Covid-19 population lockdowns may worsen socio-economic inequities disproportionately impacting racial minorities: Machine learning-augmented cost effectiveness and computational ethical analysis with personalist social contract

Los confinamientos de la población por el Covid-19 pueden empeorar las desigualdades socioeconómicas que impactan de forma desproporcionada en las minorías raciales: rentabilidad aumentada por aprendizaje automático y análisis ético computacional con contrato social personalista

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Abstract

The novel coronavirus disease of 2019 (Covid-19) produced by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a pandemic creating a growing global health crisis given its novelty, scope, and initially limited efficacious treatment options. Yet little is known about optimal non-pharmaceutical interventions to improve its morbidity and mortality, particularly their cost effectiveness and ethical aspects. This is thus the first known machine learning-augmented cost effectiveness and ethical analysis of Covid-19 containment measures (and of population quarantine measures in particular for any pandemic) to assist health systems and governments in ensuring the most clinically and cost-effective care that can be equitably provided to as many patients as possible during this pandemic and future similar global crises. This analysis utilized the methodology adopted by the Centers for Disease Control and Prevention (CDC), commonly accepted figures as inputs, and both extreme and real-world minimal assumptions to provide the most robust and reliable results possible. Cost analysis indicated that in the extreme or best-case scenarios for the Covid-19 containment measure of population quarantine, there is a cost-effectiveness ratio of $154.86 million spent per averted death and a net cost of $1.92 trillion globally. In real-world scenarios, this intervention has a ratio of $2.52 billion spent per averted death for a net cost of $1.99 trillion. Personalist social contract ethics as articulated by the United Nations' popular ethical system of rights and duties highlights the particular concerns that such lockdowns may be unethical injustices perpetuated by states in a manner that undermine individual lives and liberties while disproportionately negatively impacting lower income communities particularly racial minorities. This study thus suggests that the prevalent practice of population quarantine compared to standard precautions and more targeted interventions may provide inadequate net benefit for its financial and ethical cost. At a time of global shortages straining health system capacities to adequately detect and care for Covid-19 patients particularly in developing nations and underserved communities, this study supports focusing resources less on interventions with unclear benefit-cost trade-off and more on better affordable, ethical, and equitable interventions with greater evidence for their life-saving net benefits.

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Keywords: Covid-19, health equities, cost effectiveness, global bioethics, machine learning.

1. Introduction

The novel coronavirus disease of 2019 (Covid-19) produced by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a current pandemic with pronounced mortality in the elderly with comorbidities (1), Governments are responding with history's most aggressive population-wide quarantines with over 1 of every 3 people globally under mandatory quarantine as of April 17, 2020 (2). Yet this popular measure has questionable scientific effectiveness according to systematic review of the literature and expert consensus (conducted and facilitated by the RAND study commissioned by the United States Department of Health and Human Services under President Obama) for the biologically related pandemic influenza (3), nor does clinical evidence support its effectiveness for Covid-19 based on the recent study commissioned by the World Health Organization (WHO) (4). A commonly invoked rationale for government-mandated population quarantine is that this novel virus requires aggressive measures to save as many lives as possible without waiting for additional data to determine its comparative effectiveness relative to other measures.

Yet there is increasing concern in the peer-reviewed literature that this 'fire first and ask questions later' approach has insufficient theoretical and practical benefit to justify the known extreme costs of the economic collapse on populations and patients (5). With robust meta-analysis data demonstrating that poverty (accelerated by economic downturns) kills more people than clinical causes (including cardiovascular disease, cancer, and respiratory infections) (6) and with increasing reports that highlight shortages of ventilators and providers as well as personal protective equipment (PPE) needed to improve patient and healthcare workforce survival chances

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(7), we conducted the first known cost effectiveness, cost-benefit, and ethical analysis of Covid-19 measures (and of population quarantine measures for any pandemic) to assist health systems and governments helping ensuring the most clinically, cost-effective, and ethical care can be equitably provided to as many patients as possible during this pandemic and future similar global crises.

