File No. CI 20-01-29284

THE QUEEN'S BENCH
Winnipeg Centre

APPLICATION UNDER: *The Constitutional Questions Act*, C.C.S.M., c. 180

AND UNDER: The Court of Queen's Bench Rules, M.R. 553/88

IN THE MATTER OF: *The Public Health Act*, C.C.S.M. c. P210

BETWEEN:

GATEWAY BIBLE BAPTIST CHURCH, PEMBINA VALLEY BAPTIST CHURCH, REDEEMING GRACE BIBLE CHURCH, THOMAS REMPEL, GRACE COVENANT CHURCH, SLAVIC BAPTIST CHURCH, CHRISTIAN CHURCH OF MORDEN, BIBLE BAPTIST CHURCH, TOBIAS TISSEN, DJ'S FAMILY RESTAURANT, LYLE NEUFELD, HELEN NEUFELD, ROSS MACKAY

Applicants,

– and –

HER MAJESTY THE QUEEN IN RIGHT OF THE PROVINCE OF MANITOBA and DR. BRENT ROUSSIN in his capacity as CHIEF PUBLIC HEALTH OFFICER OF MANITOBA,

FILED JAN 07 2021

Respondents.

AFFIDAVIT OF JAY BHATTACHARYA
SWORN JANUARY 5, 2021

JUSTICE CENTRE FOR CONSTITUTIONAL FREEDOMS
Allison Kindle Pejovic / Jay Cameron
[redacted]

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Applicants,

– and –

HER MAJESTY THE QUEEN IN RIGHT OF THE PROVINCE OF MANITOBA and DR. BRENT ROUSSIN in his capacity as CHIEF PUBLIC HEALTH OFFICER OF MANITOBA,

Respondents.

AFFIDAVIT OF JAY BHATTACHARYA

I, JAY BHATTACHARYA of the City of Los Altos, in the County of Santa Clara, in the State of California,

MAKE OATH AND SAY AS FOLLOWS:

1. I have personal knowledge of the facts and matters hereinafter deposed to by me, except where same are stated to be based upon information and belief, and those I do verily believe to be true.

2. I am 52 years old and am otherwise competent to submit this Affidavit.

3. I am among infectious disease epidemiologists, public health scientists and medical practitioners worldwide who have grave concerns about the damaging physical and mental health impacts of the prevailing COVID-19 policies, including government lockdown orders. I co-authored *The Great Barrington Declaration* ("The Declaration") with Dr. Martin Kulldorff, professor of medicine at Harvard University, a biostatistician, and epidemiologist with expertise in detecting and monitoring infectious disease outbreaks and vaccine safety evaluations, and Dr. Sunetra Gupta, professor at Oxford University, an epidemiologist with expertise in immunology, vaccine development, and mathematical modelling of infectious diseases. As of January 4, 2021, the online signature count on the Declaration includes 13,084 medical & public health scientists, 39,545 medical practitioners and 712,345 concerned citizens. A copy of The Declaration is attached hereto and marked as **Exhibit "A"**.

4. I am a Professor of Medicine at Stanford University and have worked in the Stanford University faculty since 2001. I have an MD and a Ph.D. in economics, both earned from Stanford University. I am the director of the Stanford Center for Demography and Economics of Health and Aging. At Stanford, I teach courses on health economics in the Economics Department and on advanced statistical methods in the School of Medicine.

5. My primary research area is health economics, including a focus on epidemiology and infectious disease epidemiology. By 1996 and 2020, I have published 140 articles in peer-reviewed journals, including top-ranked

journals in the economics, statistics, public health, epidemiology, medicine and health policy literatures. I have published numerous papers on the economics and medicine of infectious disease, including on the economics and epidemiology of HIV, H1N1 flu, H5N1 flu, seasonal influenza, antimicrobial resistance and antibiotic use, and COVID-19. I have written a popular textbook, *Health Economics*, used to teach the subject in universities around the world. The textbook includes a chapter on economic epidemiology that surveys the literature of disease modelling, including compartment models such as the Susceptible Infected-Recovered (SIR) models, commonly in use to forecast the COVID-19 epidemic.

6. I have been actively researching the COVID-19 epidemic using my expertise in infectious disease epidemiology and health economics. To date, I have published four papers in peer-reviewed journals related to the epidemic. In addition, I have written two articles that are currently under consideration at peer-reviewed journals, and I have published multiple editorials on economic and epidemiological issues related to the epidemic, including an editorial on optimal public health management of the epidemic.

7. My published papers on COVID-19 include the first published serological study measuring the prevalence if the COVID-19 epidemic. This study, conducted in Los Angeles County ("LA County"), uses evidence from a specific antibody response to SARS-CoV-2 (the virus that causes COVID-19) infection in an adult community-dwelling sample picked to be representative of that county. This piece was published in the *Journal of the American Medical Association,* one of the leading peer-reviewed journals in medicine. I served as the senior author for this article.

8. I have also published a second peer-reviewed paper in the *Journal of Public Health* on racial disparities in knowledge and attitudes regarding the danger posed by COVID-19 infection and the efficacy of personal behaviours like hand washing and social distancing in protecting against infection. I reviewed the literature cited in the paper regarding best practices for personal protection to prevent exposure to SARS-CoV-2.

9. I am a co-author of a peer-reviewed paper titled "Visualizing the Invisible: The Effect of Asymptomatic Transmission on the Outbreak Dynamics of COVID-19," recently published in *Computer Methods in Applied Mechanics and Engineering*. This paper presents the first forecasting model that accounts for data provided by seroprevalence studies such as the LA County study. In particular, the model accounts for the vast population of previously infected people identified by the seroprevalence studies and challenges the notion that contact tracing can be a viable strategy to control the further spread of COVID-19 infection.

10. I am the co-author of a peer-reviewed paper published in the *European Journal of Clinical Investigation* entitled "Assessing Mandatory Stay-at-Home and Business Closure Effects on the Spread of COVID-19". This paper compares the effectiveness of mandatory lockdown orders versus less restrictive policies adopted by eleven European and Asian countries. The main conclusion arising from this analysis is that "While small benefits cannot be excluded, [my co-authors and I] do not find significant benefits on case growth of more restrictive NPIs. Similar reductions in case growth may be achievable with less restrictive interventions."

11. I currently have two unpublished papers on COVID-19 presently undergoing peer review reporting on seroprevalence studies. I am the senior author of the Santa Clara County ("SCC") seroprevalence study. It is the first seroprevalence study where the study team made a scientific paper available (undergoing peer review), and it is still, to my knowledge, the largest community seroprevalence survey in the US. The results from SCC were similar to the results from the LA County seroprevalence study. On April 3rd & 4th, 2020, the seroprevalence of SARS-CoV-2 antibodies in the SCC sample, reweighted to match the zip code to residence, sex, and race distribution of SCC study, though not peer-reviewed, has generated 342 citations (according to Google Scholar accessed on January 4, 2021) to date.

12. I am also the senior author of a study (still undergoing peer review) measuring the seroprevalence of SARS-CoV-2 infection among employees of Major League Baseball on April 14th &15th, 2020. This is the first seroprevalence study of national scope measuring the extent of COVID-19. The main finding from that study is that, as of the date of data collection, the prevalence of current or prior COVID-19 infection in the MLB employee population was 0.7%.

13. In addition to my published work, over the past seven months, I have been invited to serve as a peer reviewer for many scientific journals to review COVID- 19 related submissions by other scientists. These journals include the *British Medical Journal, Health Affairs,* the *Journal of Infectious Disease, and the Annals of Internal Medicine.* For these journals, I have provided scientific advice regarding the publication of articles on topics related to the COVID-19 epidemic.

14. In May 2020, I testified at a virtual roundtable organized by Senator Pat Toomey on the subject of the potential reopening of youth baseball leagues while protecting the safety of participants. At this roundtable, I reviewed the evidence regarding the relatively low mortality and morbidity risk that SARS-CoV-2 infection poses to children and adolescents, and I discussed social distancing and other protocols to make youth baseball safer for coaches, umpires, and other adult participants.

15. In July 2020, I was invited to testify at a House Oversight Briefing to the Economic and Consumer Policy Subcommittee on SARS-CoV-2 vaccine development. My testimony focused on the randomized trials and other studies currently underway to produce a safe and effective vaccine to SARS-CoV-2 infection, and in particular on the confidence that the public can have on the US Food and Drug Administration's (FDA) evaluation of the scientific evidence regarding new vaccines.

16. In September 2020, I participated in an invited live roundtable discussion led by Florida Governor Ron DeSantis on the evidence regarding the safety of reopening Florida and the health harms from continued lockdown. My testimony presented the scientific evidence on the infection fatality rate from COVID-19 infection by age, the collateral damage from lockdowns on physical and psychological health, and on the safety of opening schools for in-person instruction.

17. In December 2020, I was invited to testify at the US Senate Homeland Security and Governmental Affairs Committee regarding the mortality risk posed by COVID-19 infection, the efficacy and harms of lockdowns aimed at reducing the spread of COVID-19 disease, and

incentives of private corporations and the government to invest in research on low-cost treatments for COVID-19 disease.

18. The Applicants' counsel contacted me about providing expert testimony regarding: a cost/benefit analysis of the Manitoba lockdowns, including an explanation of the findings of the Great Barrington Declaration regarding such measures; an analysis of polymerase chain reaction ("PCR") diagnostic tests for COVID-19, including their accuracy/inaccuracy, their use to determine cases of COVID-19, and whether people who test positive from a PCR test are infected/contagious with COVID-19; a breakdown of demographic vulnerability to COVID-19; and how medically risky is it for Manitobans to attend church, gather in groups outdoors, go to restaurants, patron small businesses, peacefully protest, and have friends over vis a vis COVID-19. I agreed to provide an expert report with my professional opinion on these matters.

19. A copy of my curriculum vitae is attached hereto and marked as **Exhibit "B"**.

20. A copy of my expert report as described above is attached hereto and marked as **Exhibit "C"**.

21. I make this affidavit *bona fide*.

SWORN before me in the City of _____, in the County of _____, in the State of California, this 5th day of January, 2021.

_____
A Notary Public in and for the State of California

_____
JAY BHATTACHARYA

Jan. 5, 2021

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of California
County of San Mateo

Subscribed and sworn to (or affirmed) before me on this 05 day of Jan, 2021 by Jay Bhattacharya

proved to me on the basis of satisfactory evidence to be the person(s) who appeared before me.

(Seal) Signature _____

HAMED JTRSARAEI
COMM. #2217313
NOTARY PUBLIC CALIFORNIA
SAN MATEO COUNTY
My Comm. Exp. Oct. 8, 2021

AB153

AB154

THIS IS **EXHIBIT "A"** TO THE AFFIDAVIT OF JAY BHATTACHARYA SWORN BEFORE ME AT THE CITY OF _____, IN THE COUNTY OF _____, IN THE STATE OF CALIFORNIA, THE 5TH DAY OF JANUARY, 2021.

A NOTARY PUBLIC IN AND FOR THE STATE OF CALIFORNIA

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

Jayanta Bhattacharya
Jan 5, 2021

HAMED JIRSARAEI
COMM. #2217313
NOTARY PUBLIC - CALIFORNIA
SAN MATEO COUNTY
My Comm. Exp. Oct. 8, 2021

State of California
County of San Mateo

Subscribed and sworn to (or affirmed) before me on this 05 day of JAN 20 21 by Jay Bhattacharya

proved to me on the basis of satisfactory evidence to be the person(s) who appeared before me.

(Seal) Signature

The Great Barrington Declaration

The Great Barrington Declaration – As infectious disease epidemiologists and public health scientists we have grave concerns about the damaging physical and mental health impacts of the prevailing COVID-19 policies, and recommend an approach we call Focused Protection.

Coming from both the left and right, and around the world, we have devoted our careers to protecting people. Current lockdown policies are producing devastating effects on short and long-term public health. The results (to name a few) include lower childhood vaccination rates, worsening cardiovascular disease outcomes, fewer cancer screenings and deteriorating mental health – leading to greater excess mortality in years to come, with the working class and younger members of society carrying the heaviest burden. Keeping students out of school is a grave injustice.

Keeping these measures in place until a vaccine is available will cause irreparable damage, with the underprivileged disproportionately harmed.

Fortunately, our understanding of the virus is growing. We know that vulnerability to death from COVID-19 is more than a thousand-fold higher in the old and infirm than the young. Indeed, for children, COVID-19 is less dangerous than many other harms, including influenza.

As immunity builds in the population, the risk of infection to all – including the vulnerable – falls. We know that all populations will eventually reach herd immunity – i.e. the point at which the rate of new infections is stable – and that this can be assisted by (but is not dependent upon) a vaccine. Our goal should therefore be to minimize mortality and social harm until we reach herd immunity.

The most compassionate approach that balances the risks and benefits of reaching herd immunity, is to allow those who are at minimal risk of death to live their lives normally to build up immunity to the virus through natural infection, while better protecting those who are at highest risk. We call this Focused Protection.

Adopting measures to protect the vulnerable should be the central aim of public health responses to COVID-19. By way of example, nursing homes should use staff with acquired immunity and perform frequent testing of other staff and all visitors. Staff rotation should be minimized. Retired people living at home should have groceries and other essentials delivered to their home. When possible, they should meet family members outside rather than inside. A comprehensive and detailed list of measures, including approaches to multi-generational households, can be implemented, and is well within the scope and capability of public health professionals.

Those who are not vulnerable should immediately be allowed to resume life as normal. Simple hygiene measures, such as hand washing and staying home when sick should be practiced by everyone to reduce the herd immunity threshold. Schools and universities should be open for in-person teaching. Extracurricular activities, such as sports, should be resumed. Young low-risk

adults should work normally, rather than from home. Restaurants and other businesses should open. Arts, music, sport and other cultural activities should resume. People who are more at risk may participate if they wish, while society as a whole enjoys the protection conferred upon the vulnerable by those who have built up herd immunity.

On October 4, 2020, this declaration was authored and signed in Great Barrington, United States, by:

Dr. Martin Kulldorff, professor of medicine at Harvard University, a biostatistician, and epidemiologist with expertise in detecting and monitoring infectious disease outbreaks and vaccine safety evaluations.

Dr. Sunetra Gupta, professor at Oxford University, an epidemiologist with expertise in immunology, vaccine development, and mathematical modeling of infectious diseases.

Dr. Jay Bhattacharya, professor at Stanford University Medical School, a physician, epidemiologist, health economist, and public health policy expert focusing on infectious diseases and vulnerable populations.

Co-signers -- Medical and Public Health Scientists and Medical Practitioners

Dr. Alexander Walker, principal at World Health Information Science Consultants, former Chair of Epidemiology, Harvard TH Chan School of Public Health, USA

Dr. Andrius Kavaliunas, epidemiologist and assistant professor at Karolinska Institute, Sweden

Dr. Angus Dalgleish, oncologist, infectious disease expert and professor, St. George's Hospital Medical School, University of London, England

Dr. Anthony J Brookes, professor of genetics, University of Leicester, England

Dr. Annie Janvier, professor of pediatrics and clinical ethics, Université de Montréal and Sainte-Justine University Medical Centre, Canada

Dr. Ariel Munitz, professor of clinical microbiology and immunology, Tel Aviv University, Israel

Dr. Boris Kotchoubey, Institute for Medical Psychology, University of Tübingen, Germany

Dr. Cody Meissner, professor of pediatrics, expert on vaccine development, efficacy, and safety. Tufts University School of Medicine, USA

Dr. David Katz, physician and president, True Health Initiative, and founder of the Yale University Prevention Research Center, USA

Dr. David Livermore, microbiologist, infectious disease epidemiologist and professor, University of East Anglia, England

Dr. Eitan Friedman, professor of medicine, Tel-Aviv University, Israel

Dr. Ellen Townsend, professor of psychology, head of the Self-Harm Research Group, University of Nottingham, England

Dr. Eyal Shahar, physician, epidemiologist and professor (emeritus) of public health, University of Arizona, USA

Dr. Florian Limbourg, physician and hypertension researcher, professor at Hannover Medical School, Germany

Dr. Gabriela Gomes, mathematician studying infectious disease epidemiology, professor, University of Strathclyde, Scotland

Dr. Gerhard Krönke, physician and professor of translational immunology, University of Erlangen-Nuremberg, Germany

Dr. Gesine Weckmann, professor of health education and prevention, Europäische Fachhochschule, Rostock, Germany

Dr. Günter Kampf, associate professor, Institute for Hygiene and Environmental Medicine, Greifswald University, Germany

Dr. Helen Colhoun, professor of medical informatics and epidemiology, and public health physician, University of Edinburgh, Scotland

Dr. Jonas Ludvigsson, pediatrician, epidemiologist and professor at Karolinska Institute and senior physician at Örebro University Hospital, Sweden

Dr. Karol Sikora, physician, oncologist, and professor of medicine at the University of Buckingham, England

Dr. Laura Lazzeroni, professor of psychiatry and behavioral sciences and of biomedical data science, Stanford University Medical School, USA

Dr. Lisa White, professor of modelling and epidemiology, Oxford University, England

Dr. Mario Recker, malaria researcher and associate professor, University of Exeter, England

Dr. Matthew Ratcliffe, professor of philosophy, specializing in philosophy of mental health, University of York, England

Dr. Matthew Strauss, critical care physician and assistant professor of medicine, Queen's University, Canada

Dr. Michael Jackson, research fellow, School of Biological Sciences, University of Canterbury, New Zealand

Dr. Michael Levitt, biophysicist and professor of structural biology, Stanford University, USA. Recipient of the 2013 Nobel Prize in Chemistry.

Dr. Mike Hulme, professor of human geography, University of Cambridge, England

Dr. Motti Gerlic, professor of clinical microbiology and immunology, Tel Aviv University, Israel

Dr. Partha P. Majumder, professor and founder of the National Institute of Biomedical Genomics, Kalyani, India

Dr. Paul McKeigue, physician, disease modeler and professor of epidemiology and public health, University of Edinburgh, Scotland

Dr. Rajiv Bhatia, physician, epidemiologist and public policy expert at the Veterans Administration, USA

Dr. Rodney Sturdivant, infectious disease scientist and associate professor of biostatistics, Baylor University, USA

Dr. Salmaan Keshavjee, professor of Global Health and Social Medicine at Harvard Medical School, USA

Dr. Simon Thornley, epidemiologist and biostatistician, University of Auckland, New Zealand

Dr. Simon Wood, biostatistician and professor, University of Edinburgh, Scotland

Dr. Stephen Bremner,professor of medical statistics, University of Sussex, England

Dr. Sylvia Fogel, autism provider and psychiatrist at Massachusetts General Hospital and instructor at Harvard Medical School, USA

Tom Nicholson, Associate in Research, Duke Center for International Development, Sanford School of Public Policy, Duke University, USA

Dr. Udi Qimron, professor of clinical microbiology and immunology, Tel Aviv University, Israel

Dr. Ulrike Kämmerer, professor and expert in virology, immunology and cell biology, University of Würzburg, Germany

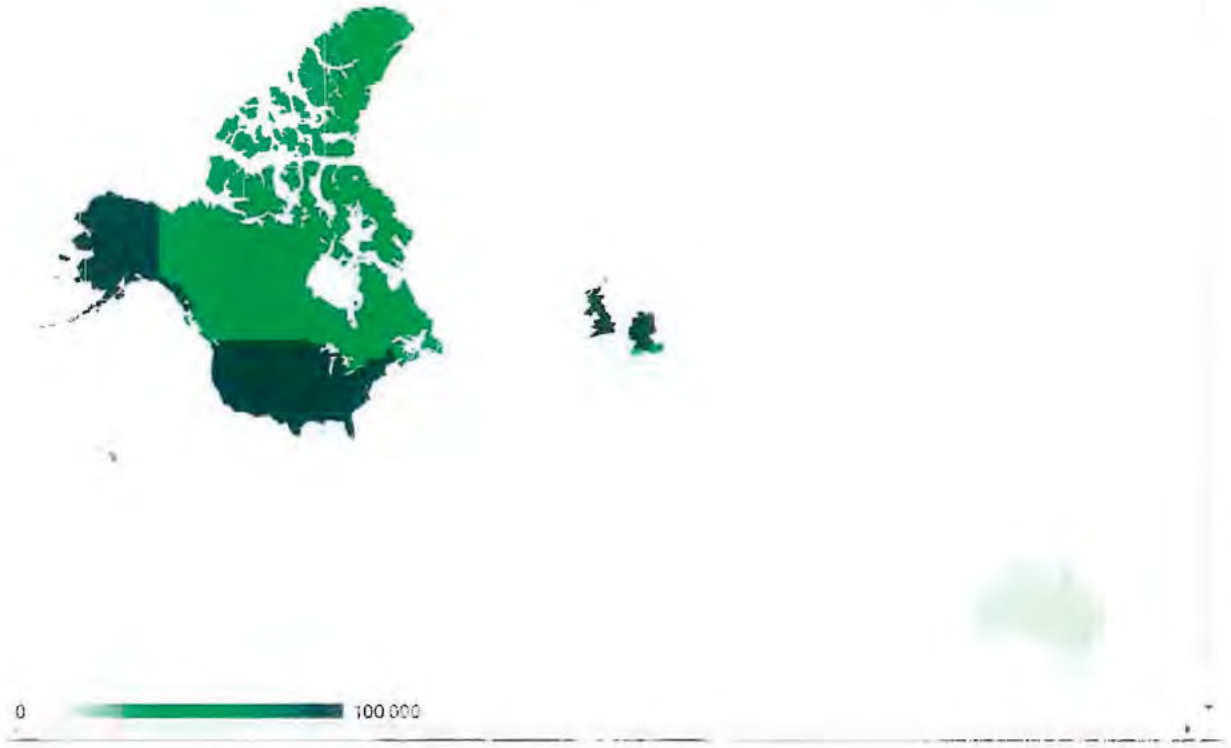
Dr. Uri Gavish, biomedical consultant, Israel

Dr. Yaz Gulnur Muradoglu, professor of finance, director of the Behavioural Finance Working Group, Queen Mary University of London, England

Signatures

As clinicians, researchers, policymakers and public health scientists we have grave concerns about the damaging physical and mental health impacts of the prevailing COVID-19 policies and recommend an approach rooted in evidence and ethics.

concerned citizens	medical & public health scientists	medical practitioners
712,348	13,084	39,545



AB160

Jayanta Bhattacharya

Jan 5, 2021

THIS IS **EXHIBIT "B"** TO THE AFFIDAVIT OF JAY BHATTACHARYA SWORN BEFORE ME AT THE CITY OF _____, IN THE COUNTY OF _____, IN THE STATE OF CALIFORNIA, THE 5TH DAY OF JANUARY, 2021.

_____

A NOTARY PUBLIC IN AND FOR THE STATE OF CALIFORNIA

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of California
County of San Mateo

Subscribed and sworn to (or affirmed) before me on this 05 day of Jan, 2021, by Jay Bhattacharya

proved to me on the basis of satisfactory evidence to be the person(s) who appeared before me.

