-ups, bronchitis, cough, wheeze, chest infections (eg, aspergillosis), shortness of breath, rhinitis, allergic reactions, and in rarer cases hypersensitivity pneumonitis

12. How Wildfire Smoke Raises Infectious Disease Risk
    The Scientist, 2021

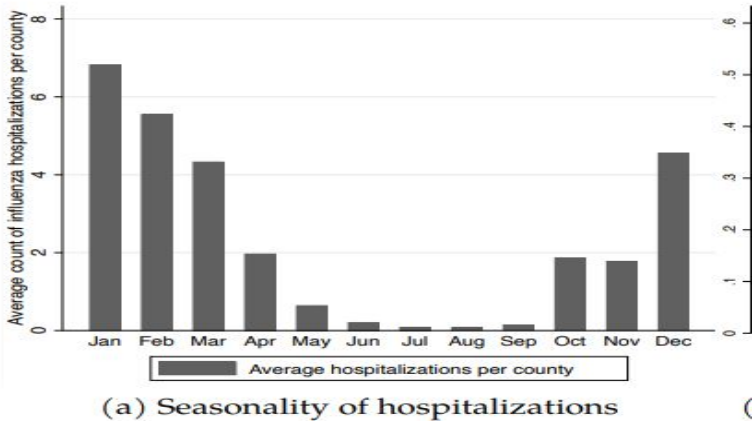
Alongside a global pandemic that has killed millions, residents of the American West have for two consecutive summers confronted unprecedented wildfire seasons. So far this year, roughly 43,500 wildfires have charred more than 5 million acres, and fires continue to grow in frequency and intensity. With them come a number of human health concerns, including the risk that bodies worn down by exposure to smoke could more easily succumb to infectious diseases. PM2.5 attributed to wildfire smoke was associated with a 10 percent increase in hospitalizations for respiratory events. Wildfire-specific PM2.5 appeared to be up to 10 times more harmful to human health than that from other sources. PM2.5 stemming from wildfires has a different composition than particulate matter from other sources. Wildfires burn wood, cause respiratory issues

13. How Wildfires Affect Our Health
    American Lung Association, 2016

In recent years, wildfires have made headlines as they blazed across the west, Alaska and Canada, burning more than 9.8 million acres just last year, according to the National Interagency Fire Center.Not only were people forced to flee their homes, but smoke from fires in the north and west also threaten the lung health of Americans thousands of miles away. In fact, in one fire alone, wildfire pollutants reached people in North Dakota, South Dakota, Minnesota and Iowa from flames in northern Canada. Children who breathed the smoky air during wildfires had more coughing, wheezing, bronchitis, colds, and were more likely to have to go to the doctor or to the hospital for respiratory causes

Incidence of Influenza

According to WHO's Global Health Estimate for 2023, There are around a billion cases of seasonal influenza annually, including 3–5 million cases of severe illness. It causes 290 000 to 650 000 respiratory deaths annually. (WHO) Additionally, there is growing concern about climate change increasing the potential for pandemic viruses, including influenza. Doctors in England have reported three times more flu patients in 2024 than last year (NHS England, 2024). Pollution levels significantly increase flu inpatient hospitalizations; a one-standard-deviation increase in the monthly Air Quality Index (10.9-unit increase) amounts to approximately 35.7% additional flu-related inpatient hospitalizations in the U.S. during influenza season; Influenza hospitalizations due to air pollution accounts for roughly 18% of all respiratory hospitalizations. Influenza and air pollution are significant public health risks that impact nations around the world. The flu causes an estimated 3-5 million severe cases per year, and nearly half a million deaths. Air pollution causes 4.5 million annual deaths, with annual economic costs estimated to exceed $US 800 billion in the U.S. alone. (Zivin J et al.,2022)

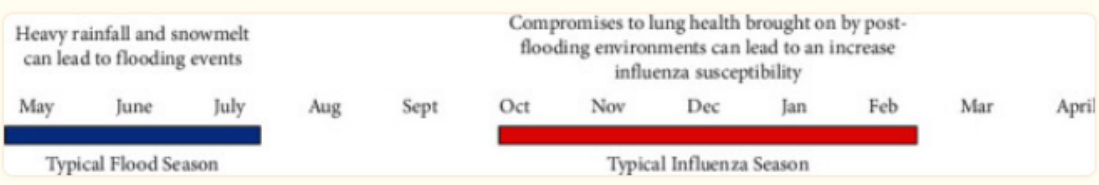


(a) Seasonality of hospitalizations (

The average count of influenza inpatient hospitalizations per county-month in the HCUP (2018b) (Zivin J et al.,2022)