2. Methods

2.1. Cost effectiveness analysis

We performed this cost analysis utilizing the methodology adopted by the Centers for Disease Control and Prevention (CDC) (8), commonly accepted figures as inputs, and both extreme and real-world minimal assumptions to respectively estimate the upper limit (extreme model) and mean (real-world model) of the expected success of the intervention (population-wide quarantine) relative to standard precaution measures for viral infection prevention and control (hand hygiene, healthcare worker respiratory precautions, and quarantine of cases and close associates) (3, 4). The cost analysis was focused on the time frame of February 1st to April 16th of 2020 for the following traits of this index time period based on prior pandemics and the current: the highest infection fatality rate (IFR), the majority of population quarantines or lockdowns, and the associated primary economic costs (1, 9, 10, 11, 12). While the clinical and financial consequences will continue beyond this point, the data was most robust and uniform for the above time frame (1, 3, 9, 10).

2.1.1. Statistical and machine learning analysis

To confirm the above results, traditional statistical analysis was conducted using publicly available datasets from the World Bank (https://data.worldbank.org) on population, health expenditures,

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and income group (low, medium, and high) by nation in 2017 (with nation exclusion based on those with values missing for the above variables). Descriptive and multivariable analysis by income group was conducted (with one-way ANOVA for normal independent variables and Kruskal Wallis test for interval ordinal). The above analysis was augmented by machine learning to confirm adequately robust estimates using the same estimated variables created. The 43 supervised learning algorithms were utilized with 10-fold cross-validations selected based upon the data type. Performance among algorithms were assessed based on higher accuracy, lower root relative squared error (RRSE) with model acceptability set at 100% (for comparison among ML algorithms), and lower root mean squared error (RMSE, for comparison to traditional statistical models). The following algorithms by type were tested: Bayesian (Bayes Net, Naive Bayes, Naive Bayes Multinomial Text, and Naive Bayes Updateable), Functions (Logistic, Multilayer perceptron, SGD, SGD Text, Simple Logistic, SMO, and Voted Perceptron), Lazy (IBK, KStar, and LWL), Meta (AdaBoostM1, Attribute Selected Classifier, Bagging, Classification via Regression, CV Parameter Selection, Iterative Classifier Optimizer, Logit Boost, Multiclass Classifier, Multiclass Classifier Updateable, Multi-Scheme, Random Committee, Randomizable Filtered Classifier, Random Sub-Space, Stacking, Vote, and Weighted Instances Handler Wrapper), Miscellaneous (Input Mapped Classifier), Rules (Decision Table, JRip, OneR, Part, and ZeroR), and Trees (Decision Stump, Hoeffding Tree, J48, LMT, Random Forest, Random Tree, and REP Tree).

2.2. Health equity analysis

Equitable health outcomes were assessed based on publicly available official estimates pertaining to socioeconomic and racial groups as defined in the current Covid-19 literature to determine possible divergences in outcome not adequately explained by bio-

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logy and pathophysiology but potentially by modifiable sociocultural traits.

2.3. Ethical analysis

Ethical analysis with Artificial intelligence-driven Computational Ethics (AICE) was conducted by integrating the above quantitative analysis with the global bioethical framework of personalist social contract, a novel integration of Thomistic-Aristotelian personalism with the Kantian-based Rawlsian social contract as historically articulated in the 1948 *United Nations Declaration of Human Rights* (11) (UDHR) and formally defined by Monlezun 2020 (13-15). Personalist social contract was selected as the primary analytic framework for practical, political, and philosophical reasons. Practically, personalist social contract is the only known global bioethical model that facilitates convergence of diverse belief systems (including religiously unaffiliated, secular liberalism, Islam, Judaism, Christianity, Buddhism, Confucianism, and folk religions) which over 99% of the world's population identify) (16) thus providing a better representation than Kantian and related post-European Enlightenment birthing modern philosophy that largely excluded 84% of the world's population (13). Politically, the personalist social contract was chosen as it is the philosophical foundation and frame work of the world's most dominant ethical system –human rights and duties as articulated by the UDHR– that generated the subsequent body of international law and was assented by nearly every nation through the United Nations. According to the Lebanese Thomistic-Aristotelian philosopher and the UDHR's chief architect, Dr. Charles Malik, along with the French Thomistic personalist and UDHR chief philosopher who coordinated its philosophical underpinning, Jacques Maritain, and the UN Secretary General the year following the Declaration's ratification, Carlos Rómulo (17) Thomist-Aristotelian metaphysics and its derivative natural law serve as the foundation of the UDHR (13) (and even Enlightenment-