(Seal)

Signature _____

HAMED JIRSARAEI
COMM. #2217313
NOTARY PUBLIC CALIFORNIA
SAN MATEO COUNTY
My Comm. Exp. Oct. 8, 2021

HAMED JIRSARAEI
COMM. #2217313
NOTARY PUBLIC - CALIFORNIA
SAN MATEO COUNTY
My Comm. Exp. Oct. 8, 2021

JAY BHATTACHARYA, M.D., Ph.D.

January 2020

Address
Center for Primary Care and Outcomes Research
Stanford University School of Medicine
[redacted]

Phone: [redacted]

Email: [redacted]

RESEARCH INTERESTS

Health economics, health policy, and outcomes research

A. ACADEMIC HISTORY:

Stanford University	A.M., A.B.	1990
Stanford University School of Medicine	M.D.	1997
Stanford University Department of Economics	Ph.D.	2000

B. EMPLOYMENT HISTORY:

2001 – present	Professor (Assistant to Full), Stanford University Department of Medicine, Department of Economics (by courtesy) and Department of Health Research and Policy (by courtesy)
2013 – present	Senior Fellow, Stanford Institute for Economic Policy Research
2014 – present	Senior Fellow Stanford Freeman Spogli Institute
2007 – present	Research Associate, Sphere Institute / Acumen LLC
2002 – present	FRF to Research Associate, National Bureau of Economic Research
2006 – 2008	Research Fellow, Hoover Institution
1998 – 2001	Economist (Associate to Full), RAND Corporation
1998 – 2001	Visiting Assistant Professor, UCLA Department of Economics

C. SCHOLARLY PUBLICATIONS:

PEER-REVIEWED ARTICLES (141 total)

1. Yoshikawa A, Vogt W.B., Hahn J., **Bhattacharya J.**, "Toward the Establishment and Promotion of Health Economics Research in Japan," *Japanese Journal of Health Economics and Policy* 1(1):29-45, (1994).
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12. Studdert D, **Bhattacharya J**, Warren B, Schoenbaum M, Escarce JJ. "Personal Choices of Health Plans by Managed Care Experts." *Medical Care* 40(5):375-86 (2002).
13. **Bhattacharya J**, Schoenbaum M, and Sood N. "Optimal Contributions to Flexible Spending Accounts for Medical Care." *Economics Letters* 76(1):129-135 (2002).
14. Reville R, Neuhauser F, **Bhattacharya J**, and Martin C, "Comparing Severity of Impairment for Different Permanent Upper Extremity Musculo-Skeletal Injuries" *Journal of Occupational Rehabilitation* 12(3):205-21 (2002).
15. Lakdawalla D., Goldman D, **Bhattacharya J**, Hurd M, Joyce G, and Panis C., "Forecasting the Nursing Home Population", *Medical Care* 41(1):8-20 (2003) See comments "Forecasting the Nursing Home Population," *Medical Care* 41(1):28-31 (2003).
16. **Bhattacharya J**, Deleire T, Haider S, Currie J. "Heat or Eat? Cold-Weather Shocks and Nutrition in Poor American Families," *American Journal of Public Health* 93(7):1149-1154 (2003).
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Dynamics." *Journal of Law and Economics* 46:599-626 (2003).

18. **Bhattacharya J**, Goldman D, Sood N. "The Link Between Public and Private Insurance and HIV-Related Mortality," *Journal of Health Economics* 22:1105-1122 (2003).
19. Lakdawalla D, **Bhattacharya J**, and Goldman D. "Are the Young Becoming More Disabled?" *Health Affairs* 23(1):168-176 (2004).
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31. **Bhattacharya J** and Sood N, "Health Insurance and the Obesity Externality" *Advances In Health Economics And Health Services Research* 17:279-318 (2007).
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134. Alobuia WM, Dalva-Baird NP, Forrester JD, Bendavid E, **Bhattacharya J**, Kebebew E. Racial disparities in knowledge, attitudes and practices related to COVID-19 in the USA [published online ahead of print, 2020 Jun 3]. J Public Health (Oxf). 2020;fdaa069. doi:10.1093/pubmed/fdaa069
135. Shin SH, Lillard DR, **Bhattacharya J**. Understanding the correlation between Alzheimer's Disease polygenic risk, wealth, and the composition of wealth holdings. *Biodemography and Social Biology* (2020) Oct 28;268:113473. doi: 10.1016/j.socscimed.2020.113473
136. Curto V, Einav L, Levin J, and **Bhattacharya J**. Can Health Insurance Competition Work? Evidence from Medicare Advantage. *Journal of Political Economy* (2020, forthcoming)
137. Sandhu AT, **Bhattacharya J**, Lam J, Bounds S, Luo B, Moran D, Uwilingiyimana AS, Fenson D, Choradia N, Do R, Feinberg L, MaCurdy T, Nagavarapu S. Adjustment For Social Risk Factors Does Not Meaningfully Affect Performance On Medicare's MIPS Clinician Cost Measures. *Health Aff* (Millwood). 2020 Sep;39(9):1495-1503. doi: 10.1377/hlthaff.2020.00440. PMID: 32897780.
138. Kasajima M, Hashimoto H, Suen SC, Chen B, Jalal H, Eggleston K, **Bhattacharya J**. Future projection of the health and functional status of older people in Japan: A multistate transition microsimulation model with repeated cross-sectional data. *Health Econ*. 2020 Jul 14. doi: 10.1002/hec.3986. Epub ahead of print. PMID: 32662080.
139. Lin E, Chertow GM, **Bhattacharya J**, Lakdawalla D. Early Delays in Insurance Coverage and Long-term Use of Home-based Peritoneal Dialysis. Med Care. 2020 Jul;58(7):632-642. doi: 10.1097/MLR.0000000000001350. PMID: 32520837; PMCID: PMC7295012.
140. Peirlinck M, Linka K, Costabal FS, **Bhattacharya J**, Bendavid E, Ioannidis J, Kuhl E (2020), "Visualizing the Invisible: The Effect of Asymptotic Transmission on the Outbreak Dynamics of COVID-19" *Computer Methods in Applied Mechanics and Engineering*. 372: 1 Dec. 2020, 113410. https://doi.org/10.1016/j.cma.2020.113410.
141. Bendavid E, Oh C, **Bhattacharya J**, Ioannidis J (2020) "Assessing Mandatory Stay-at-Home and Business Closure Effects on the Spread of COVID-19" European Journal of Clinical Investigation. 5 January 2020. doi:10.1111/eci.13484

NON-PEER-REVIEWED WORK (32 total)

1. **Bhattacharya J**, Garber AM, MaCurdy T. Cause-Specific Mortality among Medicare Enrollees. *National Bureau of Economic Research Working Paper Series*. 1996;No. 5409.
2. **Bhattacharya J,** Currie J. "Youths at Nutritional Risk : Malnourished or Misnourished?" *National Bureau of Economic Research Working Paper Series*. 2000;No. 7686(7686):483–522.
3. **Bhattacharya J,** Lakdawalla D. Does Medicare Benefit the Poor? New Answers to an Old Question. *National Bureau of Economic Research Working Paper Series*. 2002;No. 9280.
4. **Bhattacharya J.** "Coinsurance, Cost Sharing, and the Demand Managed Behavioral Health Services" *Frontlines: Linking Alcohol Services Research & Practice*, June (2003).
5. **Bhattacharya J,** Lakdawalla D. Time-Inconsistency and Welfare. *National Bureau of Economic Research Working Paper Series*. 2004;No. 10345.
6. Sood N, Alpert A, **Bhattacharya J**. Technology, Monopoly and the Decline of the Viatical Settlements Industry. *National Bureau of Economic Research Working Paper Series*. 2005;No. 11164(March).
7. **Bhattacharya J**, Vogt WB. Employment and Adverse Selection in Health Insurance. *National Bureau of Economic Research Working Paper Series*. 2006;No. 12430(August).
8. **Bhattacharya J.** "Dollars to Doughnuts" *Hoover Digest* 3 (2007).
9. **Bhattacharya J**, Vogt WB. Do Instrumental Variables Belong in Propensity Scores? National Bureau of Economic Research, Inc, NBER Technical Working Papers: 0343; 2007;No. 343.
10. **Bhattacharya J**, Packalen M. Is Medicine an Ivory Tower? Induced Innovation, Technological Opportunity, and For-Profit vs. Non-Profit Innovation. *National Bureau of Economic Research Working Paper Series*. 2008;No. 13862.
11. Atella V, **Bhattacharya J**, Carbonari L. Pharmaceutical Industry, Drug Quality and Regulation: Evidence from US and Italy. *National Bureau of Economic Research Working Paper Series*. 2008.
12. Yoo B-K, Kasajima M, **Bhattacharya J.** Public Avoidance and the Epidemiology of novel H1N1 Influenza A. *National Bureau of Economic Research Working Paper Series*. 2010;15752:1–39.
13. Aranovich G, **Bhattacharya J**, Garber A, MaCurdy T, "Coping with Chronic Disease? Chronic Disease and Disability in Elderly American Population 1982-1999," NBER Working Paper *#14811* (2009)
14. Jena AB, Schoemaker L, **Bhattacharya J**, Seabury SA. "Authors' reply to Barbieri and Kovarik, Mariani, and Waxman and Kanzaria." BMJ. 351:h6774. doi: 10.1136/bmj.h6774. (2015) PMID: 26668033
15. Gidwani R, **Bhattacharya J.** "CMS Reimbursement Reform: Authors' Reply." *J Gen Intern Med*. 2015 30(11):1588. doi: 10.1007/s11606-015-3465-5. PMID: 26179821

16. **Bhattacharya J.** "A way out of the dismal arithmetic of hepatitis C treatment." *Am J Manag Care*. (6 Spec No.):SP183-4. (2016) PMID: 27266945
17. Liu V, Fielding-Singh V, Iwashyna TJ, **Bhattacharya J**, Escobar G. "Reply to the Timing of Early Antibiotics and Hospital Mortality in Sepsis - Playing Devil's Advocate. *Am J Respir Crit Care Med*. doi: 10.1164/rccm.201704-0774LE. (2017) PMID: 28485627
18. Bendavid E and **Bhattacharya J** "Is the Coronavirus as Deadly as They Say?" Wall Street Journal, March 24, 2020.
19. Bendavid, E., Mulaney, B., Sood, N., Shah, S., Ling, E., Bromley-Dulfano, R., Lai, C., Weissberg, Z., Saavedra, R., Tedrow, J., Tversky, D., Bogan, A., Kupiec, T., Eichner, D., Gupta, R., Ioannidis, J., & **Bhattacharya, J.** (2020). COVID-19 Antibody Seroprevalence in Santa Clara County, California. medRxiv, 2020.04.14.20062463. https://doi.org/10.1101/2020.04.14.20062463
20. **Bhattacharya J** and Packalen M "Lives vs. Lives: The Global Cost of Lockdown" Spectator, May 13, 2020
21. **Bhattacharya J** and Packalen M "Focused COVID-19 Restrictions Will Save Lives in Poor Countries", Financial Post, July 3, 2020.
22. **Bhattacharya J** and Agarwal S. "Lift lockdowns, protect the vulnerable, treat Covid like a health issue and not a disaster" The Print. July 24, 2020
23. **Bhattacharya J** and Kulldorff M. "The Case Against Covid Tests for the Young and Healthy" Wall Street Journal, Sept. 3, 2020
24. **Bhattacharya J.** A Sensible and Compassionate Anti-COVID Strategy. *Imprimis* 49(10). October 2020. https://imprimis.hillsdale.edu/sensible-compassionate-anti-covid-strategy/
25. Kulldorff M, Gupta S, and **Bhattacharya J.** Great Barrington Declaration. Oct. 4, 2020.
26. Kulldorff M, Gupta S, and **Bhattacharya J** "Our COVID-19 plan would minimize mortality and lockdown-induced collateral damage" USA Today, Oct. 22, 2020.
27. **Bhattacharya J** "It's Time for an Alternative to Lockdown" Spectator, Oct. 29, 2020.
28. Kulldorff M, Gupta S, and **Bhattacharya J** "We Should Focus on Protecting the Vulnerable from COVID Infection" Newsweek, Oct. 30, 2020.
29. Kulldorff M and **Bhattacharya J.** "Lockdown Isn't Working" Spectator, Nov. 2, 2020.
30. Kulldorff M, Gupta S, and **Bhattacharya J.** Focused Protection: The Middle Ground between Lockdowns and "Let it Rip". Great Barrington Declaration, Nov. 25, 2020.
31. **Bhattacharya** J and Makridis C "Facts – not fear – will stop the pandemic" The Hill, Dec. 3, 2020.
32. **Bhattacharya** J and Gupta S. "How to End the Lockdowns Next Month" Wall Street Journal, Dec. 17, 2020.

JAY BHATTACHARYA, M.D., Ph.D. **January 2020**

BOOKS AND REPORTS (9 total)

1. Yoshikawa A, **Bhattacharya J**, Vogt WB eds. Health Economics of Japan: Patients, Doctors, and Hospitals Under a Universal Health Insurance System, Tokyo: University of Tokyo Press, (1996).
2. Goldman DP, Hurd M, Shekelle PG, Newberry SJ, Panis CWA, Shang B, **Bhattacharya J**, Joyce GF, Lakdawalla D. Health Status and Medical Treatment of the Future Elderly: Final Report, TR-169-CMS, Santa Monica, CA: RAND (2004).
3. **Bhattacharya J**, Currie J, Haider SJ, Variyam J. Evaluating the Impact of School Nutrition Programs: Final Report. E-FAN-04-008, Washington D.C.: Economic Research Service, USDA (2004).
4. **Bhattacharya J**, Hyde T, Tu P. Health Economics, London: Palgrave-MacMillan, (2013).
5. MaCurdy T, **Bhattacharya J**, Perlroth D, Shafrin J, Au-Yeung A, Bashour H, Chicklis C, Cronen K, Lipton B, Saneinejad S, Shrestha E, Zaidi S. Geographic Variation in Spending, Utilization, and Quality: Medicare and Medicaid Beneficiaries. Acumen Report to the Institute of Medicine Committee Study of Geographic Variation in Health Care Spending and Promotion of High-Value Health Care, Washington, DC: Institute of Medicine (2013)
6. MaCurdy T, **Bhattacharya J**, Shafrin J, Chicklis C, Cronen K, Friley J, Lipton B, Rogers D, Zaidi S. IOM Study of Geographic Variation: Growth Analysis. Acumen Report to the Institute of Medicine Committee Study of Geographic Variation in Health Care Spending and Promotion of High-Value Health Care, Washington, DC: Institute of Medicine (2013)
7. **Bhattacharya J**, Chandra A, Chernew M, Goldman D, Jena A, Lakdawalla D, Malani A, Philipson T. Best of Both Worlds: Uniting Universal Coverage and Personal Choice in Health Care, American Enterprise Institute (AEI) White Paper, Washington DC: AEI Press (2013)
8. **Bhattacharya J**, Vail D, Moore D, Vogt W, Choradia N, Do R, Erickson K, Feinberg L, Isara F, Lin E, Narayanan V, Vaikath M, MaCurdy T. Medicare Current State and Future Trends Environment Scan. Center for Medicare and Medicaid Services (CMS) White Paper (2019)
9. **Bhattacharya J**, Packalen M. On the Futility of Contact Tracing. *Inference* 5(3) September (2020) https://inference-review.com/article/on-the-futility-of-contact-tracing

BOOK CHAPTERS (15 total)

1. **Bhattacharya** J, Garber AM, MaCurdy T. "Cause-Specific Mortality Among Medicare Enrollees," in Inquires in the Economics of Aging, D Wise (ed.), Chicago, IL: University of Chicago Press. (1997).
2. MaCurdy T, Nechyba T, **Bhattacharya J.** "Ch. 2: An Economic Model of the Fiscal Impacts of Immigration," The Immigration Debate: Studies on the Economic, Demographic, and Fiscal Effects of Immigration, J Smith (ed.), National Academy of Sciences Commission on Behavioral and Social Sciences and Education: Washington D.C., (1998).
3. **Bhattacharya J**, Currie J. "Youths and Nutritional Risk: Malnourished or Misnourished?" in Risky Behavior Among Youths, J Gruber (ed.), (2001).
4. Yoshikawa A. and **Bhattacharya J.** "Japanese Health Care" in World Health Systems: Challenges and Perspectives, Bruce Fried and Laura M. Gaydos (eds.), Chicago, IL: Health Administration Press (2002).
5. **Bhattacharya J**, Cutler D, Goldman DP, Hurd MD, Joyce GF, Lakdawalla DN, Panis CWA, and Shang B, "Disability Forecasts and Future Medicare Costs" Frontiers in Health Policy Research, Vol. 6, Alan Garber and David Cutler (eds.) Boston, MA: MIT Press (2003).
6. **Bhattacharya J**, Choudhry K, and Lakdawalla D. (2007) "Chronic Disease and Trends in Severe Disability in Working Age Populations" Proceedings from the Institute of Medicine workshop, 'Disability in America: An Update,' Institute of Medicine: Washington, D.C.
7. **Bhattacharya J**, Garber AM, MaCurdy T. "Trends in Prescription Drug Use by the Disabled Elderly" in Developments in the Economics of Aging, D. Wise (ed), Chicago, IL, University of Chicago Press (2009).
8. **Bhattacharya** J and Richmond P "On Work and Health Among the American Poor" in Pathways to Self-Sufficiency: Getting Ahead in an Era Beyond Welfare Reform John Karl Scholz and Carolyn Heinrich (eds), New York, NY, Russell Sage Foundation (2009).
9. **Bhattacharya** J, Garber A, MaCurdy T "The Narrowing Dispersion of Medicare Expenditures 1997-2005" in Research Findings in the Economics of Aging, D. Wise (ed.), Chicago, IL, University of Chicago Press (2010)
10. **Bhattacharya J**, Bundorf MK, Pace N, and Sood N "Does Health Insurance Make You Fat?" in Economic Aspects of Obesity Michael Grossman and Naci Mocan (eds.), Chicago, IL, University of Chicago Press (2010)
11. **Bhattacharya** J, Garber A, Miller M, and Perlroth D "The Value of Progress against Cancer in the Elderly" Investigations in the Economics of Aging, David Wise (ed), Chicago, IL, University of Chicago Press (2012)
12. Yoshikawa A. and **Bhattacharya J.** "Japanese Health Care" in World Health Systems: Challenges and Perspectives, 2nd edition, Bruce Fried and Laura M. Gaydos (eds.), Chicago, IL: Health Administration Press (2012).
13. Hanson, J., Chandra, A., Moss, E., **Bhattacharya,** J. Wolfe, B., Pollak, S.D.. Brain Development and Poverty: Preliminary Findings. In Biological Consequences of

Socioeconomic Inequalities. B. Wolfe, T. Seeman, and W. Evans (Eds). NY: Sage. (2012)

14. **Bhattacharya J** "The Diffusion of New Medical Technologies: The Case of Drug-Eluting Stents (A Discussion of Chandra, Malenka, and Skinner)" In Explorations in the Economics of Aging, David Wise (ed.), Chicago, IL, University of Chicago Press (2014).
15. MaCurdy T and **Bhattacharya J** "Challenges in Controlling Medicare Spending: Treating Highly Complex Patients" in Insights in the Economics of Aging, David Wise (ed.) Chicago, IL, University of Chicago Press (2015).

ABSTRACTS (3)

1. Su CK and **Bhattacharya J.** Longitudinal Hospitalization Costs and Outcomes in the Treatment of the Medicare Breast Cancer Patient. *International Journal of Radiation Oncology Biology Physics* (1996); 36(S1): 282. [abstract]
2. Nguyen C, Hernandez-Boussard T., Davies S, **Bhattacharya J**, Khosla R, Curtin C. *Cleft Palate Surgery: Variables of Quality and Patient Safety.* Presented at the 69th Annual American Cleft-Palate Craniofacial Association (2012). [abstract]
3. Patel MI, Ramirez D, Agajanian R, Bhattacharya J, Milstein A, Bundorf MK. "The effect of a lay health worker-led symptom assessment intervention for patients on patient-reported outcomes, healthcare use, and total costs." Journal of Clinical Oncology 36(15 Suppl):6502 [abstract]

D. PUBLIC AND PROFESSIONAL SERVICE:

JOURNAL EDITING

Journal of Human Capital, Associate Editor (2015-present)
American Journal of Managed Care, Guest Editor (2016)
Journal of Human Resources, Associate Editor (2011-13)
Forum for Health Economics & Policy, Editorial Board Member (2001-2012)
Economics Bulletin, Associate Editor (2004-2009)

SERVICE ON SCIENTIFIC REVIEW AND ADVISORY COMMITTEES (Selected)

- Standing member of the Health Services Organization and Delivery (HSOD) NIH review panel, 2012-2016
- NIH reviewer (various panels, too numerous to list) 2003-present
- NIH Review Panel Chair: 2018 (P01 review), 2020 (DP1 review).
- Invited Reviewer for the European Research Council, ERC Advanced Grant 2015 RFP
- NIH Stage 2 Challenge Grant Review Panel, July 2009
- Appointed a member of an Institute of Medicine (IOM) panel on the regulation of work hours by resident physicians, 2007-8.
- Standing member of the NIH Social Science and Population Studies Review Panel, Fall 2004-Fall 2008

- Invited Reviewer for National Academy of Sciences report on Food Insecurity and Hunger, November 2005.
- Invited Reviewer for the National Academy of Sciences report on the Nutrition Data Infrastructure, December 2004
- Invited Reviewer for the National Institute on Health (NIH) Health Services Organization and Delivery Review Panel, June 2004, Alexandria, VA.
- Invited Reviewer for the Food Assistance and Nutrition Research Program US Department of Agriculture Economic Research Service Research Proposal Review Panel, June 2004, Stanford, CA.
- Invited Reviewer for the National Institute on Health (NIH) Social Science and Population Studies Review Panel, February 2004, Alexandria, VA.
- Invited Reviewer for the National Institute on Health (NIH) Social Sciences and Population Studies Review Panel, November 2003, Bethesda, MD.
- Invited Reviewer for the National Institute on Health (NIH) Social Science, Nursing, Epidemiology, and Methods (3) Review Panel, June 2003, Bethesda, MD.
- Invited Reviewer for the Food Assistance and Nutrition Research Program US Department of Agriculture Economic Research Service Research Proposal Review Panel, August 2002.
- Research Advisory Panel on Canadian Disability Measurement, Canadian Human Resources Development Applied Research Branch, June 2001 in Ottowa, Canada.
- Invited Reviewer for the National Institute of Occupational Safety and Health R18 Demonstration Project Grants Review panel in July 2000, Washington D.C.
- Research Advisory Panel on Japanese Health Policy Research. May 1997 at the Center for Global Partnership, New York, NY.

