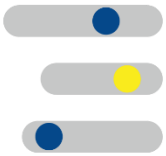

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Mitigating Cognitive and Behavioural Biases during Pandemics Responses: Open-science evidence-based methodologies for the development of epidemic combating policies

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Contents

SUMMARY

In managing the Covid-19 pandemic, several compelling narratives seem to have played a significant role in the decision-making processes regarding which risk mitigation and management measures to implement. Many countries were to a large extent unprepared for such a situation, even though predictions about a significant probability for a pandemic to occur existed, and national governments of several countries often acted in an uncoordinated manner, which resulted in many inconsistencies in the disaster risk reduction processes. Limited evidence has also made room for strategic narratives meant to persuade the public of the chosen set of actions, even though the degree of uncertainty regarding the outcomes of these was high, further complicating the situation.

The transformation of societal systems cannot be determined solely by any technological or economic assumed rationality. Rather, there is a wide range of social, political, and institutional factors that interact in a systemic fashion and influencing their development. The acknowledgement of the multiple factors at stake in handling the crisis has more often than not been omitted from public communication, where public officials' statements mostly framed the problem unilaterally, basing their narratives on warnings coming from the medical and public health scientific community.

Representing complex scenarios in socioeconomic systems has the potential to inform policy formation processes, and we believe that such a framework can decrease irrational decisions disturbed by a variety of cognitive and political biases as well as reducing the number of measures with insignificant effects or with highly undesirable side-effects. There is a multitude of issues in connection with crisis management that must be clarified in advance and well-anchored in the broader populations, another reason why transparent and deliberated policies should be analysed and in place beforehand. To do this, there is a need for integrated methodologies and decision processes for how country strategies and action plans should be aligned with overall objectives and stakeholder perceptions and preferences. Deliberated strategies must be a prerequisite for policy formation and they should furthermore be developed together with the civil society in order to be better prepared for future crises.

In this report, we suggest an integrated framework for a more elaborated decision analysis under the ambiguity of how to contain the virus spread from a policy point of view, while considering epidemiologic estimations and socioeconomic factors in a multi-stakeholder-multi-criteria context based on a co-creative work process for eliciting attitudes, perceptions, as well as preferences amongst relevant stakeholder groups. The framework is applied in three phases, in Botswana, with a focus on the epidemiological model, in Romania where we tested the decision model and questionnaire reception, and in Jordan in a slightly broader study. We thus tested the full-scale model in the latter two cases for evaluating mitigation measures for the Covid-19 situation, to mobilise better response strategies for future scenarios related to pandemics and other hazardous events, as well as to structure the production and analysis of narratives on the current pandemic effects.

PART I: INTRODUCTION

The recent emergence of the Covid-19 pandemic situation highlighted that many countries have to a large extent been unprepared for it[1]. Decision-makers had to operate in conditions of severe uncertainty about the case fatality rate, the spreading of the virus, the timing of infectiousness, the number of asymptomatic cases - just to mention a few[2]. Risk mitigation measures such as vaccines were missing[3] and decision-makers did not have reliable information about critical measures to protect society from the virus spread or at least to reduce its exposure and vulnerability. Another critical problem in assessing the risk was that the evidence about the case fatality rate was unknown[4]. As a result of this and many other factors during the COVID-outbreak[5], public authorities had to make decisions based on uncertain quantitative evidence and expert scientific advice (e.g. about possible future scenarios), on assessments of the health system capacity (especially of intensive care units), on expected public adoption of more or less restrictive measures, and on the evolution of national public debates about the issue[6]. Nevertheless, the disaster risk reduction of the Covid-19 pandemic showed that in deciding which measures to implement, many countries acted in an apparently uncoordinated manner, at least at the beginning of the pandemic. The measures undertaken by bordering countries or regions within one country were many times inconsistent, and decisions on whether or not to impose lockdown were not taken only based on the number of confirmed cases. The effects of these inconsistencies are to a large extent still unforeseeable. Moreover, many non-pharmaceutical measures are progressively limiting individual freedom and have high economic and societal costs when undertaken with the aim to avoid fatalities in the short term, even though the same measures might produce indirect long-term fatalities due to economic recession and restricted access to healthcare by non-Covid-19 patients, restricted access to education[7] and other effects upon a large number of socioeconomic factors.

Several cognitive and behavioural biases seem also to have played a role in the decision-making processes. One such is connected with risk perceptions under conditions of ambiguity[8]. There are also the availability cascade[9], i.e., individuals adopt a new insight since other people have adopted it, and the availability heuristic, the mixture of frequency, and the ease with which examples come to mind[10]. There are bandwagon effects and information cascades, where the individual adoption is strongly correlated to the proportion of people who have already adopted an idea, combined with the enormous amount of

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[1] GHS. Global Health Security Index (2020). https://www.ghsindex.org/ [Accessed June 15, 2020].
[2] Andersen K, Rambaut A, Lipkin W, Holmes E, Carry R. The proximal origin of SARS-CoV-2. Nature Medicine (2020) 26:450-452.
[3] Amanat F, Krammer F. SARS-CoV-2 Vaccines: Status Report. Immunity (2020). 52(4):583-589
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[5] The New York Times. Embracing the Uncertainties (2020). https://www.nytimes.com/2020/04/07/science/coronavirus-uncertainty-scientific-trust [Accessed April 7, 2020].
[6] Time. The National Divide Over COVID-19 Testing Threatens Our Progress (2020). https://time.com/5826997/divide-covid-19-testing-threatens-progress/ [Accessed April 27, 2020].
[7] UNESCO. Adverse consequences of school closures (2020). https://en.unesco.org/covid19/educationresponse/consequences [Accessed May 20, 2020].
[8] Ellsberg, D., (1961). "Risk, Ambiguity, and the Savage Axioms". Quarterly Journal of Economics. 75 (4): 643–669.
[9] Kuran, T., and Sunstein, C., (1999). Availability Cascades and Risk Regulation, Stanford Law Review, Vol. 51, No. 4 (1999).
[10] Tversky, A., Kahneman, D., (1973). Availability: A heuristic for judging frequency and probability, Cognitive Psychology, Volume 5, Issue 2, Pages 207-232.

available information[11], base rate fallacy[12], probability neglects[13], exaggerated expectations, framing[14], group thinks in general[15], and many others. A probable component is also bounded rationality, when individuals are limited regarding their ability or willingness to collect information and are unable to identify an even perceived optimal solution, leading to decisions being made in a significantly simplified decision space. Decision-makers thus search in this sense for a satisfactory solution, but they focus only on a limited set of options from available alternatives[16,17]. While comparing actions of disaster risk reduction, there is also the issue of representativeness heuristics, i.e., the degree to which an event is similar in essential characteristics to its parent population and reflects the salient features of the process by which it is generated. Then there is of course an inevitable component of dread risk (compare, e.g., with hazardous technologies) connected with the judgments of people about unknown risks and their "perceived lack of control, dread, catastrophic potential, fatal consequences, and the inequitable distribution of risks and benefits"[18].

1. Objectives

The existing decision-making mechanisms under conditions of uncertainty are thus quite limited, in contexts where reliable data is scarce and the impact of the chosen policy across a variety of interconnected sectors and social categories is potentially quite serious. Rather than looking only at epidemiologic and healthcare factors, our purpose is to expand the policy problem and to include socioeconomic factors as well in the decisions over measures to be adopted in response to the pandemic, since the consequences of any chosen policy upon a variety of fields and groups need to be carefully and transparently weighed.

The aim of our project was ***to develop a framework for elaborated decision-making under uncertainty about the spread of the virus***, which includes epidemiological estimations and socioeconomic factors in a multi-criteria-multi-stakeholder context. This framework can be used both in handling the current or future challenges of pandemic situations, to facilitate management and mitigation of similar crisis situations in the future, in any regions. It also provides recommendations for the assessment and evaluation of different scenarios and their impacts. These recommendations could be also used more generally, on change-induced hazards as well as assess the potential outcomes of different scenarios on hazards. Moreover, it can be also used for strategic communication in the public sphere and for the facilitation of discussions about various policies, alternatives and trade-offs under conditions of strong uncertainty.

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[11] Morton, R., Mueller, D., Page, P., Torgler, B., (2015). Exit polls, turnout, and bandwagon voting: Evidence from a natural experiment. European Economic Review. 77: 65–81. doi:10.1016/j.euroecorev.2015.03.012.
[12] Bar-Hillel, M., (1980). The base-rate fallacy in probability judgments. Acta Psychologica. 44 (3): 211–233. doi:10.1016/0001-6918(80)90046-3.
[13] Sunstein, C., (2003). Probability Neglect: Emotions, Worst Cases, and Law, Chicago Law & Economics, Olin Working Paper No. 138.
[14] Tversky, A., Kahneman, D., (1981). "The Framing of decisions and the psychology of choice". Science. 211 (4481): 453–58.
[15] Turner, M. E., Pratkanis, A. R., (1998). "Twenty-five years of groupthink theory and research: lessons from the evaluation of a theory". Organizational Behavior and Human Decision Processes. 73 (2–3): 105–115.
[16] Lindblom, C., (1959), The handling of norms in policy analysis, in Abramovitz, Moses; et al. (eds.), The allocation of economic resources: essays in honor of Bernard Francis Haley, Stanford, California: Stanford University Press.
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[18] Slovic, P., (1987). Perception of risk. Science, 236(4799), 280–285.

In this project, the decision process is based on a recognition of the complex relationships between different criteria and is supposed to support national and local strategies in dealing with pandemic emergencies and action plans, allowing for an alignment of overall objectives with perceptions and preferences of various stakeholder groups on priorities. Since there is a heterogeneity of opinions and potential conflicts of various stakeholders about disaster risk reduction measures, the recommendations should be based on compromise solutions to increase the quality, acceptability and legitimacy of the decision-making processes.

More concretely, our framework includes:

- A ***multi-criteria model***, based on a demography-based model for contagion rate and socio-economic impact estimates;
- A ***co-creation framework***, where relevant stakeholder groups (policy-makers, private sector, decision-makers, academia, civil society, banks and local community representatives) can evaluate available mitigation measures of choice against the different criteria based on stakeholder preferences;
- A balanced ***set of sustainability criteria*** aspects based on literature reviews and stakeholder's judgments;
- A ***policy recommendation*** on how an emergency process also for future events can be designed in a publicly acceptable way with the potential for "triple wins" concerning catastrophic events, sustainable development, and social protection in a broader sense.

The framework was applied and adapted in different phases in three countries: Botswana, Romania and Jordan. These countries represent different socioeconomic systems (transition and developing economies) and have very different demographics and healthcare capacities, affecting the feasibility of some risk mitigation measures. In the case of Botswana, we provided alternative mitigation measures and a set of sustainability criteria to inform a computer-supported framework for decision analysis, as well as a demography-based epidemiologic model. Further on, in Romania, aside from establishing a set of criteria and of mitigation measures that could be adopted, as well as modelling the epidemiologic evolution in every alternative scenario, we have also provided socioeconomic estimates for a number of criteria and have used a co-creation framework by which we obtained stakeholder feedback on risk attitudes and value trade-offs. These were then aggregated and evaluated in the decision analysis software DecideIT. Further, in Jordan we have adjusted the criteria set based on stakeholders' input and replicated the methodology and data collection process, as well as the epidemiologic and decision analyses, refining and expanding the stakeholder consultation process. Inputs from stakeholders were essential for developing compromise-oriented policy solutions for management and mitigation of similar risks in the future, achieving a greater level of acceptance and legitimacy, as well as facilitated and improved implementation processes of various risk mitigation measures.

The resulting integrated multi-stakeholder-multi-criteria framework can be used for better emergency preparedness for the Covid-19 pandemic, but also for future catastrophe scenarios. We recognise that socioeconomic conditions, as well as healthcare capacities, can be very different, affecting the feasibility of some measures for particular regions, but also the quality of data. Therefore, any framework must be used with an awareness of national and regional conditions, and in health emergencies, the Global Health Security Index for instance can provide rapid data on a country's detection, response and healthcare

capacity, as well as on its norms and risks so as to have a baseline when considering mitigation measures. The Covid-19 spread pattern also emphasises that the model must be flexibly used and regionally adapted. Nevertheless, measures need to be based on adequate risk estimations of a situation as far as possible, including epidemiologic modelling and integrated analyses of the costs of reducing the risk, as well as a more systematic analysis of the extent to which various measures can reduce it. Because of the fluctuating data quality and other factors, any framework must be able to handle the various uncertainties involved. Furthermore, individual perception and factors influencing the said perceptions, including behaviours, narratives and framing, as well as the emotions stirred by media representations and by the level of uncertainty, must be taken into consideration during the deliberation. And there must be a preparedness which needs to be made in advance, as much as possible.

