1 Title:

2 Closed environments facilitate secondary transmission of coronavirus disease 2019

3 (COVID-19)

4 Running title: Closed environment and COVID-19

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Abstract

Objective: To identify common features of cases with novel coronavirus disease (COVID-19) so as to better understand what factors promote secondary transmission including superspreading events.

Methods: A total of 110 cases were examined among eleven clusters and sporadic cases, and investigated who acquired infection from whom. The clusters included four in Tokyo and one each in Aichi, Fukuoka, Hokkaido, Ishikawa, Kanagawa and Wakayama prefectures. The number of secondary cases generated by each primary case was calculated using contact tracing data.

Results: Of the 110 cases examined, 27 (24.6%) were primary cases who generated secondary cases. The odds that a primary case transmitted COVID-19 in a closed environment was 18.7 times greater compared to an open-air environment (95% confidence interval [CI]: 6.0, 57.9).

Conclusions: It is plausible that closed environments contribute to secondary transmission of COVID-19 and promote superspreading events. Our findings are also consistent with the declining incidence of COVID-19 cases in China, as gathering in closed environments was prohibited in the wake of the rapid spread of the disease.

40   Introduction

41   Although the incidence of coronavirus disease 2019 (COVID-19) in China began to

42   decrease in February 2020,[1] many countries are struggling with containment of the

43   disease. To effectively reduce the spread of COVID-19, it is vital to identify common

44   features of cases so as to better understand what factors promote superspreading events,[2]

45   wherein an extraordinarily large number of secondary transmissions are produced by a

46   single primary case. Commissioned by the Minister of the Ministry of Health, Labour,

47   and Welfare of Japan, we collected secondary transmission data with the aim of

48   identifying high risk transmission settings.

49   Methods

50   As of 28 February 2020,[3] we examined a total of 110 cases among eleven

51   clusters and sporadic cases, and investigated who acquired infection from whom. The

52   clusters included four in Tokyo and one each in Aichi, Fukuoka, Hokkaido, Ishikawa,

53   Kanagawa and Wakayama prefectures. All traced transmission events were examined in

54   relation to close contact in indoor environments, including fitness gyms, a restaurant

55   boat on a river, hospitals, and a snow festival where there were eating spaces in tents

56   with minimal ventilation rate. The number of secondary cases generated by each

57   primary case was calculated using contact tracing data.

58   Results

59   Of the 110 cases examined, 27 (24.6%) were primary cases who generated

60   secondary cases. Figure 1 shows the distribution of these transmissions, of which the

61   mean and variance were 0.6 cases and 2.5 cases^2, respectively. The odds that a primary

62   case transmitted COVID-19 in a closed environment was 18.7 times greater compared

63   to an open-air environment (95% confidence interval [CI]: 6.0, 57.9).

64   If superspreading events are defined as events where the number of secondary

65   cases generated by a single primary case is greater than the 95th percentile of the

66   distribution (i.e. transmission to three or more persons), then seven of the 110 cases

67   (6.4%) were involved in such events. Six of these events (85.7%) took place in closed

68   environments, and the odds ratio (OR) of superspreading events in closed environments

69   was as high as 32.6 (95% CI: 3.7, 289.5).

70   Discussion

71   It is plausible that closed environments contribute to secondary transmission of

72   COVID-19 and promote superspreading events. Closed environments are consistent with

73   environmental sampling study[4] and also large-scale COVID-19 transmission events such

74   as that of the ski chalet-associated cluster in France and the church- and

75   hospital-associated clusters in South Korea[5]. Our findings are also consistent with the

76   declining incidence of COVID-19 cases in China, as gathering in closed environments

77   was prohibited in the wake of the rapid spread of the disease.

78   Reduction of unnecessary close contact in closed environments may help

79   prevent large case clusters and superspreading events. We hope that with such a

80   reduction in contact the reproduction number of COVID-19 in Japan will be maintained

81   below 1 and contact tracing will be sufficient to contain disease spread.[6] As the

82   possibility of confounders and interactions was not assessed in this study, additional

83   studies must be conducted to verify the importance of closed environments as

84   facilitators for transmission of COVID-19.

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118   **Figure legend**

119   Figure 1. The distribution of the number of secondary cases generated by a single

120   primary case with novel coronavirus (COVID-19). The mean and variance were 0.6

121   cases and 2.5 cases^2, respectively.

Figure legend:
- Primary cases in closed environment
- Other primary cases

Y-axis: Frequency
X-axis: Number of secondary cases per single primary case