TESTIMONY TO GOVERNMENTAL PANELS AND AGENCIES (9)

- US Senate Dec. 2020 hearing of the Subcommittee on Homeland Security and Governmental Affairs. Testimony provided on COVID-19 mortality risk, collateral harms from lockdown policies, and the incentives of private corporations and the government to invest in research on low-cost treatments for COVID-19 disease
- "Roundtable on Safe Reopening of Florida" led by Florida Gov. Ron DeSantis. September 2020.
- "Evaluation of the Safety and Efficacy of COVID-19 Vaccine Candidates" July 2020 hearing of the House Oversight Briefing to the Economic and Consumer Policy Subcommittee.
- Safely Restarting Youth Baseball and Softball Leagues, May 2020 US Senate virtual roundtable, invited testimony
- "Population Aging and Financing Long Term Care in Japan" March 2013 seminar at the Japanese Ministry of Health.
- "Implementing the ACA in California" March 2011 testimony to California Legislature Select Committee on Health Care Costs.
- "Designing an Optimal Data Infrastructure for Nutrition Research" June 2004 testimony to the National Academy of Sciences commission on "Enhancing the Data Infrastructure

in Support of Food and Nutrition Programs, Research, and Decision Making," Washington D.C.

- "Measuring the Effect of Overtime Reform" October 1998 testimony to the California Assembly Select Committee on the Middle Class, Los Angeles, CA.
- "Switching to Weekly Overtime in California." April 1997 testimony to the California Industrial Welfare Commission, Los Angeles, CA.

REFEREE FOR RESEARCH JOURNALS

American Economic Review; American Journal of Health Promotion; American Journal of Managed Care; Education Next; Health Economics Letters; Health Services Research; Health Services and Outcomes Research Methodology; Industrial and Labor Relations Review; Journal of Agricultural Economics; Journal of the American Medical Association; Journal of Health Economics; Journal of Health Policy, Politics, and Law; Journal of Human Resources; Journal of Political Economy; Labour Economics; Medical Care; Medical Decision Making; Review of Economics and Statistics; Scandinavian Journal of Economics; Social Science and Medicine; Forum for Health Economics and Policy; Pediatrics; British Medical Journal

Trainee	Current Position
Peter Groeneveld, MD, MS	Associate Professor of Medicine, University of Pennsylvania
Jessica Haberer, MD, MS	Assistant Professor of Medicine, Harvard Medical School
Melinda Henne, MD, MS	Director of Health Services Research, Bethesda Naval Hospital
Byung-Kwang Yoo, MD, PhD	Associate Professor, Public Health, UC Davis
Hau Liu, MD, MS, MBA	Chief Medical Officer at Shanghai United Family Hospital
Eran Bendavid, MD, MS	Assistant Professor, General Medicine Disciplines, Stanford University
Kaleb Michaud, MS, PhD	Associate Professor of Medicine, Rheumatology and Immunology, University of Nebraska Medical Center
Kanaka Shetty, MD	Natural Scientist, RAND Corporation
Christine Pal Chee, PhD	Associate Director of the Health Economics Resource Center, Palo Alto VA
Matthew Miller, MD	VP Clinical Strategy and Head of Innovation, Landmark Health
Vincent Liu, MD	Research Scientist, Kaiser Permanente Northern California Division of Research
Daniella Perlroth, MD	Chief Data Scientist, Lyra Health
Crystal Smith-Spangler, MD	Internist, Palo Alto Medical Foundation
Barrett Levesque, MD MS	Assistant Professor of Clinical Medicine, UC San Diego Health System
Torrey Simons, MD	Clinical Instructor, Department of Medicine, Stanford University
Nayer Khazeni, MD	Assistant Professor of Medicine (Pulmonary and Critical Care Medicine), Stanford University
Monica Bhargava, MD MS	Assistant Clinical Professor, UCSF School of Medicineilan
Dhruv Kazi, MD	Assistant Professor, UCSF School of Medicine
Zach Kastenberg, MD	Resident, Department of Surgery, Stanford University
Kit Delgado, MD	Assistant Professor, Department of Emergency Medicine and Faculty Fellow, University of Pennsylvania
Suzann Pershing, MD	Chief of Ophtalmology for the VA Palo Alto Health Care System
KT Park, MD	Assistant Professor, Department of Medicine, Stanford University
Jeremy Goldhaber-Fiebert, PhD	Associate Professor, Department of Medicine, Stanford University
Sanjay Basu, MD	Assistant Professor, Department of Medicine, Stanford University
Marcella Alsan, MD, PhD	Assistant Professor, Department of Medicine (CHP/PCOR), Stanford Univ.
David Chan, MD, PhD	Assistant Professor, Department of Medicine (CHP/PCOR), Stanford Univ.
Karen Eggleston, PhD	Senior Fellow, Freeman Spogli Institute, Stanford University
Kevin Erickson, MD	Assistant Professor, Department of Nephrology, Baylor College of Medicine
Ilana Richman, MD	VA Fellow at CHP/PCOR, Stanford University

Alexander Sandhu, MD	VA Fellow at CHP/PCOR, Stanford University
Michael Hurley	Medical Student, Stanford University
Manali Patel, MD	Instructor, Department of Medicine (Oncology), Stanford University
Dan Austin, MD	Resident Physician, Department of Anesthesia, UCSF School of Medicine
Anna Luan, MD	Resident Physician, Department of Medicine, Stanford University
Louse Wang	Medical Student, Stanford University
Christine Nguyen, MD	Resident Physician, Department of Medicine, Harvard Medical School
Josh Mooney, MD	Instructor, Department of Medicine (Pulmonary and Critical Care Medicine), Stanford University
Eugene Lin, MD	Fellow, Department of Medicine (Nephrology), Stanford University
Eric Sun, MD	Assistant Professor, Department of Anesthesia, Stanford University
Sejal Hathi	Medical Student, Stanford University
Ibrahim Hakim	Medical Student, Stanford University
Archana Nair	Medical Student, Stanford University
Trishna Narula	Medical Student, Stanford University
Daniel Vail	Medical Student, Stanford University
Tej Azad	Medical Student, Stanford University
Jessica Yu, MD	Fellow, Department of Medicine (Gastroenterology), Stanford University
Daniel Vail	Medical Student, Stanford University
Alex Sandhu, MD	Fellow, Department of Medicine (Cardiology), Stanford University
Matthew Muffly, MD	Clinical Assistant Professor, Dept. of Anesthesia, Stanford University

Dissertation Committee Memberships

Ron Borzekowski	Ph.D. in Economics	Stanford University	2002
Jason Brown	Ph.D. in Economics	Stanford University	2002
Dana Rapaport	Ph.D. in Economics	Stanford University	2003
Ed Johnson	Ph.D. in Economics	Stanford University	2003
Joanna Campbell	Ph.D. in Economics	Stanford University	2003
Neeraj Sood*	Ph.D. in Public Policy	RAND Graduate School	2003
James Pearce	Ph.D. in Economics	Stanford University	2004
Mikko Packalen	Ph.D. in Economics	Stanford University	2005
Kaleb Michaud*	Ph.D. in Physics	Stanford University	2006
Kyna Fong	Ph.D. in Economics	Stanford University	2007
Natalie Chun	Ph.D. in Economics	Stanford University	2008
Sriniketh Nagavarapu	Ph.D in Economics	Stanford University	2008
Sean Young	Ph.D. in Psychology	Stanford University	2008
Andrew Jaciw	Ph.D. in Education	Stanford University	2010
Chirag Patel	Ph.D. in Bioinformatics	Stanford University	2010
Raphael Godefroy	Ph.D. in Economics	Stanford University	2010
Neal Mahoney	Ph.D. in Economics	Stanford University	2011
Alex Wong	Ph.D. in Economics	Stanford University	2012
Kelvin Tan	Ph.D. in Management Science	Stanford University	2012
Animesh Mukherjee	Masters in Liberal Arts Program	Stanford University	2012
Jeanne Hurley	Masters in Liberal Arts Program	Stanford University	2012
Patricia Foo	Ph.D. in Economics	Stanford University	2013
Michael Dworsky	Ph.D. in Economics	Stanford University	2013
Allison Holliday King	Masters in Liberal Arts Program	Stanford University	2013
Vilsa Curto	Ph.D. in Economics	Stanford University	2015
Rita Hamad	Ph.D. in Epidemiology	Stanford University	2016
Atul Gupta	Ph.D. in Economics	Stanford University	2017
Min Kim	Ph.D. in Economics	Iowa State Univ.	2019

E. GRANTS AND PATENTS

PATENT (2)

1. "Environmental Biomarkers for the Diagnosis and Prognosis for Type 2 Diabetes Mellitus" with Atul Butte and Chirag Patel (2011), US Patent (pending).
2. "Health Cost and Flexible Spending Account Calculator" with Schoenbaum M, Spranca M, and Sood N (2008), U.S. Patent No. 7,426,474.

GRANTS AND SUBCONTRACTS (42)

CURRENT (6)

2019-2020	Funder: Acumen, LLC. Title: Quality Reporting Program Support for the Long-Term Care Hospital, Inpatient Rehabilitation Facility, Skilled Nursing Facility QRPs and Nursing Home Compare Role: PI
2018-2020	Funder: Acumen, LLC. Title: Surveillance Activities of Biologics Role: PI
2018-2020	Funder: France-Stanford Center for Interdisciplinary Studies Title: A Nutritional Account of Global Trade: Determinants and Health Implications Role: PI
2017-2023	Funder: National Institutes of Health Title: The Epidemiology and Economics of Chronic Back Pain Role: Investigator (PI: Sun)
2017-2021	Funder: National Institutes of Health Title: Big Data Analysis of HIV Risk and Epidemiology in Sub-Saharan Africa Role: Investigator (PI: Bendavid)
2016-2020	Funder: Acumen, LLC. Title: MACRA Episode Groups and Resource Use Measures II Role: PI

PREVIOUS (36)

2016-2018	Funder: University of Kentucky Title: Food acquisition and health outcomes among new SNAP recipients since the Great Recession Role: PI
2015-2019	Funder: Alfred P. Sloan Foundation Title: Public versus Private Provision of Health Insurance Role: PI
2015-2019	Funder: Natural Science Foundation

	Title: Health Insurance Competition and Healthcare Costs Role: Investigator (PI: Levin)
2014-2015	Funder: The Centers for Medicare and Medicaid Services Title: Effect of Social Isolation and Loneliness on Healthcare Utilization Role: PI
2014-2015	Funder: AARP Title: The Effect of Social Isolation and Loneliness on Healthcare Utilization and Spending among Medicare Beneficiaries Role: PI
2013-2019	Funder: National Bureau of Economic Research Title: Innovations in an Aging Society Role: PI
2013-2014	Funder: Robert Wood Johnson Foundation Title: Improving Health eating among Children through Changes in Supplemental Nutrition Assistance Program (SNAP) Role: Investigator (PI: Basu)
2011-2016	Funder: National Institutes of Health (R37) Title: Estimating the Potential Medicare Savings from Comparative Effectiveness Research Role: PI Subaward (PI: Garber)
2011-2016	Funder: National Institute of Aging (P01) Title: Improving Health and Health Care for Minority and Aging Populations Role: PI Subcontract (PI: Wise)

2010-2018	Funder: National Institutes of Health Title: Clinic, Family & Community Collaboration to Treat Overweight and Obese Children Role: Investigator (PI: Robinson)
2010-2014	Funder: Agency for Health, Research and Quality (R01) Title: The Effects of Private Health Insurance in Publicly Funded Programs Role: Investigator (PI: Bundorf)
2010-2013	Funder: Agency for Healthcare Research and Quality Title: G-code" Reimbursement and Outcomes in Hemodialysis Role: Investigator (PI: Erickson)
2010-2013	Funder: University of Southern California Title: The California Medicare Research and Policy Center Role: PI
2010-2012	Funder: University of Georgia Title: Natural Experiments and RCT Generalizability: The Woman's Health Initiative Role: PI
2010-2011	Funder: National Bureau of Economic Research Title: Racial Disparities in Health Care and Health Among the Elderly Role: PI
2009-2020	Funder: National Institute of Aging (P30) Title: Center on the Demography and Economics of Health and Aging Role: PI (2011-2020)
2009-2011	Funder: Rand Corporation Title: Natural Experiments and RCT Generalizability: The Woman's Health Initiative Role: PI
2008-2013	Funder: American Heart Association Title: AHA-PRT Outcomes Research Center Role: Investigator (PI: Hlatky)
2007-2009	Funder: National Institute of Aging (R01) Title: The Economics of Obesity Role: PI
2007-2009	Funder: Veterans Administration, Health Services Research and Development Service Title: Quality of Practices for Lung Cancer Diagnosis and Staging Role: Investigator
2007-2008	Funder: Stanford Center for Demography and Economics of Health and Aging Title: The HIV Epidemic in Africa and the Orphaned Elderly

	Role: PI
2007	Funder: University of Southern California Title: The Changes in Health Care Financing and Organization Initiative Role: PI
2006-2010	Funder: National Institute of Aging (K02) Title: Health Insurance Provision for Vulnerable Populations Role: PI
2006-2010	Funder: Columbia University/Yale University Title: Dummy Endogenous Variables in Threshold Crossing Models, with Applications to Health Economics Role: PI
2006-2007	Funder: Stanford Center for Demography and Economics of Health and Aging Title: Obesity, Wages, and Health Insurance Role: PI
2005-2009	Funder: National Institute of Aging (P01 Subproject) Title: Medical Care for the Disabled Elderly Role: Investigator (PI: Garber)
2005-2008	Funder: National Institute of Aging (R01) Title: Whom Does Medicare Benefit? Role: PI Subcontract (PI: Lakdawalla)
2002	Funder: Stanford Center for Demography and Economics of Health and Aging Title: Explaining Changes in Disability Prevalence Among Younger and Older American Populations Role: PI
2001-2003	Funder: Agency for Healthcare Research and Quality (R01) Title: State and Federal Policy and Outcomes for HIV+ Adults Role: PI Subcontract (PI: Goldman)
2001-2002	Funder: National Institute of Aging (R03) Title: The Economics of Viatical Settlements Role: PI
2001-2002	Funder: Robert Woods Johnson Foundation Title: The Effects of Medicare Eligibility on Participation in Social Security Disability Insurance Role: PI Subcontract (PI: Schoenbaum)
2001-2002	Funder: USDA Title: Evaluating the Impact of School Breakfast and Lunch Role: Investigator
2001-2002	Funder: Northwestern/Univ. of Chicago Joint Center on Poverty Title: The Allocation of Nutrition with Poor American Families Role: PI Subcontract (PI: Haider)
2000-2002	Funder: National Institute on Alcohol Abuse & Alcoholism (R03) Title: The Demand for Alcohol Treatment Services Role: PI
2000-2001	Funder: USDA Title: How Should We Measure Hunger?

Role: PI Subcontract (PI: Haider)

F. SCHOLARSHIPS AND HONORS

- Phi Beta Kappa Honor Society, 1988
- Distinction and Departmental Honors in Economics, Stanford University, 1990
- Michael Forman Fellowship in Economics, Stanford University, 1991-1992
- Agency for Health Care Policy and Research Fellowship 1993-1995
- Outstanding Teaching Assistant Award, Stanford University, Economics, 1994
- Center for Economic Policy Research, Olin Dissertation Fellowship, 1997-1998
- Distinguished Award for Exceptional Contributions to Education in Medicine, Stanford University, 2005, 2007, and 2013.
- Dennis Aigner Award for the best applied paper published in the *Journal of Econometrics*, 2013

AB187

THIS IS **EXHIBIT "C"** TO THE AFFIDAVIT OF JAY BHATTACHARYA SWORN BEFORE ME AT THE CITY OF _____, IN THE COUNTY OF _____, IN THE STATE OF CALIFORNIA, THE 5TH DAY OF JANUARY, 2021.

_____

A NOTARY PUBLIC IN AND FOR THE STATE OF CALIFORNIA

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of California
County of San Mateo

Subscribed and sworn to (or affirmed) before me on this 05 day of Jan, 20 21, by Jay Bhattacharya

proved to me on the basis of satisfactory evidence to be the person(s) who appeared before me.

(Seal) Signature _____

Jayanta Bhattacharya

Jan 5, 2021

HAMED JIRSARAEI
COMM. #2217313
NOTARY PUBLIC - CALIFORNIA
SAN MATEO COUNTY
My Comm. Exp. Oct. 8, 2021

Expert Report on the COVID-19 Epidemic Response in Manitoba, Canada

Jay Bhattacharya, MD, PhD

January 5, 2021

Table of Contents

A. Does Covid-19 pose a real or imminent serious threat to the health of the population?

The mortality danger from COVID-19 infection varies substantially by age and a few chronic disease indicators.[1] For a majority of the population, including the vast majority of children and young adults, COVID-19 infection poses less of a mortality risk than seasonal influenza. By contrast, for older populations – especially those with severe comorbid chronic conditions – COVID-19 infection poses a high risk of mortality, on the order of a 5% infection fatality rate.

The best evidence on the infection fatality rate from SARS-CoV-12 infection (that is, the fraction of infected people who die due to the infection) comes from seroprevalence studies. The definition of seroprevalence of COVID-19 is the fraction of people within a population who have specific antibodies against SARS-CoV-2 in their bloodstream. Seroprevalence studies provide better evidence on the total number of people who have been infected than do case reports or a positive reverse transcriptase-polymerase chain reaction (RT-PCR) test counts; these both miss infected people who are not identified by the public health authorities or do not volunteer for RT-PCR testing. Because they ignore unreported cases in the denominator, fatality rate estimates based on case reports or positive test counts are substantially biased upwards.

According to a meta-analysis[2] by Dr. John Ioannidis of every seroprevalence study conducted to date of publication with a supporting scientific paper (74 estimates from 61 studies and 51 different localities around the world), the median infection survival rate from COVID-19 infection is 99.77%. For COVID-19 patients under 70, the meta-analysis finds an infection survival rate of 99.95%. A separate meta-analysis[3] by scientists independent of Dr. Ioannidis' group, reaches qualitatively similar conclusions.

A US CDC report[4] found that there were between six and 24 times more SARS-CoV-2 infections than cases reported between March and May 2020. This study is based on serological analysis of blood samples incidentally collected by commercial laboratories in 10 cities nationwide, although the CDC does not provide the infection fatality rate estimate implied by their seroprevalence studies reviewed by Dr. Ioannidis above.

In September 2020, the CDC updated its current best estimate of the infection fatality ratio - the ratio of deaths to the total number of people infected - for various age groups.[5] The CDC

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[1] Public Health England (2020) Disparities in the Risk and Outcomes of COVID-19. August 2020. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/908434/Disparities_in_the_risk_and_outcomes_of_COVID_August_2020_update.pdf

[2] John P.A. Ioannidis , *The Infection Fatality Rate of COVID- 19 Inferred from Seroprevalence Data*, Bulletin of the World Health Organization BLT 20.265892.

[3] Andrew T. Levin, et al., *Assessing the Age Specificity of Infection Fatality Rate for COVID- 19: Meta-Analysis & Public Policy Implications* (Aug. 14,2020)MEDRXIV, http://bit.ly/3gplolV.

[4] Fiona P. Havers, et al., *Seroprevalence of Antibodies to SARS-CoV-2 in 10 Sites in the United States, March 23-May 12, 2020* (Jul. 21, 2020) JAMA INTERN MED., https://bit.ly/3goZUgy.

[5] COVID- 19 Pandemic Planning Scenarios, Centers for Disease Control and Prevention, https://www.cdc.gov/coronavirus/2019-ncov/hcp/planning-scenarios.html.

estimates that the infection fatality rate for people ages 0-19 years is 0.003%, meaning infected children have a 99.997% survivability rate. The CDC's best estimate of the infection fatality rate for people ages 20-49 years is 0.02%, meaning that young adults have a 99.98% survivability rate. The CDC's best estimate of the infection fatality rate for people age 50-69 years is 0.5%, meaning this age group has a 99.5% survivability rate. The CDC's best estimate of infection fatality rate for people ages 70+ years is 5.4%, meaning seniors have a 94.6% survivability rate.

A study of the seroprevalence of COVID-19 in Geneva, Switzerland (published in the *Lancet*)[6] provides a detailed age break down of the infection survival rate in a preprint companion paper[7] 99.9984% for patients 5 to 9 years old; 99.99968% for patients 10 to 19 years old; 99.991% for patients 20 to 49 years old; 99.86% for patients 50 to 64 years old; and 94.6% for patients above 65.

I estimated the age-specific infection fatality rates from the Santa Clara County seroprevalence study[8] data (for which I am the senior investigator). The infection survival rate is 100% among people between 0 and 19 years (there were no deaths in Santa Clara in that age range up to that date); 99.987% for people between 20 and 39 years; 99.84% for people between 40 and 69 years; and 98.7% for people above 70 years. In fact, in all of California[9] through August 20, there have been only two deaths at all among COVID-19 patients below age 18. Also, 74.2% of all COVID-19 related deaths occurred in patients 65 and older.

While I am not aware of a serosurvey available for Manitoba, it is clear that the age gradient in COVID-19 mortality found everywhere else applies. The overwhelming majority of deaths from COVID-19 in Manitoba have occurred in ages 65 and older.[10]

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[6] Silvia Stringhini, et al., *Seroprevalence of Anti-SARS-CoV-2 IgG Antibodies in Geneva, Switzerland (SEROCoV-POP): A Population Based Study* (June 11,2020) THE LANCET, https://bit.ly/3187S13.

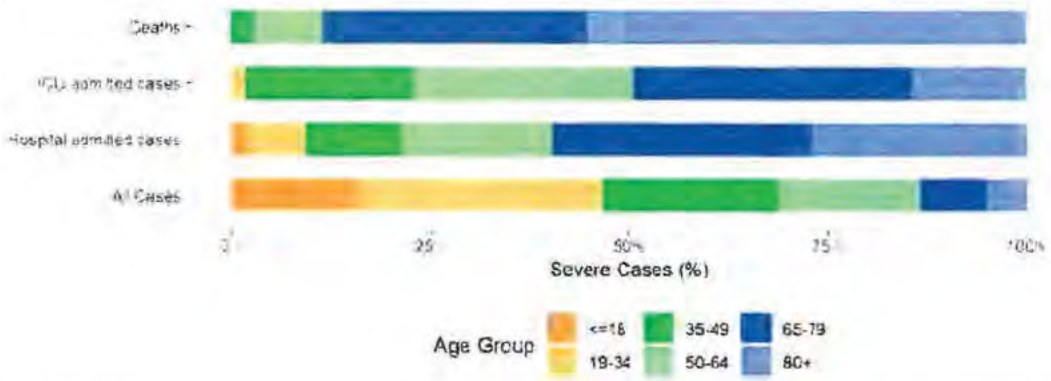
[7] Francisco Perez-Saez, et al. *Serology- Informed Estimates of SARS-COV-2 Infection Fatality Risk in Geneva, Switzerland* (June 15,2020) OSF PREPRINTS, http://osf.io/wdbpe/.

[8] Eran Bendavid, et al., *COVID- 19 Antibody Seroprevalence in Santa Clara County, California* (April 30,2020) MEDRXIV, https://bit.ly/2EuLIFK.

[9] COVID- 19, *Cases and Deaths Associated with COVID-19 by Age Group in California* (Aug. 20,2020) CAL. DEPT. OF PUB. HEALTH, https://bit.ly/31inK9q [accessed Aug. 22,2020].

