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Review of scientific reports of harms caused by face masks, up to February 2021

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Summary

It is a testimony to the power of propaganda, institutional capture, and the desire to socially conform that masking of the general population has successfully been imposed during the COVID-19 era. The harms from this imposition are palpable, and potentially long-term and gargantuan, not the least of which is the psychological training of the public to comply with an absurd measure that has direct personal negative impact. I review the mounting evidence of the obvious: Universal masking harms people and society, without any detectable benefit.

Introduction: Government's onus to evaluate safety

Following the precautionary principle, government has the onus to demonstrate absence of significant anticipated harm, prior to imposing a measure, especially with a personal medical measure applied to the general healthy population.

The precautionary principle was not followed for masks in the COVID-19 pandemic. The general masking implementations in Canadian provinces were even more aggressive than the qualified recommendations of the WHO [1].

This reckless government overreach has not been missed in recent scientific commentary. A few examples are as follows.

- As early as 20 April 2020, Lazzarino et al. directly opposed a logical perversion of the precautionary principle which has been applied by some scientists and many lawmakers (i.e., that governments should act “without definitive evidence, just in case”):

“[W]hile no single formulation of that principle has been universally adopted, (ref) the precautionary principle aims at preventing researchers and policy makers from neglecting potentially-harmful side effects of interventions. [...]

Most scientific articles and guidelines in the context of the covid-19 pandemic highlight two potential side effects of wearing surgical face

masks in the public [false sense of security, inappropriate use of face mask], but we believe that there are other ones that are worth considering before any global public health policy is implemented involving billions of people. [...]

[...] It is necessary to quantify the complex interactions that may well be operating between positive and negative effects of wearing surgical masks at population level. It is not time to act without evidence.”

[2] 2020--Lazzarino : "Rapid Response: **Covid-19: important potential side effects of wearing face masks that we should bear in mind**".

Antonio Lazzarino, A Steptoe, M Hamer, S Michie. 20 April 2020. *BMJ*. --
-- <https://www.bmj.com/content/369/bmj.m1435/rr-40>

- On 13 August 2020, the surgeons Frountzas et al. warned that COVID-19 enthusiasm for imposing personal protective equipment (PPE) on surgeons could put surgery patients at risk (the equivalent can be said of train, tram, and bus drivers, and a large sector of workers servicing the public):

“Either in the case of a second lockdown or not, the safety of PPE use against COVID-19 for surgeons should be investigated. All parts of PPE increase surgeon's body temperature and sweating, leading to an impairment of surgeon's comfort, especially during prolonged and complicated surgical procedures. As mentioned above, PPE seems to be associated with important side effects, like dermatoses and headaches for healthcare workers. The PPE-associated discomfort and side effects during surgery may increase surgeons' anxiety and fatigue while performing difficult operations.”

[3] 2020--Frountzas : M. Frountzas, C. Nikolaou, D. Schizas et al., **“Personal protective equipment against COVID-19: Vital for surgeons, harmful for patients?”**, *The American Journal of Surgery*. 13 August 2020. <https://doi.org/10.1016/j.amjsurg.2020.09.014>

- By 22 November 2020, Dr. Vainshelboim was unambiguous:

“*Abstract*: ... Although, scientific evidence supporting facemasks' efficacy is lacking, adverse physiological, psychological and health effects are established. It has been hypothesized that facemasks have compromised safety and efficacy profile and should be avoided from use. The current article comprehensively summarizes scientific evidences with respect to wearing facemasks in the COVID-19 era. ...

Long-Term health consequences of wearing facemasks: Long-term practice of wearing facemasks has strong potential for devastating health consequences. Prolonged hypoxic-hypercapnic state compromises normal physiological and psychological balance, deteriorating health and promotes the developing and progression of existing chronic diseases (10 refs).

Conclusion: ... Wearing facemasks has been demonstrated to have substantial adverse physiological and psychological effects. These include hypoxia, hypercapnia, shortness of breath, increased acidity and toxicity, activation of fear and stress response, rise in stress hormones, immunosuppression, fatigue, headaches, decline in cognitive performance, predisposition for viral and infectious illnesses, chronic stress, anxiety and depression. Long-term consequences of wearing facemask can cause health deterioration, developing and progression of chronic diseases and premature death."

[4] 2021--Vainshelboim : Vainshelboim B. "**Facemasks in the COVID-19 era: A health hypothesis**". *Medical Hypotheses*. 2021;146:110411. doi:10.1016/j.mehy.2020.110411 ----
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7680614/>

Indeed, harms from prolonged masking are increasingly being documented in many scientific studies, especially in the areas of healthcare workers, school children, newborn infants, and bacterial infections in the general population, as described below.

Context: Risk-benefit-harm analysis

In a broad policy perspective, three questions are relevant:

- What is the risk from COVID-19?
- Is there any evidence that face masks can reduce the risk from COVID-19?
- Do face masks cause harm?

Regarding the first question (What is the risk from COVID-19?), at this stage, almost a full calendar year since the pandemic was declared by the WHO on 11 March 2020, one

has an upper limit on the risk of dying from COVID-19 (“per year”), based on global statistics:

Risk = number of deaths in a full yearly spread of the pandemic / population

Risk < 2.43 M / 7.8 B = **0.03 %** (current WHO statistics, February 2021)

The thus calculated worldwide risk per year (0.03 %) is an overestimated upper bound because the deaths reported to the WHO by nation states are deaths “with” COVID-19, not deaths determined to be “caused by” COVID-19, and because the recommended RT-PCR test is not reliable, and because attribution of COVID-19 can be based on reported symptoms alone, without laboratory viral identification, in a global context of high likelihood of reporting bias.