2. Project methodology

2.1. Decision analytical framework

The decision framework included several components such as participatory components, evaluation process and rankings, which are detailed in section II.1. in the present report. In our project, we use multi-attribute evaluations under risk. This methodology proved to be useful also in our earlier works on complex or contested policy issues with imprecise utilities, probabilities and weights. We also apply the DecideIT software tool which is a patented algorithm and was successfully used for decision-making processes in large-scale energy policy planning, allocation planning, demining, financial risks, gold mining and others.

2.2. Alternative measures under uncertainty

The first phase of the project consisted of desk research by which we identified possible mitigation measures in response to the pandemic. Measures to contain the spread of the novel SARS-CoV-2 virus have to a large extent been based on various epidemiologic risk assessments, which were made primarily by centres of disease control and prevention in Europe and the USA and by the World Health Organization, as well as by various consultants and trusted parties[19]. These assessments established scenarios starting from the number of confirmed infections in a country, with every scenario having a series of recommendations on containment measures to use in order to limit the spread of the virus. There are, however, challenges with modelling the effects of risk mitigation measures. Many epidemiologic models do not take into consideration demographics, distribution of population, age groups and their interaction patterns. Furthermore, there is limited evidence included in currently used models[20] on how each measure reduces the rate of transmissibility. The assumptions which serve as a basis for predictions are that there is no change in behaviour and that preventive measures are put in place at one specific time-point. Then time calibration is done using the observed number of case fatalities and estimates of the time between infection and death and the infection fatality risk. It is also assumed that the overall effect of preventive measures is known. The effects are estimated

[19] Walker P, Whittaker C, Watson O et al. The Global Impact of COVID-19 and Strategies for Mitigation and Suppression. Imperial College London (2020). doi: https://doi.org/10.25561/77735.

[20] Ferguson N, Laydon D, Nedjati-Gilani G et al. Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. Imperial College London (16-03-2020). doi: https://doi.org/10.25561/77482.

from the observed increased doubling time after preventive measures are put in place. However, the predictions are highly sensitive to the doubling times without and with preventive measures, as well as to, for instance, the reproduction number, but less sensitive to the estimates used for time-calibration: observed number of case fatalities, the typical time between infection and death, and the infection fatality risk[21] .

Aside from the increased healthcare and treatment optimization efforts, non-pharmaceutical interventions are layered progressively, starting from more low-cost measures (increasing personal hygiene through hand washing, disinfecting surfaces and wearing face masks), to isolating individuals confirmed positive with the virus, to, eventually, more aggressive and costly social distancing measures. Countries have taken different approaches as to which set of measures to introduce and when, which of course is difficult given the uncertainty regarding the time frame for containing the pandemic, how much the economy can sustain the associated costs of social distancing and isolation measures, as well as the uncertainty of how long citizens can comply with certain measures.

Some countries, such as Japan, have mainly focused on contact tracing and testing, recommending people to restrict their travels, and teach and work from home. Sweden chose to cancel larger public events, but did not close primary schools and workplaces, while the idea of keeping social distance has been largely promoted. South Korea had a similar approach, but with more intensive contact tracing using digital systems. Interestingly, Taiwan, in spite of its proximity to China, had one of the lowest stringency levels[22] , as they did not close down schools, workplaces or public transport, and instead mostly focused on tracing and isolating measures. Taiwan's experience with the 2003 SARS epidemic could account for a series of quick decisions involving traveller screening, a wide distribution of masks, hand sanitizers and thermometers[23], as well as the investment of approx. $6.8 million into the manufacturing sector to create 60 new mask production lines.

There is a dominant approach, however, which seems to have been preferred by countries including Romania, Austria, Denmark, Norway, Germany and many others, who have adopted extreme social distancing measures going from case quarantine and public gatherings bans to partial lockdowns, closing schools and many workplaces, public transport, only allowing people to leave their homes for specific purposes, with an even tighter curfew imposed on the elderly. These measures were defended for their short-term capacity to reduce the rate of transmissibility and to flatten the epidemic curve as much as possible in order to primarily keep the hospital systems from getting overburdened.

The short-, medium- and long-term socioeconomic costs associated with these extreme measures are definitely a matter of discussion and have been putting pressure on countries to relax the situation. It has also been argued that "the incremental effect of adding another restrictive measure is only minimal and must be contrasted with the unintended negative

[21] Britton T. Basic estimation-prediction techniques for Covid-19, and a prediction for Stockholm. ArXiv [Preprint] (2020). Available at: https://www.medrxiv.org/content/10.1101/2020.04.15.20066050v1.full.pdf [Accessed April 20, 2020].
[22] Hale T, Webster S, Petherick A, Phillips T, and Kira B. Oxford COVID-19 Government Response Tracker, Blavatnik School of Government (2020). https://covidtracker.bsg.ox.ac.uk/ [Accessed May 20, 2020].
[23] Business Insider. Taiwan has only 77 coronavirus cases. Its response to the crisis shows that swift action and widespread healthcare can prevent an outbreak (2020). https://www.businessinsider.com/coronavirus-taiwan-case-study-rapid-response-containment-2020-3 [Accessed May 17, 2020].

effects that accompany it"[24]. We actually begin to know more about some measures' effectiveness in containing the virus spread. For instance, combining case quarantine with other public health measures is shown to be more effective than only relying on case quarantine. When combined with contact tracing, the impact of some measures increases[25]. Contact tracing combined with public disclosure of active cases' location seems to lower the number of deaths, having 50% lower economic costs than full lockdown[26]. A comparatively cheap measure is to wear masks and some evidence suggests that wearing such can reduce transmissibility and be highly effective when compliance is high, at the same time substantially reducing both the death toll and the economic impact[27]. Wearing them at 96% alone could flatten an epidemic growing at a rate of 0.3/day by bringing down the reproduction number from an original value of 3.68 to 1. But what about the other measures? How effective is it to close schools, close borders and to suspend or reduce national and international travels[28], or restrict certain workplace activities? And, finally, how much can a country build up its healthcare system during the restriction period?

A detailed analysis of all sectors of all countries is naturally a tremendous work and definitely beyond the scope of this report, and we will herein highlight some classes of measures for a more high-level perspective. There are various possibilities to combine measures in order to see their different effects in reducing the rate of transmissibility, while also looking at their different consequences under other criteria, including indirect deaths in different groups, inhibited work capacity in the longer and short term, or social costs, as well as their effects on democracy and human rights, among others.

For the purposes of our example applications of the framework, we have used the following alternatives of Covid-19 risk mitigation and management measures:

Level 1: An unmitigated epidemic – a scenario in which no other action is taken except pharmaceutical measures and case isolation.

Level 2: Mitigation adding to pharmaceutical measures and case isolation, public communication encouraging increased hygiene and personal protection, localized action (closing a school/workplace in case of a number of cases) - influenza epidemics protocol.

Level 3: Mitigation adding to pharmaceutical measures and case isolation, personal protective measures (stay home when sick, hand washing, respiratory etiquette, clean frequently touched surfaces daily, wearing face masks), mild social distancing measures

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[24] Nussbaumer-Streit B, Mayr V, Dobrescu Alulia, Chapman A, Persad E, Klerings I, Wagner G, Siebert U, Christof C, Zachariah C, Gartlehner G. Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review. Cochrane Database of Systematic Reviews (2020) 4. doi: 10.1002/14651858.CD013574.

[25] Tian L, Li X, Qi F, Tang Q, Tang V, Liu J, Li Z, Cheng X, Li X, Shi Y, Liu H, Tang L. Calibrated Intervention and Containment of the COVID-19 Pandemic. ArXiv [Preprint] (2020). Available at: https://arxiv.org/abs/2003.07353v4 [Accessed April 15, 2020].

[26] Argente D, Hsieh C-T, Lee M. The Cost of Privacy: Welfare Effects of the Disclosure of Covid-19 Cases. SSRN Electronic Journal (2020). doi: http://dx.doi.org/10.2139/ssrn.3601143

[27] Howard J, Huang A, Li Z, Tufekci Z, Zdimal V, van der Westhuizen H-M, et al. Face Masks Against COVID-19: An Evidence Review. Preprints [Preprint] (2020). Available at: http://dx.doi.org/10.20944/preprints202004.0203.v3

[28] Camitz M, Liljeros F. The effect of travel restrictions on the spread of a moderately contagious disease. BMC Med (2006) 4:32. doi: https://doi.org/10.1186/1741-7015-4-32.

(large public gatherings banned, work from home where possible, social distancing recommended).

Level 4: Suppression (lockdown for two months) - pharmaceutical measures and case isolation, personal protective measures (stay home when sick, hand washing, respiratory etiquette, clean frequently touched surfaces daily, wearing face masks), imposed social distancing measures and restrictions on mobility: school closures, restaurants and large shopping centres closed, people can go out only for their basic necessities and work.

2.3. Criteria sets

A multitude of methods for analysing and evaluating decision problems with multiple stakeholders and multiple criteria have been developed during the last decades. A fundamental component here is a set of criteria, under which the various options are considered. The possible measures to be taken are valued under each criterion and the relative importance of the criteria themselves is usually represented by a set of weights that can be defined in several ways. For instance, a set of criteria for the Covid-19 pandemic could include:

a. Epidemiological & healthcare systems effects: (a1) direct fatalities, (a2) indirect fatalities;

b. Economic aspects: (b1) short term costs, (b2) unemployment, (b3) taxes, (b4) specific industries affected, (b5) growing industries;

c. Social and behavioural aspects: (c1) human rights, (c2) protection of vulnerable groups, (c3) criminality rates, (c3) mental health, (c4) education and training;

d. Environmental: (d1) climate change;

e. Political and governance: (e1) risk of short-term governmental abuse, (e2) citizen approval of measures, (e3) trust in the government, (e4) resilience – improving preparedness for catastrophic events;

A subset of these was used in our framework application in Romania. Alternatively, depending on the public debates and agenda, country development, stakeholders' priorities and data availability, the following set can be also used:

a. Health aspects: (a1) direct fatalities; (a2) indirect fatalities; (a21) changes to adult social care; (a22) impacts of social distancing and economic deprivation; (a3) mental health; (a4) universal healthcare access;

b. Economic impact: (b1) GDP growth; (b2) unemployment; (b3) country development; (b31) Human Development Index; (b32) Democracy Index;

c. Education: (c1) number of school days lost; (c2) educational inequalities; (c3) risk of school dropout

d. Well-being: (d1) quality of life; (d11) emotional impact; (d12) violence against women; (d2) community mobility,

as well as others, a set that can be refined after further literature reviews, projections and data elicitation from stakeholders. A subset of the latter criteria was used for our framework application in Jordan. The criteria sets were established after media monitoring of pandemic response statements between February and September 2020 in Romania and Jordan, as well as after two rounds of research surveys of scientific and grey literature on Covid-19.

2.4. Value estimates

Since estimations of Covid-19 cases and fatalities were the main triggers of the emergency situation and of resulting adoptions of various mitigation measures, we used our own calculations with a SEIR (Susceptible, Exposed, Infected, Recovered) model. Such models are common to represent the spread of disease in a population, where people are divided into compartments depending on their immunity status. We applied a regionalised demography augmented SEIR model for modelling the health effects of various risk mitigation measures. This model includes country-specific information such as population size in a certain region divided into age groups, morbidities in the population per age group, current numbers of confirmed cases per day, divided per age group and case severity. The input data are detailed in Part III and Appendices, for all three countries. The simulations of the measures' effects in containing the virus spread were made in AnyLogic 8. The results need to be considered against a benchmark for the medical system capacity of every country (no. of ICU beds, ventilators, medication, testing capacity).

For socioeconomic estimates on the chosen criteria, we collected data from official statistics, indices, economic monitors and forecasts, as well as scientific and grey literature on the impact of the pandemic in Romania and Jordan. These, as well as the reasoning used for estimating values in hypothetical scenarios, will be detailed in Part III under the respective case studies.

2.5. Questionnaires design

Our methodology relies on decision-analytical models of elicitation of values from various stakeholders' groups. Not only politicians but also representatives of the business sector and in particular of the industries directly affected by the various measures discussed, such as the hospitality industry, retail, cultural and educational sectors and transportation, should be a part of the elicitation process. Participation and stakeholders' engagement is required for the development of policy interventions under conditions of large uncertainty and with high socioeconomic costs. Policy-makers need to weigh their decisions against, among other things, the political costs of implementing sometimes unpopular sets of rules affecting social mobility, social interaction or work organization.