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inspired liberal democracies as the United States with its *Declaration of Independence*) which thus supports the philosophical frame of the social contract (later championed by its most prominent proponent, John Rawls) as the Enlightenment product arguing for pluralistic convergence of diverse belief systems through overlapping consensus of common principles that are thus commonly binding on each individual). Yet the modern social contract's rejection of a metaphysical foundation (i.e. that justice objectively exists and binds individuals to give to each what is due because of their common human nature) limits its ability to consistently recognize and protect the individuality of each person, especially if they identify with religiously affiliated belief systems (as the majority if the world's peoples) who are thus excluded from the social contract (13), leading to ethical systems intolerant to multicultural and pluralistic dialogue.

Philosophically, the personalist social contract was chosen for its Thomistic-Aristotelianism robust metaphysics that can form a durable philosophical foundation, while its recent exposition of personalist elements (as evidenced by the United Nations General Assembly 1995 Address by the former Polish philosopher, Karol Wojtyla) makes its classical system of thought subjectively more accessible for diverse belief systems (i.e. the common human experience that gives rise to subsidiarity and solidarity to build a family of nations not simply an administrative collaborative). And it is this metaphysics that in particular provides the legal system of natural law (as each person's human nature allows it to be directly knowable as a universal imperative to do good and avoid evil) underpinning and uniting diverse belief systems while articulating commonly held principles such as human dignity and resultant individual rights and societal duty to respect those rights for every person due to her/his common human nature. The personalist social contract thus is a middle point or bridge between the post-Enlightenment liberal social contract (that lacks a robust metaphysics and thus recognition and defense of the individuality, dignity, and

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thus rights of each unique person by rather mischaracterizing individuals predominantly as replicable autonomous wills bound by artificial social rules limiting negative impacts of individual self-orientated behavior) and classical personal communion (in the Aristotelian tradition flowing from a metaphysical foundation uniting diverse religiously affiliated and unaffiliated belief systems by accounting for the individuality of each person as a member of a global human community that is a family which can understand each individual as an embodied soul or form-animating matter binding each in organic social relationships guarding the good of each person in reciprocal inter-dependency facilitating positive other-orientated behavior).

Given the widespread modern breakdown of constructive ethical debate within and among diverse belief systems (with such Rawlsian claims as incommensurability) given the abandonment in general of natural law or any otherwise potentially logically compelling and politically popular system, the ethical analysis provided here will feature an explicit definition of terms (including explicit metaphysical presumption), argument structure (in the forms of premises and conclusions), and reliance on Aristotelian formal logic. This logical structure is utilized given Aristotle's historic creation of this sub-philosophical discipline defining minimum requirements for a valid or good argument (in contrast to a logical fallacy invalidating an argument as otherwise valid or logically binding the reader to the conclusions arrived at from sound premises building stepwise to the conclusion), its profound influence on philosophy, the absence of any significant comparable competitor to it, and its endorsement by Immanuel Kant as one of the most widely recognized chief defenders of modern philosophy (defined here as principally Western post-Enlightenment philosophy due to the largely continuous and rich development of Eastern philosophy from its antiquity and classical periods, and the Western modern philosophies following the skepticism and nihilism championed by

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Nietzsche and Sartre) given their devolving into foundational metaphysical contradictions (i.e. in a circular logical fallacy metaphysically asserting there is no metaphysics or known that is knowable) and thus failing to produce overarching subsequent comprehensive and consistent philosophical systems (18).