More importantly, the thus calculated overestimated upper-bound risk (0.03 %) is further overestimated because it does not take into account the large and known age-dependent susceptibility for death from COVID-19. An age-susceptibility-corrected upper-bound risk can be estimated as follows. (The correction is needed because a COVID-19 death does not cause as many lost years lived as an average death from a cause that does not discriminate by age.)

- Global average age = 29.6 years
- Global life expectancy at birth = 71.5 years
- Global population = 7.8 B
- Global life-year pool = (7.8 B) x (71.5 - 29.6 years) = 327 B life-years
- Average loss of life years per COVID-19 death = 0.5 to 5 years, say 2.75 years
- Global loss of life-years from COVID-19 per year = (2.43 M per year) x (2.75 years) = 6.68 M life-years per year (of COVID-19 pandemic)
- Adjusted Risk < 6.68 M / 327 B = **0.002 %**

The unadjusted overestimated upper-bound global risk per year of dying from COVID-19 (0.03 %) is five times less than the risk per year of dying from cancer in Canada. The age-susceptibility-corrected (lost-life-years-adjusted) overestimated upper-bound risk per year from COVID-19 (0.002 %) is five times less than the risk per year of dying from a car accident in the USA.

Regarding the second question (Is there any evidence that face masks can reduce the risk from COVID-19?), as per [5] [6] [7]:

- The only way to scientifically measure the efficacy of masks is using a randomized controlled trial (RCT) with “verified outcome” (laboratory confirmed infection) because: (a) the efficacy is small compared to other known and unknown factors, (b) the person to person variations of infectiousness and susceptibility are known to be large compared to the averages, and (c) there is a high potential for bias in data collection/selection and in interpretation, in any substandard study.
- There have been no less than 15 policy-grade RCTs with verified outcome, in health care, community, and general-population settings. All but the most recent one have been analyzed in published formal systematic reviews. All 15 studies find that no reduction in risk of being infected can be detected with statistical significance. This means that any benefit is too small to be detected by science.
- The government claims that masks work are in effect disingenuous propaganda, improperly relying on substandard and irrelevant studies (Exhibit-54).
- Therefore, the presumption that masks work is incorrect. It is disproved by science: Any risk reduction is too small to be detected using usual and established statistical criteria.

There is no reliable or policy-grade evidence that face masks can reduce the risk from COVID-19.

Regarding the third question (Do face masks cause harm?), as indicated above, there is presently a surge of scientific reports about harm caused by face masks, which I describe below.

There is no doubt that prolonged mask wearing causes significant harm and disability to healthy individuals. Recent studies have focussed on:

- healthcare workers
- school children
- newborn infants
- healthy adults

The early review (19 June 2020) of Bakhit et al. was for harms from face masks in any setting (home, workplace, etc.). They screened 5471 potential articles and identified 37 studies that reliably reported harms from masks. These 37 studies were published as early as 2004, and included two studies published in 2020. In these 37 studies (their Table 1): 20 reported “discomfort and irritation”; 4 reported “dyspnoea & other”; 6 reported “psychological impacts”; 9 reported “communication impacts”; and “mask contamination” was reported in one study. Bakhit et al.’s Conclusion (in Abstract) was:

“There are insufficient data to quantify all of the adverse effects that might reduce the acceptability, adherence, and effectiveness of face masks. New research on facemasks should assess and report the harms and downsides. Urgent research is also needed on methods and designs to mitigate the downsides of facemask wearing, particularly the assessment of alternatives such as face shields.”

[8] 2020--Bakhit : **“Downsides of face masks and possible mitigation strategies: a systematic review and meta-analysis”**. Mina Bakhit, Natalia Krzyzaniak, Anna Mae Scott, Justin Clark, Paul Glasziou, Chris Del Mar. *medRxiv* 2020.06.16.20133207; doi: <https://doi.org/10.1101/2020.06.16.20133207>. Now accepted for publication in *BMJ Open*. ----
<https://www.medrxiv.org/content/10.1101/2020.06.16.20133207v1>

Healthcare workers (HCWs)

Not eight months later, following the Bakhit et al. review, Galanis et al. (5 February 2021, preprint) published a systematic review and meta-analysis to “assess the impact of PPE use on HCWs’ physical health during the COVID19 pandemic”. Their “review included 14 studies with 11746 HCWs from 16 counties”:

[9] 2021--Galanis : Galanis P, Vraka I, Fragkou D, Bilali A, Kaitelidou D. **“Impact of personal protective equipment use on health care workers’ physical health during the COVID-19 pandemic: a systematic review and meta-analysis”**. *medRxiv*, 2021. DOI: 10.1101/2021.02.03.21251056. ----
<https://www.medrxiv.org/content/medrxiv/early/2021/02/05/2021.02.03.21251056.full.pdf>

Nine prominent recent studies focussed on healthcare workers (HCWs) are as follows:

→ *“Results (Abstract):* A total of 343 healthcare professionals on the COVID-19 front lines participated in this study [New York City]. 314 respondents reported adverse effects from prolonged mask use with headaches being the most common complaint (n = 245). Skin breakdown was experienced by 175 respondents, and acne was reported in 182 respondents.

