1   Title:

2   Closed environments facilitate secondary transmission of coronavirus disease 2019

3   (COVID-19)

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25 Main text:

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

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

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

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

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

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

32 and Welfare of Japan (see Supplementary text), we collected secondary transmission data

33 with the aim of identifying high risk transmission settings.

34 As of 26 February 2020,[3] we examined a total of 110 cases among eleven

35 clusters and investigated who acquired infection from whom. The clusters included four

36 in Tokyo and one each in Aichi, Fukuoka, Hokkaido, Ishikawa, Kanagawa and

37 Wakayama prefectures. All clusters were associated with close contact in indoor

38 environments, including fitness gyms, a restaurant boat on a river, hospitals, and a snow

39 festival where there were eating spaces in tents with minimal ventilation rate.

40 The number of secondary cases generated by each primary case was calculated

41 using contact tracing data. Of the 110 cases examined, 27 (24.6%) were primary cases

42 who generated secondary cases. Figure 1 shows the distribution of these transmissions,

43 of which the mean and variance were 0.6 cases and 2.5 cases[2], respectively. The odds

44 that a primary case transmitted COVID-19 in a closed environment was 18.7 times

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

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

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

2

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

49   (10.0%) were involved in such events. Nine of these events (81.8%) took place in

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

51   environments was as high as 29.8 (95% CI: 5.8, 153.4).

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

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

54   large-scale COVID-19 transmission events such as that of the ski chalet-associated

55   cluster in France and the church- and hospital-associated clusters in South Korea[4]. Our

56   findings are also consistent with the declining incidence of COVID-19 cases in China, as

57   gathering in closed environments was prohibited in the wake of the rapid spread of the

58   disease.

59   Reduction of unnecessary close contact in closed environments may help

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

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

62   below 1 and contact tracing will be sufficient to contain disease spread.[5] As the

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

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

65   facilitators for transmission of COVID-19.

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67   **Conflict of interest:**

68   We declare that we have no conflict of interest.

69   **Acknowledgement:**

70   We sincerely thank staff of local governments, including health centers and prefectural

71   institutes of public health, healthcare facilities, and associated companies and

72 organizations for cooperating us to collect and investigate secondary transmission data.

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91 **Figure legend**

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

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

94 cases and 2.5 cases^2, respectively.

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