[10] Provincial Covid-19 Surveillance, Manitoba, Week 45, https://www.gov.mb.ca/health/publichealth/surveillance/covid-19/week_45/index.html

Figure 6. Age Distribution of Severe COVID-19 Cases Compared to All Cases, Manitoba, 2020

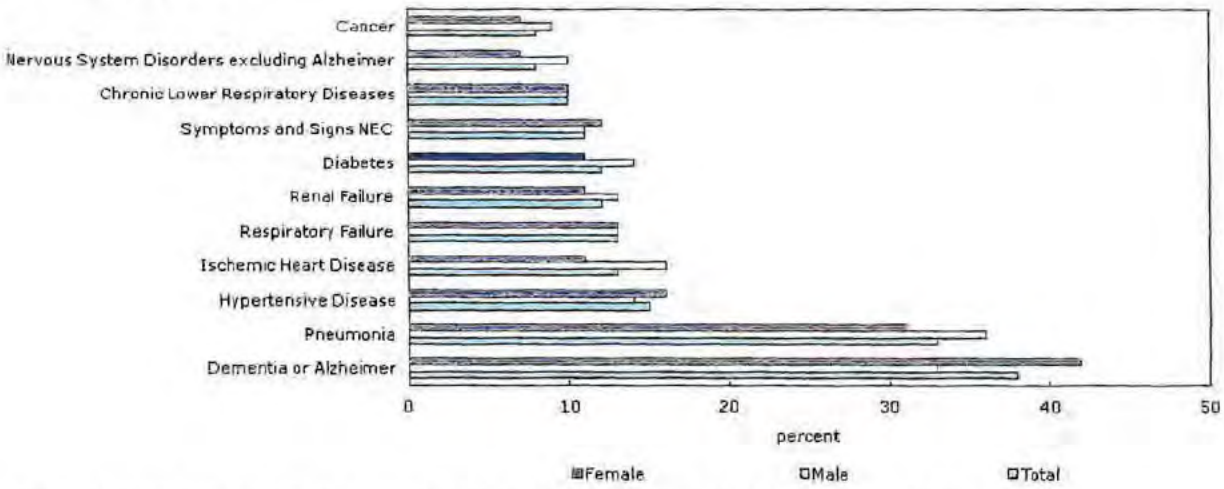


In addition to the risk posed by old age, COVID-19 infection poses an elevated mortality risk for people with certain chronic conditions like diabetes. We now have good evidence on the relative risk posed by the incidence of chronic conditions, so we know that among common conditions, age is the single most important risk factor. For instance, a 65-year-old obese individual has about the same COVID-19 mortality risk conditional upon infection as a 70-year-old non-obese individual.

According to data from Statistics Canada[11], "Of the over 9,500 COVID-involved deaths between March and July, the majority (90%) had at least one other cause, condition or complication reported on the certificate."

Chart 1
Common medical conditions or complications (comorbidities) associated with a severe course of COVID-19 resulting in death, by sex

Common COVID-19 comorbidities



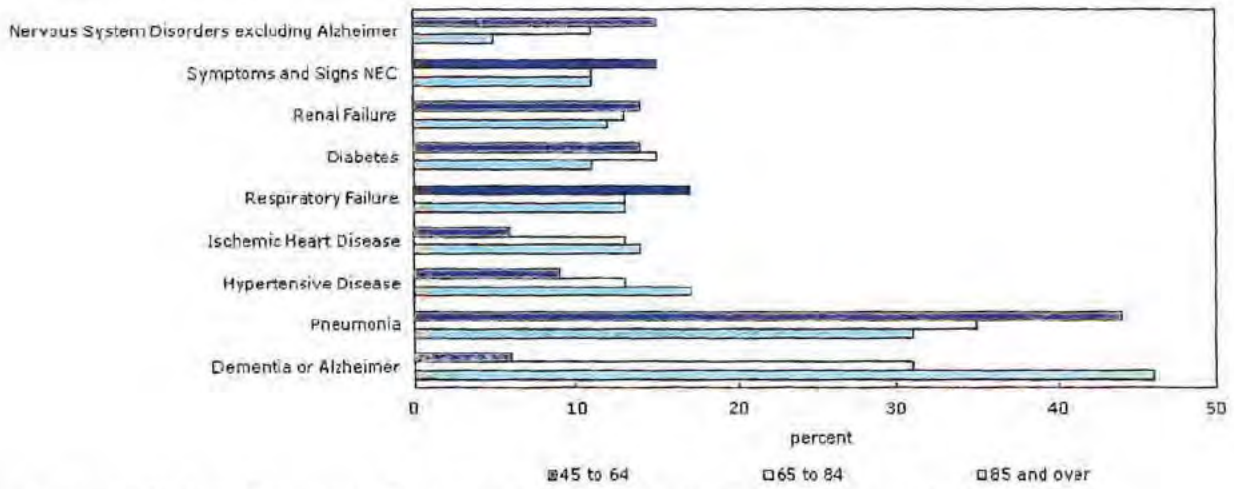
Note: Comorbidities for deaths occurring between March 1, 2020 and July 31, 2020, where COVID-19 was involved.
Source: Canadian Vital Statistics – Death Database (2020).

[11] Kathy O'Brien, et. al., "Covid-19 Death Co-Morbidities in Canada" Statistics Canada, November 16, 2020, https://www150.statcan.gc.ca/n1/pub/45-28-0001/2020001/article/00087-eng.htm

Further, from the first wave of the pandemic until to the end of May 2020, 80% of the COVID-19 deaths in Canada occurred at long-term care facilities and retirement homes[12]. Dementia or Alzheimer's disease were most often listed as comorbidities among Canadians aged 65 years or older whose deaths involved COVID-19—especially among those aged 85 or older.

According to Statistics Canada,[13] "When a pre-existing condition is suspected of putting a person at higher risk of a severe course of COVID-19 resulting in death, the death is counted as a death due to COVID-19 rather than a death due to the pre-existing condition...It is also possible that the death may have been influenced by COVID-19 but caused by another disease or an unintentional injury event. In these situations, COVID-19 should still be recorded on the medical certificates of cause of death..." Pre-existing conditions can also put people at a higher risk of severe courses of influenza resulting in death, but to my knowledge such deaths are not counted as influenza deaths. Such a discrepancy in counting COVID-19 deaths and influenza deaths makes comparisons between the two respiratory illnesses difficult and results in artificially elevated death statistics due to COVID-19.

Chart 2
Common medical conditions or complications (comorbidities) associated with a severe course of COVID-19 resulting in death, by select age groups



Note: Comorbidities for deaths occurring between March 1, 2020 and July 31, 2020, where COVID-19 was involved.
Source: Canadian Vital Statistics - Death Database (2020).

In summary, Covid-19 does not pose a real or imminent serious threat to the health of the population in general but only to the health of a specific part of the population – the elderly and a limited number of people with certain chronic conditions. Age is the single most important risk factor, with a worldwide 99.95% infection survival rate for people under 70 and 95% infection survival rate for people 70 and over.

Further, COVID-19 case fatality rates have been dropping steadily since the disease emerged.

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[12] *Ibid.*
[13] *Ibid.*

Peer-reviewed studies document these trends.[14] One study in England found that "30-day mortality peaked for people admitted to critical care in early April… There was subsequently a sustained decrease in mortality risk until the end of the study period" in late June. This trend was found for people of all age groups, and survived adjustment for patient characteristics, which strongly suggests an improvement in treatment and patient management as the cause.[15]

Ventilator protocols which were used during the early days of the epidemic were too aggressive, with physicians too quick to place patients on mechanical ventilation. In those early days, nearly 90% of all COVID-19 patients on mechanical ventilation died.[16] New discoveries about the use of histamine blockers in conjunction with ventilators contribute to improved survival of hospitalized COVID-19 patients.[17, 18] Separately, there were particular problems in the care of elderly COVID-19 patients in state run nursing homes in Quebec, as an example, during the early days of the epidemic, where some COVID-19 patients were neglected and died from thirst and hunger.[19] Quebec also did very poorly because the government failed to protect the vulnerable population in the CHSLD by sending COVID infected patients to nursing homes that were unable to isolate them from the rest of the population, greatly increasing patient mortality.[20] Addressing this neglect certainly contributed to improved outcomes in Quebec.

The discovery that a deadly immune over-reaction to SARS-CoV-2 infection in some patients could be modulated by dexamethasone has greatly improved patient outcomes.[21, 22] There has

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[14] Brumfiel G. (2020) Studies Point To Big Drop In COVID-19 Death Rates. NPR. October 20, 2020. https://www.npr.org/sections/health-shots/2020/10/20/925441975/studies-point-to-big-drop-in-covid-19-death-rates

[15] Dennis JM, McGovern AP, Vollmer SJ, Mateen BA. Improving Survival of Critical Care Patients With Coronavirus Disease 2019 in England: A National Cohort Study, March to June 2020. Crit Care Med. 2020 Oct 26. doi: 10.1097/CCM.0000000000004747. Epub ahead of print. PMID: 33105150.

[16] Richardson S, Hirsch JS, Narasimhan M, et al. Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area. JAMA. 2020;323(20):2052–2059. doi:10.1001/jama.2020.6775

[17] Hogan Ii RB, Hogan Iii RB, Cannon T, Rappai M, Studdard J, Paul D, Dooley TP. Dual-histamine receptor blockade with cetirizine - famotidine reduces pulmonary symptoms in COVID-19 patients. Pulm Pharmacol Ther. 2020 Aug;63:101942. doi: 10.1016/j.pupt.2020.101942. Epub 2020 Aug 29. PMID: 32871242; PMCID: PMC7455799.

[18] Janowitz T, Gablenz E, Pattinson D, Wang TC, Conigliaro J, Tracey K, Tuveson D. Famotidine use and quantitative symptom tracking for COVID-19 in non-hospitalised patients: a case series. Gut. 2020 Sep;69(9):1592-1597. doi: 10.1136/gutjnl-2020-321852. Epub 2020 Jun 4. PMID: 32499303; PMCID: PMC7299656.

[19] Richer J. (2020) Aînés affamés et déshydratés: «ils ont crevé de faim». Journal de Montreal. April 23, 2020. https://www.journaldemontreal.com/2020/04/23/aines-affames-et-deshydrates

[20] Quebec Ombudsman (2020) COVID-19 in CHSLDs during the first wave of the pandemic. Learning from the crisis and moving to uphold the rights and dignity of CHSLD residents. Dec. 10, 2020. https://protecteurducitoyen.qc.ca/sites/default/files/pdf/rapports_speciaux/progress-report-chslds-covid-19.pdf

[21] RECOVERY Collaborative Group, Horby P, Lim WS, Emberson JR, Mafham M, Bell JL, Linsell L, Staplin N, Brightling C, Ustianowski A, Elmahi E, Prudon B, Green C, Felton T, Chadwick D, Rege K, Fegan C, Chappell LC, Faust SN, Jaki T, Jeffery K, Montgomery A, Rowan K, Juszczak E, Baillie JK, Haynes R, Landray MJ. Dexamethasone in Hospitalized Patients with Covid-19 - Preliminary Report. N Engl J Med. 2020 Jul 17:NEJMoa2021436. doi: 10.1056/NEJMoa2021436. Epub ahead of print. PMID: 32678530; PMCID: PMC7383595.

also been an improved understanding of the pathophysiological reasons why some patients progress to more severe outcomes from SARS-CoV-2 infection, while others do not.[23] So, the improvements in outcomes for COVID-19 patients derive from multiple sources. In summary, COVID-19 infection is less deadly than it was when it arrived in North America in winter 2020.

B. How common is the spread of the SARS-CoV-2 virus by individuals who are infected, but display no symptoms?

Much of the infrastructure of COVID-19 lockdown policies is premised on the idea that the SARS-CoV-2 virus can spread from infected people who display no symptoms that are typical of COVID-19 infection (that is, asymptomatic individuals) to uninfected individuals. If asymptomatic or pre-symptomatic disease spread is uncommon, lockdown policies could be replaced with much less onerous policies, such as symptom checking in public venues and public health advice for people with symptoms to stay home and avoid public places, with little effect on infection transmission rates.

According to a comprehensive survey of the literature on reported cases through early June 2020, about 20% of COVID-19 cases are asymptomatic.[24] Seroprevalence studies tend to report a larger fraction of infections (often not identified as cases) as asymptomatic.[25] In any case, asymptomatic viral carriers clearly make up a large fraction of COVID-19 cases and infections, so a good understanding of how likely they are to transmit the disease to others should play an important role in the determination of COVID-19 infection control policies.

The scientific evidence now strongly suggests that COVID-19 infected individuals who are asymptomatic are more than an order of magnitude less likely to spread the disease to even close contacts than symptomatic COVID-19 patients. A meta-analysis of 54 studies from around the

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[22] Tomazini BM, Maia IS, Cavalcanti AB, Berwanger O, Rosa RG, Veiga VC, Avezum A, Lopes RD, Bueno FR, Silva MVAO, Baldassare FP, Costa ELV, Moura RAB, Honorato MO, Costa AN, Damiani LP, Lisboa T, Kawano-Dourado L, Zampieri FG, Olivato GB, Righy C, Amendola CP, Roepke RML, Freitas DHM, Forte DN, Freitas FGR, Fernandes CCF, Melro LMG, Junior GFS, Morais DC, Zung S, Machado FR, Azevedo LCP; COALITION COVID-19 Brazil III Investigators. Effect of Dexamethasone on Days Alive and Ventilator-Free in Patients With Moderate or Severe Acute Respiratory Distress Syndrome and COVID-19: The CoDEX Randomized Clinical Trial. JAMA. 2020 Oct 6;324(13):1307-1316. doi: 10.1001/jama.2020.17021. PMID: 32876695; PMCID: PMC7489411.

[23] McCullough, Peter A et al. "Pathophysiological Basis and Rationale for Early Outpatient Treatment of SARS-CoV-2 (COVID-19) Infection." The American journal of medicine, S0002-9343(20)30673-2. 7 Aug. 2020, doi:10.1016/j.amjmed.2020.07.003

[24] Buitrago-Garcia D, Egli-Gany D, Counotte MJ, Hossmann S, Imeri H, Ipekci AM, Salanti G, Low N. Occurrence and transmission potential of asymptomatic and presymptomatic SARS-CoV-2 infections: A living systematic review and meta-analysis. PLoS Med. 2020 Sep 22;17(9):e1003346. doi: 10.1371/journal.pmed.1003346. PMID: 32960881; PMCID: PMC7508369.

[25] Bendavid, E., Mulaney, B., Sood, N., Shah, S., Ling, E., Bromley-Dulfano, R., Lai, C., Weissberg, Z., Saavedra, R., Tedrow, J., Tversky, D., Bogan, A., Kupiec, T., Eichner, D., Gupta, R., Ioannidis, J., & Bhattacharya, J. (2020). COVID-19 Antibody Seroprevalence in Santa Clara County, California. medRxiv, 2020.04.14.20062463. https://doi.org/10.1101/2020.04.14.20062463

world found that within households – where none of the safeguards that restaurants are required to apply are typically applied – symptomatic patients passed on the disease to household members in 18% of instances, while asymptomatic patients passed on the disease to household members in 0.7% of instances.[26] A separate, smaller meta-analysis similarly found that asymptomatic patients are much less likely to infect others than symptomatic patients.[27]

A large study of 10 million residents of Wuhan, China, all tested for the presence of the virus, found a total of 300 cases, all asymptomatic. A comprehensive contact tracing effort identified 1,174 close contacts of these patients, none of whom tested positive for the virus.[28] This is consistent with a vanishingly low level of asymptomatic spread of the disease. While theoretical modeling work from earlier in the epidemic (including some of my own published research[29]) predicts some level of asymptomatic disease spread, the empirical evidence at this point later in the epidemic strongly shows very little evidence that this is an important empirical reality.

By contrast with asymptomatic patients, symptomatic patients are very likely to infect others with the virus during extended interactions, especially in the initial period after they develop symptoms. A careful review of 79 studies on the infectivity of COVID-19 patients found the even symptomatic patients are infectious for only the first eight days after symptom onset, with no evidence of live virus detected beyond day 9 of illness.[30]

In summary, asymptomatic individuals are an order of magnitude less likely to infect others than symptomatic individuals, even in intimate settings such as people living in the same household where people are much less likely to follow social distancing and masking practices that they follow outside the household. Spread of the disease in less intimate settings by asymptomatic individuals – including religious services, in-person restaurant visits, gyms, and other public settings – are likely to be even less likely than in the household. The clear implication of this scientific fact is that many intrusive lockdown policies (including church and business capacity limitations and closures) could be replaced with less intrusive symptom checking requirements, with little or no detriment to infection control outcomes.

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[26] (Madewell ZJ, Yang Y, Longini IM, Halloran ME, Dean NE. Household Transmission of SARS-CoV-2: A Systematic Review and Meta-analysis. *JAMA Netw Open*. 2020;3(12):e2031756. doi:10.1001/jamanetworkopen.2020.31756)

[27] Buitrago-Garcia D, Egli-Gany D, Counotte MJ, Hossmann S, Imeri H, Ipekci AM, Salanti G, Low N. Occurrence and transmission potential of asymptomatic and presymptomatic SARS-CoV-2 infections: A living systematic review and meta-analysis. PLoS Med. 2020 Sep 22;17(9):e1003346. doi: 10.1371/journal.pmed.1003346. PMID: 32960881; PMCID: PMC7508369.

[28] (Cao, S., Gan, Y., Wang, C. et al. Post-lockdown SARS-CoV-2 nucleic acid screening in nearly ten million residents of Wuhan, China. *Nat Commun* 11, 5917 (2020). https://doi.org/10.1038/s41467-020-19802-w)

[29] Peirlinck M, Linka K, Costabal FS, Bhattacharya J, Bendavid E, Ioannidis J, Kuhl E (2020), "Visualizing the Invisible: The Effect of Asymptotic Transmission on the Outbreak Dynamics of COVID-19" Computer Methods in Applied Mechanics and Engineering. 372: 1 Dec. 2020, 113410. https://doi.org/10.1016/j.cma.2020.113410.

[30] Cevik M, Tate M, Lloyd O et al. SARS-CoV-2, SARS-CoV, and MERS-CoV viral load dynamics, duration of viral shedding, and infectiousness: a systematic review and meta-analysis. The Lancet Microbe. Nov. 19, 2020. DOI:https://doi.org/10.1016/S2666-5247(20)30172-5

C. What are the principles govern good health policy and public health practice?

The principles of good public health[31] and health policy practice predate the epidemic. While the topic is voluminous, there are a few principles that are particularly relevant to COVID-19 policy making, including the following guidelines for decision makers:

- Consider both the costs *and* benefits of alternative policies, choosing policies that appropriately balance the two.
- Appropriately account for uncertainty in the projected costs and benefits of policy options.
- Account for the strength of the scientific evidence.
- Be constrained in policy making by democratic norms and ethical principles.
- Choose policies that treat people in society equitably, and in particular eschew policies that disproportionately favor richer members of society over poorer members.

Sound health policy decision making requires a careful evaluation of both the costs and benefits over both the long and short term. The nature of these costs and benefits considered should be broadly considered, including physical costs (such as enhanced risk of mortality and morbidity from all sources), psychological harms (such as increased rates of depression and suicidality), as well as the economic damage (such as increased joblessness, closed businesses, and reduced income).

The costs and benefits of every potential policy involves some degree of uncertainty, including lockdowns. In the face of uncertainty, public health decision making should be based on the best available evidence regarding the most likely outcomes from the imposition of the policy. Public health decision making should eschew decision making based on worst-case or best-case assumptions about the outcomes that may happen if alternate policies are adopted. It is particularly bad practice to make decisions that assume worst case scenarios regarding the costs of a policy and best-case scenarios regarding the benefits of a policy, or vice versa. So, for instance, it is poor public health practice to assume that lockdowns, if implemented will have a dramatic effect on disease transmission and mortality with no consideration of the harms associated with lockdowns.[32]

In addition to the costs and benefits, public health policy must consider the strength of the scientific evidence regarding the measure in achieving the aims it proposes. Of course, without

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[31] Public Health Leadership Society (2002) Principles of the Ethical Practice of Public Health. American Public Health Association. https://www.apha.org/-/media/files/pdf/membergroups/ethics/ethics_brochure.ashx

[32] In Manitoba, Chief Public Health Officer Dr. Brent Roussin adopted the position in November 2020 that lockdowns would stop the spread of Covid-19 and save lives: "We need to turn these numbers around and we need to turn them around now. . . . [T]hese new restrictions will help halt the spread of this virus, to protect Manitobans, and to ensure that our healthcare system can continue to function..."These next few weeks will be difficult for many. And we know that. But this sacrifice over this time (sic) will save lives." Dr. Brent Roussin, 2020-11-10 Press Conference, Video at 23:10 and 31:16 https://news.gov.mb.ca/news/index.html?item=49737.

solid scientific evidence in favor of a policy – especially one with enormous costs – its imposition by a government on a population would be unethical. The greater the potential harms from the policy on some part of the population, the greater the evidentiary standard required to establish its necessity.

Finally, equity is a key principle of public health. Public health officials must consider whether the harms of a policy like lockdowns fall disproportionately on the poor, on minority populations, or on others who are of low socio-economic status. Similarly, policies that accrue benefits disproportionately to the rich, to majority populations, and to people of high socio-economic status should be redesigned to comport with the requirement for equity in public health decision making.

In summary, sound public health practice adheres to key principles aimed at grounding policy in good science, respecting human rights and democratic norms, appropriately accounting for costs and benefits of policies and uncertainty in outcomes, treating people equitably, as well as other principles not discussed here.

D. Are the lockdowns (including, but not limited to, shelter-in-place orders and forced quarantines, business, cultural, sports and religious service restrictions and closures, restrictions on in-person schooling, restrictions on private gatherings, travel restrictions across provinces, restrictions on children playing together and scholastic sport, and the arbitrary designation of businesses into 'essential' and 'non-essential') necessary to maintain and enhance the health and well-being of the general population?

Since the available epidemiological literature often tends to group many of the items in the list above under the moniker of "lockdown" or "non-pharmaceutical intervention (NPI)" we will consider the evidence regarding the items together based on the criteria for good public health practice we discussed above.

Theoretical Considerations. The theoretical models used to justify lockdowns – compartment or SEIR models – do not predict a decrease in the total number of infected people but shift in the timing of infections.

Compartment models work by envisioning a population exposed to a new pathogen like the SARS-CoV-2 virus. In the simplest versions of these models, everyone in the population is initially susceptible to infection. The epidemic starts with one person being infected and in turn infecting other people in the pool of susceptible people. Many infected people recover from the disease and – because of immunity induced by infection – are no longer susceptible. Over time, the population of susceptible people diminishes to the point where a newly infected person infects one or fewer people, and the epidemic declines.

In models like this, which are in common use to forecast the COVID-19 epidemic, lockdowns play a role of dampening the number of interactions between susceptible people and infected people, slowing the growth of the epidemic. However, unless the number of infections is reduced

to zero – a result clearly not in evidence in the COVID-19 epidemic – the disease continues to spread in the population.

The clear theoretical implication from these models is that lockdowns delay infections into the future, rather than prevent them from occurring altogether.[33] But society-wide lockdowns are not a tool of disease eradication, and in fact have never in history eradicated a disease. This "benefit" – a theoretical delay in the incidence of cases – should be considered against the harms from lockdowns, some of which are described below.