Impaired cognition was reported in 81 respondents. ... Some respondents experienced resolved side effects once masks were removed, while others required physical or medical intervention.

Conclusion (Abstract): Prolonged use of N95 and surgical masks by healthcare professionals during COVID-19 has caused adverse effects such as headaches, rash, acne, skin breakdown, and impaired cognition in the majority of those surveyed. ...”

[10] 2020--Rosner : Elisheva Rosner E (2020) “**Adverse Effects of Prolonged Mask Use among Healthcare Professionals during COVID-19**”. *Journal of Infectious Disease and Epidemiology* 6:130. doi.org/10.23937/2474-3658/1510130 ----
<https://clinmedjournals.org/articles/jide/journal-of-infectious-diseases-and-epidemiology-jide-6-130.php>

→ “*Abstract:* ... All participants wore either surgical masks or N95 respirators for a minimum of 4 h per day [India]. ... A total of 250 healthcare workers participated in the study ... The acquired results were excessive sweating around the mouth accounting to 67.6%, difficulty in breathing on exertion 58.2%, acne 56.0% and itchy nose 52.0%. This study suggests that prolonged use of facemasks induces difficulty in breathing on exertion and excessive sweating around the mouth to the healthcare workers which results in poorer adherence and increased risk of susceptibility to infection.”

[11] 2021--Purushothaman : Purushothaman, P.K., Priyanga, E. & Vaidhyswaran, R. “**Effects of Prolonged Use of Facemask on Healthcare Workers in Tertiary Care Hospital During COVID-19 Pandemic**”. *Indian J Otolaryngol Head Neck Surg* 73, 59–65 (2021).
<https://doi.org/10.1007/s12070-020-02124-0>

→ “*Results (Abstract):* A total of 158 healthcare workers participated in the study [Singapore]. ... Out of 158 respondents, 128 (81.0%) respondents developed de novo PPE-associated headaches. A pre-existing primary headache diagnosis (OR = 4.20, 95% CI 1.48-15.40; P = .030) and combined PPE usage for >4 hours per day (OR 3.91, 95% CI 1.35-11.31; P = .012) were independently associated with de novo PPE-associated headaches. Since COVID-19 outbreak, 42/46 (91.3%) of respondents with pre-existing headache diagnosis either "agreed" or "strongly agreed" that the increased PPE usage had affected the control of their background headaches, which affected their level of work performance.

Conclusion (Abstract): Most healthcare workers develop de novo PPE-associated headaches or exacerbation of their pre-existing headache disorders.”

[12] 2020--Ong : Ong JJY, Bharatendu C, Goh Y, Tang JZY, Sooi KWX, Tan YL, Tan BYQ, Teoh HL, Ong ST, Allen DM, Sharma VK. “**Headaches Associated With Personal Protective**

Equipment - A Cross-Sectional Study Among Frontline Healthcare Workers During COVID-19". *Headache: The Journal of Head and Face Pain*. 2020 May;60(5):864-877. doi: 10.1111/head.13811. Epub 2020 Apr 12. PMID: 32232837. ----
<https://pubmed.ncbi.nlm.nih.gov/32232837/>

[13] 2020--Magnavita (critique of Ong, 2020): Magnavita, N. and Chirico, F. (2020), **"Headaches, Personal Protective Equipment, and Psychosocial Factors Associated With COVID-19 Pandemic"**. *Headache: The Journal of Head and Face Pain*, 60: 1444-1445. <https://doi.org/10.1111/head.13882>

[14] 2020--Goh (response to critique of Ong, 2020): Goh Y, Ong JJY, Bharatendu C, Tan BYQ, Sharma VK. **"Headaches Due to Personal Protective Equipment During COVID-19 Pandemic: A Comment"**. *Headache: The Journal of Head and Face Pain*. 2020;60(7):1446-1447. doi:10.1111/head.13879 ---- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7323331/>

→ *"Results (Abstract):* A total of 400 healthcare providers completed the questionnaire, 383 of them met the inclusion criteria [Italy]. The majority were doctors, with a mean age of 33.4 ± 9.2 years old. Among 166/383 subjects, who were headache free at baseline, 44 (26.5%) developed de novo headache. Furthermore, 217/383 reported a previous diagnosis of primary headache disorder: 137 were affected by migraine and 80 had tension-type headache. A proportion (31.3%) of these primary headache sufferers experienced worsening of their pre-existing headache disorder, mainly for migraine frequency and attack mean duration.

Conclusions (Abstract): Our data showed the appearance of de novo associated facemask headache in previous headache-free subjects and an exacerbation of pre-existing primary headache disorders, mostly experienced by people with migraine disease."

[15] 2021--Rapisarda : Rapisarda, L., Trimboli, M., Fortunato, F. et al. **"Facemask headache: a new nosographic entity among healthcare providers in COVID-19 era"**. *Neurological Sciences* (2021). <https://doi.org/10.1007/s10072-021-05075-8>

→ *"Conclusion (Abstract):* (A total of 155 healthcare workers responded to the questionnaire [Morocco].) The increased use of PPE, especially high filtrating masks during the COVID-19 outbreak is responsible for generating headaches in healthcare workers on frontline (62%) either De novo (33%) or as an aggravation of pre-existing one (29%). Working conditions have the greater impact on generating these types of headaches more than any pre-existing comorbidity. ..."

