Networks of Necessity: Preventing COVID-19 Among Disabled People and Their Caregivers

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Approximately 7.3% of Canadians [20] and 6% of Americans [3] are disabled and require assistance from caregivers with activities of daily living (such as bathing and toileting). Consequently, despite contact-limiting (also called "social distancing" and "physical distancing") measures that are designed to reduce the spread of COVID-19, contacts between disabled people and their caregivers cannot be reduced. We are a team of disabled people and scientists who sought to determine how best to protect the disabled population and their caregivers using two preventative measures that are known to mitigate COVID-19 spread: limiting contacts and wearing masks. We conducted hundreds of computer simulations of the spread of COVID-19 in a city of approximately one million people using case data from Ottawa, Canada. Our simulations implemented a well-validated epidemiological model on a network of contacts in which individuals can progress through various disease stages: susceptible, asymptomatic, ill, hospitalized, and recovered or deceased. We estimate the percent reduction in cases from mitigation strategies as compared to a baseline in which no one limits contacts or wears masks. The numbers that we report reflect the time from the first case in the city until businesses reopen and contact-limiting begins to relax. We find strong evidence that: **(1) Contact-limiting in the general population can significantly reduce cases in the caregiver and disabled populations.** Strict limiting of contacts by the general population— analogous to a lockdown — decreases the number of cases of COVID-19 among caregivers and disabled people by about 50%. By contrast, when only disabled people limit their contacts, about 10% of cases among caregivers and about 15% of cases among disabled people are prevented. **(2) Mask-wearing by the disabled and caregiver populations significantly reduces cases in both groups.** Without limiting contacts, mask-wearing by caregivers and disabled people prevents over 60% of cases in both groups, with an additional boost if essential workplaces also wear masks. When the whole population limits contacts and both disabled people and their caregivers wear masks, cases among disabled people and caregivers decrease by over 90%. *Our work illustrates that to protect the disabled population, mask-wearing and contact-limiting must be implemented not only by the disabled population, but by the general population as well.*

Limiting Contacts

Although contact-limiting measures have prevented millions of cases of COVID-19 [9], they have also severely affected the economy. As a result, some have called for an end to contact-limiting for the general population, with only vulnerable groups, such as disabled people, continuing to limit contacts. We tested the efficacy of this strategy using our model. We find that when disabled people try to limit contacts to household members and caregivers, but the general population does not limit contacts, there is only a minor decrease in the number of cases in the disabled and caregiver populations (see Fig. 1). Therefore, a **strategy in which only disabled people limit contacts is likely to be ineffective**. By contrast, when the entire population except for essential workers (those whose occupation prevents contact-limiting) limits contacts, about 50% of cases among caregivers and disabled people are avoided. **Contact-limiting in the general population protects disabled people and caregivers**. We also find that there is a small benefit to disabled people of reducing the number of caregivers that they contact (data not shown). However, it is often impossible

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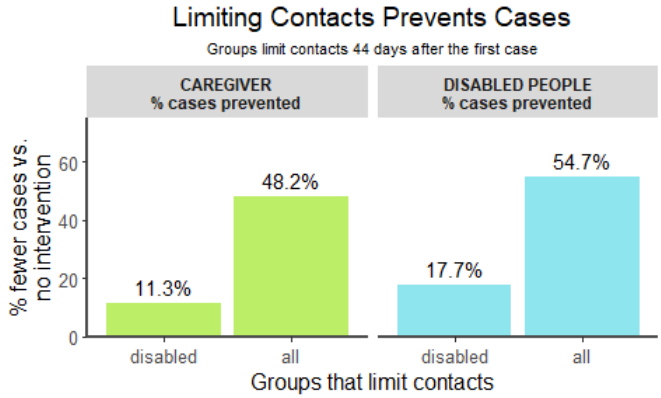

Fig 1. Note on range of outcomes: Our simulations tend to produce consistent results, which produce small error bars that indicate high certainty. However, many of our simulation's inputs may fall within a range of values, including efficacy of masks and the relative risks of different types of personal contact. The exact effects of the interventions that we describe in this white paper may vary depending on the true values of these inputs. Therefore, we have chosen to omit error bars from our graphs, as we feel that the high consistency in our simulations would produce a misleading impression of high confidence in the exact numbers. This issue notwithstanding, we are confident in our assessment of the relative effectiveness of the interventions that we have studied.