Climate change and Influenza

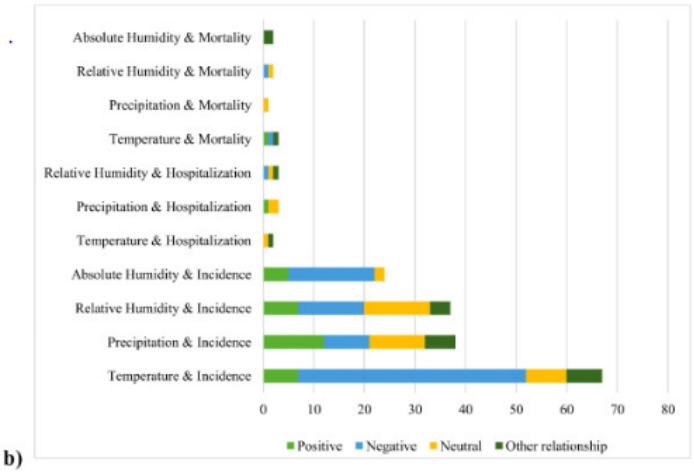
Temperature, UV radiation, and relative humidity are found to be inversely related to influenza virus viability, infectivity, and transmissibility. And absolute humidity was found to have a negative association with incidence. Low temperature is also found to be correlated with high mutation rates of the hemagglutinin protein of the virus, which may affect transmissibility through its ability to adapt to new environments, evade host immune systems, and generate drug-resistant strains (Lane M ***et al.,*** 2022)**,** whereas high temperatures have been associated with increased risks of respiratory disease hospitalizations and mortality. Warm winters are usually followed by more severe influenza epidemics (Andersen Z et al.,2023). Influenza viruses are also known to be more stable in the cold; thus, robust transmission at 5°C and highly inefficient transmission at 30°C may be due to an increased virus half-life at lower temperatures. In considering the effects of temperature, it is important to note that guinea pigs shed higher titers **of influenza A and B viruses** when housed in the cold. Increased shedding may be due to an effect of cold conditions on the host. Transmission at low (5°C) versus intermediate (20°C) temperatures was also tested with **two influenza B viruses** and found to be more efficient under colder conditions. Alternatively, virus may be more stable within the nasal passages when the epithelial surface is cooled by colder ambient air. Increased virion stability at lower temperatures is likely due in part to decreased activities of proteases. In addition, changes in the physical properties of the virion envelope may contribute. At temperatures of <41°C, domains of ordered and disordered lipids were found to coexist within virion membranes. The fraction of lipids within ordered domains, or a gel phase, increased with decreasing temperature (Lowen AC et al., 2014). The Human Influenza virus are most prevalent in conditions associated with wind and dust storms (Uwishema O et al., 2023). Direct exposure to floodwater also increases the risk of influenza-like illnesses.(He Y et al., 2023). Acute respiratory infections like coughs, colds, influenza and pneumonia are common following flood disasters.(Gavi, 2024) The association between extreme precipitation events and risk of emergency room visit for influenza in Massachusetts during 2002–2008 was evaluated. Extreme precipitation was significantly associated with ER visits for influenza in children ages 5–18 years (OR = 1.32 (95%CI: 1.14, 1.52) and adults ages 19–64 years ((OR = 1.23 (95%CI: 1.15, 1.32). Influenza B isolations to be positively associated with daily rainfall . A 24 month study comparing throat and nasal swabs from young children also in India found a strong positive correlation between influenza A virus and rainfall (Smith G et al., 2017). Water-saturated areas caused by flooding are prone to mold growth and growth of other spore-forming microbes that affect respiratory health. Increases in flooding-induced allergens led to increased asthma attacks and subsequently increased risk of influenza infection even months later. Flooding affects many members of a population, exposure to these postflood environments could influence influenza rates at a population level months after initial flooding events (Kontowicz E et at., 2022)