[16] 2020--Hajjij : Hajjij A, Aasfara J, Khalis M, et al. **"Personal Protective Equipment and Headaches: Cross-Sectional Study Among Moroccan Healthcare Workers During COVID-**

19 Pandemic". *Cureus*. 2020 Dec;12(12):e12047. DOI: 10.7759/cureus.12047. ----
<https://europepmc.org/article/med/33447477>

→ *Results (Abstract)*: (315 participants, Turkey) ... New-onset symptom rate was 66% (n=208). The most common new-onset symptom was headache (n=115, 36.5%) followed by breathing difficulty-palpitation (n=79, 25.1%) and dermatitis (n=64, 20.3%). Extended use of PPE, smoking, and overweight were independently associated with developing new-onset symptoms. A clear majority of symptomatic participants pointed out impact on working performance (193/208, 92.7%).

[17] 2020-- Çağlar : Çağlar, A., Kaçer, İ, Hacimustafaoğlu, M., Öztürk, B., & Öztürk, K. (2020). **"Symptoms associated with personal protective equipment among frontline healthcare professionals during the COVID-19 pandemic"**. *Disaster Medicine and Public Health Preparedness*, 1-15. doi:10.1017/dmp.2020.455 ----
<https://www.cambridge.org/core/journals/disaster-medicine-and-public-health-preparedness/article/symptoms-associated-with-personal-protective-equipment-among-frontline-healthcare-professionals-during-the-covid19-pandemic/FD3DF0B1437D8E4C9C577D09A2295C68>

→ *"Results (Abstract)*: The subjects are n=306, 244 women (79.7%), with an average age of 43 years (range 23–65) [Spain]. Of the total, 129 (42.2%) were physicians, 112 (36.6%) nurses and 65 (21.2%) other health workers. 208 (79.7%) used surgical masks and 53 (20.3%) used filter masks. Of all those surveyed, 158 (51.6%) presented 'de novo' headache. The occurrence of a headache was independently associated with the use of a filter mask, OR 2.14 (95% CI 1.07 to 4.32); being a nurse, OR 2.09 (95% CI 1.18 to 3.72) or another health worker, OR 6.94 (95% CI 3.01 to 16.04); or having a history of asthma, OR 0.29 (95% CI 0.09 to 0.89). According to the type of mask used, there were differences in headache intensity, and the impact of a headache in the subjects who used a filter mask was worse in all the aspects evaluated.

Conclusion (Abstract): The appearance of 'de novo' headache is associated with the use of filter masks and is more frequent in certain healthcare workers, causing a greater occupational, family, personal and social impact."

[18] 2020--Ramirez-Moreno : Ramirez-Moreno JM, Ceberino D, Gonzalez Plata A, et al. **"Mask-associated 'de novo' headache in healthcare workers during the COVID-19 pandemic"**. *Occupational and Environmental Medicine*. Published Online First: 30 December 2020. doi: 10.1136/oemed-2020-106956 ---- <https://oem.bmj.com/content/early/2020/12/29/oemed-2020-106956>

→ “*Results*: ... Out of 241 [Pakistan], 68 participants (28.2%) reported de novo headaches since the start of the pandemic, with majority describing the headache as bilateral in location (n = 47, 69%), with pressure/heaviness in quality (n = 31, 45.5%) and moderate in intensity (n = 45, 66%). ... Out of the 68 participants with new-onset headaches, 16 (23.5%) stated that the headache started more than 2 hours after donning PPE, while 19 (27.9%) participants stated that the headache ended between 1-2 hours after doffing of PPE. Fifty-three respondents (77.9%) experienced the headaches for 4 or less days per month. ...”

[19] 2020--Zaheer : Rumeesha Zaheer, Maheen Khan, Ahmed Tanveer, Amal Farooq, Zohaib Khurshid. “**Association of Personal Protective Equipment with De Novo Headaches In Frontline Healthcare Workers during COVID-19 Pandemic: A Cross-Sectional Study**”. *European Journal of Dentistry*. 2020 Dec;14(S 01):S79-S85. doi: 10.1055/s-0040-1721904. Epub 2020 Dec 26. PMID: 33368069; PMCID: PMC7775222. ----
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7775222/>

→ “...Several dermatoses [skin defects or lesions on the skin] have been reported due to PPE, such as pressure injury, contact dermatitis, pressure urticaria [hives] and exacerbation of pre-existing skin diseases, including seborrheic dermatitis [scales] and acne.(2 refs) We report a preliminary data of HCW who experienced facial dermatoses due to the use of PPE. From 24 March 2020 to 16 April 2020, we came across with 43 patients comprising physicians, nurses and paramedical staff who involved (directly/indirectly) in managing patients of COVID-19 [India]. ... The most commonly noted dermatoses were irritant contact dermatitis (ICD; 39.5%) followed by friction dermatitis (25.5%). Goggles were the most common culprit agent among all PPE causing any one of the dermatoses (51.92%), followed by N95 masks (30.77%) and face shields (17.31%). Nasal bridge (63%) was the commonest anatomical site affected due to dermatoses followed by cheeks and chin (26%). However, there was a considerable overlap of different dermatoses with affliction of multiple sites. The most common symptom experienced by patients was pruritus [itchiness] (67.44%), while erythema [redness] (53.49%) was the most common sign observed. Interestingly, we observed two distinct dermatoses, i.e. whole face erythema (suffusion; 21%) attributed to doffing after a long shift and lip lick dermatitis due to constant licking of lips, because of feeling of intense thirst due to restricted fluid intake after donning PPE. The duration of wearing the goggles and mask, excessive sweating and ill-fitting masks, all were associated with increased sensation of irritation. Most of these dermatoses responded well to topical moisturizer, calamine lotion and oral antihistamines. Overall, 21% patients suffered from work absenteeism due to one of the dermatoses. Personal protective equipment-induced dermatoses occur mainly due to the occlusion and hyper-hydration effect of PPE and friction leading breach in the epidermal integrity.(ref) Recently, in China, authors noted a very high prevalence, i.e. 97% of skin damages in first-line HCW fighting COVID-19.(ref)”

