Disaster Medicine and Public Health Preparedness

www.cambridge.org/dmp

Public Health Preparedness in the Era of Weather Modification and Climate Engineering

Christos Tsagkaris MD[1], Andreas S. Papazoglou MD, MSc[2], Dimitrios V. Moysidis MD, MSc[3] and Anna Loudovikou MSc[4]

[1]European Student Think Tank, Public Health and Policy Working Group, Amsterdam, Netherlands; [2]Athens Naval Hospital, Athens, Greece; [3]Hippokration University Hospital, Aristotle University of Thessaloniki, Thessaloniki, Greece and [4]Aristotle University of Thessaloniki, Faculty of Philosophy, Thessaloniki, Greece

Brief Report

Cite this article: Tsagkaris C, Papazoglou AS, Moysidis DV, Loudovikou A. Public health preparedness in the era of weather modification and climate engineering. *Disaster Med Public Health Prep*. **17**(e308), 1–3. doi: https://doi.org/10.1017/dmp.2022.274.

Keywords:
climate engineering; public health preparedness; weather modification

Corresponding author:
Andreas S. Papazoglou,
Email: andreaspap797@gmail.com.

Abstract

The use of technological and chemical means aiming to achieve favorable weather conditions or reduce the risk of weather extremes is known as Weather Modification (WM). The United States of America, the People's Republic of China, Thailand, the United Arab Emirates, and Europe have employed WM in an effort to prevent hurricanes and storms, control precipitations, mitigate deforestation and drought, and enhance agriculture. Recently, the use of WM has been expanded toward decreasing air pollution and creating favorable weather conditions for major political and athletic events. The increasing significance and use of WM call for consideration upon its positive and negative effects on human health, close collaboration among health experts and WM decision makers, and relevant public health emergency contingency planning.

Weather modification (WM) pertains to the use of technological and chemical means, aiming to achieve or prolong favorable weather conditions and reduce the risk of weather extremes. The first scientific weather modification attempts were recorded in the 19th century. WM was widely used between 1950 and 1970 in both the military sector and agriculture. While its use in warfare was prohibited, WM was further researched and used in the United States of America, the People's Republic of China, Thailand, and the United Arab Emirates (UAE) in an effort to prevent hurricanes and storms, mitigate deforestation and drought, and enhance crop production.[1] Recent reports suggest that WM was deployed to decrease air pollution in large urban centers and create favorable weather conditions for major political and athletic events,[2] inaugurating what is considered as the era of climate engineering. The increasing significance and use of WM call for consideration upon its positive and negative effects on human health.

Evidence Regarding Weather Modification

A rapid search in major biomedical research databases reveals limited knowledge on the matter. The majority of studies document environmental impacts of cloud seeding but provide limited information regarding its actual effect on human health. In this sense, it has become obvious that WM can lead to increased air stagnation over residential areas, particularly during winter,[3,4] as well as to a decrease in the photosynthetic ability of terrestrial plants and phytoplankton.[5,6] The available studies have also examined the distribution of particles used for the purpose of WM in atmospheric air[7] or in the water[8] and novel cloud seeding techniques capable of decreasing the amount of greenhouse gases trapped by the clouds.[9] Such studies provide a standpoint for hypotheses and predictions and show a considerable knowledge gap with regard to WM safety and potential health benefits.

To date, not only studies on toxicity of compounds used in cloud seeding are limited, but also some of them have gained expressions of concern or been retracted on the grounds of scientific integrity.[10,11] It appears that WM-associated air stagnation can trigger asthma exaggeration,[12] while manual treatment of cloud seeding compounds increases the risk for occupational contact dermatitis.[13] Until a large-scale investigation of the real-world health implications of WM means and techniques is performed, relevant public health preparedness needs to be based on the existing knowledge about the interconnection of climate, climate change, and climate adaptation on human health.