For our co-creation processes in Romania and Jordan, we used stakeholder consultations through in-depth web surveys, which were refined as more data became available. The aim of these questionnaires was to obtain stakeholders' rankings of mitigation measures and criteria. In Romania, the questionnaire included questions on risk perception as well: "For Romania, what would you consider to be an unacceptably high mortality caused by Covid-19?", "In your view, how serious is the risk of high mortality rates caused by Covid-19?" and "How likely do you think it is for the SARS-CoV-2 epidemic in Romania to have a high mortality rate, if left unmitigated?". These were followed by rankings of the measure sets described above, as well as by rankings of criteria and sub-criteria: "Which are, in your view,

the main concerns to be addressed by governmental responses to the SARS-CoV-2 pandemic?", "What health problems do you think are more important to limit during a SARS-CoV-2 epidemic in Romania?", "Which are, in your view, the most important economic aspects to be addressed in a pandemic response action?", and so on, respondents being instructed to drag a slider scale using the mouse to specify what had more priority. The questionnaire was built using a survey platform of the Department of Computer and Systems Sciences, Stockholm University[29], and it was sent in June-July 2020 to 17 government officials, 16 healthcare experts, 11 representatives from the business sector, 9 non-governmental organizations and 11 experts from academia in Romania. 16 respondents filled in the questionnaire, the results of which will be discussed in Part III, section 2.1.

For the co-creation process in Jordan, we used two web surveys using Google Forms, which were sent in November 2020 and January-February 2021, respectively. The first survey aimed at obtaining stakeholders' input on the relevant criteria to be considered for the pandemic management in Jordan, the first question asking them to provide a criterion they considered of importance, aside from those that were discussed in the public sphere (health, education, financial aspects and well-being). Then, according to their perception of the relative importance, stakeholders were asked to rank criteria, including the one they added. The second questionnaire was sent after value estimates were obtained for the final set of criteria, in every scenario. This time, respondents were given our impact estimates for four criteria and for each criterion, they were asked to rank the measures according to their estimated effects: "1. Which measure set do you think is better if you take into consideration their estimated effects on direct fatalities? Please rank the measure sets from the worst (1) to the best (10)" and so on. After seeing the impact estimates and ranking the measures, the stakeholders were asked again to rank the criteria according to their perception of the relative importance, on a scale from 1 to 10. We collected 78 responses, out of which 44 came from the education and research sector, 14 from the private sector, 10 from the government, 8 from the healthcare system, and 2 from the non-governmental sector. The results will be discussed in Part III, section 3.4.

PART II: THE DECISION ANALYTICAL FRAMEWORK

There are several studies investigating specific performance aspects of interventions against pandemics but they are most often limited to a single scenario and they are seldom designed to explicitly acknowledge the inherent uncertainties in both simulation results and scenario likelihoods. We have previously applied more dynamic multi-criteria decision analysis approaches to synthesize outcome predictions and stakeholder preferences from multiple perspectives into decision recommendations[30]. Applied to the Covid-19 mitigation problem, the methodological components could, for instance, be partitioned into (i) a co-creative preference elicitation component, (ii) an epidemiological component, (iii) a socioeconomic component, and (iv) an aggregation and analysis component. The basic idea is to, relative to a set of possible mitigation measures, model the actual spread and its effects on the population with respect to critical health care, taking demographic and regional conditions into account, and furthermore estimate the effects from other perspectives,

[29] https://uv.dsv.su.se/

[30] Larsson A, Fasth T, Wärnhjelm M, Ekenberg L, Danielson M. Policy Analysis on the Fly with an Online Multi-Criteria Cardinal Ranking Tool. Journal of Multi-Criteria Decision Analysis (2018). doi: https://doi.org/10.1002/mcda.1634.

predominantly socioeconomic. A main point here is also that there should be adequate support tools for the deliberative process for structuring the decision situation and for providing information regarding possible measures and criteria. These processes should of course, to a large extent, be in place in advance and not conceived during an emergency, when there might be very little time for a more time-consuming decision apparatus.

1. Co-creation framework

The involvement of stakeholders in decision-making processes and model development is generally essential for catering to stakeholder requirements, but also for increasing the acceptability of the chosen set of measures. Policy-makers need to weigh their decisions against, among other things, the political costs of implementing sometimes unpopular sets of rules affecting social mobility, social interaction or work organization. Not least in public health emergency situations, a distributed decision-making process could contribute to ensuring that the responsibility for the result is as well distributed, lowering the political costs and making way for a consideration of a variety of criteria relevant to the problem at hand.

A number of techniques may here be employed, relying on models from the decision-analytic field aimed at eliciting users' values through studying their preferences and gathering preferential data from several stakeholders in order to provide at least reasonable values, while keeping within the resource limits available[31]. From the outset, it is usually a good idea to identify and have access to the relevant stakeholders for the problem which is addressed. In the case of situations such as the SARS-CoV-2 pandemic, aside from the first responders including the government, national institutes of public health and the sanitary system, social and economic agents should also be included since the non-pharmaceutical measures which are taken have a direct impact upon their activity. Among these, representatives of the business sector and in particular of the industries directly affected by the various measures discussed, such as the hospitality industry, retail, cultural and educational sectors and transportation, should be part of the elicitation process. Of course, chain reactions affect other sectors as well including banking, suppliers and various small and medium enterprises which are affected by lowered consumption during various measures' implementations, so representatives of both business owners and employees would need to be included. Social groups need to be represented as broadly as possible through, for instance, relevant members of civil society with good knowledge and experience with communities and municipalities. The need to protect vulnerable groups from the virus primarily concerns the care for the elderly and chronically ill patients, who are more exposed to serious forms of Covid-19. In addition to these, other groups who are directly affected by the measures under consideration include a variety of patients in need of healthcare whose access to medical services could be jeopardized during a lockdown, as well as women at risk of domestic violence, children and families at risk of poverty or precarious workers. Policymakers have the institutional legitimacy and capacity to call for broad participation in the elicitation process and many of them have had consultations with some of the stakeholders in order to, among other things, allocate supplementary funds and financial stimuli packages to mitigate

[31] Danielson M, Ekenberg L, Komendantova N, Al-Salaymeh A , Marashdeh L. "A Participatory MCDA Approach to Energy Transition Policy Formation,". In: de Almeida A, Ekenberg L, Scarf P, Zio E, Zuo MJ, editors. Multicriteria Decision Models and Optimization for Risk, Reliability, and Maintenance Decision Analysis - Recent Advances. Springer International Publishing (2020).

the socioeconomic costs of a lockdown. However, such consultations are unstructured, often not transparent and can – intentionally or not – give a higher weight to some groups who are, for instance, more dominant or outspoken in the public sphere.

There are various guidelines to inform decision-makers of the acceptable norms that need to be taken into consideration when weighing the various policy solutions for managing the pandemic long-term, such as ensuring well-being, liberty and justice[32]. This ethical component can be further detailed by including the ethics of care[33], where the moral salience of meeting the needs of vulnerable groups also implies the question of which vulnerable groups need more or equal protection in the current crisis, entailing perhaps equal weights for groups affected directly by Covid-19 and groups affected by the containment measures. It could be more informative (and perhaps less triggering in the public debate) to define the problem using cultural norms, drawing on cultural theories of risk[3435] which inform a criteria evaluation according to the analytic tool which distinguishes five cultural typologies – individualism, egalitarianism, hierarchism, fatalism and autonomy – characterising people's preferences regarding how to manage, for instance, a pandemic. An individualist voice would choose a cost-benefit calculation, favouring a narrative that recognizes the trade-off between lives saved and economic costs, and between lives lost short-term and long-term. If the individualist would support a set of measures to 'flatten the curve' as long as it would not bring intolerable economic costs (see, for instance, public statements voicing concerns that the cure must not be worse than the disease[36]), an egalitarian would reject economic considerations and cost-benefit analyses, placing a higher value on equity and on protecting vulnerable groups of the population first.

Depending on the available time frame, on the level of access to different stakeholder groups as well as on external circumstances which could make collaborative workshops difficult to organize (such as strict social distancing measures), various elicitation methods can be used to obtain rankings of the criteria with various degrees of robustness. Data from available surveys on social values[37] and cultural frames[38] can provide a preliminary hierarchy of people's values in the region where the measures have to be selected. Such frames can be identified in existing cultural analyses of specific regions, but they can also be extracted from public statements and texts circulated in mass media and social media, once the problem becomes part of the public agenda. These, however, have some limitations in eliciting evaluations from multiple stakeholders, as the visibility of different voices in the public sphere is not equal and is often affected by, among other things, restricted access, media partisanship, echo chambers, and institutional and commercial dominance. One of the challenges in designing a participatory approach to multi-criteria decision analysis is,

[32] Bernstein J, Hutler B, Rieder T, Han H, Barnhill A. An Ethics Framework for the COVID-19 Reopening Process (2020). Available at: https://bioethics.jhu.edu/research-and-outreach/covid-19-bioethics-expert-insights/resources-for-addressing-key-ethical-areas/grappling-with-the-ethics-of-social-distancing/ [Accessed May 14, 2020].

[33] Held V. The Ethics of Care: Personal, Political and Global. Oxford and New York: Oxford University Press (2006). 211p.

[34] Douglas M, and Wildavsky AB. Risk and Culture: An essay on the selection of technical and environmental dangers. Berkeley: University of California Press (1982). 224p.

[35] Thompson M, Ellis R, and Wildavsky A. Cultural Theory. Boulder: Westview Press (1990). 296p.

[36] The New York Times. Trump Says Coronavirus Cure Cannot 'Be Worse Than the Problem Itself (2020). https://www.nytimes.com/2020/03/23/us/politics/trump-coronavirus-restrictions.html [Accessed March 29, 2020].

[37] Schwartz SH. "Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries,". In Zanna M P, editor. Advances in experimental social psychology, Volume 25. San Diego, CA: Academic Press (1992). pp. 1-65.

[38] Thompson M, Ellis R, and Wildavsky A. Cultural Theory. Boulder: Westview Press (1990). 296p.

therefore, to avoid reproducing the same inequalities in representation that are well-known in mainstream as well as social media.

A full societal analysis is far beyond the ambitions of this report, but it deserves to be emphasised that there are several options to create a transparent and deliberated framework for eliciting societal preferences. To demonstrate a comparatively uncomplicated method for at least obtaining a template for how a larger-scale survey could look, we designed a series of questionnaires by which to elicit some stakeholders' preferences and tested them in Romania on a limited amount of stakeholders, addressing differences in risk perception and in assessing the severity of the risks, and further on in Jordan, on a larger number of stakeholders. A continuation here could be the organisation of stakeholder processes with the implementation of further engagement methods such as discussion workshops and forums when this is again possible vis-à-vis mobility and other restrictions. Our former experiences in particular regarding stakeholder workshops in a structured manner have been very promising[39].

2. The evaluation process

For the particular evaluations in our suggested framework, we use a method for integrated multi-attribute evaluation under risk, subject to incomplete or imperfect information. The software originates from our earlier work on evaluating decision situations using imprecise utilities, probabilities, and weights, as well as qualitative estimates between these components derived from convex sets of weight, utility and probability measures. To avoid some mathematical aggregation problems when handling set membership functions and similar, we introduced higher-order distributions for better discrimination between the possible outcomes[40]. For the decision structure, we use a common tree formalism. The data quality and regional conditions can be very different and there are thus large uncertainties in the background material that must be considered. We must therefore have a mechanism for taking this into account, but still being able to use the available data, even if the actual uncertainties are significant, and the use of, e.g., precise numbers is misleading. To alleviate some of the problems, we suggest a new evaluation method based on the resulting belief mass over the output intervals, but without trying to introduce further complicating aspects into the decision situation. During the process, we consider the entire range of values as the alternatives presented across all criteria as well as how plausible it is that an alternative outranked the remaining ones, and thus provide a robustness measure. Because of the complexity in these calculations, we use the software tool DecideIT for the analysis which allows for imprecision of the kinds that exist in this case. The tool is based on patented algorithms[41] and several versions have been successfully used in a variety of decision

[39] Komendantova N, Ekenberg L, Marashdeh L, Al-Salaymeh A, Danielson M, and Linnerooth-Bayer J. Are Energy Security Concerns Dominating Environmental Concerns? Evidence from Stakeholder Participation Processes on Energy Transition in Jordan. Climate (2018) 6:88. doi: https://doi.org/10.3390/cli6040088.

[40] Danielson. M, and Ekenberg L. An Improvement to Swing Techniques for Elicitation in MCDM Methods, Knowledge-Based Systems (2019). doi: https://doi.org/10.1016/j.knosys.2019.01.001

[41] Danielson M, Ekenberg L, inventors. Method for decision and risk analysis in probabilistic and multiple criteria situations. United States patent US 7257566 (2007).

situations, such as large-scale energy planning[42], allocation planning[43], demining[44], financial risks[45], gold mining[46], and many others[47].

