COVID-19 Epidemiological and Economic Model Atlas

The Coronavirus Pandemic Working Group for Models of Total Harm Minimization

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Information needs code	Definition
ACC_SYR	Accuracy of serological tests
AVAIL_SYR	Availability of serological test
BED_CAP	Health system bed capacity
DEMOG	Demographic data
ECON_PRIORITY	Economic priority of industry
HOSP_DUR_NO_VENT	Duration of hospital stay without full ventilator use
HOSP_DUR_VENT	Duration of hospital stay with full ventilator use
HOSPRATE_STRAT	Hospitalization rate (stratified by demographics, socioeconomic statusl, etc.)
ICURATE_STRAT	ICU admissions rate (stratified by demographics, socioeconomic statusl, etc.)
IND_OCC_DIST	Industry occupational distribution

Information needs code (cont)	Definition
MEDHIST	Medical histories (ideally at individual level)
MITIG	Mitigant interventions for sub-population
MORT	Mortality rates, given positive diagnosis
P_IMMUNE	Probability of confirmed immunity, given infection
PHENO	Phenotypical data
INCRATE	Baseline incidence rate (from random sample, with bias information)
R0	R0 (R-naught)
RECOV	Recovery rates given positive diaganosis
VENT_CAP	Health System ventilator capacity

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Basawapatna	**Intentional Immunity Through Voluntary Exposure**	Basawapatna_Intentional-Immunity-Through-Voluntary-Exposure.pdf	Agent Based Modeling With Risk Stratification	✓	×	×	Population	Mortality Rate, Peak Sickness	HOSP_DUR_VENT, HOSP_DUR_NO_VENT, MEDHIST,DEMOG		In our rush to flatten the COVID-19 infection curve through lockdown, we have inadvertently made ourselves more vulnerable to a post-lockdown resurgence. Assuming we can predict low-risk individuals, by allowing low risk individuals to opt in to voluntary exposure we can decrease the number of susceptible people in the general population, decrease the post-lockdown peak sickness at any one time, decrease post-lockdown mortality, and begin to give people their lives and livelihoods back. Data on risk factors in low risk populations is still needed to enact this ethically.
Brown	**Quarantines, travel bans, and closures in response to SARS-CoV-2 / COVID-19 may be a disservice to public health**		AI and machine learning: Graph Convolutional Policy Networks	✓	×	×	Individual/Population	Real-time optimization of public policy for total harm minimization	BED_CAP, MORT, P_IMMUNE, R0, RECOV, VENT_CAP	ECON_PRIORITY, IND_OCC_DIST	Total Harm Minimization policies require combining statistical with epidemiological and economic models – and are essential to our capacity to build and inform productive public policy decisions. To date, the lack of even a single random sample from a community has prevented epidemiologists from obtaining accurate estimates of infection rates or overall mortality. Nor has data been available to understand if different strains of the novel corona virus exhibit different infectivity or mortality. Human genetics data has yet to be collected at scale to reveal if some individuals are at greater intrinsic risk from COVID-19 than others. Given that we have known for decades that mortal risk infectious disease exhibits stronger heritability than cardiovascular, cerebrovascular, and most oncologic causes of death, it is astounding that we lack the infrastructure to routinely collect this data.
Cannon	**COVID models in support of selective quarantine**	Cannon_COVID-models-in-support-of-selective-quarantine.pdf	Dynamical Systems (unspecified); Highly stylized	✓	×	×	Population	Total infected, Total Quarantined, People at Work, Total Mortality, Total on Ventilators, Total Ventilators Needed	See document		Suppose we insist that the higher-risk population to stay in their homes for ~150 days while the virus sweeps the lower risk population. Can we achieve herd immunity while the high-riskers stay home, saving tons of high-risk lives while creating minimal economic disruption?
Gold and Altman	**Covid-19 A Rational Total Retun Response**	Gold-Altman_Covid-2020-Response.pdf	Model free start	✓	×	O	Individual/Population	Policy for returning workers to the workforce quickly and providing the elderly quality of life while in forced segregation	INCRATE, MORT	HOSPRATE_STRAT, ICURATE_STRAT	Minimizing infections and deaths from COVID-19 are not the same thing. While society has some control on the final number of infected individuals through intervention and mitigation strategies, we have much greater control over the age-profile of the final cohort of infected individuals. By ignoring this distinction, strategies which focus on minimizing transmission rates to every extent possible in the entire population could increase deaths among all age groups. We also recognize that destroying the world economy, without consideration, will result in the deaths of countless that will make this viris seem like a walk in the park. Our strategy has three main pillars; 1. Infect the low risk while everyone else is in bunkers. 2. Segregated safe communities, The elderly (55 or 60 and above) should enter designated safe community centers and resources after a 30 day full isolation period and commitment to remain segregated and in contact with community members only. 3. Middle risk community: Once the sub 30 population is immune and the elderly segregated the Curve is automatically flattened.