What is the evidence that these theoretical models provide accurate forecasts of the future path of the pandemic? Unfortunately, their track record is poor. According to a comprehensive evaluation of the performance of these models by an international group of statisticians and mathematicians, their poor performance stems from a wide variety of problems, including:[34]

> Poor data input, wrong modeling assumptions, high sensitivity of estimates, lack of incorporation of epidemiological features, poor past evidence on effects of available interventions, lack of transparency, errors, lack of determinacy, looking at only one or a few dimensions of the problem at hand, lack of expertise in crucial disciplines, groupthink and bandwagon effects and selective reporting are some of the causes of these failures.

Given this poor track record in prediction, extreme caution should be exercised by public health decision makers in using compartment models to forecast the future direction of the pandemic and in predicting the effects of policy interventions such as lockdowns on COVID-19 outcomes such as mortality and hospitalization.[35]

Empirical Literature on Lockdown Benefits. In the case of lockdowns and social distancing interventions, there is no existing randomized study – the gold standard study type in clinical therapeutics and public health interventions – that has evaluated the efficacy or costs of these measures. Scientific experts have argued for the necessity and feasibility of such randomized evaluation of restricting schools, universities, and workplaces, banning public gatherings, and the like.[36] If one were to view these lockdowns and activity restrictions as a medical intervention, it would be unethical to implement them in the absence of randomized evidence in support of their efficacy.

In the absence of such evidence, scientists and public health officials tend to rely on studies that are less rigorous than randomized trials in establishing causal links between the intervention and outcomes, including event studies and other observational studies. In the case of the lockdowns, the evidence from these sources is decidedly mixed. Evidence from the draconian lockdown

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[33] Chikina M and Pegden W (2020) A Call to Honesty in Pandemic Modeling. *Medium*. https://medium.com/@wpegden/a-call-to-honesty-in-pandemic-modeling-5c156686a64b

[34] Ioannidis JPA, Cripps S, Tanner MA. Forecasting for COVID-19 has failed. Int J Forecast. 2020 Aug 25. doi: 10.1016/j.ijforecast.2020.08.004. Epub ahead of print. PMID: 32863495; PMCID: PMC7447267.

[35] Chin V, Ioannidis J, Tanner M, Cripps S. (2020) Effects of Non-Pharmaceutical Interventions on COVID-19: A Tale of Three Models. medRxiv. https://www.medrxiv.org/content/10.1101/2020.07.22.20160341v2

[36] Cristea, I. A., Naudet, F., & Ioannidis, J. P. A. (2020). Preserving equipoise and performing randomized trials for COVID-19 social distancing interventions. *Epidemiology and Psychiatric Sciences*. https://doi.org/10.1017/S2045796020000992

order in China – including home and centralized quarantine, severe travel restrictions, cordon sanitaire, mandated centralized symptom reporting, and other interventions inconsistent with democratic norms – suggests that lockdowns can "temporarily" reduce spread of the virus.[37] Evidence from the early days of the epidemic (March and early April 2020) in the US found that states that imposed strict stay-at-home orders had a slower growth in the epidemic that states that did not over that short period of time.[38]

The problem with these event studies is that they cannot be used to forecast the effect of imposing less strict lockdowns (such as restrictions on businesses and gatherings). Focused as they are on quarantine or stay-at-home orders and the draconian policies imposed during the early epidemic in China, they represent a best case for the effectiveness of lockdowns. More importantly, they only measure the effect of lockdown on the speed of disease spread in the short run and should not be used to forecast the effect of lockdown on long run epidemic outcomes, since the theoretical literature strongly cautions against it. Recall that in those models, lockdowns push cases into the future; they do not prevent them altogether.

In fact, there are many possible reasons why the number of cases might change over time outside of lockdowns, and these should be accounted for in any accurate estimation of lockdown effects. Perhaps most importantly, these simple event studies do not account for the environmental, epidemiological, and economic factors that impact disease spread, imputing changes in the track of the epidemic almost entirely to policy interventions. There are many possible reasons why the number of cases might change over time outside of lockdowns, and these should be accounted for in any accurate estimation of lockdown effects. For instance, there is evidence that COVID-19 infection rates are increased during cold weather seasons.[39, 40] It is striking that the recent sharp rise in COVID-19 cases in California corresponds with colder weather, despite the continuing lockdowns. Even authors who favor lockdowns as a policy option in summarizing this evidence agree that seasonality plays an important role in case spread:[41]

> "A convincing argument that weather influences COVID-19 can be formulated in three parts: (1) experimental data suggest SARS-CoV-2 persistence on surfaces or in the air is sensitive to temperature, humidity, and ultraviolet light; (2) other environmentally sensitive respiratory viruses are seasonal, and more

[37] Pan A, Liu L, Wang C, et al. Association of Public Health Interventions With the Epidemiology of the COVID-19 Outbreak in Wuhan, China. *JAMA*. 2020;323(19):1915–1923. doi:10.1001/jama.2020.6130

[38] Mark N Lurie, Joe Silva, Rachel R Yorlets, Jun Tao, Philip A Chan, Coronavirus Disease 2019 Epidemic Doubling Time in the United States Before and During Stay-at-Home Restrictions, The Journal of Infectious Diseases, Volume 222, Issue 10, 15 November 2020, Pages 1601–1606, https://doi.org/10.1093/infdis/jiaa491; The article also had a correction appended. Mark N Lurie, Joe Silva, Rachel R Yorlets, Jun Tao, Philip A Chan, Corrigendum to: COVID-19 Epidemic Doubling Time in the United States Before and During Stay-at-Home Restrictions, The Journal of Infectious Diseases, Volume 222, Issue 10, 15 November 2020, Page 1758, https://doi.org/10.1093/infdis/jiaa506

[39] Araujo MB and Naimi B (2020) Spread of SARS-CoV-2 Coronavirus Likely Constrained by Climate. medRxiv. https://www.medrxiv.org/content/10.1101/2020.03.12.20034728v3.article-info

[40] Sajadi, Mohammad M. and Habibzadeh, Parham and Vintzileos, Augustin and Shokouhi, Shervin and Miralles-Wilhelm, Fernando and Amoroso, Anthony, Temperature, Humidity and Latitude Analysis to Predict Potential Spread and Seasonality for COVID-19 (March 5, 2020). Available at SSRN: https://ssrn.com/abstract=3550308 or http://dx.doi.org/10.2139/ssrn.3550308

[41] Carson CJ, Gomez ACR, Shweta B, and Ryan SJ (2020) "Misconceptions about Weather and Seasonality Must not Misguide COVID-19 Response" Nature Communications 11: 4312. https://doi.org/10.1038/s41467-020-18150-z

> common in winter; and therefore, (3) climatic effects could be protective over space (hot, dry places might have less transmission) and time (summer might see reduced transmission compared to winter)."

This is not to say that other factors play no role, but rather that seasonality should be accounted for in any analysis of case spread. Studies decomposing lockdown effects should also account for the fact that, even in the absence of policy interventions, people change their behavior to protect themselves from disease risk if they perceive the danger from infection to be high.[42]

The best studies, which account for environmental, epidemiological, and economic factors alongside policy interventions conclude that the mortality from COVID-19 infection in different regions is not primarily driven by policy decisions like lockdowns, but rather by other factors specific to each region.[43] A comprehensive international cross-country study, analyzing data from the first eight months of the pandemic, conclude that:[44]

> Countries that already experienced a stagnation or regression of life expectancy, with high income and non-communicable disease rates, had the highest price to pay. This burden was not alleviated by more stringent public decisions. Inherent factors have predetermined the Covid-19 mortality: understanding them may improve prevention strategies by increasing population resilience through better physical fitness and immunity…The death rate appears not to be linked with the responses of governments.

In other words, countries that had a population predisposed to poor COVID-19 infection outcomes, especially countries that had an older population, tended to have worse outcomes irrespective of whatever lockdown policies they implemented.

E. What are the harms of lockdowns and governmental actions aiming to slow down the propagation of the disease on the health of the population?

While the evidence on the benefits of lockdowns is equivocal, the harms of the lockdowns are manifold and devastating. The effects on the health of populations, in particular, warrants careful attention, since they can be compared directly against the harms from COVID-19 infection. The COVID-19 lockdowns have often featured the cessation of elective and other medical services to keep hospital and health care systems available for COVID-19 patients. Naturally, patients who skip medical services will suffer adverse health consequences as a result. The empirical evidence supporting these ideas includes documentation for plummeting childhood vaccination

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[42] Yoo BK, Kasajima M, Bhattacharya J. (2020) "Public Avoidance and the Epidemiology of novel H1N1 Influenza A." National Bureau of Economic Research Working Paper #15752. DOI 10.3386/w15752. https://www.nber.org/papers/w15752

[43] Atkeson A, Kopecky K, Zha T. (2020) "Four Stylized Facts about COVID-19" National Bureau of Economic Research Working Paper #27719. DOI 10.3386/w27719. https://www.nber.org/papers/w27719

[44] De Larochelambert Q, Marc A, Antero J, Le Bourg E, and Toussaint JF. (2020) Covid-19 Mortality: A Matter of Vulnerability Among Nations Facing Limited Margins of Adaptation. Front. Public Health, 19 November 2020 | https://doi.org/10.3389/fpubh.2020.604339

rates[45], worse cardiovascular disease outcomes (in part because patients delayed necessary cardiac care)[46], less cancer screening[47 48] and deteriorating mental health[49 50 51].

Non-urgent procedures and tests were cancelled in Manitoba on March 24, 2020[52], and wait times for non-urgent MRIs and ultrasounds (such as bone density tests) are nearly triple what they were at the end of 2019.[53] Specifically regarding children's surgeries, authors writing in the Canadian Medical Association Journal reported that, "although nearly 9000 emergency and urgent surgeries were completed in Canadian children's hospitals between mid-March and June, there were an estimated 7600 surgery postponements with an additional estimated 4000 children not wait-listed owing to reduced access to consultation."[54]

In addition to the physical health harms from lockdown, there has been immense psychological harm. The social isolation induced by lockdown has led to a sharp rise in opioid and drug-related overdoses[55 56 57], similar to the "deaths of despair" that occurred in the wake of the 2008 Great Recession.[58] Social isolation of the elderly has contributed to a sharp rise in dementia-related

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[45] CDC (2020) Effects of the COVID-19 Pandemic on Routine Pediatric Vaccine Ordering and Administration — United States, 2020. MMWR. 69(19): 591-3. https://www.cdc.gov/mmwr/volumes/69/wr/mm6919e2.htm

[46] Ball S, Banerjee A, Berry C, et alMonitoring indirect impact of COVID-19 pandemic on services for cardiovascular diseases in the UKHeart Published Online First: 05 October 2020. doi: 10.1136/heartjnl-2020-317870

[47] Rutter MD, Brookes M, Lee TJ, et alImpact of the COVID-19 pandemic on UK endoscopic activity and cancer detection: a National Endoscopy Database AnalysisGut Published Online First: 20 July 2020. doi: 10.1136/gutjnl-2020-322179

[48] https://www.bbc.com/news/health-53300784, UK scientists warned in July that delayed cancer diagnosis and treatment due to lockdown measures could cause at least 7,000 additional deaths in the UK alone, and as many as 35,000 deaths in a worst-case scenario. If the lockdowns had the same impact in Canada, a population just less than half of the UK, 3,500 to 17,500 deaths could have occurred.

[49] Vizard T, Davis J, White E, Beynon B (2020) Coronavirus and depression in adults, Great Britain: June 2020. Office for National Statistics, UK. https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/coronavirusanddepressioninadultsgreatbritain/june2020

[50] United Nations. Policy Brief: COVID-19 and the Need for Action on Mental Health. 13 May 2020. New York, New York: United Nations Sustainable Development Group, https://unsdg.un.org/resources/policy-brief-covid-19-and-need-action-mental-health

[51] Centre for Addiction and Mental Health, Mental Health in Canada, Covid-19 and Beyond: CAMH Policy Advice, July 2020, http://www.camh.ca/-/media/files/pdfs---public-policy-submissions/covid-and-mh-policy-paper-pdf.pdf

[52] Kristin Annable, "Wait times for diagnostic tests climb in Manitoba after pandemic prompted spring shutdown", July 30, 2020, https://www.cbc.ca/news/canada/manitoba/wait-tests-manitoba-1.5667409

[53] Diagnostic Services, Bone Density Test wait times (in weeks), updated November 24, 2011, https://www.gov.mb.ca/health/waittime/historical/diagnostic.pdf

[54] Erik D. Skarsgard, Prioritizing specialized children's surgery in Canada during the COVID-19 pandemic, *CMAJ*, October 13, 2020 192 (41) E1212-E1213; DOI: https://doi.org/10.1503/cmaj.201577

[55] Public Health Ontario, Preliminary Patterns in Circumstances Surrounding Opioid-Related Deaths in Ontario During the COVID-19 Pandemic, November 2020, https://www.publichealthontario.ca/-/media/documents/o/2020/opioid-mortality-covid-surveillance-report.pdf?la=en

[56] Vipal Monga, "Opioid Deaths in Canada Were Falling Then Came Coronavirus", *Wall Street Journal*, November 14, 2020 https://www.wsj.com/articles/opioid-deaths-in-canada-were-falling-then-came-coronavirus-11605368112

[57] American Medical Association (2020) Issue Brief: Reports of Increases in Opioid- and Other Drug Related Overdose and Other Concerns During COVID Pandemic. AMA Advocacy Resource Center. Oct. 31, 2020. https://www.ama-assn.org/system/files/2020-11/issue-brief-increases-in-opioid-related-overdose.pdf

[58] Case A and Deaton A (2017) Mortality and Morbidity in the 21st Century. *Brookings Papers on Economic Activity*. March 23, 2017. https://www.brookings.edu/wp-content/uploads/2017/08/casetextsp17bpea.pdf

deaths around the country.[59] For children, the cessation of in-person schooling since the spring has led to "catastrophic" learning losses[60], with severe projected adverse consequences for affected students' life spans.[61] According to a US CDC estimate, one in four young adults seriously considered suicide this past June.[62] Among 25 to 44-year-olds, the US CDC reports a 26% increase in excess all-cause mortality relative to past years, though fewer than 5% of 2020 deaths have been due to COVID-19.[63, 64]

A recent study[65] in *European Psychiatry* analyzed the psychological harms of the lockdowns in Switzerland and attempted to quantify citizens' years of life lost as a result. The authors focused on deaths caused by "suicide, depression, alcohol use disorder, childhood trauma due to domestic violence, changes in marital status, and social isolation." The authors find that the 2.1% of the population who suffered from one of these conditions would suffer nearly 9.8 years of life lost in expectation as a consequence of just a three-month lockdown. They emphasize that that their estimate is likely to be an underestimate because many of the outcomes they analyze will persist even after the lockdown ends. The authors conclude,

> The literature suggests that increased duration of confinement is associated with worse outcomes for psychological health of those confined. While some of the stress-related problems ensuing from confinement may remit, an important portion of this damage may prove to be hard or impossible to reverse and the affected individuals may experience ongoing suffering. Our projection suggests that the Swiss population will incur a substantial increase in mortality as a consequence of confinement-related psychosocial stress, which should be considered in forming public health responses to the pandemic.

While the lockdowns result in direct harms for the health of populations where they are implemented, they also have devastating indirect consequences as a result of a collapse in

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[59] Alzheimer's Impact Movement (2020) The 2020 COVID-19 Pandemic and Dementia: Deaths Above Average. https://www.scribd.com/document/483085777/Dementia-Deaths-Above-Average-State-by-State-Table

[60] Center for Research on Education Outcomes (2020) Estimates of Learning Loss in the 2019-2020 School Year. CREO Stanford University. October 2020. https://credo.stanford.edu/sites/g/files/sbiybj6481/f/short_brief_on_learning_loss_final_v.3.pdf

[61] Christakis DA, Van Cleve W, Zimmerman FJ. Estimation of US Children's Educational Attainment and Years of Life Lost Associated With Primary School Closures During the Coronavirus Disease 2019 Pandemic. JAMA Netw Open. 2020;3(11):e2028786. doi:10.1001/jamanetworkopen.2020.28786

[62] Czeisler MÉ , Lane RI, Petrosky E, et al. Mental Health, Substance Use, and Suicidal Ideation During the COVID-19 Pandemic — United States, June 24–30, 2020. MMWR Morb Mortal Wkly Rep 2020;69:1049–1057. DOI: http://dx.doi.org/10.15585/mmwr.mm6932a1

[63] Rossen LM, Branum AM, Ahmad FB, Sutton P, Anderson RN. Excess Deaths Associated with COVID-19, by Age and Race and Ethnicity — United States, January 26–October 3, 2020. MMWR Morb Mortal Wkly Rep 2020;69:1522–1527. DOI: http://dx.doi.org/10.15585/mmwr.mm6942e2

[64] CDC (2020) Provisional COVID-19 Death Counts by Sex, Age, and State. https://data.cdc.gov/NCHS/Provisional-COVID-19-Death-Counts-by-Sex-Age-and-S/9bhg-hcku

[65] Dominik A. Moser, Jennifer Glaus, Sophia Frangou and Daniel S. Schechter, "Years of Life Lost Due to the Psychosocial Consequences of Covid-19 Mitigation Strategies Based on Swiss Data" 19 May 2020, *European Psychiatry*, 63(1), e58, 1–7, https://doi.org/10.1192/j.eurpsy.2020.56

worldwide economic outcomes, with a particularly large and negative effect on poor countries.[66] This economic harm translates directly into health harm, as large populations are no longer able to feed themselves due to poverty. The UN estimates that an additional 130 million poor people will be at risk of starvation as a consequence of the economic collapse caused by the lockdowns – predicting a famine of "biblical" proportions.[67] Estimates suggest that an additional 400,000 people will die from inadequate tuberculosis treatment as a consequence of diversion of resources away from TB identification and treatment.[68] Vaccination campaigns in rich and poor countries that address diseases like diphtheria and polio have been suspended due to the lockdowns.[69] According to a recent editorial in the journal *Nature*, COVID-19 is "fuelling a resurgence of AIDS, malaria, and tuberculosis" around the world.[70]

F. Are the harms of the lockdowns equitably distributed?

The harms of lockdowns are unequally distributed. In the US, for instance, economists have found that only 37% of jobs in the US can be performed wholly on-line, and high-paying jobs are overrepresented among that set.[71] By declaring janitors, store clerks, meat packers, postal workers, and other blue-collar workers as "essential" workers in most states, regardless of whether they qualify as high COVID mortality risk, the lockdowns have failed to shield the vulnerable in these occupations. The same is true in Canada as well. Canada has the highest unemployment rate in the G7.[72] The impact of this unemployment has fallen most severely on younger and less well-educated workers.[73]

The economic dislocation from the lockdowns has increased the number of households where young adults who have lost their jobs co-reside with vulnerable older parents,[74] which may

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[66] Bhattacharya J and Packalen M (2020) Focused COVID-19 Restrictions will Save Lives in Poor Countries. Financial Post. July 3, 2020. https://financialpost.com/opinion/focused-covid-19-restrictions-will-save-lives-in-poor-countries

[67] Dowsett C (2020) As famines of 'biblical proportion' loom, Security Council urged to 'act fast'. UN News. April 21, 2020. https://news.un.org/en/story/2020/04/1062272

[68] McKie R (2020) Covid set to cause 400,000 surge in TB deaths as medics diverted. The Guardian. Nov. 8, 2020. https://www.theguardian.com/world/2020/nov/08/covid-set-to-cause-400000-surge-in-tb-deaths-as-medics-diverted

[69] GAVI (2020) At least 80 million children at risk of disease as COVID-19 disrupts vaccination efforts, warn Gavi, WHO and UNICEF. May 22, 2020. https://www.gavi.org/news/media-room/least-80-million-children-risk-disease-covid-19-disrupts-vaccination-efforts

[70] Nature (2020) How to stop COVID-19 fuelling a resurgence of AIDS, malaria and tuberculosis. Nature 584: 169. August 12, 2020. doi: https://doi.org/10.1038/d41586-020-02334-0

[71] Dingel JI and Neiman B (2020) How Many Jobs Can Be Done at Home? National Bureau of Economic Research Working Paper #26948. April 2020

[72] Goldsetein L (2020) We're Number One! Highest Unemployment Rate in the G7. Toronto Sun. Sept. 30, 2020. https://torontosun.com/opinion/columnists/goldstein-were-number-one-highest-unemployment-rate-in-the-g7

[73] Beland LP, Brodeur A, Mikola D, and Wright T. (2020) Here's how the coronavirus is affecting Canada's labour market. The Conversation. May 13, 2020. https://theconversation.com/heres-how-the-coronavirus-is-affecting-canadas-labour-market-137749

[74] Evandrou M, Falkingham J, Qin M, and Vlachantoni A (2020) Changing Living Arrangements, Family Dynamics and Stress During Lockdown: Evidence from Four Birth Cohorts in the UK. University of Southampton Eprint Soton. https://eprints.soton.ac.uk/443865/1/family_dynamics_during_covid_19_final.pdf

increase the risk of COVID-related death.[75] Lockdowns thus fail the test of imposing costs and conferring benefits equitably.[76]

G. What is the magnitude of the risk children pose in disease spread? Is there any rationale for lockdown related restrictions on children?

The overwhelming weight of scientific data suggests that the risk of transmission of the virus from younger people aged 18 and below to older people is small or negligible, and the risk of transmission from people 18 to 25 to older people is small relative to the risk of transmission from people older than 25 to others older than 25.

The most important evidence on childhood spread of the disease comes from a study conducted in Iceland and published in the New England Journal of Medicine.[77] The data for this study comes from Iceland's systematic screening of its population to check for the virus. This is the most important study on this topic because it is the only study that definitively establishes the direction of spread of the virus from contact to contact. The study reports on both a population-representative sample and a sample of people who were tested because of the presence of symptoms consistent with COVID-19 infection. The study team isolated SARS-CoV-2 virus samples from every positive case, sequenced the genome of the virus for every case and tracked the mutation patterns in the virus. This analysis, along with contact tracing data, allowed the study team to identify definitively who passed the virus to whom. There have been hundreds of minor mutations of the virus identified, which typically do not alter the function of the virus much, but which provide a unique fingerprint, of sorts, that makes it possible to tell whether two patients could possibly have passed the virus to one another. From this analysis, the senior author of the study, Dr. Kari Stefansson, concluded[78] that "[E]ven if children do get infected, they are less likely to transmit the disease to others than adults. We have not found a single instance of a child infecting parents. There is amazing diversity in the way in which we react to the virus."

Although the Iceland study is the only definitive study, there are a number of other studies that use contact tracing methods to investigate the role of children in disease spread. The bulk of such studies conclude that children play a small role, consistent with the Iceland data. A French study,[79] conducted by scientists at the L'Institut Pasteur, examined data from late April 2020 on schoolteachers, students, and their parents in Crepy-en-Valois in France. The schools in France

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[75] Fenoll AA & Grossbard S (2020) Intergenerational residence patterns and Covid-19 fatalities in the EU and the US, Economics & Human Biology, 39. https://doi.org/10.1016/j.ehb.2020.100934.

