Role of a Habitat's Air Humidity in Covid-19 Mortality.

Irina V. Biktasheva[1,2,*]

[1] *Department of Computer Science, University of Liverpool, Liverpool L69 3BX, UK*
[2] *CEMPS, University of Exeter, Exeter EX4 4QF, UK*

(Dated: April 17, 2020)

Transient local over-dry environment might be a contributor and an explanation for the observed asynchronous local rises in Covid-19 mortality. We propose that a habitat's air humidity negatively correlate with Covid-19 morbidity and mortality, and support this hypothesis on the example of publicly available data from German federal states.

Keywords: COVID-19 Mortality; Habitat; Air Humidity; Negative Correlation

Introduction. Covid-19 virus (Zhou *et al.*, 2020) is transmitted through droplets which last longer in humid air. Therefore, humidity is believed to be pro-Covid-19 infection and mortality. There are, however, data that contradict this belief. For instance, Wuhan, where Covid-19 was first identified and studied, is in humid subtropical climate zone (Wiki-Wuhan, 2020), but December, when mortality sharply raised, is the driest month of the year there. The purpose of this communication is to present and substantiate a viewpoint that air humidity negatively correlate with Covid-19 morbidity and mortality.

The main hypothesis consists of two parts, of different degree of plausibility. First, mucous membranes of the upper respiratory tract present the first and essential barrier against Covid-19 virus entering human organism. Hence the state of the mucous membranes is a correlate to organism's resistivity. Second, a dry season normally cause respiratory mucosa to become over-dry. In presence of Covid-19 virus the latter might become a factor of massive fatality.

Direct evidence in support of the hypothesis. Correlation of Covid-19 with age, both in terms of registered cases and of mortality is the first and best known fact about this strain (Xu, Mao, and Chen, 2020). The state of respiratory mucosa also correlates with age (Beule, 2010).

Correlation of Covid-19 mortality with low air humidity is less obvious. By way of anecdotal evidence, in addition to the coincidence of the beginning of the epidemic with the dry season in Wuhan mentioned above, note that Seoul and especially Tokyo, where the incidence and mortality have been lower, have on average wetter climate (Wiki-Seoul, 2020; Wiki-Tokyo, 2020). Correlate of sharp raise in Covid-19 mortality with local dry period may also be seen on the example of Lombardy, where February is the driest month in Milan (Wiki-Milan, 2020), as opposed to a wetter beginning of the spring in Rome (Wiki-Rome, 2020). The much dryer March in Spain as opposed to e.g. more humid neighbouring Portugal (Wiki-Lisbon, 2020) seem to point in the same direction of raise in Covid-19 mortality correlate with transient over-dry local environment.

As an illustrative and preliminary example of a more systematic evidence, we have considered Covid-19 mor-

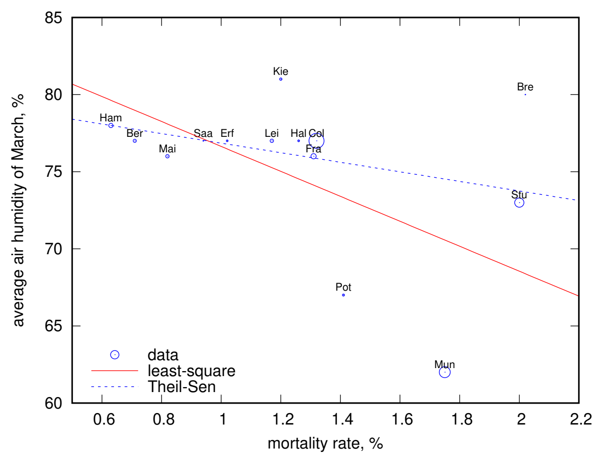

FIG. 1 Air humidity in March vs Covid-19 mortality in German federal states (circles). The size of the circles is proportional to the population of the federal state; the labels are abbreviations for the largest cities of the federal lands. Red solid line shows the linear regression. Theil-Sen regression is shown with the blue dashed line.

* ivb@liverpool.ac.uk

tality rate, defined as the number of deaths per number of confirmed infections, in German federal states (Wiki-Pandemic-Germany, 2020) where the majority of deaths happened last March 2020. FIG.1 shows the Covid-19 mortality rate in the federal states vs the average local air humidity in March. The local air humidity was defined as proxy recorded in the largest city of each federal state (Weather and Climate, 2020). The choice of the German federal states data sets is motivated by the data availability and reliability, and, in particular, by the presumed uniformity of the data collection protocols in Germany. Mecklenburg-Vorpommern has been excluded as the resource (Weather and Climate, 2020) gives no humidity data neither for Rostock nor for Schwerin. The linear least squares fit (red solid line), weighted by the most recent population size of the federal states as given by Wikipedia, gives the slope of -8.09 with a standard deviation of ± 3.32, i.e. reliably negative. We have also applied the Theil-Sen estimator, also weighing the data points proportionally to population sizes, which gives the slope of -3.10. The corresponding fits are also shown in FIG.1 (blue dashed line). The discrepancy between the linear and Theil-Sen estimates are not surprising as the problem is clearly multi-factorial and we are looking at only one of the factors. Still, the two estimates concur that the slope of the dependence is negative, that is mortality is on average higher in a drier air and lowers with rise of air humidity, which confirms our hypothesis on negative correlate of Covid-19 mortality with local air humidity.