Flood-influenza (flu) year. All data for this study were aggregated to this yearly structure for each three-digit ZCTA in Iowa. (Kontowicz E et at., 2022)

a)

	Temperature	Precipitation	Relative Humidity	Absolute Humidity	Other Climatological Factor
Incidence	67	38	37	24	19
Mortality	3	1	2	2	1
Hospitalizations	2	3	3	0	4



a) Heat map of the epidemiological factors examined across studies on climate change and influenza that found an association between an epidemiological and climatological factor. b) Associations between the climatological factors and epidemiological factors studied in articles on climate change and influenza. Temperature and incidence of influenza saw an inverse relationship, with lower temperature associated with higher. Absolute humidity also often found a negative association with incidence. The associations between incidence and precipitation and relative humidity were less consistent across studies. (Lane M *et al.*, 2022)

Air Pollution and Influenza

Air pollution has adverse effects on influenza outbreaks. Air pollution particles could extend the airborne survival of viruses outside the body and thus increase the probability of disease transmission (Zivin J et al.,2022). **Flu-A** has a higher sensitivity to increased pollution than **Flu-B**. A 10 μg/m3 increment in concentrations of PM2.5, PM10, and O3 at lag 04, was associated with a 2.103 (95%CI: 1.528–2.893), 1.618 (95%CI: 1.311–1.996), and 1.569 (95%CI: 1.214–2.028) of the relative risk (RR) of **Flu-A**, respectively. A 5 μg/m3 increase in NO2 was associated with higher risk of Flu-A at lag 03 (RR = 1.646, 95%CI: 1.295–2.092) (Ma P et al.,2023) Short-term exposure to increased PM, increases susceptibility to respiratory infections including influenza. Lower temperature was associated with higher incidence of **influenza A**. Warmer winters were associated with more severe epidemics of **influenza A and B** during the following winter season. In human bronchial epithelial cells exposed to urban PM, enhanced activation of the NLRP3 inflammasome was observed with increased production of interleukin (IL)-1β following **influenza A** infection, but not RSV infection, suggesting an exaggerated inflammatory response. (Burbank A, 2023). Air pollutants, especially PM2.5, PM10, CO and SO2, can increase the risk of influenza like illness. (Su W et al., 2019). Influenza is negatively correlated with the concentration of O_3 and may have a specific correlation with the bactericidal characteristics of O_3 (Zhang Y et al.,2022) Air pollution can impair the respiratory functioning of patients, it damages the respiratory epithelium, thereby facilitating the progression of influenza virus beyond the epithelial barrier into the lungs. (Zivin J et al.,2022). A study conducted across 47 Chinese

cities showed that, a 10 µg/m3 increase in PM2, was associated with an increased risk of influenza (RR 1.020, 95% CI 1.006, 1.034) (Burbank A, 2023)

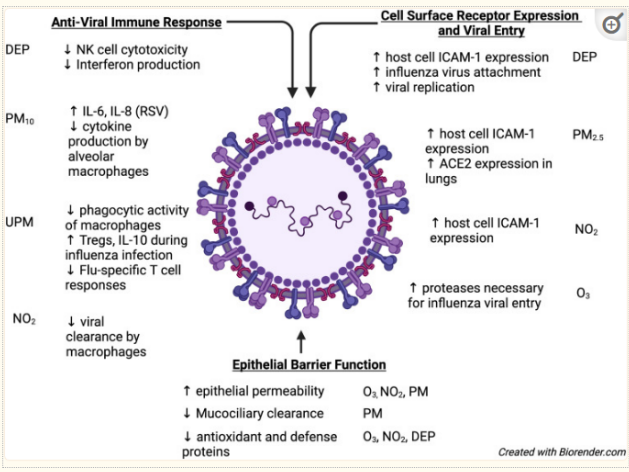


Figure 1

Proposed mechanisms by which air pollutants contribute to viral respiratory infection susceptibility and severity.