[20] 2020--Singh : Singh, M., Pawar, M., Bothra, A., Maheshwari, A., Dubey, V., Tiwari, A. and Kelati, A. (2020), "**Personal protective equipment induced facial dermatoses in healthcare workers managing Coronavirus disease 2019**". *Journal of the European Academy of Dermatology and Venereology*, 34: e378-e380. <https://doi.org/10.1111/jdv.16628>

Physiological impacts of face masks in healthy adults

In addition to the large focus on healthcare workers, a significant body of recent studies is accumulating about the harms to infants and school children (described below). Also, studies about measured physiological impacts of face masks in healthy adults are beginning. In 2005, Li et al. reported on the temperature and humidity microclimates of face masks; and apparently the first physiological measurements on masked healthy adults were reported in 2020 by Fikenzler et al.:

→ "*Discussion (Abstract):* We discuss how N95 and surgical facemasks induce significantly different temperature and humidity in the microclimates of the facemasks, which have profound influences on heart rate and thermal stress and subjective perception of discomfort."

[21] 2005--Li : Li Y, Tokura H, Guo YP, et al. "**Effects of wearing N95 and surgical facemasks on heart rate, thermal stress and subjective sensations**". *Int Arch Occup Environ Health*. 2005;78(6):501-509. doi:10.1007/s00420-004-0584-4 ----
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7087880/>

→ "*Discussion:* This first randomized cross-over study assessing the effects of surgical masks and FFP2/N95 masks on cardiopulmonary exercise capacity yields clear results. Both masks have a marked negative impact on exercise parameters such as maximum power output (Pmax) and the maximum oxygen uptake (VO₂max/kg). FFP2/N95 masks show consistently more pronounced negative effects compared to surgical masks. Both masks significantly reduce pulmonary parameters at rest (FVC, FEV₁, PEF) and at maximum load (VE, BF, TV). ...

Pulmonary function: ... The data of this study are obtained in healthy young volunteers, the impairment is likely to be significantly greater, e.g., in patients with obstructive pulmonary diseases (ref). From our data, we conclude that wearing a medical face mask has a significant impact on pulmonary parameters both at rest and during maximal exercise in healthy adults.

Cardiac function: ... These data suggest a myocardial [relating to the muscular tissue of the heart] compensation for the pulmonary limitation in the healthy volunteers. In patients with impaired myocardial function, this compensation may not be possible.”

[22] 2020--Fikenzer : Fikenzer S, Uhe T, Lavall D, Rudolph U, Falz R, Busse M, Hepp P, Laufs U. “**Effects of surgical and FFP2/N95 face masks on cardiopulmonary exercise capacity**”. *Clin Res Cardiol.* 2020 Dec;109(12):1522-1530. doi: 10.1007/s00392-020-01704-y. Epub 2020 Jul 6. PMID: 32632523; PMCID: PMC7338098. - <https://link.springer.com/article/10.1007/s00392-020-01704-y>

Psychological harm in the general population

One research focus area that appears to be entirely lacking, in examining the harms of masks, is the broad psychological (and therefore social) impact of mandatory masking policies applied to the general population.

The current knowledge of the individual’s fundamental psychological needs that determine well-being is expressed in the modern theory known as “self-determination theory” (SDT), which is also the scientific basis for personal motivation:

“Self-Determination Theory (SDT) proposes that certain evolved psychological needs must be satisfied if individuals are to develop to their fullest potential, in the same way that plants require key nutrients to thrive (refs). SDT posits three universal needs: autonomy, competence, and relatedness. Autonomy involves the need to experience one’s behavior as freely chosen and volitional, rather than imposed by external forces. Competence involves the need to feel capable and effective in one’s actions. Relatedness involves the need for belonging, intimacy, and connectedness to others. SDT theorists view these needs as broad motivational tendencies that operate across life domains and contend that satisfaction of all three needs, not just one or two, is essential for well-being. Although the expression or means of satisfying these needs may vary across cultures, their satisfaction is viewed as essential for well-being in all cultures.” [highlights added]

[23] 2013--Church : Church AT, Katigbak MS, Locke KD, et al. “**Need Satisfaction and Well-Being: Testing Self-Determination Theory in Eight Cultures**”. *Journal of Cross-Cultural Psychology.* 2013;44(4):507-534. doi:10.1177/0022022112466590 ----

<https://www.webpages.uidaho.edu/klocke/publications/2013%20Church%20etal%20JCCP.pdf>

There can be little doubt that forced masking of the general population has a significant potential to deteriorate the three fundamental psychological needs of the individual: autonomy, competence, and relatedness. This harm to individuals and the societal implications have not been studied. The impact may be gargantuan.