Note that (Klein *et al.*, 2020) presents evidence of negative correlation of air humidity with Covid-19 transmission rate based on all-China data. A similar study (Ma *et al.*, 2020) based on Wuhan data indicates negative correlation of air humidity with Covid-19 mortality. Both of the studies did not seem to take into account the effect of non-causal correlation between the seasonal increase of humidity and decrease in transmission rate due to the taken administrative measures. Still, both studies are interesting as they present an approach complementary to the one we used in FIG.1, namely, both studies do not take into account regional variations of air humidity and Covid-19 statistics; instead, (Ma *et al.*, 2020) is exploiting their temporal variations. In any case, the overall conclusion from those studies concurs with our hypothesis.

The above is “direct” evidence as it allows one to hypothesise direct causal relationship: dry air causing overdry respiratory mucosa in older and vulnerable population causing increase of Covid-19 mortality.

Indirect evidence in support of the hypothesis. Dry nasal mucosa correlates with loss of smell and taste (Beule, 2010), and loss of smell and taste correlates with Covid-19 statistics (Bagheri *et al.*, 2020).

Dry air is a known risk factor for dry eyes (NHS UK, 2018), with dry eyes being a risk factor for conjunctivitis (Brazier, 2018). Recent reports show correlates of Covid-19 statistics with conjunctivitis (Chen *et al.*, 2020; The Royal College of Ophthalmologists and College of Optometrists, 2020).

Some groups of patients identified as particularly vulnerable to Covid-19, e.g. diabetes (Xu, Mao, and Chen, 2020), also correlate with the diminished function of respiratory mucosa (Beule, 2010).

For these above evidence, the direction of causal links, if any, is less clear.

Verifiable predictions of the hypothesis. A direct verification of the proposed hypothesis would be analysis of the instant local air humidity in the statistics of Covid-19 incidence and mortality. A statistically significant correlation would confirm the hypothesis.

A more sophisticated way of checking the hypothesis would be via spatiotemporal modelling of the pandemic. Such modelling, which no doubt will be attempted by many research groups, will be most successful if and when it takes into account as many relevant factors as possible. Hence if the proposed hypothesis is true, taking into account the air humidity of the habitat would improve the quality and predictive power of the models.

Discussion and practical consequences. Air humidity depends on multiple parameters: the local instant and annual rate of precipitation, diurnal and annual temperature range, altitude, etc. That is why it is so difficult to estimate air humidity based on e.g. local precipitation only.

If the negative correlate of Covid-19 mortality with air humidity is verified, it might suggest certain practical steps in addition to the medical and administrative measures already in place, and those yet to be proposed based on other considerations.

Iceland’s Covid-19 screening showed people of all ages equally susceptible for the infection (Iceland Review, 2020), with about 50% of those infected having no symptoms at the time of testing (Ćirić, 2020). In the view of the latter, the world wide correlation of Covid-19 with age might appear to be skewed towards those patients showing more symptoms and therefore more tested. Therefore, it might be useful to distinguish between the spread of Covid-19 infection and the asynchronous local rises of Covid-19 mortality. For instance, a prolonged dry weather may be taken as an indication of likely local elevation of Covid-19 mortality. In Madrid, August is the driest month of the year (Wiki-Madrid, 2020), so preventative measures might be indicated to forestall or flatten the second wave of Covid-19 there. On a general point, it might take at least an annual cycle of the global data to fully appreciate the spatiotemporal pattern of Covid-19 pandemic, and build the data based model.

In presence of Covid-19 virus, patients with tendency to dry respiratory mucosa might be particularly vulnerable to the exposure to dry air. Indoor environment might become over-dry due to the winter central heating, domestic devices producing heat, especially if the only source of the indoor humidity are people themselves which might be not enough. It might be not possible to alter local microclimate, not to mention an instant change of the global one. However, control of indoor environment is feasible and might mitigate patients' exposure to Covid-19. Balance of exposure to Covid-19 virus in dry air against the well known exposure to bacterial infection in a humid environment must be taken into account when developing a healthy indoor technology. To the author's knowledge, this aspect has not yet been discussed, while, if true, this could immediately start saving lives, which is the reason for this publication.