Proposed mechanisms by which air pollutants contribute to viral respiratory infection susceptibility and severity. (Burbank A, 2023)

Future Predictions for Influenza outbreak due to climate change an urbanization
Studies have shown that climate change will lead to more persistent outbreaks of influenza, in future. The rapid weather variability in autumn will continue to strengthen in some regions of northern mid-latitudes in a warming climate, implying that the risk of an influenza epidemic may increase 20% to 50% in some highly populated regions in the later 21st century (Liu Qi et al., 2020)

The size of the urban population is positively associated with the incidence of city-level influenza. It is projected that densely populated areas would undergo the greatest rise in rapid intra-season temperature variability by the end of this century, thereby increasing the risk of influenza morbidity by up to 50%. A reduction in relative humidity is associated with a higher risk of **influenza A** in the population (Yang J et al.,2022). Higher population numbers located in increasingly dense urban locations in the tropics, where climate maintains year-round circulation of the virus, could lead to an increase in total strain diversity. Interesting analogies may apply by considering the dynamics **of influenza B**, which has a lower R0 and has a polyphyletic tree for the surface protein (hemagglutinin), compared to the monophyletic tree for influenza A. (Baker R et al.,2021).

HCPs awareness and education to address the climate-related health issues

Health experts have pointed out that health is already being harmed by changes in the climate and the destruction of the natural world. The 2023 United Nations Climate Change Conference (COP28) in Dubai demonstrated the growing interest and engagement of the health community in the climate fight. More than 40 million health professionals from around the globe joined the call to action by the World Health Organization (WHO) and civil society organizations, to prioritize health in climate negotiations at COP28. Health workers demand immediate and bold action to phase out fossil fuels, transition to clean energy, build resilience and to support people and communities most vulnerable to impacts of the changing climate (WHO, 2023). For the first time, more than 110 state health ministers attended COP alongside their peers in environment, finance and other sectors. This signaled a shift in how climate policies are considered, with a stronger focus on the social and health implications of decision-making. The health community has grown in both size and confidence, emerging as a formidable ally for those engaged in climate action (UN MERIT, 2024)

PAHO offers essential information for medical personnel and other health professionals to realize the impacts of climate change on their daily practice. With this quick reference guide, providers can easily recognize diseases and side effects related to climate change, implement appropriate management and provide guidance to exposed populations, provide up-to-date information on the relationship between the adverse effects of certain drugs and the worsening of climate-sensitive health conditions, and determine the possible consequences of climate change for health services (PAHO, Pocket Book)

Main activities by PAHO Climate Change and Health team:

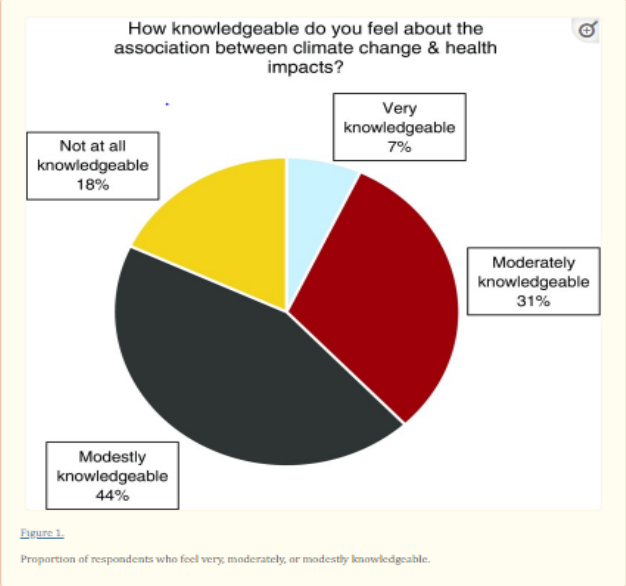
- Improve health infrastructure: assess and transform health infrastructure to make them safer and operational during and after climate-related events, and using greener technologies;
- Provide training and awareness-raising: capacity building through workshops and courses on climate change and health, on site and at PAHO's virtual campus;
- Build partnerships for health co-benefits: promote and measure health co-benefits of intersectoral mitigation actions (PAHO)

A survey done to understand the views of HCP on climate change and health concluded that 86% of HCP say that they have a responsibility to inform the public about the health effects of climate change, and 90% say that they need to inform policymakers. But 76% of those surveyed say that they need continuing medical education on climate change and health. (Kotcher J et al.,2021)