3. Results

3.1. Cost effectiveness analysis

The extreme model inputs include the global cost of the above intervention in the interval time period set at $2 trillion based on the lower estimated limit by The United Nation's Trade and Development Agency relative to additional estimates (with economic production cut as workers were quarantined –with up to 0.03% total of the global population– during the above time frame becoming infected at the upper estimate limit with the large majority suffering mild transient symptoms) (1, 5, 19, 20). The upper limit of the intervention's success was set at 70% mortality reduction through transmission reduction and subsequent improved health system capacities to care for critically sick COVID-19 patients. The cost averted was set at $51.33 testing per person for 70% of the world's population based on the upper cost limit (in which cases are identified and standard precautions applied and medical care provided for them [with care being similarly provided in the intervention]) (1, 3, 21). The intervention benefit was calculated as the product of the upper estimate of the US federal government's value of a statistical human life ($7.4 million as the upper average limit among global statistical values), the Covid-19 IFR of 0.68% (based on the latest multi-state meta-analysis of published estimates for the interval time), its total cases, and the above mortality reduction (1, 19, 22, 23). The real-world model global inputs were based on similar pandemics and current Covid-19 trends: 0.04% tested,

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0.03% infected, 5% mortality reduced with the intervention, and 90% test costs covered by governments (1, 3-5, 9, 10, 23).

Cost analysis indicated that in the extreme or best-case scenarios for the Covid-19 containment measure of population quarantine or lockdown, there is a cost-effectiveness ratio of $154.86 million spent per averted death and a net cost of $1.92 trillion globally. In real-world scenarios, this intervention has a ratio of $2.52 billion spent per averted death for a net cost of $1.99 trillion. Machine learning analysis produced comparable above results by RMSE.

3.2. Health equity analysis

Health equity analysis then considered the United Nations World Economic Situation and Prospects mid-2020 report identifying state lockdowns in response to Covid-19 (with up to 90% of the world's economy in some lockdown as of May 13, 2020) as the primary driver of the $8.5 trillion related 2020-2021 total cost, pushing 34.3 million additional people into extreme poverty by 2020 and up to 130 milion by 2030.24 The World Bank projected this contraction to be the most severe since World War II and totaling up to 7%, with the hardest hit economies being in nations with developing and emerging economies disproportionately dependent on commodity exports, external financing, global trade, and tourism instead of for domestic consumerism and service provision in higher income economies (25). The Covid -19 crisis is unfolding in the context of health spending globally that prior to it totaled $7.8 trillion, with high income nations (the majority in Caucasian-predominant North America and Western European nations) spending 70 times more per capita than low income nations who spent $41 per person annually according to the World Health Organization (26). The scientific research community including with the Journal of the American Medical Association have recently highlighted the growing concern of such inequities especially racial

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inequities even in high income nations like the United States: racial minorities are significantly more likely to have lower socioeconomic status than the Caucasian majority in addition to at least 2.5 times higher likelihood of being hospitalized with Covid-19; African Americans in particular are twice as likely to die compared to Caucasians irrespective of disease severity and health system traits (27).

The above translates into Covid-19 lockdowns exceeding global health spending by 110% and annual health expenditures in low income nations by 3'306,000% who are already at a 70-fold spending deficit compared to higher income nations, reinforcing pre-existing structural racial and socioeconomic disparities (28) as an additional barrier to social and economic upward mobility of minority-predominant nations with developing and emerging economies and minorities in higher income communities who are more vulnerable to the lockdown effects including job loss, wage reduction, decreased health system access for pre-existing conditions, and increased maladaptive health behaviors including substance dependence and related overdoses, self-harm, domestic abuse, and impaired acute and chronic disease management. Machine learning analysis produced comparable above results by RMSE.

3.3. Personalist social contract computational ethical analysis

The primary material object of the current case is state-mandated population lockdowns that require over 50% reduction in movement of over 50% of the population and thus making such people's principal location their primary residence. The primary formal object or analytic framework is the above described personalist social contract. The Thomistic-Aristotelian metaphysical presumption is that objective human good exists, is knowable, and expressed concretely in the individual flourishing of each person through her/his commitment or duty to the common good of the community (in this case the state) which in turn is committed to

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protecting the rights or the enumerated concrete goods required for the flourishing of each person that is required therefore for her/his ultimate good or end that is her/his perfection as a human person. The metaphysical first principle of non-contradiction is additionally invoked (Aristotle: *It is impossible for the same thing to belong and not belong simultaneously to the same thing in the same respect*) (18). The extended defense of this presumption and principle is outside the scope of this manuscript and thus is referred to Monlezun 2020 (13).