Only infants and school children have so far been considered using the perspective of psychological and developmental impact (as described below).

The 11 August 2020 Commentary of Scheid et al. is not helpful, because it incorrectly disregards physiological impacts and examines psychology solely from the perspective of mask compliance [24]. (Scheid JL, Lupien SP, Ford GS, West SL. "Commentary: Physiological and Psychological Impact of Face Mask Usage during the COVID-19 Pandemic". *Int J Environ Res Public Health*. 2020 Sep 12;17(18):6655. doi: 10.3390/ijerph17186655. PMID: 32932652; PMCID: PMC7558090. ---- <https://pubmed.ncbi.nlm.nih.gov/32932652/>)

Infants and school children

When considering whether a world of masked adults and children, at a crucial period in a baby's or child's life, can have long-term detrimental psychological and development impact, I propose that the following hierarchical sequence of thought experiments is useful:

- Would babies and children entirely raised by mechanical robots be adversely affected?
- Would babies and children entirely raised by masked adults, and themselves forced to be masked beyond two years of age, be adversely affected?
- What periods, durations and circumstances of masking, distancing and shielding could have long-term psychological or developmental negative consequences?

Given the known large impact that government measures have had on school children worldwide (see below), it should be of concern to us all that apparently the first scientific

analysis to consider risk-benefit analysis for school children was published as late as August 2020. On 6 August 2020, Spitzer submitted several central propositions:

→ “*Abstract*: ... covering the lower half of the face reduces the ability to communicate, interpret, and mimic the expressions of those with whom we interact. Positive emotions become less recognizable, and negative emotions are amplified. Emotional mimicry, contagion, and emotionality in general are reduced and (thereby) bonding between teachers and learners, group cohesion, and learning – of which emotions are a major driver.

1. *Introduction*: ... along with other measures of physical distancing and economic lockdowns, school closures were implemented during March 2020 affecting more than 1.5 billion students (children and adolescents) around the globe (ref). These closures of schools lasted for a few weeks only (as in Denmark) up to several months (in Italy and many other countries; (ref)) and led to marked decreases in educational gains (ref), hunger (because school meals were no longer served), increases in child abuse (because children were no longer observed by school staff), and, in general, the risk of “scarring the life chances of a generation of young people”(ref) (because of the long-term psychological, physiological, educational and even economic burden (ref), that societies put on their most vulnerable members; (ref))...

- ... wearing masks may have physical side effects.
- Face masks impair face recognition and face identification.
- Face masks impair verbal and non-verbal communication.
- Face masks block emotional signaling between teacher and learner.

Given these pros and cons, it is not clear whether face masks should play a major role in educational settings in times of the current viral pandemic. ... This matter should be discussed urgently, since it globally affects more than 1.5 billion students, teachers, and school staff directly, and, in addition, their families indirectly.

6. *Face masks block emotional signaling between teachers and students*: ... In sum, recognition of, and response to, the outward emotional displays of one's peers' faces is a critical and necessary component of social interaction in schools. It helps pupils and teachers to modify their behavior in order to align with social communication and behavioral norms. When these emotional displays are inhibited by face masks, our ability to communicate effectively with one another is reduced and we are primarily left with mimicking negative (frown) emotions. All of this happens primarily outside of conscious awareness, and hence, is hard to be consciously controlled or even corrected. Since emotions are a major driver of group cohesion, the decreased emotionality, and decreased positive emotionality in particular, may interfere with smooth classroom action. Given the fact that the very process of learning is facilitated by emotions (this is their main *raison d'être*), face masks are likely to cause some interference with pedagogy.” [highlights are added]

[25] 2020--Spitzer : Spitzer M. “**Masked education? The benefits and burdens of wearing face masks in schools during the current Corona pandemic**”. *Trends in Neuroscience and*

Education. 2020;20:100138. doi:10.1016/j.tine.2020.100138 ----
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7417296/>

Still later, two studies pointed out the likelihood that babies are significantly harmed by general masking practices. Especially, the 22 September 2020 study of Green et al. alerted us to “potential negative effects of masks on long-term development related to human connection and attachment”:

→ “*Abstract*: ... COVID-19 has changed the way that newborn babies are cared for within the neonatal setting due to the introduction of social distancing and wearing of face masks to limit the spread of the infection. Potential implications exist related to the normal development of bonding and connections with others. This paper discusses the importance of face to face interactions for early attachment between babies and parents within the context of relevant underpinning developmental theory. ...”

[26] 2021--Green : Green, Janet et al. **“The implications of face masks for babies and families during the COVID-19 pandemic: A discussion paper”**. *Journal of neonatal nursing* : JNN vol. 27,1 (2021): 21-25. doi:10.1016/j.jnn.2020.10.005 -
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7598570/>

Likewise, on 11 February 2021, Lewkowicz pointed out the following about language acquisition by babies:

→ “...the COVID pandemic has laid bare our fundamental need to see whole faces. Could it be that babies and young children, who must learn the meaning of the myriad communicative signals normally available in their social partners’ faces, are especially vulnerable to their degradation in partially visible faces? ... in my lab ... We discovered that babies begin lip-reading at around 8 months of age. ... Crucially, once lip-reading emerges in infancy, it becomes the default mode of speech processing whenever comprehension is difficult. ...