Availability of supporting data. The datasets used and/or analysed in this paper are available from the websites.

Declaration of interests. The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement This paper is entirely the author's initiative. It does not result from any funded research project. The author is grateful to Professor Vadim Biktashev, Dr Sergey Blagodatsky, and Dr Evgenia Blagodatskaya, for much valued discussion of this paper.

REFERENCES

Bagheri, S. H. R., Asghari, A. M., Farhadi, M., Shamshiri, A. R., Kabir, A., Kamrava, S. K., Jalessi, M., Mohebbi, A., Alizadeh, R., Honarmand, A. A., Ghalehbaghi, B., and Salimi, A., "Coincidence of COVID-19 epidemic and olfactory dysfunction outbreak," https://doi.org/10.1101/2020.03.23.20041889 (2020).

Beule, A. G., GMS Current Topics in Otorhinolaryngology - Head and Neck Surgery **9**, Doc07 (2010).

Brazier, Y., "What is dry eye and how can I get rid of it?" https://www.medicalnewstoday.com/articles/170743, accessed April 6, 2020 (2018).

Chen, L., Deng, C., Chen, X., Zhang, X., Chen, B., Yu, H., Qin, Y., Xiao, K., Zhang, H., and Sun, X., "Ocular manifestations and clinical characteristics of 534 cases of COVID-19 in China: A cross-sectional study," https://doi.org/10.1101/2020.03.12.20034678 (2020).

Ćirić, J., "Is Icelands coronavirus testing showing that 50% of cases have no symptoms?" https://www.icelandreview.com/sci-tech/is-icelands-coronavirus-testing-showing-that-50-of-cases-have-no-symptoms/, accessed April 12, 2020 (April 2, 2020).

Iceland Review, "Whats the status of COVID-19 in Iceland?" https://www.icelandreview.com/ask-ir/whats-the-status-of-covid-19-in-iceland/, accessed April 12, 2020 (April 2, 2020).

Klein, E., Lin, G., Tseng, K., Schueller, E., Kapoor, G., and Laxminarayan, R., "COVID-19 for India updates," https://cddep.org/wp-content/uploads/2020/03/covid19.indiasim.March23-2-4.pdf (March 20, 2020).

Ma, Y., Zhao, Y., Liu, J., He, X., Wang, B., Fu, S., Yan, J., Niu, J., Zhou, J., and Luo, B., Science of The Total Environment **724**, 138226 (2020).

NHS UK, "Dry eyes," https://www.nhs.uk/conditions/dry-eyes/, accessed April 6, 2020 (2018).

The Royal College of Ophthalmologists, and College of Optometrists,, "Viral conjunctivitis and COVID-19," https://www.college-optometrists.org/the-college/media-hub/news-listing/viral-conjunctivitis-and-covid-19.html, accessed April 6, 2020 (March 19, 2020).

Weather and Climate, https://weather-and-climate.com, accessed April 6, 2020 (2020).

Wiki-Lisbon, https://en.wikipedia.org/wiki/Lisbon#Climate, accessed April 6, 2020 (2020).

Wiki-Madrid, https://en.wikipedia.org/wiki/Madrid#Climate, accessed April 6, 2020 (2020).

Wiki-Milan, https://en.wikipedia.org/wiki/Milan#Climate, accessed April 6, 2020 (2020).

Wiki-Pandemic-Germany, https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Germany, accessed April 6, 2020 (2020).

Wiki-Rome, https://en.wikipedia.org/wiki/Rome#Climate, accessed April 6, 2020 (2020).

Wiki-Seoul, https://en.wikipedia.org/wiki/Seoul#Climate, accessed April 6, 2020 (2020).

Wiki-Tokyo, https://en.wikipedia.org/wiki/Tokyo#Climate, accessed April 6, 2020 (2020).

Wiki-Wuhan, https://en.wikipedia.org/wiki/Wuhan#Climate, accessed April 6, 2020 (2020).

Xu, L., Mao, Y., and Chen, G., "Risk factors for severe corona virus disease 2019 (COVID-19) patients : a systematic review and meta analysis," https://doi.org/10.1101/2020.03.30.20047415 (2020).

Zhou, P., Yang, X.-L., Wang, X.-G., Hu, B., Zhang, L., Zhang, W., Si, H.-R., Zhu, Y., Li, B., Huang, C.-L., Chen, H.-D., Chen, J., Luo, Y., Guo, H., Jiang, R.-D., Liu, M.-Q., Chen, Y., Shen, X.-R., Wang, X., Zheng, X.-S., Zhao, K., Chen, Q.-J., Deng, F., Liu, L.-L., Yan, B., Zhan, F.-X., Wang, Y.-Y., Xiao, G.-F., and Shi, Z.-L., Nature **579**, 270 (2020).