The ethical analysis is therefore provided according to the following argument:

Premise 1. Every state has a duty to each citizen to secure justice collectively and individually by giving or at least not withholding to each what is her/his due.

Premise 2. Per the above analysis and literature review, population lockdowns are a cost-ineffective approach to reducing preventable Covid-19 deaths (in such a manner that also lacks compelling clinical effectiveness evidence, either by convincing biological and public health plausibility or the current relevant literature outside of modelling studies not verified with real-world outcomes) resulting in net clinical and financial harm according to the above cost effectiveness analysis (without a widely accepted consensus in the current Covid-19 or modern pandemic literature that refutes the above conclusions). Such harms disproportionally and negatively affect lower socioeconomic communities particularly nations with developing and emerging economies and non-white minorities in North American and Western European nations, and thus reinforce societal stereotypes grouping such individuals into these minority groups by impairing upward socioeconomic and thus public esteem of such individuals that would otherwise allow them to be self-identified rather than more readily identified by society according to such groups, with such characterization and even such grouping potentially identified as racist.

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Premise 3. Such net clinical and financial harm is preventable and withholds from each citizen what is due to them which is at least no harm committed by the state in programs or policies whose aim is the optimization of individual and collective survival likelihood. This net harm limits the liberty of each person to pursue her/his good (which supports typically the sustainability of her/his life such as work and individually identified goods of social interaction with family, friends, and co-workers) without correlative sufficient individual or collective benefit.

Premise 4. Personalist social contract underlines how persons from diverse belief systems have common individual experiences by virtue of their common human nature (as a rational animal nature) about the subjectively grasped good of justice (that is an objective good in its essence) that protects them from undue and particularly preventable harms.

Premise 5. The vast majority of the world's persons are citizens of states of which the vast majority explicitly recognize and agree to be bound by the UDHR and its ethical articles that recognize «everyone has the right to life, liberty and security of person» because it is this «recognition of the inherent dignity and of the equal and inalienable rights of all members of the human family [that] is the foundation of freedom, justice and peace in the world» (Preamble, Article 1-3) (11). Respect for the rights of each person in general is consistent with ethical behavior and disrespect with unethical behavior.

Conclusion. Therefore, state-ordered and/or enforced population lockdowns are unethical and so logically indefensible when they unjustly limit individual rights without sufficient concrete or theoretical justification for their net individual or collective benefit, with the additional unethical aspect in that they subsequently accelerate disparities and through this accentuate pre-existing health challenges primarily for lower socioeconomic peoples, particularly racial minorities.

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4. Discussion

This is the first known cost effectiveness and computational ethical analysis of Covid-19 population quarantine or lockdowns (with particular focus on health equities) and the first known to use an integrated machine learning approach to strengthen robust statistical results and a global bioethical framework to strengthen pluralistic convergence on its proposed conclusions. This comprehensive study suggests that the current global practice of population lockdowns compared to standard precautions causes greater overall harm than the pandemic, with such widespread quarantines driving in real-world scenarios a net cost of nearly $2 trillion total (or $2.52 billion spent to save one Covid-19 patient's life) with disproportionate harm to lower socioeconomic communities notably racial minorities in developed countries and lower income nations who tend to be non-white. While not sufficiently supported by cost effectiveness or ethical considerations, lockdowns through the accentuation of economical imbalances may thus discrepantly impact low socioeconomic communities and minorities in a manner that further limits their justification relative to alternative pandemic measures.

These results suggest focusing resources less on interventions with unclear benefit-cost trade-off such as lockdowns and more on affordable interventions that are proven to affordably save lives and minimize negative impact on the lower resource minority communities and non-white peoples in developing or emerging economies (with such measures as hand hygiene, targeted quarantine of cases and close contacts, appropriate intensive care resources including ventilators, and potentially facial coverings and social distancing). The above concerns of lockdowns' questionable clinical and cost effectiveness and inequitable negative impact on lower socioeconomic groups were recently echoed by the World Health Organization as it advocated for more «targeted interventions» as possible (29), with this study mathematically and ethically sugges-

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ting that it is challenging to demonstrate convincingly that any use of lockdowns is justifiable for producing sufficient net benefit (though it is possible such benefit may later be convincingly demonstrated).