Overall, the research to date demonstrates that the visible articulations that babies normally see when others are talking play a key role in their acquisition of communication skills. Research also shows that babies who lip-read more have better language skills when they’re older. If so, this suggests that masks probably hinder babies’ acquisition of speech and language.”

[27] 2021--Lewkowicz : **“Masks Can Be Detrimental to Babies' Speech and Language Development”**. David J. Lewkowicz. *Scientific American*. Cognition, Opinion. 11 February 2021. -

--- <https://www.scientificamerican.com/article/masks-can-be-detrimental-to-babies-speech-and-language-development/>

On 20 August 2020, Karvounides et al. submitted that mask wearing is a potential trigger for youth with chronic migraine:

→ “Many common triggers such as dehydration, fasting, sleep problems, and stressors were discussed above. Here we highlight [computer] screen use and mask wearing as potential additional school-related triggers. ... Pressure created by the mask or its straps against various contact points on the face or scalp could trigger headache”

[28] 2021--Karvounides : Karvounides, D., Marzouk, M., Ross, A.C., VanderPluym, J.H., Pettet, C., Ladak, A., Ziplow, J., Patterson Gentile, C., Turner, S., Anto, M., Barmherzig, R., Chadehumbe, M., Kalkbrenner, J., Malavolta, C.P., Clementi, M.A., Gerson, T. and Szperka, C.L. (2021), “**The intersection of COVID-19, school, and headaches: Problems and solutions**”. *Headache: The Journal of Head and Face Pain*, 61: 190-201. <https://doi.org/10.1111/head.14038>

The idea of a mask is to breathe through the material and not have large gaps. This implies fastening bands and a tight fit, which implies pressure on the head, ears, nose, and face. The pressure points, in turn cause discomfort, at the very least, which is aggravated by lengthy duration and micro-environmental, psychological and physiological effects. Removing the pressure or the mouth and nose coverage defeats the purpose of the mask, in the belief that masks work to prevent transmission of the virus. And there are always unforeseen negative effects, such as causing permanent ear protrusion:

→ “Abstract: ... Among those on the market, surgical masks with elastic loops are the ones most chosen by parents for their children. These elastics cause constant compression on the skin and, consequently, on the cartilage of the auricle, leading to erythematous and painful lesions of the retroauricular skin when the masks are used for many hours a day. Pre-adolescent children have undeveloped auricular cartilage with less resistance to deformation; prolonged pressure from the elastic loops of the mask at the hollow or, even worse, at the anthelix level can influence the correct growth and angulation of the outer ear. In fact, unlike when using conservative methods for the treatment of protruding ears, this prolonged pressure can increase the cephaloauricular angle of the outer auricle. It is important for the authorities

supplying the masks to be aware of this potential risk and for alternative solutions to be found ...”

[29] 2020--Zanotti : Zanotti, B., Parodi, P.C., Riccio, M. et al. “**Can the Elastic of Surgical Face Masks Stimulate Ear Protrusion in Children?**”. *Aesth Plast Surg* 44, 1947–1950 (2020). <https://doi.org/10.1007/s00266-020-01833-9> - <https://link.springer.com/article/10.1007/s00266-020-01833-9>

Most importantly, however, whereas most professional public health agents and health researchers have been loath to embark on objective risk-benefit analysis, parents in Germany have answered a recent research-group’s call to provide observations regarding masks on children. On 18 December 2020, Schwarz et al. reported striking results. Here is the full (v2) abstract of their preprint:

→ “*ABSTRACT*

Background: Narratives about complaints in children and adolescents caused by wearing a mask are accumulating. There is, to date, no registry for side effects of masks.

Methods: At the University of Witten/Herdecke an online registry has been set up where parents, doctors, pedagogues and others can enter their observations. On 20.10.2020, 363 doctors were asked to make entries and to make parents and teachers aware of the registry.

Results: By 26.10.2020 the registry had been used by 20,353 people. In this publication we report the results from the parents, who entered data on a total of 25,930 children. The average wearing time of the mask was 270 minutes per day. Impairments caused by wearing the mask were reported by 68% of the parents. These included irritability (60%), headache (53%), difficulty concentrating (50%), less happiness (49%), reluctance to go to school/kindergarten (44%), malaise (42%) impaired learning (38%) and drowsiness or fatigue (37%).

Discussion: This world's first registry for recording the effects of wearing masks in children is dedicated to a new research question. Bias with respect to preferential documentation of children who are particularly severely affected or who are fundamentally critical of protective measures cannot be dismissed. The frequency of the registry’s use and the spectrum of symptoms registryed indicate the importance of the topic and call for representative surveys, randomized controlled trials with various masks and a renewed risk-benefit assessment for the vulnerable group of children: adults need to collectively reflect the circumstances under which they would be willing to take a residual risk upon themselves in favor of enabling children to have a higher quality of life without having to wear a mask.”