[76] Kulldorff M and Gupta S. (2020) Canada's COVID-19 strategy is an assault on the working class. Toronto Sun. Nov. 29, 2020. https://torontosun.com/opinion/columnists/opinion-canadas-covid-19-strategy-is-an-assault-on-the-working-class

[77] Daniel F. Gudbjartsson, Ph.D., Agnar Helgason, Ph.D., et al., *Spread of SARS-CoV-2 in the Icelandic Population*, The New England Journal of Medicine, https://www.nejm.org/doi/full/10.1056/NEJMoa2006100 (June 11, 2020).

[78] Roger Highfield, *Coronavirus: Hunting Down COVID-10*, Science Museum Group, https://www.sciencemuseumgroup.org.uk/blog/hunting-down-covid-19/ (April 27, 2020).

[79] Arnaud Fontanet, MD, DrPH, Rebecca Grant, et al., *SARS-CoV-2 Infection in Primary Schools in Northern France: A Retrospective Cohort Study in an Area of High Transmission*, Institut Pasteur, https://www.pasteur.fr/fr/file/35404/download (last visited July 9, 2020).

were closed from the end of January on, at first because of a February holiday and then the late February lockdown. The authors found three cases among kids in January using antibody tests but found no evidence of virus spread to other kids or teachers from those early cases. Any spread between the end of January and the end of April (when the authors collected samples) must have occurred during the lockdown. The kids who tested antibody positive at the end of April, because of the circumstances of the lockdown, must have become positive from a source other than their school. The main contacts of the young children were their parents, of whom 61% were positive, which is consistent with parent to child spread. Also consistent is the fact that only 6.9% of parents tested positive in April for the virus among the kids who were antibody negative. The authors' main conclusion[80] from these facts is that parents were the source of infections in school children; children were not the source. This finding mirrors the conclusion from the Icelandic study that the disease spreads less easily from children to adults than it does from adults to adults.

Researchers in Ireland conducted a similar study[81] which analyzed 1,160 children and adults in Ireland who were physically present in a school at some time between March 1st and March 13th where a COVID-19 case was identified. (Schools were closed in Ireland on March 12th). The authors found 3 children (all between 10 and 15 years old) and 3 adults who had COVID-19 infections. Their study followed students and families after the school closures to see if there was any evidence of disease spread from these identified cases. All six patients had confirmed cases of COVID-19 disease but were found to have contracted the virus from contacts outside of the school setting. Despite identifying a total of 722 contacts, the study authors reported finding no instance of an infected child infecting another child. The infected adults, by contrast, had many fewer contacts – 102 – but did pass on the infection to a few adult contacts.

A report[82] by the ministry of health in the Netherlands, based on contact tracing data, finds almost no disease spread by infected patients 20 and under at all, and only limited spread by adults 20-25 to others outside their own age category. The authors of the study concluded: "Data from the Netherlands also confirms the current understanding: that children play a minor role in the spread of the novel coronavirus. The virus is mainly spread between adults and from adult family members to children. The spread of COVID-19 among children or from children to adults is less common."

A German[83] study reports a strikingly similar finding on the likelihood of pediatric disease spread. The German Society for Pediatric Infectious Diseases collected on all children and adolescents admitted to a hospital for COVID-19 treatment between mid-March and early May 2020 – 128 patients in all, admitted to 66 different hospitals. The authors were able to find the

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[80] *COVID-19 In Primary Schools: No Significant Transmission among Children or From Students to Teachers,* Institut Pasteur, https://www.pasteur.fr/en/press-area/press-documents/covid-19-primary-schools-no-significant-transmission-among-children-students-teachers (June 23, 2020).

[81] Laura Heavey, Geraldine Casey, et al., *No Evidence of Secondary Transmission of COVID-19 from Children Attending School in Ireland, 2020,* Eurosurveillance, https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.21.2000903#html_fulltext (May 28, 2020).

[82] *Children and COVID-19,* National Institute for Public Health and the Environment, https://www.rivm.nl/en/novel-coronavirus-covid-19/children-and-covid-19 (July 2, 2020).

[83] Armann, J. P., Diffloth, N., Simon, A., Doenhardt, M., Hufnagel, M., Trotter, A., Schneider, D., Hübner, J., & Berner, R. (2020). Hospital Admission in Children and Adolescents With COVID-19. Deutsches Arzteblatt international, 117(21), 373–374. https://doi.org/10.3238/arztebl.2020.0373

source of infection for 38% of these patients, which turned out to be a parent 85% of the time. Though the authors document a limitation of small sample size, they conclude that "In contrast to other epidemic viral respiratory infections, the primary source of infection with SARS-CoV-2 appears not to be other children." The authors reported a single death among these 128 pediatric patients.

One of the largest studies in the world on coronavirus in schools, carried out in 100 institutions in the UK, recently confirmed that "there is very little evidence that the virus is transmitted" in schools.[84] Indeed, the president of the Royal College of Pediatrics and Child Health and a member of the government advisory group Sage confirmed that "there is very little evidence that the virus is transmitted in schools" based on this extensive study.

A study of 23 family disease clusters in Greece, published on Aug. 7th in the *Journal of Medical Virology*, found that in 91% of the clusters, an adult was the first person to be infected. Their contact tracing effort attempted to clarify the direction of disease spread by careful questioning about the relative timing of the development of symptoms. They found no evidence of either child to adult spread, or even of child to child spread. They concluded that "[w]hile children become infected by SARS-CoV-2, they do not appear to transmit infection to others. Furthermore, children more frequently have an asymptomatic or mild course compared to adults."[85]

A study by the Federal Office of Public Health of Switzerland analyzed 793 cases reported by Swiss doctors in late July 2020.[86] The reports included the place where each patient most likely contracted the infection. The most common source of infection was at home, with 27.2% tracing their disease there. School, by contrast, consisted of only 0.3% of the infections; exactly two of the 793 cases could be tracked to a school. There are some limitations though of this study: first, it is a contact tracing study without genetic sequencing verification so the usual caveat applies; and second, the report provides no details about the age of the cases, so it is not possible to separately glean the disease acquisition frequencies for children and adults; and third, only summer schools were in session during this time period. Nevertheless, the results strongly suggest that schools are a minor source of community spread of the infection.

A recent South Korean contact tracing study[87] was cited in the New York Times as providing evidence that "Older Children Spread the Coronavirus Just as Much as Adults." Contrary to the interpretation of the NYT headline, the pattern of evidence reported in the study does not imply that older children spread the coronavirus as much as adults. A follow-on paper on South Korean case study, reanalyzing the same data set, the same patients, and published in the *Archives of*

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[84] Sian Griffiths, *Pupils pose little risk of spreading COVID*, The Sunday Times (Aug. 9, 2020), available at https://www.thetimes.co.uk/article/pupils-pose-no-risk-of-spreading-covid-27q6zfd9l.

[85] Helena C. Maltezou Rengina Vorou Kalliopi Papadima, et al. (2020) "Transmission dynamics of SARS-CoV-2 within families with children in Greece: a study of 23 clusters" Journal of Medical Virology, https://doi.org/10.1002/jmv.26394 (accessed August 12, 2020).

[86] Office fédéral de la santé publique OFSP (2020) "Rectificatif : les lieux de contamination sont les contextes familiaux et non les boîtes de nuit" Aug. 2, 2020, available at https://www.bag.admin.ch/bag/fr/home/das-bag/aktuell/news/news-02-08-2020.html

[87] Park YJ, Choe YJ, Park O, Park SY, Kim YM, Kim J, et al. "Contact tracing during coronavirus disease outbreak, South Korea, 2020," *Emerg Infect Dis.* (Oct. 2020), available at https://doi.org/10.3201/eid2610.201315 (accessed online July 27, 2020).

Disease in Childhood, clarified the direction of transmission of disease by focusing only on cases without "shared exposure" to a positive case.[88] The idea in this reanalysis paper is to exclude from consideration situations where two people who are infected share a third contact who is also infected, since it is possible that third contact infected both the original two people. Using this method, the authors found a single case (out of 107 pediatric index cases and 248 household members who also tested positive) of a child passing on the disease to another household member – another child. They find no instances of a child passing the disease to an adult.

This reanalysis of the South Korean paper is instructive, and the lesson should be clear. Correlation studies and anecdotes that do not distinguish the direction of spread of disease provide no information whatsoever about the safety (or lack thereof) of school reopening. In every single instance, when a more careful analysis that identifies the direction of spread (such as this South Korean study) is conducted, the analysis finds that children pose a negligible risk of spreading the disease to adults, both at school and at home.

There are other contact tracing-based studies that have attempted to reach conclusions about the role of children in spreading the epidemic that suffer from the same problem as the original South Korean study referenced above. For instance, a pre-print study from the Italian province of Trento[89] reported on 2,812 cases who reported 6,690 contacts. Though there were only 14 children among these cases, the authors nevertheless conclude that they transmitted the disease at a high rate, infecting 11 of their 49 contacts, nearly all within the same household. This represents only a small fraction of cases and contacts the authors analyzed, so numerically it is incorrect to conclude that children played a key role in the spread of the epidemic. Furthermore, unlike the Icelandic study, the Italian study cannot distinguish a child infecting a contact from the contact infecting the child. To my knowledge, nearly every contact-tracing based study of the role of children in the epidemic – with the Icelandic study and reanalysis of the South Korean study cited above as notable exceptions – suffers from this same problem.

A recent report, published in the *Journal of Pediatrics* and entitled "Pediatric SARS-CoV-2: Clinical Presentation, Infectivity, and Immune Responses", measured the concentration of the SARS-CoV-2 virus in the nasopharynx of children who showed symptoms consistent with COVID-19 infection.[90] The report found that the viral load in pediatric patients with symptoms (typically mild symptoms) was higher than adult hospitalized patients with severe COVID-19 disease. This is consistent with reports from earlier in the epidemic, which found similarly high viral loads in children.[91] Many news media reports of the *Journal of Pediatrics* study extrapolated beyond the results of the study, with alarming headlines saying that children are

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[88] Kim J, Choe YJ, Lee J, et al., *Role of children in household transmission of COVID-19*, ARCHIVES OF DISEASE IN CHILDHOOD (August 7, 2020), available at doi: 10.1136/archdischild-2020-319910

[89] Pirous Fateh-Moghadam, Laura Battisti, Silvia Molinaro, Steno Fontanari, Gabriele Dallago, Nancy Binkin, Mariagrazia Zuccali (2020) "Contact tracing during Phase I of the COVID-19 pandemic in the Province of Trento, Italy: key findings and recommendations" medRxiv preprint, DOI: https://doi.org/10.1101/2020.07.16.20127357. (accessed online Aug. 6, 2020)

[90] Lael Yonker et al. (2020) "Pediatric SARS-CoV-2: Clinical Presentation, Infectivity, and Immune Responses." *The Journal of Pediatrics* DOI: 10.1016/j.jpeds.2020.08.037 https://www.jpeds.com/article/S0022-3476(20)31023-4/fulltext

[91] Terry C Jones et al. (2020) "An Analysis of SARS-CoV-2 Viral Load by Patient Age" medRxiv. doi:https://doi.org/10.1101/2020.06.08.20125484. https://www.medrxiv.org/content/10.1101/2020.06.08.20125484v1

"silent spreaders" of SARS-CoV-2.[92]

These media reports are misleading because the presence of virus in the nasopharynx is not synonymous with the transmissibility of the virus. The PCR test which checks for the presence of the virus registers false positive results in the presence of non-viable, non-infectious, viral particles.[93,94,95] So even a high viral load is not evidence of infectivity.[96] The *Journal of Pediatrics* study itself appropriately lists the fact that their study does not assess the transmissibility of the virus as a limitation of the study. The only way to check for infectivity is to conduct a careful study of actual transmission of the virus, of the sort reported in the Icelandic contact tracing/viral mutation analysis referenced earlier.[97]

Another approach to this topic involves analyzing the effect of actual school closures on the spread of the epidemic within a country. If children play a role as a key vector of the epidemic, then one would expect that countries that closed schools would see a significant effect of this policy on disease spread. In fact, the opposite is the case. Studies from around the world that have examined school closures (including Japan[98], New South Wales[99], and Sweden/Finland[100]) find little or no effect of school closure on disease spread. The studies encompass closures of both elementary schools and high schools. A study[101] analyzing the Swedish experience concluded that there was there was no additional risk to elderly people cohabiting with school age children up to age 16, despite the fact that Swedish schools were kept open throughout the epidemic. A systematic review of this evidence[102] concluded that even though it may be possible for children to be infected with the virus and even transmit it, "[o]pening up schools and

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[92] Science Daily (2020) "Researchers show children are silent spreaders of virus that causes COVID-19" Press release, August 20, 2020. https://www.sciencedaily.com/releases/2020/08/200820102442.htm

[93] Kucirka LM, Lauer SA, Laeyendecker O, et al. (2020) Variation in False-Negative Rate of Reverse Transcriptase Polymerase Chain Reaction–Based SARS-CoV-2 Tests by Time Since Exposure. *Annals of Internal Medicine.* https://doi.org/10.7326/M20-1495

[94] Lan L, Xu D, Ye G, et al. (2020) Positive RT-PCR Test Results in Patients Recovered From COVID-19. JAMA. 2020;323(15):1502–1503. doi:10.1001/jama.2020.2783

[95] Cohen AN, Kessel B (2020) False positives in reverse transcription PCR testing for SARS-CoV-2. medRxiv 2020.04.26.20080911; doi: https://doi.org/10.1101/2020.04.26.20080911. Accessed 7/22/2020.

[96] Gavin Joynt and William Wu (2020) "Understanding COVID-19: what does viral RNA load really mean?" Lancet Infectious Diseases 20(6): P635-6. DOI:https://doi.org/10.1016/S1473-3099(20)30237-1 https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30237-1/fulltext

[97] Daniel F. Gudbjartsson, Ph.D., Agnar Helgason, Ph.D., et al., Spread of SARS-CoV-2 in the Icelandic Population, The New England Journal of Medicine, https://www.nejm.org/doi/full/10.1056/NEJMoa2006100 (June 11, 2020).

[98] Kentaro Iwata, Asako Doi, and Chisato Miyakoshi (2020) "Was school closure effective in mitigating coronavirus disease 2019 (COVID-19)? Time series analysis using Bayesian inference" *International Journal of Infectious Diseases*. DOI: https://doi.org/10.1016/j.ijid.2020.07.052 (accessed online Aug. 6, 2020).

[99] Kristine Macartney, Helen Quinn, Alexis Pillsbury, et al. (2020) "Transmission of SARS-CoV-2 in Australian Educational Settings: A Prospective Cohort Study" *The Lancet Child & Adolescent Health*. DOI: https://doi.org/10.1016/S2352-4642(20)30251-0 (accessed online Aug. 6, 2020)

[100] Public Health Agency of Sweden (2020) "COVID-19 in Schoolchildren: A Comparison between Finland and Sweden" https://www.folkhalsomyndigheten.se/contentassets/c1b78bffbfde4a7899eb0d8ffdb57b09/covid-19-school-aged-children.pdf (accessed online Aug. 6, 2020)

[101] Brandén, Maria; Aradhya, Siddartha; Kolk, Martin; Härkönen, Juho; Drefahl, Sven; Malmberg, Bo; et al. (2020): Residential Context and COVID-19 Mortality among the Elderly in Stockholm: A population-based, observational study. Stockholm Research Reports in Demography. Preprint. https://doi.org/10.17045/sthlmuni.12612947.v1 (accessed online Aug. 6, 2020)

[102] Jonas Ludvigsson (2020) "Children are Unlikely to be the Main Drivers of the COVID-19 Pandemic – A Systematic Review" *Acta Paediatrica*, DOI: 10.1111/apa.15371 (accessed online Aug. 6, 2020).

kindergartens is unlikely to impact COVID-19 mortality rates in older people."

One purported counterexample to this evidence that has received widespread attention involves the reopening of school in Israel in the early summer.[103] While the Israeli opening of schools is cited as a counter-example to the many other studies showing the negligible risk of transmitting COVID-19 by children, the Israeli reports suggest it was a unique circumstance, with children crowded into a small closed space and few precautions taken against disease spread. The New York Times story cited above provides an illustrative anecdote of symptomatic teachers passing the virus to their students. And the primary source of disease spread at the Gymnasia Rehavia high school was a single symptomatic teacher infecting colleagues and students. Contemporary reports, which emphasize the success of Israel in controlling the epidemic, suggest that Israelis reduced adherence to other mitigation measures as well. The cases that arose in Israeli schools are more likely a reflection of pre-existing community spread of the virus than a cause.

Thus, with no careful study to back it, and several lines of evidence that complicate any causal inference, the role of school opening in the resurgence of COVID-19 cases in Israel is not established. If there is a lesson to be learned, it is that schools can be opened safely for in-person learning if reasonable precautions – specific to the circumstances of each school – are taken. In the Israeli case, as with much of the anecdotal evidence cited, no viral sequencing analysis was conducted to verify the direction of disease spread. A report in *Science* emphasizes that no causal connection should be inferred from the correlation between Israeli school openings and the rise in cases there: "In Israel, infections among children increased steadily after schools opened. That paralleled a rise in cases nationwide, but it's not clear whether the country's rising caseload contributed to the increase within schools or vice versa."

A large study of 1,900 children attending an urban summer schools in Barcelona, Spain over a five-week period found only 39 new index cases (30 pediatric).[104] The setting was chosen because the investigators viewed it as a model for what to expect from school openings in the fall. These kids had 253 contacts in total, of whom, only 12 developed an infection – a secondary attack rate of 4.7%. The low secondary attack rate was similar for children of all ages attending the programs, ranging up to 17 years-old. The investigators attributed the success in controlling the spread of the disease to frequent hand washing by the children and to organizing the children into "bubbles" so that the kids interacted with the same group of children all day long.

A recent and comprehensive official report by Public Health England of the role of English schools, which were reopened on June 1, 2020 despite high community case numbers, in spreading the pandemic.[105] The author of this report found that cases and outbreaks were "uncommon across all educational settings" and that "[s]taff members had an increased risk of

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[103] Isabel Kershner and Pan Belluck (2020) "When COVID Subsided, Israel Reopened Its Schools. It Didn't Go Well." New York Times. Aug. 4, 2020. https://www.nytimes.com/2020/08/04/world/middleeast/coronavirus-israel-schools-reopen.html (Accessed online Aug. 6, 2020)

[104] Oriel Guell (2020) *Major coronavirus study in Spanish summer camps shows low transmission among children.* El Pais. (Aug. 26, 2020) available at https://english.elpais.com/society/2020-08-26/major-coronavirus-study-in-spanish-summer-camps-shows-low-transmission-among-children.html

[105] Sharif Ismail et al. (2020) "SARS-CoV-2 infection and transmission in educational settings: cross-sectional analysis of clusters and outbreaks in England" Public Health England, Aug. 12, 2020 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/911267/School_Outbreaks_Analysis.pdf

SARS-CoV-2 infections compared to students in any educational setting, and the majority of cases linked to outbreaks were in staff." In response to this study, UK education minister Gavin Williamson said "The latest research, which is expected to be published later this year – one of the largest studies on the coronavirus in schools in the world – makes it clear there is little evidence that the virus is transmitted at school."[106]

The overwhelming bulk of scientific studies that have examined the topic – including the best studies, which take pains to distinguish correlation from causation – find that children play a limited role in spreading COVID-19 infection to adults and that children themselves face minimal risk of poor outcomes if they should become infected.

In summary, Canadian responses to the epidemic have included many limitations on the activities of children, including but not limited to closures of schools, limitations to in class teaching, restrictions on Bible camps and Bible studies, suspension or limitations of sports and activities, and limitations to contacts with friends. Given the evidence cited here, these policies are inconsistent with the principle that public health decisions must be grounded in good scientific evidence.

H. Do Restrictions on the Activities of Young Adults Play an Important Role in Disease Spread? Do Young adults face particular harms from the lockdown restrictions?

Unlike children, young adults who are infected – especially early in infection – spread disease as efficiently older adults. However, they are harmed by infection much less than older adults. Young adults face a very low mortality risk from COVID-19 infection – an infection survival rate of 99.98% for people aged 20-49, according the US CDC.[107]

By contrast, young adults face enormous harm from lockdowns. Indicators of psychological harm have also increased sharply in prevalence in this group. According to a US CDC survey, one in four young adults aged 18 to 24 seriously considered suicide.[108] Similarly, a Canadian Mental Health Association survey found that nearly 1 in 5 (19%) young adults in that age group had suicidal thoughts.[109] The survey also found that 60% of young adults aged 18 to 24 surveyed said that their mental health had seriously deteriorated since March 2020. Other harms include lost educational opportunities with colleges and universities shutting down or providing only online classes and catastrophically high unemployment and economic dislocation.[110] Ironically,

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[106] Peter Walker (2020) "Little Evidence COVID Spreads in Schools, says Gavin Williamson" *The Guardian*, Aug. 10, 2020. https://www.theguardian.com/world/2020/aug/10/little-evidence-covid-spreads-in-schools-says-gavin-williamson

[107] COVID- 19 Pandemic Planning Scenarios, Centers for Disease Control and Prevention, https://www.cdc.gov/coronavirus/2019-ncov/hcp/planning-scenarios.html.

[108] Czeisler MÉ , Lane RI, Petrosky E, et al. Mental Health, Substance Use, and Suicidal Ideation During the COVID-19 Pandemic — United States, June 24–30, 2020. MMWR Morb Mortal Wkly Rep 2020;69:1049–1057 DOI: http://dx.doi.org/10.15585/mmwr.mm6932a1external icon

[109] Mental Health Impacts of Covid-19, Wave 2: Canadian Mental Health Association & University of British Columbia Survey, December 3, 2020

[110] Sharp A. (2020) Youth unemployment rate spikes amid pandemic. Canada's National Observer. May 8, 2020. https://www.nationalobserver.com/2020/05/08/news/youth-unemployment-rate-spikes-amid-pandemic

the lockdowns themselves have thus increased the risk of COVID-19 faced by older populations by increasing the number of households where young adults who have lost their jobs co-reside with vulnerable older parents[111], which increases the risk of COVID-related death.[112]

For young adults then, the harms from lockdowns are substantially greater than the harms from COVID. Viewed as a medical treatment, lockdowns imposed on younger populations violates the ethical principle that medical actions should do no harm to the patient. Unlike, chemotherapy for cancer, which induces a short-term harm to a patient in exchanges for a potential longer-term benefit, lockdowns cause long lasting harm to young adults with little to no long-lasting benefit.

I. Can religious services be held safely? Are there particular benefits that derive from communal singing?

Religious activity is essential to a meaningful life for many Canadians, and the free exercise of religion is guaranteed by the Canadian Constitution. Because assembly for religious practice is so important to so many, rather than recommending that religious assembly be canceled during the pandemic, the World Health Organization has provided guidance for religious assembly in the context of COVID-19.[113] The US CDC provides similar guidance and is instructive in the North American context.