Health Considerations on Weather Modification

Climate conditions can have direct and indirect effects on health. Direct health implications include respiratory disease exacerbation, skin and eye inflammation due to low air humidity,[14]

blood pressure and heart rhythm irregularities due to low or high temperatures,[15] and altered transmission dynamics in cases of weather conditions favoring indoor gatherings or proliferation of zoonotic disease vectors and radiation-associated skin cancer.[16] Indirect health implications stem from climate change intercepting the social determinants of health. Increased temperatures, reduced rainfall, droughts, and the opposites of them can equivocally harm agricultural economy, travel and tourism, undermine food security, professional and financial stability, and pave the way toward irregular migration.[17] Simultaneously, the provision of health care services is also subject to adverse weather conditions that hinder the commute of health care professionals, patients, and supplies, or destroy sensitive equipment.[18]

While WM is regarded as reparative action toward the aforementioned climate conditions, it is still likely that efforts to decrease the temperature or induce rainfall can backfire in the form of freeze damage and floods, and vice versa. For instance, cloud seeding over remote agricultural communities with a high prevalence of respiratory and cardiovascular diseases and limited access to emergency health care may undermine the benefits from increased crop production. Similarly, unexpected rainfall or snowfall can pose a threat to remote communities, who will be deprived of supplies or access to emergency care.[19] Providing remote communities with adequate supplies, instructing people with respiratory conditions to wear a mask or stay indoors, enhancing epidemiological surveillance for zoonotic disease outbreaks, or even postponing skiing, hiking, and rafting activities in potentially affected areas are some representative examples. WM planning can become safer as long as the frequency of likely-to-be-exacerbated diseases or the presence of zoonotic disease vectors in the local biota is taken into account. Therefore, WM attempts should be promptly communicated with public health authorities to create contingency plans for WM-associated "adverse events."

WM has also the potential to benefit health. So far, rain enhancement in the UAE has improved the population's access to water. Thriving agriculture has also leveraged the living standards of communities that would otherwise face poverty.[20] Similarly, decreasing greenhouse gases can also decrease the burden of asthma, rhinosinusitis, and chronic obstructive pulmonary disease in the course of time.[9] At a larger scale improving agricultural production, maritime, trade, travel, and transportations by means of WM can contribute to financial growth, part of which can be channeled toward biomedical advances and equitable health care. In the foreseeable future, this can contribute to addressing the global financial effects of coronavirus disease (COVID-19).

Conclusions and Recommendations

Certainly, this cannot be achieved unless regulators, international organizations, and health bodies work together to monitor and mitigate the potential adverse health implications of WM. The Convention on the prohibition of military or any other hostile use of environmental modification techniques sets a worthy precedent.[21] In response to the wider use of WM, a new pact safeguarding health and well-being should be put in place. Researchers, health care professionals, and health advocates must stress that WM without public health preparedness and contingency plans can backfire into a considerable disease burden and financial disruption. The current COVID-19 pandemic has set a clear example of the potential of health crises to impact the global economy, and this notion should be respected by those who make decisions on WM.

In the future, it is possible that WM will be used widely.[22] Denouncing the use of technological and chemical means for this purpose would be unrealistic. On the contrary, putting together public health preparedness and contingency plans, and urging decision-makers to adhere to them, is a worthy endeavor.

Funding statement. None.

Conflict(s) of interest. None.