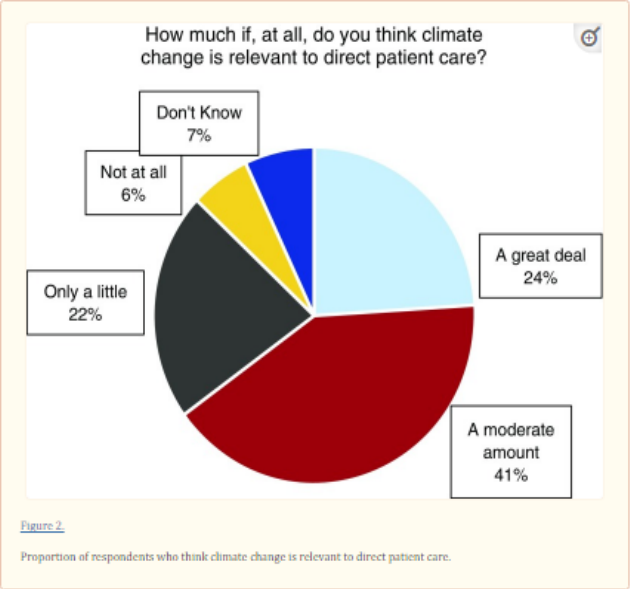
HCP's are taking initiative to discuss climate change effects on respiratory health.
In a survey on "climate change and health" done in 5,500 randomly selected members of American Thoracic Society (ATS) to assess their perceptions of, clinical experiences with, and preferred policy responses to climate change found that:

1. 38% of respondents felt "moderately" or "very" knowledgeable about the association between climate change and health; 44% felt "modestly" knowledgeable.
2. The most common health effects that participants noted among their own patients were air pollution–related increases in severity of chronic disease (77%), increased allergic symptoms (58%), injuries due to severe weather (57%), and heat-related effects (48%).

3. Across all the categories of health effects, more physicians thought their patients would experience harms in the next 10 to 20 years than are harmed currently
4. The survey indicated a significant majority believed physicians should play a role in responding to climate change including informing the public about the health effects of climate change (72%); informing patients on the health effects of climate change (62%); and encouraging offices, clinics, and hospitals to be environmentally sustainable (80%) (Sarfaty M et al, 2015)



Proportion of respondents who feel very, moderately, or modestly knowledgeable.



Proportion of respondents who think climate change is relevant to direct patient care.

To improve indoor air quality and reduce respiratory disease exacerbations, HCP advise the patients to do the following:

5. Use an air purifier
6. Close windows that face roadways
7. Remove shoes at entryways
8. Properly ventilate a gas stove or switch to an electric stove
9. Evaluate chemicals used in home cleaning.
10. Check local outdoor air-quality conditions, including smog levels, and to limit outdoor activities
11. Counsel patients on monitoring indoor air quality
12. Medication adjustments: Alternative choices might be appropriate for patients who need prescription inhalers. Inhaled corticosteroids and dry-powder inhalers are better options than metered-dose inhalers
    Climate change and respiratory disease: clinical guidance for healthcare professionals. (CCJM,2023).
13. Promote climate-friendly activities and lifestyle among patients leading to personal health and planetary co-benefits
14. Connect with nature to improve physical and mental health (Andersen ZJ et. al.,2023)

15. Use a humidifier to minimize the harmful impact of dry air in indoor spaces during winter. The ideal humidity level is between 30 and 50 percent.
16. Check the indoor heating system and do proper maintenance annually. In homes with a forced-air heating system, the air filter should be changed regularly
17. Use nasal saline spray or gel to prevent dry nose and nasal congestion (BayHealth)
18. Saline irrigation help the nose by removing mucous, pollutants and particulate matter, reduce congestion and improve symptoms such as coughing, sneezing and dry nasal passages. Doing a nasal saline irrigation once or twice daily can be extremely beneficial
19. Use respirator masks, air purifiers and HEPA filters to protect from the pollution (MultiCareVitals)
20. An N95 mask can help block air pollutants.
21. keep quick-relief medications on hand (BannerHealth)
22. Cean shared spaces to control the spread of infections (Piedmont)

Patients' awareness on below preventive measures to tackle climate change:

- Check air quality index on a weather app or bookmarked website.
- Follow simple measures to improve indoor air quality, such as removing shoes and dusting (Ilyssa O et al, 2023)
- Disinfection and good personal hygiene emphasised in guidelines from all countries to reduce the risk of enterovirus transmission (Enteroviruses one of the virus causes mild common cold, survives longer on low temperature and high humidity) (Chan Y, 2023)
- Adequate ventilation with outdoor air is recommended in all settings to reduce the transmission of influenza and other respiratory infections,
- Use of face mask can help reduce the risk of infection due to exposure to infectious droplets and aerosol,
- Wash or clean your hands frequently at least 20 seconds each time,
- If you are sick, you should cover your nose and mouth with a tissue or a mask (but not a hand) when coughing or sneezing,
- Avoid touching your eyes, nose or mouth,
- Avoid close contact with sick people (ECDPC, 2024)

A study done on "Do Americans understand how air pollution from fossil fuels harms health?" found that: (Kotcher, J. et al., 2019)

1. Most Americans (73%) are aware that air pollution from the use of fossil fuels harms human health. However, only about half (55%) are able to name even one such health impact
2. The most frequently cited health impacts are general (e.g., breathing problems, respiratory illness) rather than specific (e.g., asthma).

Air pollution-related health problems identified by respondents (open-ended)	%
General respiratory problems	35
Don't know	20
Asthma	16
Other cancer	14
No response	13
Air pollution doesn't harm health	9
Poor air quality	6
Lung cancer	5
COPD	5
Heart disease	3
Other	3
Allergies	3
Birth defects/premature birth	1
Skin irritation	1
Special populations affected	1
Climate change	1
Eye irritation	1
Neurological problems	1
Unintelligible	1
Death	1
Black lung	0
Immune deficiencies	0
Diabetes	--

A Cross-Sectional Survey Study done on "Public Perceptions of Climate Change and Health", collected and analysed 697 full data sets and found that:

1. Majority of participants agreed that human-induced climate change exists (85%), and that it has an impact on human health (83%).
2. They also perceived the global population to be more strongly impacted by climate change than themselves (89% versus 68%) (Baal K et al, 2023)

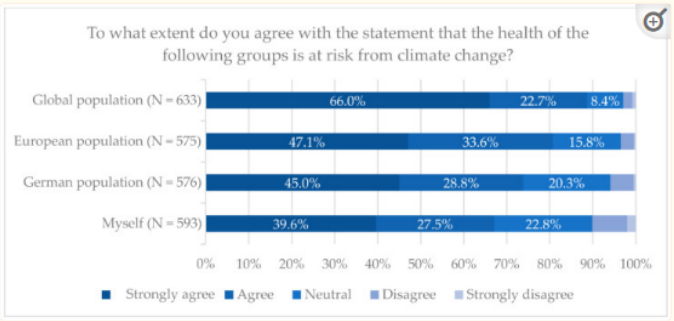


Figure 1

Health at risk from climate change, by population group.

Suspected or perceived risks and health consequences associated with climate change.

Which health risks do you perceive as connected to climate change? (N = 648)		
Accidents and death from extreme weather events (e.g., heat, cold, storms, landslides)	61.6	38.4
Skin cancer	51.7	48.3
Respiratory diseases	51.2	48.8
Allergies	39.6	42.6
Infectious diseases	56.2	43.8
Psychological trauma	38.6	61.4
Other	9.0	91.0

Have you already experienced health changes connected to climate change? (N = 627)		
Yes	114	18.2
No	340	54.2
Perhaps	173	27.6
If yes, what are those health changes? (N = 114)		
Accidents and their consequences	3	2.6
Infectious diseases	20	17.5
Cancer	10	8.8
Malnutrition	3	2.6
Psychological trauma	19	16.7
Allergies (e.g., new entrants, increases or extensions)	63	55.3
Respiratory diseases	41	36.0
Other (e.g., allergic reactions, circulation problems)	40	35.1

Conclusion

Climate change and air pollution have demonstrable impacts on the incidence and severity of cold, influenza, and flu-like illnesses. Although healthcare providers are increasingly aware of these impacts, there is a significant need for ongoing education and better communication strategies to inform both the medical community and the public. Enhancing awareness and adopting preventive measures could mitigate some of the adverse health outcomes associated with climate change.