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Short Communication

Effect of temperature on the infectivity of COVID-19

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ABSTRACT

Objectives: To evaluate the influence of temperature on the infectivity of COVID-19 in Japan.
Methods: We evaluated the relationship between the accumulated number of patients per 1,000,000 population and the average temperature in February 2020 in each prefecture by Poisson regression analysis. We introduced the monthly number of inbound visitors from China in January 2020 in each prefecture and old-age dependency ratio as additional explanatory variables in the model.
Results: Monthly inbound visitors from China in January 2020, old-age dependency ratio, and mean temperature in February 2020 are associated with the cumulative number of COVID-19 case on March 16, 2020.
Conclusions: Our analysis showed a possible association between low temperature and increased risk of COVID-19 infection. Further evaluation would be desirable at a global level.

1. Introduction

The outbreak of novel coronavirus infection (COVID-2019) was first identified in Wuhan, China, in December 2019 (Zhu et al., 2020). A large number of cases have since occurred outside China, and the World Health Organization (WHO) declared the COVID-19 outbreak to be a pandemic in March 2020.

According to WHO situation report as of March 18, 2020 (World Health Organization, 2020), outside of China, Europe currently has registered the most cases to date, with other Asian countries registering a comparatively small number of cases.

Given the climatic differences between Europe and Asia, it seems reasonable to hypothesize that temperature is associated with the infectivity of COVID-19. This short report examines the relationship between temperature and the accumulated number of COVID-19 cases in Japan at the prefectural level.

2. Methods

Between January 15 and March 16, 2020, the Japanese Ministry of Health, Labour and Welfare reported 702 confirmed cases of COVID-19 across the country's 47 prefectures. Using data publicly available on the government's websites (Japan Meteorological Agency, 2020, Ministry of Health Labour and Welfare, 2020, Ministry of Justice, 2020), we evaluated the relationship between the accumulated number of patients per 1,000,000 population and the average temperature in February 2020 in each prefecture by Poisson regression analysis. We introduced the monthly number of inbound visitors from China in January 2020 and old-age dependency ratio (the ratio of the number of people aged 65 and over, compared to the number of people 15-64 years old, derived from the website of Japanese government) in 2019 (Ministry of Internal Affairs and Communications, 2020) in each prefecture as additional explanatory variables in the model in order to reflect heterogeneity in force of infection from imported cases and age-structure of population. Statistical significance was defined by two-sided p-values < 0.05. Analysis was conducted by R, version 3.6.2 (R Core Team, 2018).

3. Results

Table 1 shows the cumulative number of COVID-19 cases per 1,000,000 population, the monthly inbound visitors from China in January 2020 per 1,000 population, and old-age dependency ratio. Table 2 shows the results of the Poisson regression analysis. All variables are associated with the cumulative number of COVID-19 case on March 16, 2020.

4. Discussion

To our knowledge, evidence of the association between temperature and number of COVID-19 cases has been scarce to date. However, Kissler and colleagues reported various projections

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Table 1
Cumulative number of COVID-19 cases in Japan, monthly inbound visitors from China in January 2020, and old-age dependency ratio in 2019