In the suggested framework, stakeholder preference elicitation is used for building preference structures where potential conflicts can arise. Here so-called surrogate weights have turned out to be useful, but since the elicitation can still be uncertain and the surrogate weights might not be a fully adequate representation of the preferences involved, we also work with intervals and their associated belief distributions, to accommodate for the uncertainties involved[4849].

The multi-criteria decision problem is evaluated as a multi-linear problem against the (imprecise) background information; in the next section, we provide the computational details of this process. Solving multi-linear optimisation problems is generally hard. There have been several attempts to solve such problems, for instance, using active set methods or simplex-like methods using varieties of reduced gradients. There are also algorithms based on primal, dual, or primal-dual active set methods, that also are less suited for the problems that we have at hand. Further methods are based on linear complementarity programming theory, where iterative schemes are introduced. These general methods have their merits, but when working with imprecise information and using various kinds of sensitivity analyses, the decision problems that we are concerned with here become quite simple but non-linear indefinite. The main iteration of our particular method generates iterative sequences that are computationally demanding from an interactive point of view, why general methods are less adequate for such problems. We base the multi-linear solver on a set of algorithm libraries particularly designed for such problems[50]. The details of these libraries are beyond the scope of this article. However, we below discuss the main principles from a conceptual viewpoint.

2.1. Rankings

We have in a number of papers argued for a set of alternatives to standard ways of addressing rankings in a computationally meaningful way. A promising such has turned out to be a new cardinal ranking method and we have there demonstrated that it is both more

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[42] Komendantova N, Ekenberg L, Marashdeh L, Al-Salaymeh A, Danielson M, and Linnerooth-Bayer J. Are Energy Security Concerns Dominating Environmental Concerns? Evidence from Stakeholder Participation Processes on Energy Transition in Jordan. Climate (2018) 6:88. doi: https://doi.org/10.3390/cli6040088.

[43] Larsson A, Fasth T, Wärnhjelm M, Ekenberg L, Danielson M. Policy Analysis on the Fly with an Online Multi-Criteria Cardinal Ranking Tool. Journal of Multi-Criteria Decision Analysis (2018). doi: https://doi.org/10.1002/mcda.1634.

[44] Ekenberg L, Fasth T, and Larsson A. Hazards and Quality Control in Humanitarian Demining. International Journal of Quality & Reliability Management (2018) 35:4. doi:10.1108/IJQRM-01-2016-0012.

[45] Danielson M, and Ekenberg L. "Efficient and Sustainable Risk Management in Large Project Portfolios". In Zdravkovic J, Grabis J, Nurcan S, Stirna J, editors. Perspectives in Business Informatics Research: Proceedings. Springer (2018). p. 143-157.

[46] Mihai A, Marincea A, Ekenberg L. A MCDM Analysis of the Roşia Montană Gold Mining Project. Sustainability (2015) 7: 7261–7288. doi:10.3390/su7067261.

[47] Ekenberg L, Hansson K, Danielson M, Cars G. Deliberation, Representation, and Equity: Research Approaches, Tools, and Algorithms for Participatory Processes. Open Book Publishers (2017). 380p. doi: 10.11647/OBP.0108.

[48] Danielson. M, and Ekenberg L. An Improvement to Swing Techniques for Elicitation in MCDM Methods, Knowledge-Based Systems (2019). doi: https://doi.org/10.1016/j.knosys.2019.01.001.

[49] Danielson M, Ekenberg L, Larsson A. A second-order-based decision tool for evaluating decisions under conditions of severe uncertainty. Knowledge-Based Systems (2020) 191. doi:10.1016/j.knosys.2019.105219.

[50] Danielson M, Ekenberg L. "Development of Algorithms for Decision Analysis with Interval Information,". In Fujita H, Mařírk V, editors. New Trends in Software Methodologies, Tools and Techniques. Amsterdam, NL: IOS Press (2009). p.314 - 335.

robust than the ones from the SMART family, AHP and many others, c.f., e.g.[51] for an overview. Below we briefly outline the main ideas behind this, using the notation from[52].

Assuming an ordering of *N* criteria, where we have an informal strength notation between the criteria as well as the measures in question, we suggest the translation:

$>_0$ Equally important (as good as)

$>_1$ Slightly more important (slightly better than)

$>_2$ More important (better than)

$>_3$ Much more important (much better than)

We here use $>_i$ to express the strength in the rankings between criteria and measures, where $>_0$ is the usual ordinal ranking $>$. For instance, in a criteria ranking, we get a user ordering $w_1 >_{i_1} w_2 >_{i_2} \ldots >_{i_{n-1}} w_n$. This is transformed into an ordering containing the symbols = and > by introducing auxiliary variables $x_{(ki)}$:

$w_k >_0 w_{k+1}$ is $w_a = w_b$

$w_k >_1 w_{k+1}$ is $w_a > w_b$

$w_k >_2 w_{k+1}$ is $w_k > x_{k(1)} > w_{k+1}$ (1)

...

$w_k >_i w_{k+1}$ is $w_k > x_{k(1)} > \cdots > x_{k(i-1)} > w_{k+1}$

This defines a new Euclidian space defined by the simplexes constrained by the new orderings and we obtain a computationally meaningful representation of the strengths. Now the number transformation of the criteria ranking is given by assigning a number to each position in the complete ordering, starting with the most important position as number 1. Each criterion *i* then get the position $p(i) \in \{1,\ldots,Q\}$, where *Q* is the total number of positions. For every two adjacent criteria c_i and c_{i+1}, whenever $c_i >_{s_i} c_{i+1}$, $s_i = |\, p(i+1) - p(i)\,|$. Position *p(i)* thus represents the importance as stated by the decision-maker.

The weights are then obtained by

$$w_i^{CSR} = \frac{{}^{1}/_{p(i)} + \frac{Q+1-p(i)}{Q}}{\sum_{j=1}^{N}\left({}^{1}/_{p(j)} + \frac{Q+1-p(j)}{Q}\right)}$$

The transformation of the mitigation value orderings is analogous. In summary, the process is then simple:

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[51] Danielson M, Ekenberg L. Automatic Criteria Weight Generation for Multi-Criteria Decision Making under Uncertainty, to appear in the proceedings from Innovation for Systems Information and Decision: Models and Applications,". In Lecture Notes in Business Information Processing Volume 405. Chennai, India: Springer (INSID 2020).

[52] Danielson M, Ekenberg L. The Car Method for using Preference Strength in Multi-Criteria Decision Making. Group Decision and Negotiation (2016) 25:4. doi:10.1007/s10726-015-9460-8.

1. For each criterion in turn, rank the alternatives from the worst to the best outcome. The strength is expressed in the notation with '$>_i$' symbols.
2. For each criterion in turn, rank the importance of the criteria from the least to the most important. The strength is expressed in the notation with '$>_i$' symbols.
3. The weighted overall value is calculated by multiplying the centroid of the weight simplex with the centroid of the alternative value simplex.

Thus, the transformation of the rankings does not introduce any computational difficulties.

2.2. Evaluation Method

What we actually evaluate here are special cases of expected values, weighted by criteria weights and (in some cases) probabilities. Furthermore, we use interval considerations that can be represented by random variables to take the inherent uncertainties into consideration. The general expected value in these contexts can be expressed as:

$$E(M_i) = \sum_{l_1=1}^{n_0} w_{l_1} \sum_{l_2=1}^{n_1} w_{l_1 l_2} \cdots \sum_{l_{m-1}=1}^{n_{m-2}} p_{l_1 l_2 \cdots l_{m-2} l_{m-1}} \sum_{l_m=1}^{n_{m-1}} p_{l_1 l_2 \cdots l_{m-2} l_{m-1} l_m} v_{l_1 l_2 \cdots l_{m-2} l_{m-1} l_m 1} \ ,$$

given the distributions over random variables *w*, *p* and *v*.

To evaluate this, we use the methods from this paper[53], taking into account that there are only two operators of relevance here, multiplication and addition. The addition case is covered by ordinary convolution, i.e., assume that *h* is the distribution on a sum $z = x + y$ associated with the distributions $f(x)$ and $g(y)$. Then the resulting distribution $h(z)$ is

$$h(z) = \frac{d}{dz} \int_0^z f(x) g(z - x) dx.$$

The multiplication case is quite similarly handled. With the same assumptions as above, the cumulative multiplied distribution $h(z)$ is derived by first defining

$$H(z) = \iint_{\Gamma_x} f(x) g(y) dx dy = \int_0^1 \int_0^{z/x} f(x) g(y) dx dy = \int_z^1 f(x) G(z/x) dx$$

where *G* is a primitive function to *g*, $\Gamma_z = \{(x,y) \mid x \cdot y \leq z\}$, and $0 \leq z \leq 1$.

Then let *h(z)* be the corresponding density function:

$$h(z) = \frac{d}{dz} \int_z^1 f(x) G(z/x) dx = \int_z^1 f \frac{f(x) g(z/x)}{x} dx.$$

Thus, the addition of the products is the standard convolution of two densities and the multiplication part is handled by a just slightly more complicated operation. Combining these two operations, we straightforwardly obtain the distribution over the expected utility.

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[53] Danielson M, Ekenberg L, Larsson A. A second-order-based decision tool for evaluating decisions under conditions of severe uncertainty. Knowledge-Based Systems (2020) 191. doi:10.1016/j.knosys.2019.105219.

The results of the process will then be a detailed analysis of each option's performance compared with the others, and a sensitivity analysis to assess the robustness of the result. During the process, the entire range of mitigation measures across all criteria can be analysed as well as how plausible it was that a strategy would outrank the remaining ones, and thus provide a robustness measure for the stability of the respective strategies.

PART III: CASE STUDIES

1. Botswana

In Botswana, we conducted a preliminary analysis of the decision context, available measures and possible criteria to be considered, out of which the most stringent was the epidemiologic one. After an initial round of consultations with members of the Covid-19 Task Force in Government, we decided that due to the limited data available on socioeconomic impacts, we would focus on the epidemiologic model, which was also provided to decision-makers and served as a basis for their pandemic response.

Botswana is an interesting case study for analysing different measures' impacts. First, it has a very young population with the median age of the population being 19.7 years in comparison to 38.4 in China and 43.1 in Europe. As evidence from other countries shows, the most severe impact from Covid-19 was on the elderly population. Second, because of the increased vulnerability of the Botswanan population to pandemic risk due to a high prevalence of HIV, TB, malnutrition and anaemia. In the year 2000, Botswana was among the countries with the highest prevalence of HIV in the world and the last decade of HIV treatment has shown to be a success story. However, the health-care system is already stretched due to the high prevalence of diabetes, hypertension, cardiovascular and renal diseases as well as cancer and accidents. It also remains insufficiently prepared to provide the necessary equipment and care for Covid-19 patients. Third, because social distancing measures might not be easy to implement in Botswana because of cultural and religious practices as well as commuting to relatives in rural areas.

1.1. Initial pandemic response

Most of the Sub-Saharan countries are facing the same challenges when it comes to health systems. Botswana, despite being among the fastest-growing African economies, is sharing the same problems as other countries in the region. Ever since it gained independence in 1966, Botswana has had an exponential growth mainly based on revenue from the mining industry and also from tourism and meat production. In the past few years, it became clear that there is a great need to diversify the economy and stimulate local production in order to create more jobs and reduce dependence on its neighbours, mainly South Africa. Another challenge Botswana has is a scarce population of just over 2 million and a huge territory the size of France or Texas. Some parts of Botswana that belong to the Kgalagardi desert have a very low density of population, less than 10 per km^2.

The first three Covid-19 cases were detected in Botswana in March 2020. Starting from April 2020 the government of Botswana introduced the lockdown measures including social distancing, restriction of movements, hand hygiene, sanitising, closure of borders and of all non-essential services. Besides having positive impacts on flattening the curve of infected people, these measures, as everywhere else, had a negative impact on socioeconomic

development, especially on local industry and the educational system. Following the situation in neighbouring countries like South Africa where, by the beginning of March 2020, there were over several hundred patients including local transmissions, the Botswana Government decided to take similarly radical steps and lock down the country on the 3rd of April 2020. Borders were closed and people coming from the outside quarantined.

A proportionate response to the risk situation needs to take into consideration the social and economic impacts as well, which may be unprecedented, as estimated by the Southern African Development Community (SADC), due to financial and healthcare systems' limitations. Multiple factors and stakeholders need to be included in opting for a set of measures.