Additional studies are required to determine the most clinically and cost-effective measures for this pandemic. Part of standard medical practice for clinicians globally is balancing clinical and financial costs of diverse interventions while remaining committed to equitable care for every patient; this study underscores the role for integrated and comprehensive clinical, cost, and ethical analyses that can empower and unite healthcare systems and governments with science and solidarity to effectively, affordably, and equitably respond to such global crises for every patient regardless her/his race, socioeconomic status, or belief system. No disease justifies indiscriminately any intervention-clinicians, health systems, and governments have a duty equally to each patient to ensure only interventions reasonably demonstrated to have at least significant likelihood of net benefit to be undertaken. This study suggests lockdowns lack such likelihood.

In the face of cardiovascular disease (CVD) which remains the largest killer globally (31%) and disproportionately plagues lower socioeconomic communities particularly racial minorities and non-white patients (30), Covid-19 based on recent multi-center meta-analysis estimates at an IFR of less than 1% is over 45 times less likely to claim patients lives (23) and over 134 times less likely based on recent World Health Organization Bulletin estimates using seroprevalence data (31). The extensive documentation already of lockdown-associated delays in needed medical care or even its complete foregoing for such conditions as CVD begs the question if such tradeoffs are sufficiently justified. This one comparison further emphasizes the importance (while providing novel results to inform this investigation) of accurately assessing burden of disease and the comparative clinical and financial effectiveness of various interventions of new (i.e. Covid-19) and pre-existing glo-

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bal health challenges (CVD, poverty, inequities, etc.) to product the most efficacious and equitable policies and care possible by triaging such challenges and prioritizing the best evidence-based interventions not in a vacuum but collectively, collaboratively, and comprehensively (as heart disease, poverty, and inequities do not pause for Covid-19).

The above results should be interpreted with caution in the context of the limitations of the study.

The study was driven by the attempt to apply evidence-based cost, ethical, and health equity methodologies to such a sensitive and relatively unique topic as Covid-19. Its limitations include the inevitable reality that model outcomes are notably influenced by its inputs which may in suboptimal situations (particularly earlier in the pandemic with evolving data) be conflicting, varied, and incomplete; therefore, the most updated and accepted estimates from largely publicly supported institutions were included as what was deemed the best possible inputs particularly after extensive data and debate in the scientific community following the interval time period. Further, population quarantine was not set at an intended target objective of preventing transmission to up to 70% of a population for herd immunity given the absence of sufficient evidence or theoretical justification to support any measure for any pandemic producing any degree of prevention at any percentage threshold (3, 4).

There may also be misinterpretation of this study to inappropriately support policies or undermine others that are outside the scope and intention of this work. Thus a scientifically careful and philosophically pluralistic approach was taken, as well as cautious interpretation of the results that are by no means the definitive exploration of this topic. It should additionally be re-iterated that the value of a human life cannot be reduced solely to a financial input (but a person's life may ethically be considered in a financial dimension for the narrowly-defined purpose of a cost effectiveness analysis particularly when the purpose of doing so is to inform

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public policy meant to maximize the net benefit or good to each person).

5. Conclusion

This novel and comprehensive machine learning-augmented cost effectiveness and computational ethical analysis suggests Covid-19 lockdowns (which lack robust evidence for their clinical effectiveness in reducing mortality) inflict massive cost ineffective net harms globally with disproportionate damage to lower socioeconomic groups notably racial minorities and non-white nations with developing and emerging nations particularly in a manner which significantly limits states and health systems' capacities to respond to the larger mortality drivers. While additional studies of non-pharmaceutical interventions for pandemics and particularly the time sensitive Covid-19 crisis are needed, our study derived from robust available data and evidence based comprehensive methodologies suggests we can save more lives for more affordable financial costs by adopting a more ethical and equitable population health management and policy approach which does not include indiscriminate population lockdowns.

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Data availability statement
Multiple publicly available data sources were utilized in this study and are appropriately identified with their repository home, as applicable in the text.

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