[30] 2021--Schwarz : Silke Schwarz, Ekkehart Jenetzky, Hanno Krafft, Tobias Maurer, David Martin. “**Corona children studies "Co-Ki": First results of a Germany-wide registry on mouth and nose covering (mask) in children**”. 18 December 2020. DOI: 10.21203/rs.3.rs-124394/v1 - <https://www.researchsquare.com/article/rs-124394/v1> ---- v2 (5 January 2021): <https://www.researchsquare.com/article/rs-124394/v2>

Microbial pathogen infections from masks

Finally, regarding potential mask harms, a notoriously understudied aspect is the potential population and individual health impacts of the development of bacterial and other pathogens on warm and humid cloth masks [1] [5] [7]. Matuschek et al. briefly reported it this way, without reference or demonstration:

→ “If masks are not exchanged regularly (or washed properly when made of cloth), pathogens can accumulate in the mask. When improperly used, the risk of spreading the pathogen—including SARS-CoV-2—might be critically increased.” (p. 5)

[31] 2020--Matuschek : Matuschek, C., Moll, F., Fangerau, H. et al. “**Face masks: benefits and risks during the COVID-19 crisis**”. *European Journal of Medical Research* 25, 32 (2020). <https://doi.org/10.1186/s40001-020-00430-5>

In November 2020, Borovoy et al. [32] published an extensive review of biological and medical knowledge that allowed them to infer a large potential for significant harms from masking, via microbial challenges from the masks. They rightly stress the known yet underplayed role of bacteria in viral pandemics, and also review respiratory diseases arising from oral bacteria, which can be induced by mask wearing to penetrate and infect the respiratory tract and lungs.

[32] 2020--Borovoy : Boris Borovoy, Colleen Huber, Maria Crisler. “**Masks, false safety and real dangers, Part 2: Microbial challenges from masks**”. *Primary Doctor Medical Journal*. November 2020. - <https://pdmj.org/>

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My competence to review science about COVID-19

I am retired and a former tenured Full Professor of Physics, University of Ottawa. Full Professor is the highest academic rank. During my 23-year career as a university professor, I developed new courses and taught over 2000 university students, at all levels, and in three different faculties (Science, Engineering, Arts). I supervised more than 80 junior research terms or degrees at all levels from post-doctoral fellow to graduate students to NSERC undergraduate researchers. I headed an internationally recognized interdisciplinary research laboratory, and attracted significant research funding for two decades.

I have been an invited plenary, keynote, or special session speaker at major scientific conferences some 40 times. I have published over 100 research papers in leading peer-reviewed scientific journals, in the areas of physics, chemistry, geology, bio-geochemistry, measurement science, soil science, and environmental science.

My scientific h-index impact factor is 40, and my articles have been cited more than 5,000 times in peer-reviewed scientific journals (profile at Google Scholar: <https://scholar.google.ca/citations?user=1ChsRsQAAAAJ>).

My personal knowledge and ability to evaluate the facts in this article are grounded in my education, research, training and experience, as follows:

- i. *Regarding environmental nanoparticles.* Viral respiratory diseases are transmitted by the smallest size-fraction of virion-laden aerosol particles, which are reactive environmental nanoparticles. Therefore, the chemical and physical stabilities and transport properties of these aerosol particles are the foundation of the dominant contagion mechanism through air. My extensive work on reactive environmental nanoparticles is internationally recognized, and includes: precipitation and growth, surface reactivity, agglomeration, surface charging, phase transformation, settling and sedimentation, and reactive dissolution. In addition, I have taught the relevant fluid dynamics (air is a compressible fluid), and gravitational settling

at the university level, and I have done industrial-application research on the technology of filtration (face masks are filters).

- ii. *Regarding molecular science, molecular dynamics, and surface complexation.* I am an expert in molecular structures, reactions, and dynamics, including molecular complexation to biotic and abiotic surfaces. These processes are the basis of viral attachment, antigen attachment, molecular replication, attachment to mask fibers, particle charging, loss and growth in aerosol particles, and all such phenomena involved in viral transmission and infection, and in protection measures. I taught quantum mechanics at the advanced university level for many years, which is the fundamental theory of atoms, molecules and substances; and in my published research I developed X-ray diffraction theory and methodology for characterizing small material particles.
- iii. *Regarding statistical analysis methods.* Statistical analysis of scientific studies, including robust error propagation analysis and robust estimates of bias, sets the limit of what reliably can be inferred from any observational study, including randomized controlled trials in medicine, and including field measurements during epidemics. I am an expert in error analysis and statistical analysis of complex data, at the research level in many areas of science. Statistical analysis methods are the basis of medical research.
- iv. *Regarding mathematical modelling.* Much of epidemiology is based on mathematical models of disease transmission and evolution in the population. I have research-level knowledge and experience with predictive and exploratory mathematical models and simulation methods. I have expert knowledge related to parameter uncertainties and parameter dependencies in such models. I have made extensive simulations of epidemiological dynamics, using standard compartmental models (SIR, MSIR) and new models.
- v. *Regarding measurement methods.* In science there are five main categories of measurement methods: (1) spectroscopy (including nuclear, electronic and vibrational spectroscopies), (2) imaging (including optical and electron microscopies, and resonance imaging), (3) diffraction (including X-ray and neutron diffractions, used to elaborate molecular, defect and magnetic structures), (4) transport measurements (including reaction rates, energy transfers, and conductivities), and (5) physical property measurements (including specific density, thermal capacities, stress response, material fatigue...). I have taught these measurement methods in an interdisciplinary graduate course that I developed and gave to graduate (M.Sc. and Ph.D.) students of physics, biology, chemistry, geology, and engineering for many years. I have made fundamental discoveries and advances in areas of spectroscopy, diffraction, magnetometry, and microscopy, which have been published in leading scientific journals and presented at international conferences. I know measurement science, the basis of all sciences, at the highest level.