The CDC guidance for communities of faith starts by recognizing the particular importance that religious communities should be permitted to gather for worship.[114] The CDC document cites the US First Amendment right to the free exercise of religion and reminds state and local authorities to account for this right in decision making about permitting religious communities to meet. Similar guarantees are present in the Canadian Constitution, as these involve fundamental human rights.

The recommendations in the CDC guidance include: (1) communication with local public health authorities regarding in person service plans; (2) protection for staff who are at higher risk for severe illness, including older staff members and those with underlying medical conditions; (3) encouragement of the congregation and staff to engage in hygienic hand washing practices; (4) encourage the congregation and staff to wear masks when social distancing is difficult, (5) promote six-foot social distancing during worship and reduce physical contact (shaking hands, hugging); (6) disinfection and cleaning of the worship space before and after each service; (7) minimize sharing of worship materials and shared food; (8) encourage staff and congregants with

[111] Evandrou M, Falkingham J, Qin M, and Vlachantoni A (2020) Changing Living Arrangements, Family Dynamics and Stress During Lockdown: Evidence from Four Birth Cohorts in the UK. University of Southampton Eprint Soton. https://eprints.soton.ac.uk/443865/1/family_dynamics_during_covid_19_final.pdf

[112] Fenoll AA & Grossbard S (2020) Intergenerational residence patterns and Covid-19 fatalities in the EU and the US, Economics & Human Biology, 39. https://doi.org/10.1016/j.ehb.2020.100934.

[113] World Health Organization (2020) Practical Considerations and Recommendations for Religious Leaders and Faith-Based Communities in the Context of COVID-19. https://www.who.int/publications/i/item/practical-considerations-and-recommendations-for-religious-leaders-and-faith-based-communities-in-the-context-of-covid-19

[114] US Centers for Disease Control (2020) Considerations for Communities of Faith. https://www.cdc.gov/coronavirus/2019-ncov/community/faith-based.html

symptoms consistent with COVID-19 infection or at high mortality risk given infection (e.g. elderly congregants and those with relevant comorbid conditions) to stay home; and (9) post signs and messages to communicate information about practices that can lead to disease spread. The CDC document is pointedly silent on singing during worship and does not make any explicit recommendations regarding communal singing. These guidelines require social distancing, which can reduce the likelihood of disease spread, but do not require a limitation to a fixed number of people in a service regardless of the size of the church, which has no scientific justification.

By following these guidelines, churches, mosques, synagogues, and other religious assemblies can safely hold indoor worship services, with minimal effect on the spread of COVID-19 disease.

The overwhelming evidence that church attendance provides psychological benefits for attendees should be considered against the cost of a marginal increase in disease spread (a harm that can be mitigated by following safety protocols). A comprehensive meta-analysis of the literature found evidence of improved mental health from religiosity (typically defined to encompass church attendance).[115] This is consistent with the broader literature on the psychological benefits of membership in voluntary associations as way to alleviate psychological distress.[116] The evidence suggesting psychological benefits of church attendance (including reductions in rates of depression) are particularly strong for adolescents.[117] Church attendance reduces stress and allostatic load (a term indicating stress endured over a long period of time),[118] which can cause both psychological and physical harms, including higher incidence of chronic disease and higher mortality.[119] There is also evidence in the medical literature regarding the particular psychological benefits provided by communal singing in the process of worship.[120] Communal singing provides a sense of belonging and connectedness that is crucially important in the life of many believers, with measurable effects on mental health.[121,122,123]

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[115] Hackney, C. H., & Sanders, G. S. (2003). Religiosity and Mental Health: A Meta-Analysis of Recent Studies. Journal for the Scientific Study of Religion, 42(1), 43–55. https://doi.org/10.1111/1468-5906.t01-1-00160

[116] Rietschlin, J. (1998). Voluntary Association Membership and Psychological Distress. Journal of Health and Social Behavior, 39(4), 348–355. https://doi.org/10.2307/2676343

[117] Demir, M., & Urberg, K. A. (2004). Church attendance and well-being among adolescents. Journal of Beliefs and Values, 25(1), 63–68. https://doi.org/10.1080/1361767042000198951

[118] Bruce, M. A., Martins, D., Duru, K., Beech, B. M., Sims, M., Harawa, N., Vargas, R., Kermah, D., Nicholas, S. B., Brown, A., & Norris, K. C. (2017). Church attendance, allostatic load and mortality in middle aged adults. PLOS ONE, 12(5), e0177618. https://doi.org/10.1371/journal.pone.0177618

[119] Juster, R. P., McEwen, B. S., & Lupien, S. J. (2010). Allostatic load biomarkers of chronic stress and impact on health and cognition. In Neuroscience and Biobehavioral Reviews (Vol. 35, Issue 1, pp. 2–16). Pergamon. https://doi.org/10.1016/j.neubiorev.2009.10.002

[120] Shakespeare T & Whieldon A (2017) Sing Your Heart Out: community singing as part of mental health recovery. *Medical Humanities*, 44(3) http://dx.doi.org/10.1136/medhum-2017-011195

[121] Clift S , Hancox G , Morrison I , et al . Choral singing and psychological wellbeing: quantitative and qualitative findings from English choirs in a cross-national survey. *J Applied Arts & Health* 2010;1:19–34.doi:10.1386/jaah.1.1.19/1

[122] Clift S , Morrison I . Group singing fosters mental health and wellbeing: findings from the East Kent 'singing for health' network project. *Mental Health and Social Inclusion* 2011;15:88–97.doi:10.1108/20428301111140930

[123] Livesey L , Morrison I , Clift S , et al . Benefits of choral singing for social and mental wellbeing: qualitative findings from a cross-national survey of choir members. *J Public Ment Health* 2012;11:10–26.doi:10.1108/17465721211207275

Of course, the spiritual benefits of in-person religious observance are personal to every member of the religious communities and should not be discounted even if they are not discretely measurable in terms of health benefits. For many believers, faith provides purpose in life.

J. Can restaurants and bars be opened safely to customers? Are there particular benefits that derive from eating in community?

Manitoba is the home to a vibrant restaurant and food service industry, including countless eateries, bars, and cafes. It is an important industry that provides entrepreneurial and employment opportunities that benefit the people of Manitoba in many ways, including providing psychologically important opportunities to eat together with friends and family. These facilities remain closed throughout Manitoba. These closure orders are not scientifically justified.

If restaurants, bars, etc. adhere to basic safety protocols promulgated by public health agencies throughout Canada (the protocols in summer/fall 2020 in Alberta are a typical example[124]), they can operate with in-person service safely. The recommendations include the following (among other items not listed here): (1) discourage patrons from congregating together while waiting for seating; (2) limit party size at tables and require a 2 metre distance between each dining party; (3) provide for physical barriers between tables when 2 metre distance is impossible; (4) use contactless payments and avoid cash payments where possible; (5) clean menus between uses or use paper menus; (6) avoid singing, or provide physical distancing between singers and patrons; (7) all employees must wear acceptable face covering at all times; (8) frequent sanitizing of surfaces, (9) encourage symptom checking of potential patrons and do not serve patrons who have symptoms consistent with COVID-19 disease.

In New York City, where a similar set of recommendations was in place for restaurants and bars, restaurants which were permitted to operate for in-person dining (until a new closure order[125] was put in place effective Dec. 14, 2020), a detailed contact tracing report found that restaurants and bars in New York City only account for 1.4% of the COVID spread. In that study, private gatherings at home account for 74% of the COVID spread.[126]

This finding should not be surprising. The evidence on the sharply lower frequency of disease spread by asymptomatic individuals (see Section B above) means that the vast majority of people visiting a restaurant pose no risk whatsoever for spreading the disease to fellow restaurant patrons, even if they happen to carry the virus. The main set of people who pose a risk of disease spread are symptomatic patients during the first eight days of infection. Requiring a

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[124] Alberta Public Health (2020) COVID-19 Information: Guidance for restaurants, cafes, pubs, and bars. September 2020.

[125] Klein C. (2020) New York City Indoor Dining Will Shut Down Again. *Intelligencer*. Dec. 11, 2020. https://nymag.com/intelligencer/2020/12/new-york-city-indoor-dining-to-shut-down-again-over-covid-19.html

[126] Adams E and Warerkar T (2020) Restaurants and Bars Account for 1.4 Percent of COVID-19 Spread in New York. Dec. 11, 2020. https://ny.eater.com/2020/12/11/22169841/restaurants-and-bars-coronavirus-spread-data-new-york

symptom check at the restaurant door is a much less onerous imposition than banning in-person dining altogether and will have about the same impact on disease spread.

Against these data regarding the negligible risks of COVID-19 transmission in indoor dining (in a restaurant following guidelines) should be considered the substantial evidence that social eating provides significant and tangible psychological and physiological benefits for diners that are lost through the imposition of such scientifically and epidemiologically unjustified blanket and untargeted bans. Those who eat socially more often feel happier and are more satisfied with life, are more trusting of others, are more engaged with their local communities, and have more friends they can depend on for support; path analysis suggests that the causal connection runs from eating together to bondedness rather than the other way around.[127] And a comprehensive survey of 17,612 men and 19,581 women over the age of 65 found that eating alone has been linked to a higher incidence of depression among adults, particularly those who live alone.[128] Eliminating the possibility of indoor dining, no matter the precautions taken, reduces or eliminates these important benefits.

K. Can gyms, martial arts studios, and other venues offering opportunities for physical activities open with minimal risk of disease spread? Are there particular benefits to health that derive from access to such facilities?

Gyms, martial arts studios, dance studios, and other venues offering opportunities physical activities are important to many Canadians as a way of staying physically fit and healthy. Despite the importance of these venues to public health, in much of Canada, Manitoba included, the lockdown orders have ordered them to stay closed for extended periods during the past months. These orders are unjustified.

To my knowledge the public health authorities in Manitoba have provided no studies – based on contact tracing or other data – to document that gyms and other such venues pose a risk of disease spread. There is one report of a "super-spreader" event that occurred in a gym in Ontario in October.[129] In that case, there was a spinning class, with stationary bicycles with wheels that in theory could aerosolize the virus. If that is true, the right remedy is to limit indoor spin classes or require physical barriers between bicycles, not to shutter gyms and fitness venues altogether. The CBC story reporting on this event cited one infectious disease expert who admitted that gyms are not high-risk environments:

> Dr. Ilan Schwartz, an infectious disease expert with the University of Alberta, said spin classes may pose more risk than other group settings because of the bikes themselves. In theory, the rapidly spinning wheels could aerosolize droplets

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[127] (Dunbar, *Breaking Bread: the Functions of Social Eating, Adaptive Human Behavior and Physiology* (*available at* https://link.springer.com/article/10.1007/s40750-017-0061-4)).

[128] Tani, et al, *Eating alone and depression in older men and women by cohabitation status: the JAGES longitudinal survey, Age Ageing* 44(6) 1019-1026 (2015) (*available at* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4621239/).

[129] Zuber MC. (2020) Heavier breathing, spewing droplets, poor ventilation add to gyms' superspreading risk. CBC. October 15, 2020. https://www.cbc.ca/news/health/gyms-superspreading-events-covid-19-1.5763297

by flinging them farther distances.

"I haven't seen any studies of this, but theoretically it makes sense," he said.

"I think going to the gym isn't necessarily high-risk, unless individuals are close together and there's poor ventilation. But there might be specific circumstances that could make it higher-risk, where something with fast, moving parts [or] a rapidly moving fan can generate aerosols as well."

Compared with this sort of anecdotal evidence, there are more systematic data from other localities that suggest that physical fitness centers play a limited role in disease spread.[130] In a study published in *Nature* analyzing the association between mobility of populations, super-spreader events and disease risk, the authors conclude that restricting occupancy in public venues is the best approach to limiting the risk of disease spread, while lockdowns aimed at general mobility restrictions work less well.[131] They find that fitness centers do not pose a very high risk of disease spread relative to other public venues.

Second, guidelines disseminated by public health agencies around Canada provide discrete steps that fitness centers can take to reduce the risk of spread of the disease at these centers.[132] These steps include physical distancing requirements, physical barriers, ventilation requirements, symptom checking, cleaning requirements, and face masks when physical distancing is impossible. Given the findings in the scientific literature, these requirements – if implemented appropriately – are sufficient to limit the probability of disease spread at fitness centers.

Third, closing fitness centers reduces the ability of the population to engage in activities that maintain physical fitness, and thus increase the risk of poor outcomes if a COVID-19 infection were to occur. For example, obesity is a risk factor for mortality from COVID-19 infection. Regular exercise is essential for patients with type 2 diabetes[133] or cardiovascular disease[134] to maintain their health. Exercise also provides people with anxiety, depression, and stress-related disorders with an important avenue to address these problems.[135, 136] The negligible benefits of

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[130] UK Office for National Statistics (2020) Which occupations have the highest potential exposure to the coronavirus (COVID-19)? May 11, 2020. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/whichoccupationshavethehighestpotentialexposuretothecoronaviruscovid19/2020-05-11

[131] Chang S, Pierson E, Koh PW, Gerardin J, Redbird B, Grusky D, Leskovec J. Mobility network models of COVID-19 explain inequities and inform reopening. Nature. 2020 Nov 10. doi: 10.1038/s41586-020-2923-3. Epub ahead of print. PMID: 33171481.

[132] Government of Canada (2020) Community-based measures to mitigate the spread of coronavirus disease (COVID-19) in Canada. October 15, 2020. https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirus-infection/health-professionals/public-health-measures-mitigate-covid-19.html#_Community_gathering_spaces

[133] Kirwan JP, Sacks J, Nieuwoudt S. The essential role of exercise in the management of type 2 diabetes. Cleve Clin J Med. 2017 Jul;84(7 Suppl 1):S15-S21. doi: 10.3949/ccjm.84.s1.03. PMID: 28708479; PMCID: PMC5846677.

[134] Nystoriak MA and Bhatnagar A (2020) Cardiovascular Effects and Benefits of Exercise. Front. Cardiovasc. Med., 28 September 2018 | https://doi.org/10.3389/fcvm.2018.00135

[135] Craft, Lynette L., and Frank M. Perna. "The Benefits of Exercise for the Clinically Depressed." Primary care companion to the Journal of clinical psychiatry vol. 6,3 (2004): 104-111. doi:10.4088/pcc.v06n0301

closing fitness centers in terms of slowing disease spread should be balanced against the health benefits of these centers for people who frequent them.

In summary, if fitness centers take standard precautions as recommended by Canadian public health agencies (symptom checking, good ventilation, physical barriers, etc.) the risk of COVID-19 disease spread from their operation is small. The most comprehensive studies confirm that fitness centers play a small role in disease spread. And finally, there are considerable harms to health – both physical and psychological health – from reducing the availability of venues for physical fitness for the population.

L. Do other measures exist that would achieve the goal of the government to protect the population from Covid-19, but that would have less or no impairments on the freedoms and liberties of the population? If yes, what are they?

Yes. The Great Barrington Declaration, of which I am a primary coauthor, describes an alternate policy of focused protection. This policy would lead to less COVID-related death and less non-COVID related deaths than the current government policy. The co-authors of the Declaration include Prof. Martin Kulldorff of Harvard University and Prof. Sunetra Gupta of Oxford University. Over 12,000 epidemiologists and public health professionals, and 35,000 medical professionals have co-signed the declaration. The text of the Great Barrington Declaration is copied immediately below.[137]

> "As infectious disease epidemiologists and public health scientists we have grave concerns about the damaging physical and mental health impacts of the prevailing COVID-19 policies, and recommend an approach we call Focused Protection.
>
> Coming from both the left and right, and around the world, we have devoted our careers to protecting people. Current lockdown policies are producing devastating effects on short and long-term public health. The results (to name a few) include lower childhood vaccination rates, worsening cardiovascular disease outcomes, fewer cancer screenings and deteriorating mental health – leading to greater excess mortality in years to come, with the working class and younger members of society carrying the heaviest burden. Keeping students out of school is a grave injustice.
>
> Keeping these measures in place until a vaccine is available will cause irreparable damage, with the underprivileged disproportionately harmed.
>
> Fortunately, our understanding of the virus is growing. We know that vulnerability to death from COVID-19 is more than a thousand-fold higher in the old and infirm than the

[136] Stubbs B, Vancampfort D, Rosenbaum S, Firth J, Cosco T, Veronese N, Salum GA, Schuch FB. An examination of the anxiolytic effects of exercise for people with anxiety and stress-related disorders: A meta-analysis. Psychiatry Res. 2017 Mar;249:102-108. doi: 10.1016/j.psychres.2016.12.020. Epub 2017 Jan 6. PMID: 28088704.
[137] Bhattacharya J, Gupta S, Kulldorff M (2020) Great Barrington Declaration. https://gbdeclaration.org

young. Indeed, for children, COVID-19 is less dangerous than many other harms, including influenza.

As immunity builds in the population, the risk of infection to all – including the vulnerable – falls. We know that all populations will eventually reach herd immunity – i.e. the point at which the rate of new infections is stable – and that this can be assisted by (but is not dependent upon) a vaccine. Our goal should therefore be to minimize mortality and social harm until we reach herd immunity.

The most compassionate approach that balances the risks and benefits of reaching herd immunity, is to allow those who are at minimal risk of death to live their lives normally to build up immunity to the virus through natural infection, while better protecting those who are at highest risk. We call this Focused Protection.

Adopting measures to protect the vulnerable should be the central aim of public health responses to COVID-19. By way of example, nursing homes should use staff with acquired immunity and perform frequent testing of other staff and all visitors. Staff rotation should be minimized. Retired people living at home should have groceries and other essentials delivered to their home. When possible, they should meet family members outside rather than inside. A comprehensive and detailed list of measures, including approaches to multi-generational households, can be implemented, and is well within the scope and capability of public health professionals.

Those who are not vulnerable should immediately be allowed to resume life as normal. Simple hygiene measures, such as hand washing and staying home when sick should be practiced by everyone to reduce the herd immunity threshold. Schools and universities should be open for in-person teaching. Extracurricular activities, such as sports, should be resumed. Young low-risk adults should work normally, rather than from home. Restaurants and other businesses should open. Arts, music, sport and other cultural activities should resume. People who are more at risk may participate if they wish, while society as a whole enjoys the protection conferred upon the vulnerable by those who have built up herd immunity."

The Great Barrington Declaration provides concrete suggestions for a strategy of focused protection. This includes a (non-comprehensive) suite of policies aimed at protecting people who are particularly vulnerable (e.g. the elderly) to mortality from COVID-19 infection. These policies differ depending on the particular living situation of vulnerable people. The current policies have failed to protect the vulnerable, as is evidenced by the large fraction of the COVID-19 deaths among the elderly in Canada. There have been many unnecessary deaths, and especially among the urban working class and poor.[138] Concrete examples of these failures include:

[138] Kulldorff M and Gupta S (2020) Canada's COVID-19 strategy is an assault on the working class. Toronto Sun. Nov. 29, 2020. https://torontosun.com/opinion/columnists/opinion-canadas-covid-19-strategy-is-an-assault-on-the-working-class

- Requiring older "essential" workers and members of the working class that cannot afford not to work to be put in work situations where they may be exposed to the virus.
- Failure to protect nursing home residents from exposure to the virus from staff members, visitors, and other residents.[139]
- No provision for elderly people living in multi-generational homes to be shielded should a family member be exposed to the virus.

Focused protection of the vulnerable provides a better alternative to lockdown to protect the vulnerable. Below, in Section N, I outline ideas for focused protection.

In summary, the Great Barrington Declaration offers a policy alternative to lockdowns that reduces COVID-19 related mortality among the vulnerable via overwhelming resources devoted to focused protection where they live. For the non-vulnerable, the lifting of lockdowns provides an enormous benefit for physical and psychological health – including mortality risk – that offsets the harm from potential COVID-19 infection.

M. Is there immunity obtained after being infected and cured from Covid-19?

The scientific evidence is overwhelming that there is lasting immunity after SARS-CoV-2 infection among people who recover from the infection.

First, SARS-CoV-2 is a coronavirus and humans have been exposed to coronaviruses for millenia. Immunologists reviewing this evidence of immunity after coronavirus infection argue that we should use this knowledge to set prior expectations about human immune response to SARS-CoV-2 infection, and these priors suggest a robust and long-lasting immune response. In the *Journal of Immunology*, immunologist Nicole Baumgarth and her colleagues write:[140]

> "[W]e argue that the normal cadence by which we discuss science with our colleagues failed to properly convey likelihoods of the immune response to SARS-CoV-2 to the public and the media. As a result, biologically implausible outcomes were given equal weight as the principles set by decades of viral immunology. Unsurprisingly, questionable results and alarmist news media articles have filled the void. We suggest an emphasis on setting expectations based on prior findings while avoiding the overused approach of assuming nothing. After reviewing Ab-mediated immunity after coronavirus and other acute viral infections, we posit that, with few exceptions, the development of protective humoral immunity of more than a year is the norm. Immunity to SARS-CoV-2

[139] Kwiatkowski M, Nadolny TL, Priest J, Stucka M (2020) 'A National Disgrace': 40,600 deaths tied to US Nursing Homes. USA Today. June 1, 2020. https://www.usatoday.com/story/news/investigations/2020/06/01/coronavirus-nursing-home-deaths-top-40-600/5273075002/

[140] Baumgarth N, Nikolich-Zugich J, Lee FEH, Bhattacharya D. (2020) Antibody Responses to SARS-CoV-2: Let's Stick to Known Knowns.

is likely to follow the same pattern."