Prefecture	Mean temperature in February 2020	COVID-19 cases per 1,000,000 population on March 17, 2020	Inbound visitors from China per 1,000 population in January 2020	Old-age dependency ratio in 2019
Hokkaido	−2.1	26.7	11.1	53.3
Aomori	0.9	0	0.1	56.0
Iwate	1.0	0	0.7	57.1
Miyagi	4.4	0.4	0.6	44.9
Akita	2.5	0.9	0	66.0
Yamagata	2.5	0	0.002	58.2
Fukushima	4.5	1.0	0	51.9
Ibaraki	6.2	0	2.02	47.4
Tochigi	5.8	1.0	0	46.1
Gunma	6.6	2.5	0	48.8
Saitama	6.2	3.6	0	41.9
Chiba	8.9	4.7	35.3	43.6
Tokyo	8.3	6.4	8.64	34.3
Kanagawa	8.9	5.3	0	39.5
Niigata	5	5.9	0.8	55.3
Toyama	5.5	0	1.1	55.0
Ishikawa	6.3	4.3	1.1	49.2
Fukui	5.9	0	0	50.9
Yamanashi	6.4	2.3	0	50.7
Nagano	2.4	1.4	0	54.2
Gifu	7	1.0	0	50.2
Shizuoka	9.4	0.8	2.6	49.4
Aichi	7.1	15.8	11.5	39.6
Mie	7.5	2.7	0	49.1
Shiga	5.9	1.4	0	42.1
Kyoto	6.9	5.3	0	48.5
Osaka	8	10.2	37.09	43.8
Hyogo	8.2	9.8	0.01	46.9
Nara	6.3	2.9	0	52.5
Wakayama	8.3	13.0	0	56.6
Tottori	6.6	0	1.0	55.1
Shimane	6.4	0	0	61.6
Okayama	6.7	0	0.6	51.1
Hiroshima	7.8	0.3	0.9	48.9
Yamaguchi	7.3	0.7	0.002	61.5
Tokushima	8.4	0	0.006	57.1
Kagawa	7.6	0	2.6	53.4
Ehime	8.4	0.7	0.2	56.7
Kochi	9	14.4	0	62.6
Fukuoka	9.7	0.56	4.5	45.1
Saga	8.8	1.2	4.1	51.1
Nagasaki	9.8	0	0.4	56.3
Kumamoto	8.9	2.8	0.09	53.5
Oita	8.7	0.8	0.003	57.1
Miyazaki	10.4	0.9	0.02	56.0
Kagoshima	11.4	0	0.6	55.4
Okinawa	18.7	2.2	16.6	34.6

COVID-19; novel coronavirus infection.

Table 2
Poisson regression analysis results.

Variable	Coefficient	Standard error	*p*-value
Intercept	3.386	0.822	< 0.001
Inbound[a]	0.0408	0.00721	< 0.001
Old-age dependency ratio[b]	−0.0313	0.0145	0.032
Temperature[c]	−0.128	0.0258	< 0.001

[a] Inbound visitors from China per 1,000 population in January 2020.
[b] The ratio of the number of people aged 65 and over, compared to the number of people 15-64 years old in 2019
[c] Mean temperature in the prefectural capitals in February 2020.

of the current pandemics with considering the seasonality of its epidemiology, in addition to that other coronavirus strains have (Kissler et al., 2020). Albeit the seasonality in infectiousness of COVID-19 has not been empirically demonstrated yet, it would be plausible that COVID-19 shows higher infectivity in winter, like other betacoronaviruses. Considering this, our results suggest that low temperature might have positive impact on the infectivity of COVID-19.

Okinawa, the southernmost prefecture that sits in the subtropical zone, has reported only 3 cases so far. Conversely, Hokkaido, the northernmost prefecture that sits in the subarctic zone, has the largest number of reported cases in Japan. Their markedly different climates but use of the same surveillance system and same policy for PCR testing is advantageous for examining the hypothesis that temperature is associated with the infectivity of COVID-19, and helps address the difficulty in comparing the number of COVID-19 cases internationally because individual countries have their own testing policies. In light of this, we suggest that temperature could be a factor associated with the infectivity of COVID-19.

Frequency of social contact with infected people might be another risk factor for infection. From the viewpoint of social contact, we would expect there to be a higher risk of new cases in large cities., However, the largest number of COVID-19 cases in Japan were in Hokkaido, which has a much smaller population and population density than Tokyo. After we adjusted the model for

population and number of monthly inbound visitors from China in January 2020, lower temperature showed a strong correlation with a larger number of cumulative cases. In addition, we adjusted age-structure of population in each prefecture by introducing old-age dependency ratio, which showed correlation between low old-age dependency ratio and larger number of cases. This also supports our hypothesis because Hokkaido showed larger old-age dependency ratio than other large cities like Tokyo.

Our analysis has several limitations. First, we examined data solely from Japan, so it is not appropriate to generalize our results globally. Nevertheless, the diversity of climate yet uniform virus testing policy in Japan enabled us to examine the relationship between temperature and number of cases to some extent. Second, we could not include other confounding factors such as humidity in our analysis, which might have influenced our results.

In conclusion, our analysis showed a possible association between low temperature and increased risk of COVID-19 infection. Further evaluation would be desirable at a global level.

Conflict of Interest

None declared.

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Ethical Approval

Not applicable because we used only published data and did not use any personal information.

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