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Hirleman	**<Comments>**	Hirleman_Commentary.pdf		✓	×	○	Population	Policy components	See document		Homemade masks on everyone the moment they leave the house. Risk Stratification as soon as data allows. Rationale: We need to show that we can reduce transmission to at-risk subpopulations by enough to make risk stratification possible. So I think the questionnaire on random testing has to be heavy on questions about current personal mitigation techniques. If we can show that amongst the sub-population that always wears a mask, cleans everything coming into the house, practices extreme physical distancing, etc. that they have effectively cut their odds of contracting and transmitting the virus (R(t) for that subpopluation <1) then you can model how fast a wave could go through the green light population without affecting the risk group. To get the R(t) of these different subpopulations we need repeated random testing, we can't just have 1 good random sample to get denominator.
Hirschhorn	**<Comments>**	Hirschhorn_Pandemic-lockdown-must-fail.pdf		✓	×	○			See document		A "reverse quarantine" (quarantining the 52 million Americans over 65) before they get sick, with government support and volunteerism. Model is based on data projected by the Harvard School of Public Health that details, for over 300 US cities, hospital bed demand over time. The rationale:
Johnson	**<Comments>**	Johnson_Commentary.pdf	Various	✓	×	○	Population	Total deaths with pivot strategy Optimal criteria for determining when it's safe to pivot.	See document		For regions or states that have used a horizontal interdiction strategy to suppress the peak of the coranavirus curve, pivoting to vertical interdiction strategy will lessen the economic impact of the virus without worsening the overall health outcome. Models may predict the optimal time to switch strategies.
Pegden and Chikina	**Fighting COVID-19: the heterogeneous transmission thesis**	Pegden-Chikina.pdf	Dynamical systems (SIR)	✓	×	×	Population	Infection rate, Hospitalization rate, Mortality Rate	BED_CAP, MORT, P_IMMUNE, R0, RECOV, VENT_CAP		Minimizing infections and deaths from COVID-19 are not the same thing. While society has some control on the final number of infected individuals through intervention and mitigation strategies, we have much greater control over the age-profile of the final cohort of infected individuals. By ignoring this distinction, strategies which focus on minimizing transmission rates to every extent possible in the entire population could increase deaths among all age groups. We argue for what we call the heterogeneous transmission thesis: in the response to a highly transmittable infectious disease with highly age-variable mortality rates, death rates (for all age groups) may be minimized by mitigation strategies which selectively reduce transmission rates in at-risk populations, while maintaining closer-to-normal transmission rates in low-risk populations.
Preston	**Ramping the Curve**	Preston_Ramping-the-Curve.pdf	Synthesis of multiple models	✓	×	○	Various	Strategic timeframes and resources needed by US States	P_IMMUNE, RECOV	Existing rates of usage for some listed healthcare system resources	This virus ends with herd immunity. Flattening the curve while leaving existing healthcare system capacity unchanged, results in a timeframe of 18-42 months til herd immunity across the U.S. This timeframe implies loss of life and wellbeing on par with a total failure to flatten the curve. Flattening the Curve is a vital first step to surviving this crisis. Ramping the Curve by building up relevant healthcare system capacity by a factor of 5x to 10x, and then accelerating exposure among the least vulnerable with optimal capacity in place, is the optimal path forward and could reduce time to herd immunity to 6 months.
Shalev-Shwartz and Shashua	**Can we Contain Covid-19 without Locking-down the Economy?**	Shashua_Can-We-Contain-Covid-19-Without-Locking-Down-the-Economy.pdf	Probability model	✓	×	×	Population	Tight bounds for determining sufficiency of healthcare system, given social isolation policy	BED_CAP, DEMOG, HOSP_RATE_STRAT, ICURATE_STRAT, INCRATE		In this article, we present an analysis of a risk-based selective quarantine model where the population is divided into low and high-risk groups. The high-risk group is quarantined until the low- risk group achieves herd-immunity. We tackle the question of whether this model is safe, in the sense that the health system can contain the number of low-risk people that require severe ICU care (such as life support systems).
Stein, Arbess, Kanef, Katz and Walsh	**A Total-Harm-Minimization Framework for Developing Expedient and Low-Risk Return-to-the-Workforce Policies During the COVID-19 Pandemic**	Stein_COVID-19-Back-to-Work.pdf	Model free triage and return-to-work framework	✓	✓	○	Individual/Population	Policy for returning workers to the workforce quickly	AVAIL_SYR, ACC_SYR, P_IMMUNE	ECON_PRIORITY, IND_OCC_DIST	Objective: Define a framework to develop a Total-Harm-Minimization policy to address the COVID-19 crisis in consideration of both economic and health risks. We describe a framework that is tolerant to the uncertainty in our current knowledge of COVID-19 that: (a) requires a very small number of assumptions; (b) involves minimal mathematical modeling; and (c) may result in acceptably low community health risk, given (a) and (b).