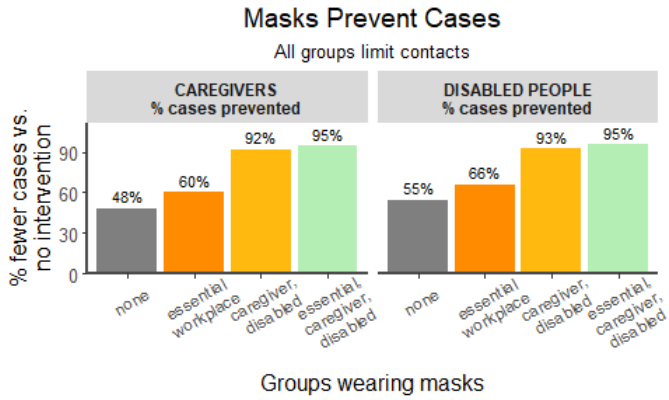

Fig 2. See the caption of Fig. 1.

for a disabled person to decrease the number of their caregivers without sacrificing the quality of their care, subjecting them to additional health risks.

Effect of Masks

We also used our model to determine what happens when masks are worn in two settings: (1) at essential workplaces and (2) during interactions between caregivers and disabled people. Wearing masks only in essential workplaces modestly decreases the number of cases in the caregiver and disabled populations (see Fig. 2). By contrast, when caregiver and disabled populations both wear masks, there is a drastic decrease in cases in both the caregiver and disabled populations (see Fig. 2). We observe similar trends whether or not the general population limited their contacts. When combined with the whole population reducing contacts, caregivers and disabled people wearing masks reduce cases in these groups by over 90%. In a city of one million, this means that approximately 23,000 disabled people and 10,500 caregivers could be spared from COVID-19 by population-wide mask-wearing. Therefore, for the protection of both groups, **it is critical that caregivers and disabled people both wear masks when they interact.**

Our Recommendations

Managing COVID-19 care for a person with a pre-existing disability is likely to be medically challenging. Therefore, in the resource-strained environment of a pandemic, preventing infection among disabled people should be a top priority. Naively, one might expect that disabled people can substantially reduce their risk by strictly limiting their contacts. However, **our model indicates that contact-limiting by the disabled population alone is only marginally effective if the general population does not also limit their contacts**. Even less effective is limiting the number of caregivers for a disabled person. **We believe that preserving consistent caregiver services for disabled people throughout the pandemic is a top priority to avoid putting disabled people at higher risk of other health complications.**

Masks are essential for caregivers to safely provide care for disabled people. Mask-wearing among disabled people and caregivers could prevent thousands of cases among these groups in every city. Some states have already provided masks to disabled residents. For example, New Jersey's Personal Preference Program (a part of their Department of Human Services) has mailed boxes of surgical masks to their clients. **We recommend that any organization that provides services to disabled people or employs caregivers should provide free masks and mandate their use.**

Parameters and Data

Our simulations require estimates for proportions of different groups in a population, transition rates between different disease states, the efficacy of masks, and so on. In this supplement, we concisely summarize the data that we used to obtain these values.

Population Parameters

The city of Ottawa has a population of approximately 994837 [18]. In 2015, about 2.6 million Canadians required assistance with daily activities [20]. Based on the Canadian population at the time [16], this amounts to about 7.3% of the population. In the United States, the corresponding figure was estimated to be 6% [3]. Based on US Labor Statistics, about 2% of the population are employed as caregivers [7]. From California data, about 12.5% of the population are essential workers (such as grocery clerks) [11].

We used Ottawa census data [17] to estimate the distribution of the number of people who live in a household. To model weak social contacts, we use the estimates that the mean value of daily contacts for people is 16.52 without contact-limiting [6] and that non-essential workers have a mean of 4 contacts/day after contact-limiting [15]. We also use an estimate that essential workers see a mean of 22 contacts/day after contact-limiting [15] and assume that they see the same number before contact-limiting is in place. We generate empirical distributions, based on a power law, for the numbers of weak social contacts that people have. We also assume that on each day, a disabled individual who requires care sees 2 professional caregivers, who we select uniformly at random from a pool of available caregivers. We consider pool sizes of both 10 and 4.

Disease Parameters

Based on a physical-distancing survey [1], we estimate that people who exhibit symptoms of COVID-19 isolate themselves with a probability of 0.92, and we use data [19] on spreading in various contexts to estimate the levels of risk for various types of interactions. When both parties wear masks, transmission probabilities drop substantially [5], and we use a conservative estimate for the relative risk probability of 0.34. To obtain approximate values for other parameters in our model, we employ the following estimates: 19% of cases require hospitalization [4]; a median duration in a hospital of 13 days [10]; a median recovery time of 14 days for individuals who are symptomatic but not critically ill [8]; a delay with a median of 5.1 days to become symptomatic after onset of infection [2]; approximately 22% of cases may be entirely asymptomatic [2]; mask-wearing and contact-limiting began in Ottawa on 24 March 2000 [12]; Ottawa began to reopen on 6 July 2020 [13]; and data on the cumulative number of COVID-19 cases in Ottawa [14]. These parameters include the infectiousness of COVID-19 and the rates that patients move between different stages of the disease.

References

1. D. Altman and K. F. Foundation, Most Americans are Practicing Social Distancing. https://www.axios.com/coronavirus-social-distancing-lockdown-polling-7c27d86f-bb4b-4cbf-aedf-cfdd26799fd1.html, Apr 2020. Accessed: 2020-06-21.