Africa Center for Strategic Studies has estimated for Botswana a risk factor of 18, which was among the lowest on the continent. The risk factor resulted from mapping the relative levels of vulnerability considering a country's international exposure, its public health system, the density and total population of urban areas, the population age, the level of government transparency, press freedom, conflict magnitude and forced displacement, concluding that "with early identification and isolation of cases, [it] may be better able to minimize the worst effects of this pandemic"[54]. Elsewhere[55], it was estimated that Botswana is among the countries with a non-negligible risk, exposed exclusively to the potential risk from airports in the Fujian province; since then, however, in April, the first community transmitted cases were registered. Furthermore, the World Health Organization estimated the country's readiness status in February as being "adequate"[56] and in the most recent situation update for the WHO African Region, it was recommended for countries with under 100 confirmed infections that "measures to contain or at least delay the spread of the outbreak need to be intensified; including active case finding, testing and isolation of cases, contact tracing, physical distancing and promotion of good personal hygiene practices"[57]. For other African countries, other analyses have suggested more severe measures, such as for instance the London School of Hygiene & Tropical Medicine (LSHTM) recommending for Nigeria a strategy which would combine the above WHO measures with "lockdowns of two months' duration, where socioeconomically feasible"[58] to delay the epidemic and gain time for planning and resource mobilization.

The effects of a lockdown compared to other mitigation measures are yet unclear; in South Africa, for instance, it was noticeable that its epidemic trajectory had started to flatten before the lockdown effects coming into place, but it is yet to be determined whether the slowed rate of infections was due to lower testing, missing cases in poorer communities or travel and public gatherings restrictions put in place before the lockdown. Some argue[59] that given the lack of certainty about the effectiveness of a lockdown at specific local levels, a direct involvement of the local communities in African countries in the decision over measures would be desirable, as they can provide the needed contextual knowledge and specific

[54] https://africacenter.org/spotlight/mapping-risk-factors-spread-covid-19-africa/
[55] https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30411-6/fulltext
[56] http://whotogo-whoafroccmaster.newsweaver.com/JournalEnglishNewsletter/g65c7ca8gui
[57] https://apps.who.int/iris/bitstream/handle/10665/331840/SITREP_COVID-19_WHOAFRO_20200422-eng.pdf
[58] https://www.lshtm.ac.uk/newsevents/news/2020/strategies-combining-self-isolation-moderate-physical-distancing-and-shielding
[59] https://www.bbc.com/news/world-africa-52268320

issues which must be included so as to preserve basic livelihoods through the chosen local strategy.

There are a few immediately visible effects of the lockdown, aside from the epidemiological ones. On the downside, industry sectors are affected to an extent that is difficult to estimate, for instance, triggering, for now, a Covid-19 Pandemic Relief Fund with a capitalization of 2 billion Pula from the Government. This was to be distributed according to four strategic objectives: for wage subsidies for business sectors with a few exceptions for the industries which continue their activity, for stabilizing businesses by offering, for instance, government loan guarantees and making tax concessions, then for ensuring strategic reserves and for promoting opportunities for the sectors which can upscale their local production. The educational system is also highly affected, as the Ministry of Basic Education signalled, who estimates that learners might find themselves in the situation of repeating their classes in 2021-2022. The closure of schools is making the duration of the current school year insufficient to meet the minimum requirements for school days number in an academic year.

Botswana could have possible advantages in the local demographics and population distribution, as mentioned above. The population of the country is young. As evidence from other countries shows, the most severe Covid-19 cases were among the elderly groups of the population. Due to the demographic situation in Botswana, the mortality rate in this country could be lower than in China and Western Europe. The density of the population in Botswana is also lower than in Europe or in China. But the healthcare system remains insufficiently prepared to provide the necessary equipment and care in case the number of Covid-19 cases will be high. It is estimated that Botswana has approximately 100 ICU fully equipped beds and 2,000 overall available hospital beds. There are also associated comorbidities such as malaria, HIV/AIDS and tuberculosis which can influence the number of potentially severe cases.

Lockdown can be an opportunity to gain the time that is necessary to increase the healthcare capacity. The government will need international support to build capacities of its medical system, such as an improvement of testing capacity and medical equipment. Such international support might not be readily available because developed countries are dealing themselves with the consequences of the pandemic[60].

Each alternative of a set of Covid-19 risk mitigation measures will have implications for socioeconomic development in the country. Therefore, the needs of various social groups and stakeholders should be considered while drafting policy measures and action plans for future pandemic risk mitigation and management. As the evidence on current pandemic risk management shows, there has been an astonishing lack of coordinated actions. Also, no vision was developed for the management of a similar or even a more serious event in the future.

There are no entirely value-neutral policy plans. Opting for the most popular vision and choosing a seemingly reasonable path ultimately requires tackling medical and financial considerations, as well as differing societal preferences together, rather than as separate issues. Understanding of preferences from various stakeholders' groups such as policy-

[60] https://news.berkeley.edu/2020/03/31/africa-faces-grave-risks-as-covid-19-emerges-says-berkeley-economist/

makers, industry, young community, civil society and academia, contributes significantly to social acceptance of risk mitigation measures. Guided by the hypothesis that contributions to such a development and preferences amongst societal stakeholders are just as important as medical or regulatory issues, ICoBaS addresses benefits and costs, perceptions and preferences, potentially arising conflicts between stakeholder groups, and political requirements of different pathways.

1.2. Criteria set

A multi-criteria decision analysis should include collected data following a **criteria setup** which is subject to refinement when gathering more available evidence. The following are important criteria sets to include:

- ✓ Epidemiological & healthcare systems: direct fatalities, indirect fatalities;
- ✓ Economic aspects: short term costs, unemployment, taxes, specific industries affected, growing industries;
- ✓ Social and behavioural aspects: criminality rates, domestic violence, mental health, education and training, social division, trust in government;
- ✓ Environmental: climate change, pollution;
- ✓ Long-term resilience: remote work and education, improving prevention and hazard response, social inclusion and coping with loneliness;
- ✓ Political: Risk of short-term and long-term abuses, citizen dissatisfaction.[61]

1.3. Epidemiologic model results

In epidemiology, so-called SIR, or SEIR, models are very common to represent the spread of disease in a population. People are divided into three (or four) compartments; susceptible (S), exposed (E), infected (I) and recovered (R), and in some models also deaths (D). In these models, a system of coupled differential equations governs the flows between the different compartments over time, people becoming infected move from S to I, and people who recover (or die) move from I to R.

System Dynamics is a natural choice for implementing models simulating transmission processes since the methodology presupposes a holistic approach and focuses on how the parts in the system affect each other with reinforcing or balancing feedback loops[62;63]. A common SEIR model operates on the following parameters: individual mortality; disease spread rate; recovery rate and the mean infection time, rate of movement from the exposed class to the infectious class and the mean latency period, and the basic reproduction 'R_0'[64].

[61] For other effects on non-medical and non-financial sectors, we need further data regarding the educational system, how many are affected, what kinds of long-term effects are coming and what are the mitigation plans and known effects.
[62] Forrester, J. W. 1968. Principles of Systems. Cambridge MA: Productivity Press
[63] Sterman JD. 2001. System Dynamics Modeling: Tools for learning in a Complex World. California Management Review. 2001;43(4).
[64] Li, M.Y. and Muldowney, J.S. 1995. Global Stability for the SEIR Model in Epidemiology. Mathematical Biosciences.Vol.125, pp.155-164

During planning for intervention measures against outbreaks of pandemics, various computer-based support tools are commonly used. For instance, in Sweden, the National Board of Health and Welfare has supported research and development of a decision support tool to complement the individual-based, total population model MicroSim[65]. The primary requirements for tools of this kind were that they should support scenario analysis, i.e. to run "what – if" experiments, and that the tools should be implemented in quick time and easy to adapt and run. The quality of the model output is also important, but precise forecasts are typically essential to produce acceptable forecasts in a timely manner. During the latter decade, various simulation environments have emerged, such as AnyLogic, enabling for swift usage of generic SEIR modelling which has been used in some recent studies, including studies of the Corona SARS-2, MERS, and the Zika virus[66];[67].

There are several studies investigating specific performance aspects of interventions against pandemics but they are most often limited to a single scenario, as well as seldom being designed to explicitly acknowledge the inherent uncertainties in both simulation results and scenario likelihoods. We have previously applied a dynamic multi-criteria decision analysis approach to synthesize outcome predictions from multiple models and explicitly elicit and imbed stakeholder preferences into decision recommendations[68]. Conforming to such an approach, dynamic, comprehensive, and transparent decision-making is enabled.

It should be emphasised that the model we have used in this tentative framework is quite simple despite there are a huge number of models around. There are nevertheless quite strong reasons to keep as much as possible as simple as possible. The more input parameters we have, the more diffuse everything becomes if we cannot make them local due to the already enormous state space. The big challenge here is rather to get the input data realistic there are still many critical uncertainties with Covid-19 and models with higher complexity than the training and validation data should be used very sparingly as decision bases.

For the example simulation (in AnyLogic 8) below, the input parameters are detailed in Appendix 1. The results from the basic assumptions are provided in the figure below. This is however based on an incomplete data set that must be adjusted and adapted to different regions, in particular since SARS-COV-2 does not seem to behave like e.g. a seasonal influenza, but is acting more "regional" than usual. The particular conditions in Botswana cannot really be compared in a simple way and the micro- and meso perspectives must play an important role.

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[65] Brouwers L, Camitz M, Cakici B, Mäkilä K, Saretok P. 2009. MicroSim: Modeling the Swedish Population. arXiv:0902.0901. Available from: http://arxiv.org/abs/0902.0901.

[66] Shi, P., Dong, Y., Yan, H., Zhao, C., Li, X., Liu, W., He, M., Tang, S., Xi, S. 2020. Impact of temperature on the dynamics of the COVID-19 outbreak in China. Science of the Total Environment 728.

[67] Jang, J. and Ahn, I. 2016. Simulation of Infectious Disease Spreading based on Agent Based Model in South Korea. Advanced Science and Technology Letters Vol.128, pp.53-58

[68] Fasth, T., Talantsev, A., Brouwers, L., Larsson, A. 2017. A Dynamic Decision Analysis Process for Evaluating Pandemic Influenza Intervention Strategies. ISPOR Value in Health, Vol. 20(9).

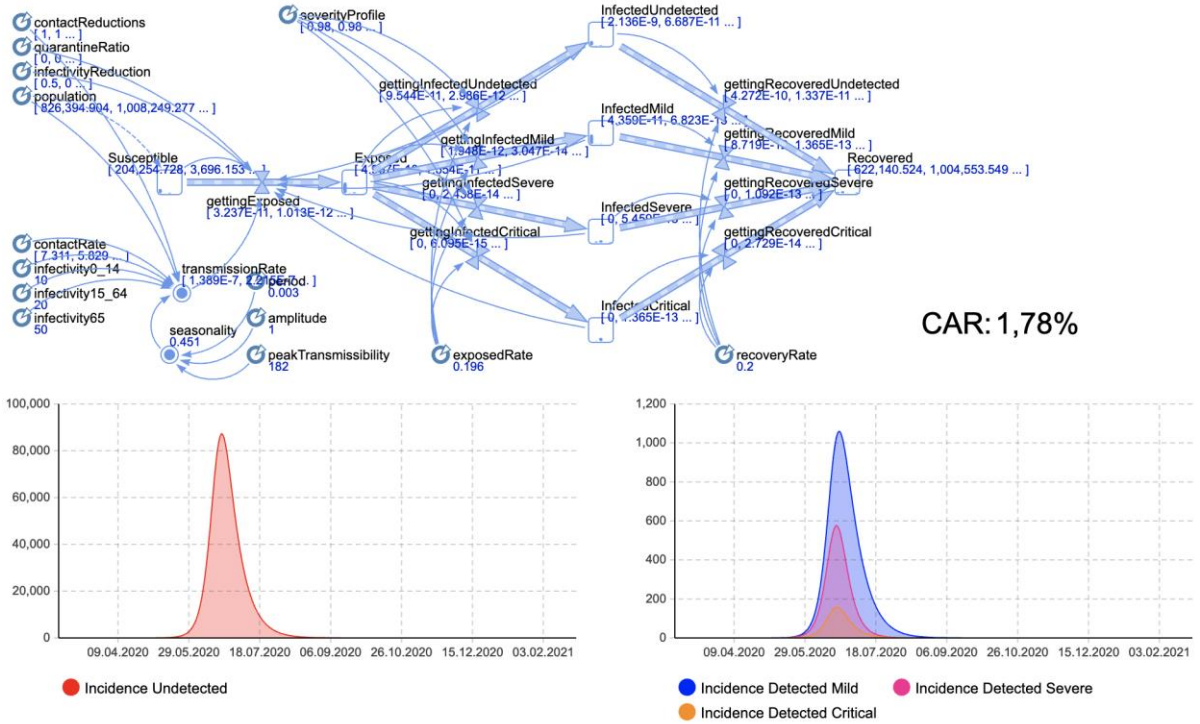

Figure 1. Estimations of detected and undetected cases in Botswana

2. Romania

In Romania, previous risk assessments of severe flu epidemic scenarios made in 2016[69] considered a novel flu virus strain with an attack rate of 35% (higher among children), a case fatality rate between 0.4 and 1.2%, leading to 30,000 hospitalizations and more than 1,000 deaths among the vulnerable age groups: people of all ages suffering from chronic illnesses, healthcare system employees, social protection facilities' employees and residents, and elderly people. In terms of impact, the health and healthcare costs were considered very high, while the economic costs were estimated to have a medium impact of 101-500 million Euro (0.03% of GDP). The non-pharmaceutical measures to contain this epidemic scenario included possible school closures affecting, for more than a week, 500,000 students at most, temporary workplace disruptions affecting mostly 500,000 employees and postponements of cultural and sports events. In contrast, between March 2020 and July 2020, the partial lockdown measures taken to contain the novel coronavirus in Romania severely affected 900,000 primary and secondary school students with no access to education for 4 months[70], led to over 900,000 suspended work contracts and almost 300,000 unemployed. The economic costs associated with the measures had an impact of over 4 billion euro (1.7-1.9% of GDP) by July 2020[71][72], at a time when in Romania there were 1,900 deaths caused by

[69] National Institute of Public Health. Descriere 5 scenarii reprezentative - epidemii (2016). https://gis.ro-risk.ro/site/documente/RezultateRO-RISK/Epidemii/Cap.4.%20Descriere%205%20scenarii%20epidemii_draft.pdf [Accessed May 19, 2020].