References

1. **Chalmin A.** Updates on weather modifications and other technologies. Published 2020. Accessed January 10, 2022. https://www.geoengineeringmonitor.org/2020/12/updates-on-weather-modifications-and-other-technologies-quarterly-4-part-3/
2. **Davidson H.** China 'modified' the weather to create clear skies for political celebration – study. Published 2021. Accessed January 10, 2022. https://www.theguardian.com/world/2021/dec/06/china-modified-the-weather-to-create-clear-skies-for-pol.itical-celebration-study
3. **Liao T, Gui K, Jiang W, *et al.*** Air stagnation and its impact on air quality during winter in Sichuan and Chongqing, southwestern China. *Sci Total Environ.* 2018;635:576-585. doi: 10.1016/j.scitotenv.2018.04.122
4. **Garrido-Perez JM, Ordóñez C, García-Herrera R, Barriopedro D.** Air stagnation in Europe: spatiotemporal variability and impact on air quality. *Sci Total Environ.* 2018;645:1238-1252. doi: 10.1016/j.scitotenv.2018.07.238
5. **Rodríguez-Sánchez VM, Rosas U, Calva-Vásquez G, Sandoval-Zapotitla E.** Does acid rain alter the leaf anatomy and photosynthetic pigments in urban trees? *Plants (Basel, Switzerland).* 2020;9(7). doi: 10.3390/plants9070862
6. **Fajardo C, Costa G, Ortiz LT, *et al.*** Potential risk of acute toxicity induced by AgI cloud seeding on soil and freshwater biota. *Ecotoxicol Environ Saf.* 2016;133:433-441. doi: 10.1016/j.ecoenv.2016.06.028
7. **Lou H, Zhao C, Yang S, *et al.*** Quantitative evaluation of legacy phosphorus and its spatial distribution. *J Environ Manage.* 2018;211:296-305. doi: 10.1016/j.jenvman.2018.01.062
8. **Deng X-L, Shi C-E, Wu B-W, *et al.*** Characteristics of the water-soluble components of aerosol particles in Hefei, China. *J Environ Sci (China).* 2016;42:32-40. doi: 10.1016/j.jes.2015.07.010
9. **Storelvmo T, Boos WR, Herger N.** Cirrus cloud seeding: a climate engineering mechanism with reduced side effects? *Philos Trans Ser A Math Phys Eng Sci.* 2014;372(2031). doi: 10.1098/rsta.2014.0116
10. **Frontiers Editorial Office**. Retraction: human and environmental dangers posed by ongoing global tropospheric aerosolized particulates for weather modification. *Front Public Health.* 2016;4:156. doi: 10.3389/fpubh.2016.00156
11. **Herndon JM.** Evidence of coal-fly-ash toxic chemical geoengineering in the troposphere: consequences for public health. *Int J Environ Res Public Health.* 2015;12(8):9375-9390. doi: 10.3390/ijerph120809375
12. **Norris G, Larson T, Koenig J, *et al.*** Asthma aggravation, combustion, and stagnant air. *Thorax.* 2000;55(6):466-470. doi: 10.1136/thorax.55.6.466
13. **Ng WT, Koh D.** Occupational contact dermatitis in manual cloud seeding operations. *Singapore Med J.* 2011;52(5):e85-e87.
14. **Sato M, Fukayo S, Yano E.** Adverse environmental health effects of ultra-low relative humidity indoor air. *J Occup Health.* 2003;45(2):133-136. doi: 10.1539/joh.45.133
15. **Liu C, Yavar Z, Sun Q.** Cardiovascular response to thermoregulatory challenges. *Am J Physiol Heart Circ Physiol.* 2015;309(11):H1793-H1812. doi: 10.1152/ajpheart.00199.2015
16. **Joszt L.** A complex web of factors causes climate change to increase the risk and burden of skin cancer. Published 2021. Accessed January 10, 2022. https://www.ajmc.com/view/a-complex-web-of-factors-causes-climate-change-to-increase-the-risk-and-burden-of-skin-cancer
17. **Semenza JC, Ebi KL.** Climate change impact on migration, travel, travel destinations and the tourism industry. *J Travel Med.* 2019;26(5):taz026. doi: 10.1093/jtm/taz026

18. **Paavola J.** Health impacts of climate change and health and social inequalities in the UK. *Environ Health.* 2017;16(1):113. doi: 10.1186/s12940-017-0328-z
19. **Friedrich K, Ikeda K, Tessendorf SA, *et al.*** Quantifying snowfall from orographic cloud seeding. *Proc Natl Acad Sci U S A.* 2020;117(10): 5190-5195. doi: 10.1073/pnas.1917204117
20. **Munoz LMP.** Seeding change in weather modification globally. World Meteorological Organization. Published 2017. Accessed January 10, 2022. https://public.wmo.int/en/resources/bulletin/seeding-change-weather-modification-globally
21. **Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques**. United Nations Treaty Collections. Published 1976. Accessed January 10, 2022. https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVI-1&chapter=26&clang=_en
22. **Zielinski S.** Is weather control a dream or nightmare? Published 2017. Accessed January 10, 2022. https://www.sciencenewsforstudents.org/article/weather-control-dream-or-nightmare

https://doi.org/10.1017/dmp.2022.274 Published online by Cambridge University Press