2. Y. M. Bar-On, R. Sender, A. I. Flamholz, R. Phillips, and R. Milo, A Quantitative Compendium of COVID-19 Epidemiology, arXiv:2006.01283 (2020).

3. Centers for Disease Control and Prevention, Current Trends Prevalence of Disabilities and Associated Health Conditions – United States, 1991-1992, Morbidity and Mortality Weekly Report, 43 (1994), pp. 730–731,737–739.

4. ——, Severe Outcomes Among Patients with Coronavirus Disease 2019 (COVID-19) - United States, February 12-March 16, 2020, Morbidity and Mortality Weekly Report, 69 (2020), pp. 343–346. Accessed: 2020-06-21.

5. D. K. Chu, E. A. Akl, S. Duda, K. Solo, S. Yaacoub, H. J. Schünemann, A. El-harakeh, A. Bognanni, T. Lotfi, M. Loeb, et al., Physical Distancing, Face Masks, and Eye Protection to Prevent Person-to-Person Transmission of SARS-CoV-2 and COVID-19: A Systematic Review and Meta-Analysis, The Lancet, 395 (2020), pp. 1973–1987.

6. S. Y. Del Valle, J. M. Hyman, H. W. Hethcote, and S. G. Eubank, Mixing Patterns Between Age Groups in Social Networks, Social Networks, 29 (2007), pp. 539–554.

7. Employment Projections Program, U.S. Bureau of Labor Statistics, Employment by Detailed Occupation. https://www.bls.gov/emp/tables/emp-by-detailed-occupation.htm, Sep 2019. Accessed: 2020-06-21.

8. W.-j. Guan, Z.-y. Ni, Y. Hu, W.-h. Liang, C.-q. Ou, J.-x. He, L. Liu, H. Shan, C.-l. Lei, D. S. Hui, et al., Clinical Characteristics of Coronavirus Disease 2019 in China, New England Journal of Medicine, 382 (2020), pp. 1708–1720.

9. S. Hsiang, D. Allen, S. Annan-Phan, K. Bell, I. Bolliger, T. Chong, H. Druckenmiller, L. Y. Huang, A. Hultgren, E. Krasovich, et al., The Effect of Large-Scale Anti-Contagion Policies on the COVID-19 Pandemic, Nature, 584 (2020), pp. 262–267.

10. Johns Hopkins University Bloomberg School of Public Health, New Study on COVID-19 Estimates 5.1 Days for Incubation Period. https://www.sciencedaily.com/releases/2020/03/200310164744.htm, Mar 2020. Accessed: 2020-06-21.

11. W. R. Milligan, Z. L. Fuller, I. Agarwal, M. B. Eisen, M. Przeworski, and G. Sella, Impact of Essential Workers in the Context of Social Distancing for Epidemic Control, medRxiv 2020.05.05.20092262 (2020).

12. K. Nielson, A Timeline of the Novel Coronavirus in Ontario. https://globalnews.ca/news/6859636/ontario-coronavirus-timeline/, 2020. Accessed: 2020-06-21.

13. Ottawa City Council, City of Ottawa's Reopening Plan. https://www.omaa.on.ca/en/workshops-and-events/resources/2020-COVID-19-Special-Info/10-Ottawa_Council-Presentation_June102020.pdf, 2020. Accessed: 2020-06-21.

14. Ottawa Public Health, Daily COVID-19 Dashboard. https://www.ottawapublichealth.ca/en/reports-research-and-statistics/daily-covid19-dashboard.aspx, 2020. Accessed: 2020-08-24.

15. J. Rothwell, A Survey of Essential Workers Shows a Political Divide, The New York Times (2020). https://www.nytimes.com/2020/04/27/upshot/red-blue-workplace-differences-coronavirus.html.

16. Statistics Canada, Canada's Population Estimates: Age and Sex, July 1, 2015. https://www150.statcan.gc.ca/n1/daily-quotidien/150929/dq150929b-eng.htm, 2015. Accessed: 2020-06-21.

17. ——, Census Profile, 2016 Census. https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E, Jun 2019. Accessed: 2020-06-21.

18. UNdata, UN city population. https://www.google.com/publicdata/explore?ds=z5567oe244g0ot_, 2017. Accessed: 2020-08-24.

19. X. Wang, Y. Pan, D. Zhang, L. Chen, L. Jia, X. Li, P. Yang, Q. Wang, and C. R. Macintyre, Basic Epidemiological Parameter Values from Data of Real-World in Mega-Cities: The Characteristics of COVID-19 in Beijing, China, BMC Infectious Diseases, 20, 526 (2020).

20. E. Woolley, How Many Homeless People Live with Disabilities? https://www.homelesshub.ca/blog/how-many-homeless-people-live-disabilities, 2015. Accessed: 2020-06-21.