[70] Fundatia Viata si Lumina, FEPAL - Federatia Parintilor si Apartinatorilor Legali, IRES. Școala în stare de urgență: Accesul copiilor școlari din România la educație online - Studiu național (2020). https://ires.ro/uploads/articole/ires_accesul-elevilor-scolari-la-educatie-online_policy-paper_mai-2020.pdf [Accessed June 1, 2020].

[71] Ministry of Public Finances. Executia bugetului general consolidat (2020). https://www.mfinante.gov.ro/static/10/Mfp/buget/executii/nota_bgcmai2020.pdf?fbclid=IwAR1TyhNP7uechKn4zMrfxKzJNzPtFf2dDAhQ4WgX2vH8M-hMhbS_E9i_TXg [Accessed May 30, 2020].

Covid-19, the majority of confirmed cases (over 40,000) being however asymptomatic or mild. The uncertainty of epidemiologic evidence transferred to general uncertainty about policy impact, leading to much higher socioeconomic costs than the ones previously envisioned in case of a severe epidemic.

We use our framework to evaluate different measures that could be adopted in Romania in response to the epidemic against a subset of criteria from the larger set described above in Part I, section 2.3. These were ranked by a small group of stakeholders in a consultation process using an online questionnaire which will be discussed in the next subsection. Then, we describe the input data to estimate the impacts of the alternative measures across every criterion.

Identifying the best set of measures to be implemented would firstly involve defining possible alternatives for Romania's response to the epidemic. Typical mitigation measures are partitioned into sets with different subordinate restriction levels, reflecting some important aspects of possible mitigation strategies, such as[73] going from an unmitigated epidemic to a suppression strategy or proposing a schedule for every industrial sector activity in a risk adjustment strategy[74]. Another option is to devise a set of measures that combines these approaches and also reflects the most common public debates on this issue:

- Level 1: An unmitigated epidemic – a scenario in which no other action is taken except pharmaceutical measures and case isolation;
- Level 2: Mitigation adding to pharmaceutical measures and case isolation, public communication encouraging increased hygiene and personal protection, localized action (closing a school/workplace in case of a number of cases) - influenza epidemics protocol
- Level 3: Mitigation adding to pharmaceutical measures and case isolation, personal protective measures (stay home when sick, hand-washing, respiratory etiquette, clean frequently touched surfaces daily, wearing face masks), mild social distancing measures (large public gatherings banned, work from home where possible, social distancing recommended);
- Level 4: Suppression (partial lockdown) - pharmaceutical measures and case isolation, personal protective measures (stay home when sick, hand-washing, respiratory etiquette, clean frequently touched surfaces daily, wearing face masks), imposed social distancing measures and restrictions on mobility: school closures, restaurants and large shopping centres closed, 'stay-at-home' orders - as implemented in Romania for 2 months.

[72] Comisia Naţională de Strategie şi Prognoză. Proiecția principalilor indicatori macroeconomici - 2020 (2020). http://www.cnp.ro/user/repository/prognoze/Prognoza_principalilor_indicatori_macroeconomici_2020_varianta_preliminara.pdf [Accessed April 25, 2020].

[73] Ferguson N, Laydon D, Nedjati-Gilani G et al. Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. Imperial College London (16-03-2020). doi: https://doi.org/10.25561/77482.

[74] Government of South Africa. Draft Framework for Consultation on COVID-19 Risk Adjusted Strategy (2020). https://sacoronavirus.co.za/covid-19-risk-adjusted-strategy/ [Accessed April 30, 2020].

A full-scale multi-criteria decision analysis should also include collected data following a more extensive criteria setup which can be subject to refinement when gathering more available evidence, but for demonstrational purposes, we use the following criteria:

Health impact

- Direct fatalities

Economic impact

- Short-term costs
- Impact on specific industries

Socio-behavioural impact

- Human rights
- Vulnerable groups
- Access to education
- Mental health

Political and governance impact

- Risk of governmental abuses
- Resilience

On these aspects, we have gathered stakeholder preferences as described below and we have estimated the values for the respective measures under each criterion, the input data being explained further in sections 2.2.1 and 2.2.2. Needless to say, other data, such as business demographics data would be required to produce an estimate of how many lives can be saved as well as what the direct short-term and long-term costs of different risk mitigation measures would be. For our purposes here, we will handle this on a higher level of abstraction. Each component requires a significant amount of investigation in itself regarding the correlations between different factors, so the actual estimates herein are used for demonstration purposes only and can be updated with more extensive impact assessments. As more data becomes available from these fields, the model can be continuously updated for every criterion to produce new results, without its performance being affected.

2.1. Eliciting stakeholder preferences

The participatory process was organized in the form of an in-depth web-based survey. The questionnaire for this survey was developed based on a comprehensive literature review about factors that are relevant for Covid-19 disaster risk reduction, and it addressed questions regarding risk perception, preferences for measures to be taken, and evaluations of relative criteria importance. We used an automatic web questionnaire (Appendix 2) to elicit stakeholder opinions, which was sent in June-July 2020 to 17 government officials, 16 healthcare experts, 11 representatives from the business sector, 9 non-governmental organizations and 11 experts from academia. 16 respondents filled in the questionnaire, out of which three were medical doctors specialized in epidemiology, pulmonology and public healthcare, five were university researchers specialized in sociology, political sciences and philosophy, one was a representative of a workers' federation in Romania, and the rest were employees in the public sector and in NGOs. Since the purpose of the questionnaire was to both test the validity of the elicitation method for multi-criteria multi-stakeholder decision analyses on pandemic responses, and to obtain a sample of criteria rankings for our demonstrative evaluation, we consider the number to be sufficient, but not by any means representative at a national scale. In a full-scale setting, this should be quantitatively and

qualitatively elaborated in a variety of respects, and augmented, e.g., via stakeholder discussion workshops, preferably supported by institutions with decision-making attributions in managing the epidemic crisis.

The result of this survey was that two-thirds of the respondents considered that an unacceptably high mortality from Covid-19 in Romania would have been between 1,001 and 5,000 deaths, a risk they considered to be very serious and very likely to happen.[75] One-third of the respondents (mainly sociology and public health policy experts) perceived the risk differently since the mortality caused by Covid-19 deemed by them to be unacceptable was significantly higher (between 10,001 and 20,000 deaths), an outcome which they estimated to be likely or very likely. Depending on this risk perception, stricter social distancing measures to keep the critical cases within the acceptable range can be justified or not, so a more representative number of respondents could ensure that the response to the current pandemic is not perceived as being disproportionate.

The most stringent problems brought by the SARS-CoV-2 pandemic in Romania were, according to the responses, the following (in no particular order): premature deaths and threats to people's health; the economic impact, including social and economic depression, loss of jobs, small companies closing down; the increased social isolation of the elderly and of those with less material means; overburdening the healthcare system, the lack of education for personal hygiene; the risks for mental health; the population's lack of trust long-term and disrespect towards rules, as well as the political calculations above medical and scientific interventions and the lack of evidence in decisions made. These suggested problems confirm the reliability of the proposed set of criteria for our integrated model of evaluation.

The survey asked respondents to evaluate 6 different measures, including alongside the ones we describe a testing and contact tracing strategy and enhanced isolation of the elderly strategy; however, since both of them are unfeasible for Romania, the former due to lack of infrastructural capacity and the latter due to a downright rejection of it by the public on ethical grounds, our evaluation focuses on the 4 alternative measures and selected criteria listed above. In evaluating the set of measures, respondents' preferences were expressed by ordering the given alternative measures, followed by the ordering of the different criteria and sub-criteria, from the least important (coded with the value 0) to the most important aspects (coded with value 14) for them. The results of their aggregated weights show that the measures preferred by respondents in mitigating the SAS-CoV-2 epidemic in Romania are the ones that have been applied in real-life (lockdown – Level 4 in our analysis), followed by the measures being applied during influenza epidemics (Level 2) and by Sweden's measures (Level 3). These weighed significantly more than not using any non-pharmaceutical measures to mitigate the epidemic (Level 1). In what concerns the criteria rankings relevant for our demonstration here, respondents considered that the health aspects were much more important than the economic impact, which in turn was seen as much more important than social and behavioural aspects. The political and governmental aspects were weighed as being less important than the social aspects. In what concerns sub-criteria, the impact on specific industries was considered more important than the short-term costs (measured here through GDP decrease). The impacts on human rights, on

[75] When the questionnaire was sent, there had already been over 1,500 deaths caused by COVID-19 in Romania.

education and on mental health were seen as equally important, while the impact on vulnerable groups was considered much less important than the former aspects. How these weights are calculated in the formal decision analysis will be explained in section 2.3.

2.2. Value estimates

In this section, we will describe the data collection process on which the value estimates used in our impact assessments for the chosen criteria rely. Since the biggest degree of uncertainty, but also the justification of some countries' mitigation measures, resided in estimations of the virus spread and resulting fatalities, we will firstly present a model we have used to estimate the direct fatalities which would result in the 4 different scenarios under evaluation. Secondly, we will describe socioeconomic data on which our assessments were based. What is important for the evaluation of alternatives is to have variables that indicate the impact of every set of measures at a local level; thus, matters such as infrastructure (number of hospitals, ICU beds or ventilators), access to healthcare or institutional capacity, which are not influenced by the non-pharmaceutical measures considered here, represent the local benchmark used when comparing the impact estimations. Such a benchmark could be set, as abovementioned, by the Global Health Security Index[76] or by the INFORM Risk Index[77], where Romania's estimated risk class is low, but its institutional coping capacity is at high risk (INFORM Institutional 5.7).

2.2.1. Epidemiologic model results

In epidemiological modelling, there are various tools available for supporting scenario analyses and (assumingly) producing acceptable forecasts in a timely manner. System Dynamics is a natural choice for implementing models simulating transmission processes since the methodology presupposes a holistic approach and focuses on how the parts in the system affect each other with reinforcing or balancing feedback loops[7879]. The family of SEIR (Susceptible, Exposed, Infected, Recovered) models are quite common to represent the spread of disease in a population, where people are divided into compartments depending on their immunity status. In these models, a system of coupled differential equations governs the flows between the different compartments over time, where people becoming infected move from S to I and people who recover (or die) move from I to R. SEIR models usually operate on individual mortality, disease spread rate, recovery rate and the mean infection time, rate of movement from the exposed class to the infectious class, the mean latency period, and the basic reproduction number R_0[80]. During the latter decade, various simulation environments have also emerged, such as AnyLogic, enabling for swift usage of, e.g., generic SEIR modelling which has been used in some recent studies, including studies of the Corona SARS-2, MERS, and the Zika virus[8182]. Alternative models are taking more

[76] GHS. Global Health Security Index (2020). https://www.ghsindex.org/ [Accessed June 15, 2020].
[77] European Commission DRMKC. INFORM Risk Index 2021 (2021). https://drmkc.jrc.ec.europa.eu/inform-index/ [Accessed January 15, 2021].
[78] Forrester JW. Principles of Systems. Cambridge MA: Productivity Press (1968).
[79] Sterman JD. System Dynamics Modeling: Tools for learning in a Complex World. California Management Review (2001) 43:4. doi:10.2307%2F41166098.
[80] Li MY, Muldowney JS. Global Stability for the SEIR Model in Epidemiology. Mathematical Biosciences (1995) 125:155-164.
[81] Shi P, Dong Y, Yan H, Zhao C, Li X, Liu W, He M, Tang S, Xi S. Impact of temperature on the dynamics of the COVID-19 outbreak in China. Science of the Total Environment (2020) 728. doi: https://doi.org/10.1016/j.scitotenv.2020.138890.
[82] Jang J, Ahn I. Simulation of Infectious Disease Spreading based on Agent Based Model in South Korea. Advanced Science and Technology Letters (2016) 128:53-58.

parameters into account and hopefully producing better predictions. For instance, in Sweden, the National Board of Health and Welfare has supported research and development of a decision support tool to complement the individual-based, total population model MicroSim[83,84]. In order to model the effects of containment measures applied for a specific demographic, models such as[85] or the Covid-19 scenarios at the University of Basel[86], or another candidate in the abundance thereof, could also be considered depending on the circumstances and the available level of specificity for the data sets, social characteristics and healthcare capacity. There are still many critical uncertainties with Covid-19 and every model with higher complexity than the training and validation data should be used very carefully as a decision basis, why the micro- and meso perspectives must again play an important role.