The direct evidence in favor of a robust and long-lasting immune response is also overwhelming. In a paper published in the journal *Immunity*, immunologist Deepta Bhattacharya (no relation) and his colleagues show that recovered COVID-19 patients show "durable antibody production for at least 5-7 months after infection."[141] Several other studies, published in prominent immunology journals, confirm this report and show that the vast majority of people who are infected produce specific antibodies in response to the infection, which confer immunity or substantial protection against reinfection.[142, 143]

Over time, as is the normal course of an infection, the specific antibodies to SARS-CoV-2 infection fade. The immune memory persists in dormant or resting cells, called memory cells, who do not actively secrete antibodies, but nevertheless continue to provide lasting protection against SARS-CoV-2 infection. This is entirely consistent with a typical immune response to a challenge by a virus like SARS-CoV-2. Viral infections are most often addressed through CD8 T cells, which do not produce antibodies, but rather directly eliminate virus-infected cells to shortcut viral replication. Indeed, SARS-CoV-2 specific CD4 and CD8 T cells have been detected in convalescent patients.[144]

This T-cell mediated immunity is also long lasting. A preprint study released last month documents this fact, and the title of the piece summarizes its result: "Robust SARS-CoV-2 specific T-cell Immunity is Maintained at Six Months Following Primary Infection."[145] Another pre-print released last month identifies long-lasting protection after SARS-CoV-2 infection from memory B-cells, which can produce specific antibodies in response to reinfection by the virus.[146]

Finally, it is apparently the case that many individuals who have not been infected by SARS-CoV-2 possess T-cells that recognize it and can neutralize cells infected by the virus. The hypothesized mechanism involves infection by other coronaviruses, which share some molecular structural properties with SARS-CoV-2. A separate study published in Nature found both CD4 and CD8 T cells which provide recognize (and hence attack) regions of the SARS-CoV-2 virus in both convalescent patients and patients who had previously been infected with other coronaviruses including SARS-CoV-1, seventeen years after infection.[147] Summarizing this evidence, Francis Collins (Director of the National Institutes of Health) writes:

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[141] Ripperger TJ et al. (2020) Orthogonal SARS-CoV-2 Serological Assays Enable Surveillance of Low-Prevalence Communities and Reveal Durable Humoral Immunity. *Immunity* 53, 925–933. Nov. 17, 2020. https://doi.org/10.1016/j.immuni.2020.10.004

[142] Ni, Ling, et al. (2020) "Detection of SARS-CoV-2-specific humoral and cellular immunity in COVID-19 convalescent individuals." *Immunity*. https://doi.org/10.1016/j.immuni.2020.04.023

[143] Moderbacher CR et al. "Antigen-specific adaptive immunity to SARS-CoV-2 in acute COVID-19 and associations with age and disease severity." Cell 183.4 (2020): 996-1012. DOI:https://doi.org/10.1016/j.cell.2020.09.038

[144] *Ibid.*

[145] Zuo J et al. (2020) Robust SARS-CoV-2-specific T-cell immunity is maintained at 6 months following primary infection. medRxiv. doi: https://doi.org/10.1101/2020.11.01.362319

[146] Dan JM et al. (2020) Immunological memory to SARS-CoV-2 assessed for greater than six months after infection. medRxiv. doi: https://doi.org/10.1101/2020.11.15.383323

[147] Le Bert, N., Tan, A.T., Kunasegaran, K. et al. (2020) SARS-CoV-2-specific T cell immunity in cases of COVID-19 and SARS, and uninfected controls. Nature 584, 457–462. https://doi.org/10.1038/s41586-020-2550-z

> Much of the study on the immune response to SARS-CoV-2, the novel coronavirus that causes COVID-19, has focused on the production of antibodies. But, in fact, immune cells known as memory T cells also play an important role in the ability of our immune systems to protect us against many viral infections, including—it now appears—COVID-19…This might potentially explain why some people seem to fend off the virus and may be less susceptible to becoming severely ill with COVID-19.

All these conclusions are well reflected in the fact that that despite millions of people infected worldwide to date after 10 months living with the virus, we have seen only a handful of patients who re-tested positive after being discharged, all of whom showed no evidence of being contagious and all presented milder symptoms. Scientific evidence strongly suggests that recovery from SARS-Cov-2 infection will provide lasting protection against reinfection, either complete immunity or protection that makes a severe reinfection extremely unlikely.

N. What is herd immunity? What is the most effective way to reduce harm until endemic equilibrium?

Herd immunity – also known as endemic equilibrium – occurs when enough people have immunity so that most infected people cannot find new uninfected people to infect, leading to the end of the epidemic/pandemic. This means that the epidemic/pandemic will end before everyone is infected, although it will continue in endemic form with low rates of infections. Herd immunity is a scientifically proven phenomenon. Sooner or later, herd immunity will be reached either through natural infection or through a combination of vaccinations and natural infection.

To protect the vulnerable elderly living in nursing homes and other care settings, a focused protection strategy would include frequent testing of nursing home staff members who are not already immune, testing of visitors, and less staff rotation so that residents only interact with a limited number of staff people. Rapid antigen tests could be used to avoid the problem of a delay between sample collection and the development of test results and to reduce the possibility of functional false positive results in PCR testing (see Section O below). COVID-19 infected individuals should not be sent to nursing homes, and all new residents should be tested. Sequestering of care home residents who have COVID-19 is also important.

To protect older people living at home, during high transmission times, older people should be offered home delivery of groceries and other essentials. When seeing friends and relatives, it is best to do it outdoors. Testing should be available for relatives and friends who want to visit. Free N95 masks should be provided for when they cannot avoid potential exposure.

Focused protection requires protecting protect older people still in the work force. People in their 60s are at somewhat high risk, and many are still in the workforce. Those that can work from home should be allowed to do so. For example, teachers in their 60s could teach online courses, or help fellow teachers with grading exams, essays and homework. Those that cannot work from home should be funded to take a 3 to 6-month sabbatical. In addition, workplace disability laws

should require employers to provide reasonable accommodations to protect high COVID-19 risk workers without losing their jobs.

Focused protection requires protecting elderly people living in multigenerational homes. University closures and the economic displacement caused by lockdowns has led millions of young adults to live with older parents, increasing regular close interactions across generations. We know that older people living with working-age adults have higher COVID-19 risk than older people living with other older people. There is no further excess risk if also living with children though. This is the toughest challenge, and family specific solutions must be found. If the working-age household members can work from home, they can isolate together. If that is not possible, the older family member might temporarily be able to live with an older friend or sibling, with whom they can self-isolate together during the height of community transmission. As a last resort, empty hotel rooms could be used for temporary housing.

Focused protection also requires protecting younger people with chronic conditions like diabetes, severe asthma, or obesity that place them at higher mortality risk should they become infected. The focused protection plan for these individuals is the same as that for the elderly and will vary depending upon their living circumstance.

The deployment of a safe and effective SARS-CoV-2 vaccine – if people who are most vulnerable are prioritized for inoculation -- offers an opportunity for near perfect focused protection. For this population, the harms from COVID-19 infection are far greater than the possible harms from vaccination.

Effective focused protection reduces the number of people who will need hospitalization for COVID-19 infection, since hospitalization risk, like mortality risk, rises sharply with patient age.[148] Thus, if effective focused protection is implemented, the probability of overcrowded hospital systems is greatly reduced.[149]

Lockdowns actually extend the time that the vulnerable are at risk of infection. By delaying infections into the future, lockdowns delay the establishment of herd immunity in a population. Focused protection of the vulnerable is possible but without an effective vaccination campaign, requires vigilance which cannot be maintained forever.

In summary, replacing a lockdown policy with a policy of focused protection of the vulnerable would greatly reduce the lockdown harms for less vulnerable populations, while protecting the vulnerable from COVID-19 risk. The concrete suggestions outlined here are not comprehensive, and with the advent of a safe and effective vaccine in December 2020, there should be no controversy over whether this policy is possible. It is a failure of public health officials in Manitoba that they have not engaged in developing strategies like those listed here. Reducing the risk of harm to the vulnerable and non-vulnerable alike from infectious (COVID-19 related) and non-infectious (lockdown related) causes should be the goal of public health policy. An aim that focuses solely on slowing disease spread – lockdown – ultimately increases both COVID-19

[148] US Centers for Disease Control (2020) COVID-19 Hospitalization and Death by Age. Aug. 18, 2020. https://www.cdc.gov/coronavirus/2019-ncov/covid-data/investigations-discovery/hospitalization-death-by-age.html
[149] Chikina M, Pegden W. Modeling strict age-targeted mitigation strategies for COVID-19. PLoS One. 2020 Jul 24;15(7):e0236237. doi: 10.1371/journal.pone.0236237. PMID: 32706809; PMCID: PMC7380601.

related and lockdown harms relative to a policy of focused protection.

O. What are RT-PCR tests? What is a Cycle Threshold and What is the Likelihood of Infection with Covid-19 with a CT over 30? How Does a Positive PCR Result Correlate to Manitoba's Definition of a "Case" of Covid-19?

The RT-PCR test for the SARS-CoV-2 virus is at the heart of the testing system adopted by Canada. The RT-PCR tests, as used in most laboratories in Manitoba, likely registers a positive test result even for non-infectious viral fragments. The RT-PCR test amplifies the virus – if present – by a process of repeatedly doubling the concentration of viral genetic material. If the viral load is small, many doublings are required before it is possible to detect the virus.

The problem arises from the fact that the implementation of the RT-PCR test for COVID-19 requires that clinical laboratories decide in advance how many doublings of the genetic material they will require before deciding that a sample is negative for the presence of the virus. This threshold, known as the "cycle time" of the test, determines both the rate at which a positive test result will be returned when the original sample does not include viral concentrations in sufficient amount to be infectious (hereafter, the functional false positive rate), and the rate at which a negative test result will be returned when the original sample does include viral concentrations in sufficient amount to be infectious (hereafter, the functional false negative rate).

A higher cycle time threshold – requiring more doublings before declaring a negative test result – increases the functional false positive rate of the RT-PCR test because even if a non-infectious viral load is present in the sample obtained from the patient, a large number of permitted doublings could amplify whatever is present such that test result is positive. In such a case, this positive test result would not mean that the individual was infectious or contagious.

The RT-PCR test is commonly known in the literature as the gold standard to check for the presence of the SARS-CoV-2 virus. This is true, but beside the point. The important question is not whether RT-PCR is a "gold standard" test for viral presence, but rather whether it is a gold standard test for determining whether a patient is infectious, which it is not. Rather, the gold standard test for infectivity involves checking whether a sample taken from the nasopharynx of a patient can infect, in vitro, a cell culture. Infectious samples are known as "culture positive", while non-infectious samples are known as "culture negative". From an epidemiological point of view, infectivity measurement is more important than a measurement of whether the virus is present, since it is possible for a patient to have non-viable viral fragments present, a positive PCR test, and yet not be infectious.

The relevant question then, is whether the RT-PCR test is sufficiently accurate to use as a tool to decide whether to sharply curtail the normal activities of over a million people living in Manitoba, imposing untold harm on them related to the lockdown, and the unfortunate answer is no.

A systematic review of the literature on cycle time thresholds for the SARS-CoV-2 RT-PCR tests (encompassing 25 different published studies on the topic) concludes that "The evidence is increasingly pointing to the probability of culturing live virus being related to the amount of viral RNA in the specimen and therefore, inversely related to the cycle threshold. Thus, detection of

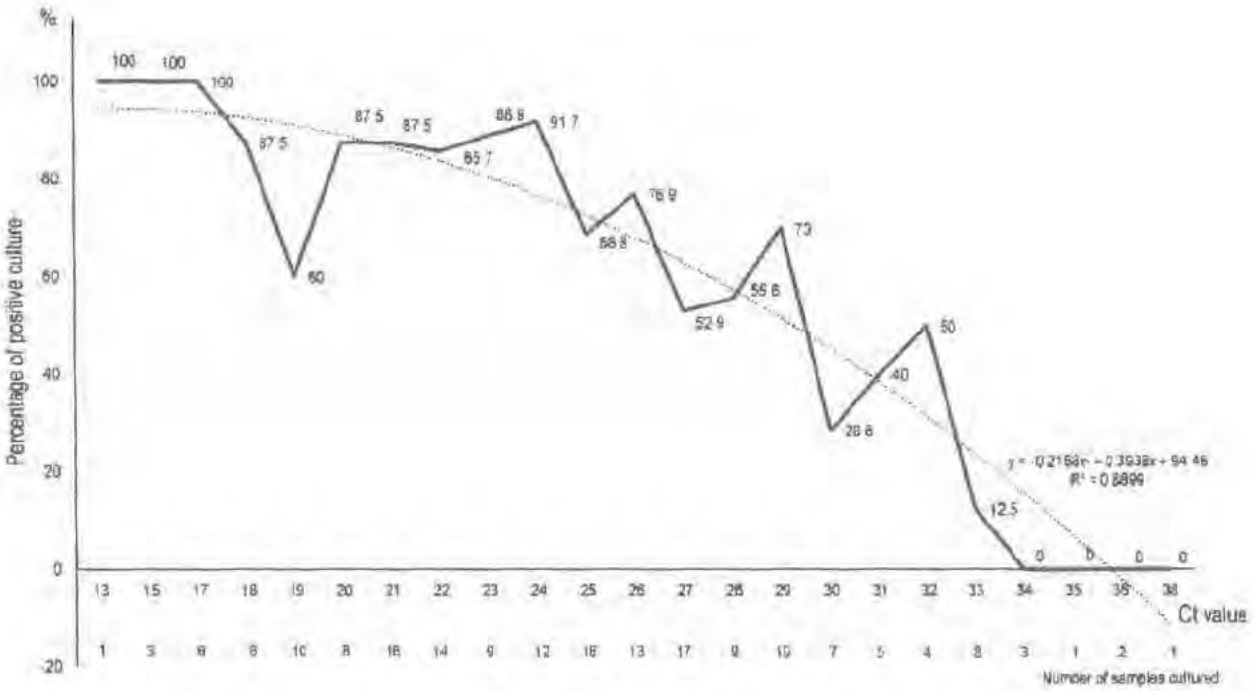
viral RNA per se cannot be used to infer infectiousness."[150] In other words, the scientific evidence now shows that the RT-PCR test for the presence of the SARS-CoV-2 virus will often generate a positive result even when an individual is not infectious (that is, does not pose a danger of infecting other people). The difficulty is that the RT-PCR test permits too many doubling cycles of viral particles before declaring a negative test. The functional false positive rate increases with the number of cycles (known as a Ct value) required to produce a positive result. The review recommends requiring clinical evidence of infection alongside a PCR result with a low cycle time count before designating a patient as a COVID-19 case.

Similar results were observed in a study[151] published in the *European Journal of Clinical Microbiology & Infectious Diseases*. The study aimed to determine when it would be safe to discharge COVID-19 patients in Marseille, France. The authors observed a significant relationship between Ct value and culture positivity rate (see Fig. 1). Samples with Ct values of 13–17 all led to positive culture. Culture positivity rate then decreased progressively according to Ct values to reach 12% at 33 Ct. No culture was obtained from samples with Ct $\geq$ 34.

[150] Jefferson T, Spencer EA, Brassey J, Heneghan C. Viral cultures for COVID-19 infectious potential assessment - a systematic review. *Clin Infect Dis*. 2020 Dec 3:ciaa1764. doi: 10.1093/cid/ciaa1764. Epub ahead of print. PMID: 33270107.

[151] La Scola, B., Le Bideau, M., Andreani, J. *et al.* Viral RNA load as determined by cell culture as a management tool for discharge of SARS-CoV-2 patients from infectious disease wards. *Eur J Clin Microbiol Infect Dis* **39,** 1059–1061 (2020). https://doi.org/10.1007/s10096-020-03913-9

Fig. 1



Percentage of positive viral culture of SARS-CoV-2 PCR-positive nasopharyngeal samples from Covid-19 patients, according to Ct value (plain line). The dashed curve indicates the polynomial regression curve

The study concluded that patients with Ct values equal or above 34 did not excrete infectious viral particles.

Further, according to a careful study published in *Eurosurveillance* (a top journal in the field of epidemiology), if 27 cycles are needed for a positive test, the false positive rate is 34%; if 32 cycles are needed for a positive test, the false positive rate is 72%, and if 37 cycles are needed for a positive test, the false positive rate is 92%.[152] If more than 40 cycles are needed for a positive test, the functional false positive rate is nearly 100%.

Twenty-two top international scientists came to a similar conclusion in respect of false positive test results and cycle thresholds. On November 27, 2020, they submitted a retraction request letter[153] to the *Eurosurveillance* editorial board, requesting that the paper published by *Eurosurveillance* on January 23, 2020, entitled, "Detection of 2019 novel coronavirus (2019-

[152] Singanayagam A, Patel M, Charlett A, Lopez Bernal J, Saliba V, Ellis J, et al. Duration of infectiousness and correlation with RT-PCR cycle threshold values in cases of COVID-19, England, January to May 2020. Eurosurveillance. 2020;25(32):2001483. 2020

[153] Retraction request letter to Eurosurveillance editorial board re: Cormen-Drosten Paper, Dr. Pieter Borger et al., November 26, 2020, https://cormandrostenreview.com/retraction-request-letter-to-eurosurveillance-editorial-board/

nCoV) by real-time RT-PCR"[154] (the "Corman-Drosten paper") be retracted due to its severe flaws. (It was this paper that led to the worldwide usage of PCR tests to diagnose COVID-19.) In addition to their letter, these scientists submitted a Review report[155] of the Corman-Drosten paper outlining 10 fatal flaws in the paper. One of the flaws they listed was with the recommended cycle time value:

> In case of virus detection, >35 cycles only detects signals which do not correlate with infectious virus as determined by isolation in cell culture; if someone is tested by PCR as positive when a threshold of 35 cycles or higher is used (as is the case in most laboratories in Europe & the US), the probability that said person is actually infected is less than 3%, the probability that said result is a false positive is 97%.

Even the World Health Organization recently published an Information Notice[156] warning users of PCR tests that it had "received user feedback on an elevated risk for false SARS-CoV-2 results when testing specimens using RT-PCR reagents on open systems."

This error in the test is a major problem for Manitoba, since the public health authority tracks "cases" per capita and percent positivity of test results to measure the spread of the disease in the population.[157] Both of these measures depend on the accuracy of the RT-PCR tests to determine whether an individual is infected with the virus.[158] The text of Manitoba's COVID-19 Surveillance Case Definition as of December 16, 2020 is reproduced below:[159]

> **Surveillance Case Definition**
>
> Cases include both confirmed and probable cases. Surveillance case definitions are provided for the purpose of standardizing case classification and reporting. They are based on evidence, public health response goals, and are subject to change as new

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[154] Victor M. Corman, Olfert Landt, Marco Kaiser, Detection of 2019 novel coronavirus (2019-nCoV) by real-time RT-PCR, Eurosurveillance. 2020 Jan 23; 25(3): 2000045 doi: 10.2807/1560-7917.ES.2020.25.3.2000045; this paper's approval and publication in Eurosurveillance in January 2020 led many world nations to utilize the PCR test to diagnose COVID-19

[155] Pieter Borger et al. External peer review of the RTPCR test to detect SARS-CoV-2 reveals 10 major scientific flaws at the molecular and methodological level: consequences for false positive results., November 27, 2020. https://cormandrostenreview.com/report/

[156] WHO Information Notice for IVD Users, December 14, 2020, https://www.who.int/news/item/14-12-2020-who-information-notice-for-ivd-users?fbclid=IwAR0Si8UnfvZc8iOppsSPO2kuzXJ-rMYMJvuHCtF4OfHODLchDsyUr7z2XXY

[157]Covid-19 Surveillance Report 2020 Technical Notes, webarchive December 16, 2020 https://www.gov.mb.ca/health/publichealth/surveillance/covid-19/resources/Notes.html

[158] Interim Guidance Public Health Measures, *Managing Novel Coronavirus (Covid-19) Cases and Contacts In Community*, December 16, 2020, https://manitoba.ca/asset_library/en/coronavirus/interim_guidance

[159] Covid-19 Surveillance Report 2020 Technical Notes, webarchive December 16, 2020 https://www.gov.mb.ca/health/publichealth/surveillance/covid-19/resources/Notes.html; See also: COVID-19 Epidemiology and Surveillance Definitions: Manitoba Health, Seniors and Active Living Version: June 10, 2020, https://www.gov.mb.ca/health/publichealth/surveillance/docs/es_definitions.pdf; See also: Interim national case definition: Coronavirus disease (COVID-19)Last Updated: April 2, 2020, https://www.canada.ca/en/public-health/services/diseases/2019-novel-coronavirus-infection/health-professionals/national-case-definition.html#nat

a positive test on a single real-time PCR target or a positive test with an assay that has limited performance data available),

- NAATs must be validated for detection of the virus that causes COVID-19.
- An indeterminate result on a real-time PCR assay is defined as a late amplification signal in a real-time PCR reaction at a predetermined high cycle threshold value. This may be due to low viral target quantity in the clinical specimen approaching the limit of detection of the assay or may represent nonspecific reactivity (false signal) in the specimen. When clinically relevant, indeterminate samples should be investigated further in the laboratory (e.g. by testing for an alternate gene target using a validated real-time PCR or nucleic acid sequencing that is equally or more sensitive than the initial assay or method used) or by collection and testing of another sample from the patient with initial indeterminate result.

- A (un-tested) person with:
  - Fever (over 38 degrees Celsius), **AND/OR**
  - Cough (new or exacerbated chronic); **AND**
  - Close contact with a confirmed case of COVID-19, **OR**
  - Lived in or worked in a closed facility known to be experiencing an outbreak of COVID-19 (e.g., long-term care facility, correctional facility)

Confirmed case – A person with a laboratory confirmation of infection with the virus that causes COVID-19 performed at a community, hospital or reference laboratory (NML or a provincial public health laboratory) running a validated assay. This consists of detection of at least one specific gene target by a NAAT assay (e.g. real-time PCR or nucleic acid sequencing).

Since nucleic acid sequencing is uncommon, Manitoba diagnoses a confirmed case of COVID-19 with a positive result on a PCR test without the requirement for a clinical diagnosis by a qualified medical practitioner. It is problematic as without a clinical diagnosis of symptoms related to COVID-19, a positive PCR test alone is too unreliable to conclude that an individual is infectious with COVID-19, especially if that test is run at a high cycle threshold.

Another problem is that Manitoba counts "Probable cases" as "cases" for its official case surveillance, and a probable case can include an "un-tested person" who was in close contact with a confirmed case of COVID-19[160]. As previously stated, the method for confirming a case of COVID-19 using PCR tests is highly unreliable, so that un-tested person may be counted as a COVID-19 case in error.

The PCR test's inaccuracies imply that the criteria for reopening do not reflect the risk of community spread of the virus because a "high case count" or positivity rate may be due instead to functional false positive outcomes (that is, people who test positive for the virus at a high cycle threshold, but who are not infectious). Given this scientific evidence, it is certain that lockdowns are being imposed – along with their attendant costs– even when the risk of community spread of COVID-19 does not warrant it.

In summary, the scientific literature establishes the importance of cycle time thresholds in interpreting RT-PCR SARS-CoV-2 results to establish the infectivity of the samples;[161] A reliance on a test that is run up to 40 cycles, (or any number of cycles higher than 30) — is certain to produce a very large proportion of false positive outcomes. Lockdowns that are imposed on the basis of "case" counts derived from PCR tests will be only marginally related to the threat posed by the spread of the SARS-CoV-2 virus.

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[160] This is also an issue with classification of deaths in Canada – "Statistics Canada and provincial and territorial vital statistics agencies use two codes to identify COVID-19 reported as a cause of death: U071 for COVID-19 specified as confirmed by a positive test result and U072 for COVID-19 described as "possible," "probable," or "pending a (positive) test result". The total number of deaths due to COVID-19 is determined by adding counts in these two categories. The former also includes those deaths where the certificate makes no specification as "positive", "possible," "probable," or "pending". In Canada, the majority of COVID-19 deaths were classified as U071 (86%)." See: Kathy O'Brien, et. al., "Covid-19 Death Co-Morbidities in Canada" Statistics Canada, November 16, 2020, https://www150.statcan.gc.ca/n1/pub/45-28-0001/2020001/article/00087-eng.htm

[161] Rita Jaafar, Sarah Aherfi, Nathalie Wurtz, Clio Grimaldier, Thuan Van Hoang, Philippe Colson, Didier Raoult, Bernard La Scola, "Correlation Between 3790 Quantitative Polymerase Chain Reaction–Positives Samples and Positive Cell Cultures, Including 1941 Severe Acute Respiratory Syndrome Coronavirus 2 Isolates", Clinical Infectious Diseases, ciaa1491, https://doi.org/10.1093/cid/ciaa1491