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Stein	**The relationship between default prediction and lending profits: Integrating ROC analysis and loan pricing**		Probabilistic optimizaiton	×	✓			Optimal cutoff policy to maximize value (minimize loss) by trading off risky costs and benefits with an imperfect diagnostic model (General methodology using a finance example.)	See document		In evaluating credit risk models, it is common to use metrics such as power curves and their associated statistics. However, power curves are not necessarily easily linked intuitively to common lending practices. Bankers often request a specific rule for defining a cut-off above which credit will be granted and below which it will be denied. In this paper we provide some quantitative insight into how such cut-offs can be developed. This framework accommodates real-world complications (e.g., ''relationship'' clients). We show that the simple cut-off approach can be extended to a more complete pricing approach that is more flexible and more profitable. We demonstrate that in general more powerful models are more profitable than weaker ones and we provide a simulation example. We also report results of another study that conservatively concludes a mid-sized bank might generate additional profits on the order of about $4.8 million per year after adopting a moderately more powerful model.
Szapudi	**Staged social distancing: a COVID-19 mitigation strategy**	Szapudi_Staged-Social-Distancing.pdf		✓	×		Population	Policy for restarting the economy without overwhelming the health care system and minimizing death	INCRATE, MORT		The COVID-19 pandemic is about to wreck both our health care system and our economy. The bottleneck for proper treatment is the number of ICU beds with respirators. Social distancing, to "flatten the curve" such that the number of critically ill always stays below a threshold, is unsustainable. Recently, Ferguson et al. 2020, proposed an adaptive triggering strategy, where a certain level of ICU occupancy triggers a strict social isolation period. According to their models, approximately 2/3 of the next two years would trigger the isolation policy to avoid overwhelming the British health care system. The economic cost of sustained isolation, even with an adaptive trigger, is inconceivable. Here we present an alternative approach, staged social distancing, that saves lives compared to the chaos of the "do nothing" approach that is sure to follow the present distancing policies when economic resources and people's patience run out.
Szapudi	**Pooled sampling strategies for CoViD-19 data gathering**	PooledSampling.pdf	Statistical	✓	×		Individual/Population	A strategy for pooled sampling	NA		Sample pooling of CoViD-19 PCR tests has been recently pro- posed as a low cost alternative to individual tests. We show that sample pooling is efficient as long as the fraction of the pop- ulation infected is relatively small. Fisher information theory suggests a rule of thumb that for low infection rates p, pooling 2/p samples is close to optimal. We present a simple strategy for survey design when not even a ballpark estimate of the infection rate is available.