For our purposes herein, we apply regionalised demography augmented SEIR model for modelling the health effects of various risk mitigation measures. The model thus requires country-specific information (see Appendix 3) including population size in country/region/city divided into age groups, so as to model the effects of various measures in the desired area. It moreover can include morbidities in the population per age group, inasmuch as these figures are available in national statistics and relevant literature, and current numbers of confirmed cases per day, divided per age group and case severity. The benchmark for the medical system capacity (no. of ICU beds, ventilators, medication, testing capacity) should in principle be run against structural possibilities to increase it in a given timeframe, namely access to national or international funds, workforce capacity, relevant research, etc. As will be seen from the example demonstration below, it seems to work quite decently, but can be substituted by any other adequate one if preferred and more data is available.

The simulations of the measures' effects in containing the virus spread in Romania below were made in AnyLogic 8, based on a data set that should be adjusted and adapted to different regions. As input, the model uses the Romanian population divided into three age groups: 0–19, 20–59, and 60 years or older, according to national severity profiles which show a higher incidence of severe Covid-19 cases and deaths in the 60+ age group, due to existing comorbidities[87]. The number of days between being infected to becoming infectious is, on average, 5.1 days[88,89], and the time being infectious 5.0[90]. The model was fitted against the daily number of reported cases, fatalities and ICU occupancy in Romania by

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[83] Brouwers L, Camitz M, Cakici B, Mäkilä K, Saretok P. MicroSim: Modeling the Swedish Population. arXiv [Preprint] (2009). Available at: http://arxiv.org/abs/0902.0901.

[84] Brouwers L, Cakici B, Camitz M, Tegnell A, Boman . Economic consequences to society of pandemic H1N1 influenza 2009: Preliminary results for Sweden. Euro Surveill (2009) 14:37. doi: https://doi.org/10.2807/ese.14.37.19333-en.

[85] Flaxman S, Mishra S, Gandy A et al. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. Nature (2020) 584: 257–261. doi: https://doi.org/10.1038/s41586-020-2405-7.

[86] Noll N, Aksamentov I, Druelle V, Badenhorst A, Ronzani B, Jefferies G, Albert J, Neher R. COVID-19 Scenarios: an interactive tool to explore the spread and associated morbidity and mortality of SARS-CoV-2. medRxiv [Preprint] (2020). Available at: https://doi.org/10.1101/2020.05.05.20091363.

[87] Pantea Stoian, A., Pricop-Jeckstadt, M., Pana, A. et al. Death by SARS-CoV 2: a Romanian COVID-19 multi-centre comorbidity study. Sci Rep 10 (2020) 21613. doi: https://doi.org/10.1038/s41598-020-78575-w.

[88] Li Q, Guan X, Wu P et al. Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus– Infected Pneumonia. N Engl J Med (2020) 382:1199-1207. doi: 10.1056/NEJMoa2001316.

[89] Linton NM, Kobayashi T, Yang Y et al. Incubation Period and Other Epidemiological Characteristics of 2019 Novel Coronavirus Infections with Right Truncation: A Statistical Analysis of Publicly Available Case Data. J Clin Med (2020) 9:2. doi:10.3390/jcm9020538.

[90] Wölfel R, Corman VM, Guggemos W et al. Virological assessment of hospitalized patients with COVID-2019. Nature (2020) 581:465-469. doi:https://doi.org/10.1038/s41586-020-2196-x.

January 3rd, 2021. An infectivity parameter, a relative contact reduction, and the proportion of unreported cases were calibrated for each age-group. Unreported cases were assumed to be less infectious than reported cases, considering that these have milder symptoms. The contact profile changes three times during the simulation, and we have two periods with different infectivity and share of unreported. Further details regarding input parameters are found in Appendix 3. This baseline scenario was then used to simulate the various strategies of mitigation, starting with January 3rd, 2021. The 14-day case notification rate per 100.000 was 253.08, a significantly increased rate compared to the June-July period when the rate was 31.2.

The results from the four alternative measures with their assumptions are provided in Figures 2-5 below, where the simulated results from December 31, 2019, to the end of 2021 are shown together with the actual reported cases by January 3rd, 2021. Since our example uses values estimating the impact of various measures for the year 2020, in estimating direct fatalities we have summed the total of unreported infections in one year for scenarios 1-4 and then assumed an overall infection fatality rate of 0.23[91], which can, of course, be modified accordingly when other values are established either per the general population, or per age group.

In the figures below, the red graphs show the number of simulated reported positive cases per day, and the blue ones show the simulated unreported cases per day:

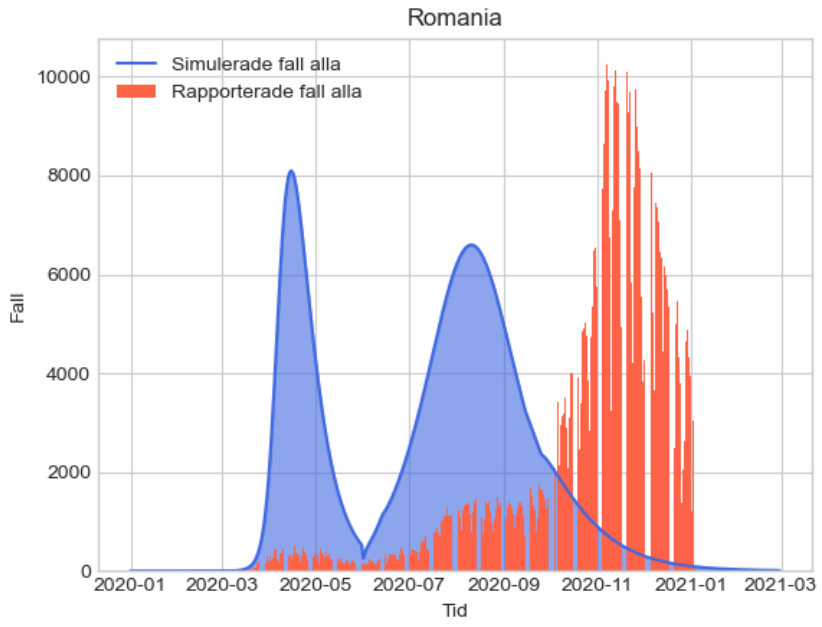

Figure 2. L1: Epidemiologic evolution without any social distancing measures. Total unreported cases 2020-2021: 14,260,483.4; total unreported cases 2020: 14,260,483.4; total estimated fatalities 2020: 32,799.11182

[91] Ioannidis, J. P A. Infection fatality rate of COVID-19 inferred from seroprevalence data. Bulletin of the World Health Organization (2021) 99:19-33F. doi: http://dx.doi.org/10.2471/BLT.20.265892.

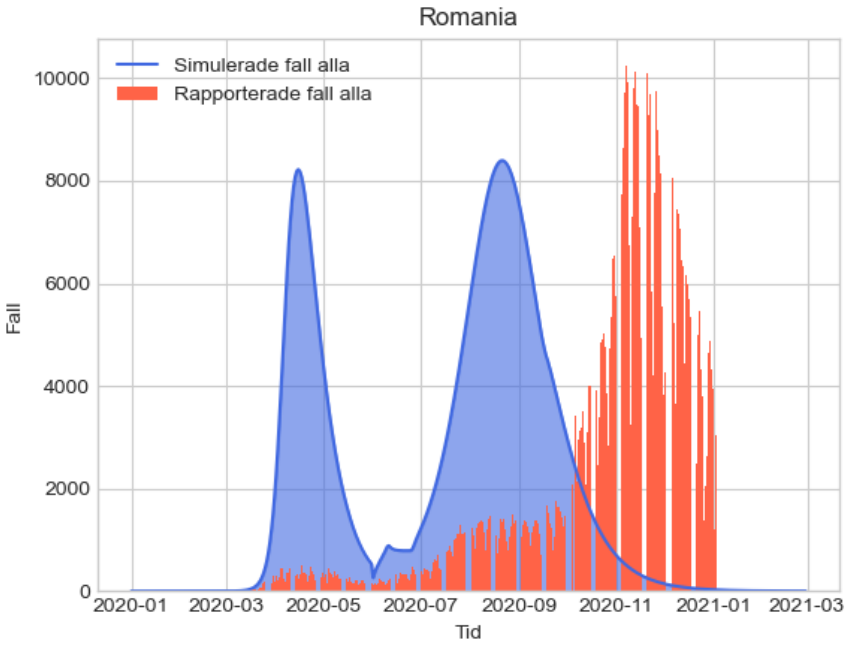

Figure 3. L2: Epidemiologic evolution using the influenza season protocols. Total unreported cases 2020-2021:14,855,222.113; total unreported cases 2020: 14,847,477.491; total estimated fatalities 2020: 34,149.19

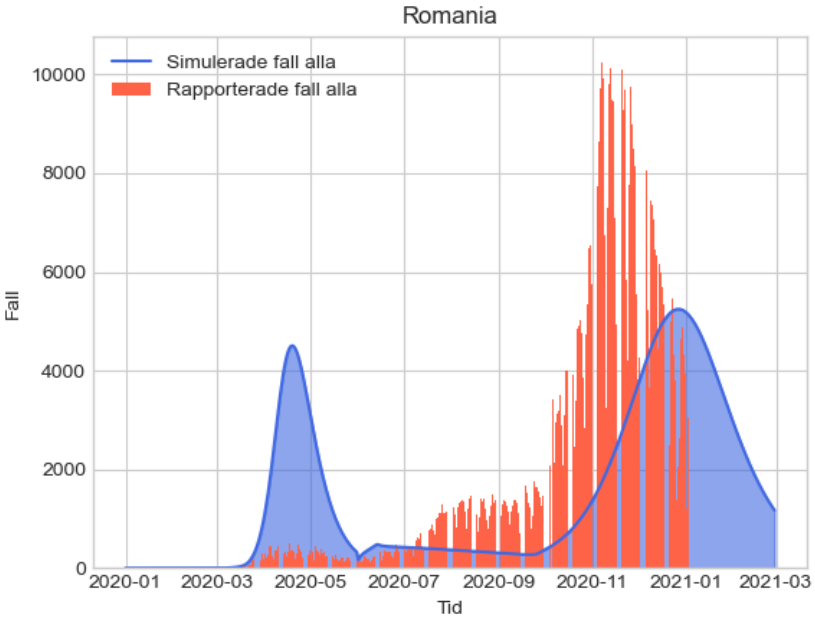

Figure 4. L3: Epidemiologic evolution with social distancing recommended. Total unreported cases 2020-2021: 12,930,507.92; total unreported cases 2020: 9,623,212.942; total estimated fatalities 2020: 22,133.38

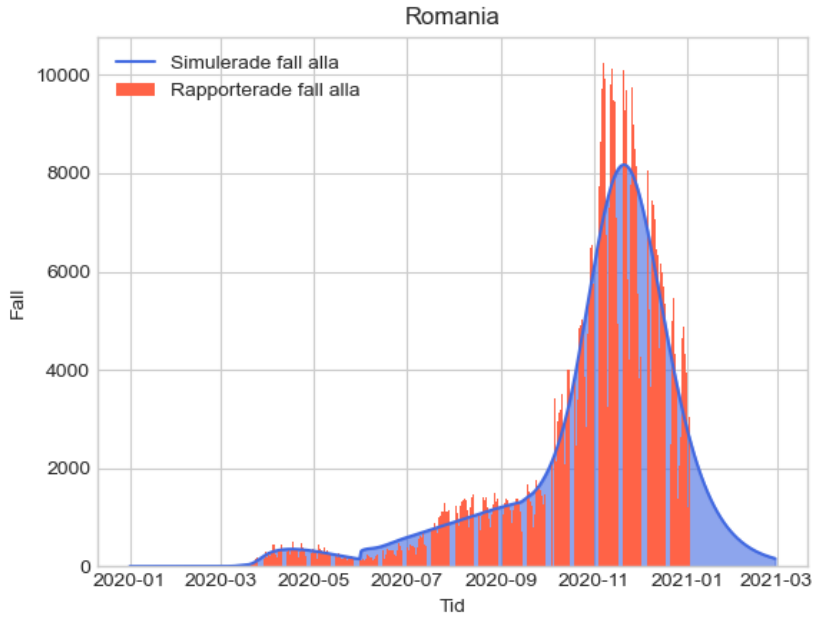

Figure 5. L4: Epidemiologic evolution with suppression for 2 months. Total unreported cases 2020-2021: 13,490,259.84; total unreported cases 2020: 12,525,884.439; total estimated fatalities 2020: 28,809.53

Since the estimations do not take into consideration other factors such as improvements of treatments, regional patterns of spread and other variables, we used a 10% confidence interval for the total estimated fatalities. In this case, in scenario 4 using the real-life measures taken in Romania, we obtain an interval of [25929; 31691]. This is consistent with the sum of reported fatalities in Romania caused by Covid-19 in 2020 (around 17,000) and excess deaths caused by conditions which could reasonably be attributed to undetected Covid-19, such as, among others, circulatory system diseases (10,000 more deaths than in 2019). Recent analyses based on excess mortality in Romania in 2020 also suggest that the real figure of Covid-19 fatalities was most likely over 26,000 in the first year of the pandemic[92].

2.2.2. Socioeconomic estimates

If the number of total Covid-19 fatalities for every level was obtained using the abovementioned epidemiologic model, the estimated socioeconomic impact of every set of measures was based on various data sources and indices, which will be explained below. These estimations can, of course, be refined at any point. The framework does not depend on the input data or on certain epidemiologic or economic models chosen to generate such data. However, the results of the final evaluation of alternatives do depend on the input data, therefore the following evaluation is subject to change if different data will be produced. Note that in the evaluations, we make the quite uncontroversial assumptions that more cases, less GDP decrease, and fewer students getting education are considered to be inferior to fewer cases and so on.

[92] Sandu, D. Câți români a ucis COVID-19 cu adevărat? (2021). https://mindcraftstories.ro/coronavirus/cati-romani-a-ucis-covid-19-cu-adevarat/ [Accessed January 22, 2021].

The short-term costs are measured by GDP growth, which was -5.0 in Romania in 2020[93], this corresponding to our Level 4, the real-life scenario where the two months of lockdown included closures of non-essential shops, restaurants, theatres and schools, among others. Employees working in affected sectors were sent to technical unemployment, and the government introduced a deferral of payment of certain taxes and utilities, as well as a moratorium on loan repayment for companies and individuals. Monthly estimates of GDP growth in 2020 recorded by the Covid-19 – Romanian Economic Impact Monitor[94] show that the GDP growth forecast was estimated at -10.3% during the lockdown, followed by -5.7% in July-September and by -1.5% in October-December 2020, as various sectors were allowed to reopen their activity and citizen mobility increased. Taking into consideration the various trans-border effects of measures taken within the EU and globally, affecting macroeconomic indicators and some sectors' activities, including trade and tourism, we have estimated GDP deficits for other scenarios as being slightly smaller in case of recommended social distancing and much smaller in case no social distancing measures are introduced. Similarly, the effect of the four different mitigation strategies upon specific sectors' economic activity gradually worsens as more sectors are either closed or are indirectly affected by closures and imposed social distancing. According to the abovementioned Economic Impact Monitor, economic activity indicators show that, aside from health services and the public administration sectors, all other economic sectors were negatively impacted, the most affected industries being tourism and hospitality (-64.4% in Q2 of 2020), culture and arts (-60.4%) and the heavy industries (-29.1%). In Q3, corresponding to a Level 3 stringency level in our evaluation, most sectors recovered, aided by governmental fiscal facilities as well, except for agriculture (-19.4%). It is, thus, reasonable to consider that the more stringent the measures are, the more industries get negatively impacted, resulting in the ordinal ranking in Table 1 below.

Qualitative assessments are also made for two socio-behavioural criteria, namely human rights and mental health. The impact of alternative measures upon these aspects also worsens as stringency levels increase; before introducing lockdown, the Romanian state activated Art. 15 of the European Convention on Human Rights on March 15, 2020. The derogation gave the government broad powers in taking measures to contain the spread of the virus, trading off rights such as access to healthcare, freedom of movement, freedom of assembly, access to justice and access to education[95]. For two months, both public and private hospitals suspended healthcare for all non-emergent medical cases by a governmental order, affecting chronic patients' treatments: compared with 2019, in April and May 2020 there were 70.98% and, respectively, 61.48% fewer hospitalizations, and specifically around 80% less chronic patients' hospitalizations[96]. In Romania, there are 17,500 TB patients, 16,500 HIV patients, over 1 million diabetes patients and 488,824

[93] European Commission. Economic forecast for Romania. https://ec.europa.eu/info/business-economy-euro/economic-performance-and-forecasts/economic-performance-country/romania/economic-forecast-romania_en [Accessed February 15, 2021].
[94] UBB-FSEGA. COVID-19 - Romanian Economic Impact Monitor (2020). https://econ.ubbcluj.ro/coronavirus/ [Accessed January 28, 2021].
[95] Human European Consultancy. Coronavirus pandemic in the EU – Fundamental Rights Implications. Romania (2020). https://fra.europa.eu/sites/default/files/fra_uploads/ro_report_on_coronavirus_pandemic_june_2020.pdf [Accessed November 30, 2020].
[96] Fundația Romanian Angel Appeal – Apelul Îngerului Român and Observatorul Român de Sănătate. Impactul pandemiei COVID-19 asupra accesului bolnavilor cronici la servicii medicale. Focus pe TBC, HIV, oncologie, diabet (2020). https://health-observatory.ro/wp-content/uploads/2020/10/Raport_ORS-impact_pandemie_cronici_2020.pdf [Accessed October 3, 2020].

cancer patients. For estimating the impact on human rights of other measures, we take into consideration border restrictions, case quarantine and temporary school closures (Level 2), as well as limits to the freedom of assembly through bans of large gatherings (Level 3).

In what concerns mental health, preliminary reports from the COH-FIT project[97] on Romanians' mental health during the pandemic show worsening stress and nervousness levels reported by almost half of respondents within the population aged 28-50 years old, as well as an intensification of pre-existing conditions reported by a third of respondents, and an increased sense of loneliness. The reported factors which exacerbated the impact were poverty, unemployment, physical diseases and the loss of a loved one. During lockdown, a series of five national surveys on Romanians' perceptions, attitudes and behaviours, conducted by the Romanian Institute for Evaluation and Strategy (IRES), showed that loneliness was substantially reported by teenagers and by the elderly respondents, while 4 in 10 respondents reported they feared losing their means of livelihood because of the crisis[98]. Separating measures' effects from the effects the pandemic itself has is difficult since Covid-19 and the fear of disease can cause declining mental health and well-being on their own, as reports have shown. However, declining mental health due to isolation and financial scarcity associated with job losses can be attributed to mitigation measures. Therefore, we have considered that the impact of Levels 1 and 2 on mental health is smaller than the impact of Level 3, which involves social distancing, the highest negative impact on this criterion being under Level 4.

For estimating the impact of various measures on education, we looked at the number of school days lost in each case. During the lockdown period, an initial school closure for 18 days led 3,526,200 students to not have access to education. After this, the educational activities were resumed online for another 36 days, but an estimated number of 903,870 students (32% of pre-university students) did not have access to distance learning due to lack of material means, such as digital devices or internet access[99]. From September until November 2020, more localized measures were introduced, whereby the choice for face-to-face, hybrid or distance learning was continuously revised based on incidence rates at county levels, therefore a precise number of days lost during this period is difficult to estimate. After November 9th, all schools switched to distance learning. In estimating the number of days for other measures, we assume schools do not close (Levels 1 and 3) or that only schools with 3 confirmed cases switch to distance learning for 14 days (Level 2).

In estimating the impact of mitigation measures upon vulnerable groups we used values from the INFORM Index for Risk Management, where Romania had a score of 1.7 for the Vulnerability component for 2020. Compared to 2019, this score has remained constant and the Vulnerable group's indicator has slightly improved (from 1.5 to 1.4), but data reliability in estimating its sub-indicators could be affected by the reduced access to healthcare during and after lockdown by chronic patients, as described above. Moreover, the socioeconomic

[97] Romania Insider. The emotional impact of COVID-19: Romanians are sadder and angrier, study shows (2020). https://www.romania-insider.com/covid-romanians-sadder-angrier-study [Accessed January 4, 2021].
[98] IRES. O lună de singurătate: Starea emoțională a românilor în pandemie (2020). https://ires.ro/articol/389/o-luna-de-singur-tate---starea-emo%C8%9Bional%C4%83-a-romanilor-in-pandemie [Accessed May 2, 2020].
[99] IRES. Școala în stare de urgență: Accesul copiilor școlari din România la educație online. https://cdn.edupedu.ro/wp-content/uploads/2020/05/ires_accesul-elevilor-din-romania-la-educatie-online_studiu-national_aprilie-2020.pdf [Accessed May 2, 2020].

vulnerability has worsened, in particular with regard to inequality (from 2.7 to 3.5). For these reasons, we use the general Vulnerability Index in our estimates, which we suggest would be lower for Levels 1-3, in correlation with less severe economic impacts.

Finally, we have used two more indices, this time to assess the measures' effects on political and governance aspects; the risk of governmental abuses was measured through the 2020 Democracy Index[100] and the impact on resilience was estimated using Bloomberg's Covid Resilience Ranking[101]. Compared to 2019, the functioning of government has slightly worsened (from 5.71 to 5.36), decreases in political culture (from 4.38 to 3.75) and civil liberties (from 7.65 to 7.06) also being noticeable during the pandemic. We assume that, as civil liberties would increase under Levels 3, 2 and 1, so would Romania's democracy score. Other sources can of course be used, such as the Political and security risk and the Socioeconomic resilience indicators of the Global Health Security (GHS) Index, both indicators mainly relying on data from The Economist Democracy Index.

Needless to say, the values should, in an extended analysis, be refined through economic models, empirical data, more well-deliberated qualified estimates, etc. The measures considered under the respective criteria are summarised in Table 1.

Table 1. The value estimates for the respective measure under each criterion:

Criterion /	Health	Economic		Social and behavioural				Political and governance	
Measure	Direct fatalities	Short term costs	Impact on specific industries	Human rights	Vulnerable groups	Access to education	Mental health	Risk of abuses	Resilience
Level 1	29438.1 - 35979.9	1-3	Better than L2	Better than L2	1.4	0	Better than L3	6.49	47.9
Level 2	30733.2 - 37562.8	1-4	Better than L3	Better than L3	1.4	14-28	Better than L3	6.49	44.9
Level 3	19752.3 - 24141.7	3-5	Much better than L4	Better than L4	1.6	0	Better than L4	6.44	50.9
Level 4	25830 - 31570	5-6			1.7	54-84		6.4	41.9

[100] The Economist Intelligence Unit. Democracy Index 2020: In sickness and in health? (2021). https://www.eiu.com/n/campaigns/democracy-index-2020/ [Accessed February 2, 2021]

[101] Bloomberg. The Covid Resilience Ranking. The Best and Worst Places to Be in Covid: U.S. Stages a Recovery (2020). https://www.bloomberg.com/graphics/covid-resilience-ranking/ [Accessed February 20, 2020].

2.3. Measures and Criteria

As described in section 2.1, the sampled opinions are too few to be representative and the example questionnaire is not granulated enough for a real model input, which is why the limited representation below should be considered as a model demonstration and not a policy recommendation. It nevertheless indicates that this representation format actually is very feasible (see Appendix 4) and should be quite straightforward to use in an extended study, thus we suggest a representation of a subset of the preferences as a ranking of the criteria:

CH2: Direct fatalities >> Economic >> Social and behavioural > Political and governmental
CH1: Industrial effects > Short term GDP
CH3: Human rights = Access to education = Mental health >> Vulnerable groups
CH4: Resilience >> Risk of governmental abuses

This is not a pure ordinal ranking and we have to use a different representation thereof. We need supplementary statements for the criteria to calibrate the different scales involved since they are of very different character and we simply assume (because a formal P-SWING procedure was not performed) that this representation becomes the criteria tree in Figure 6.

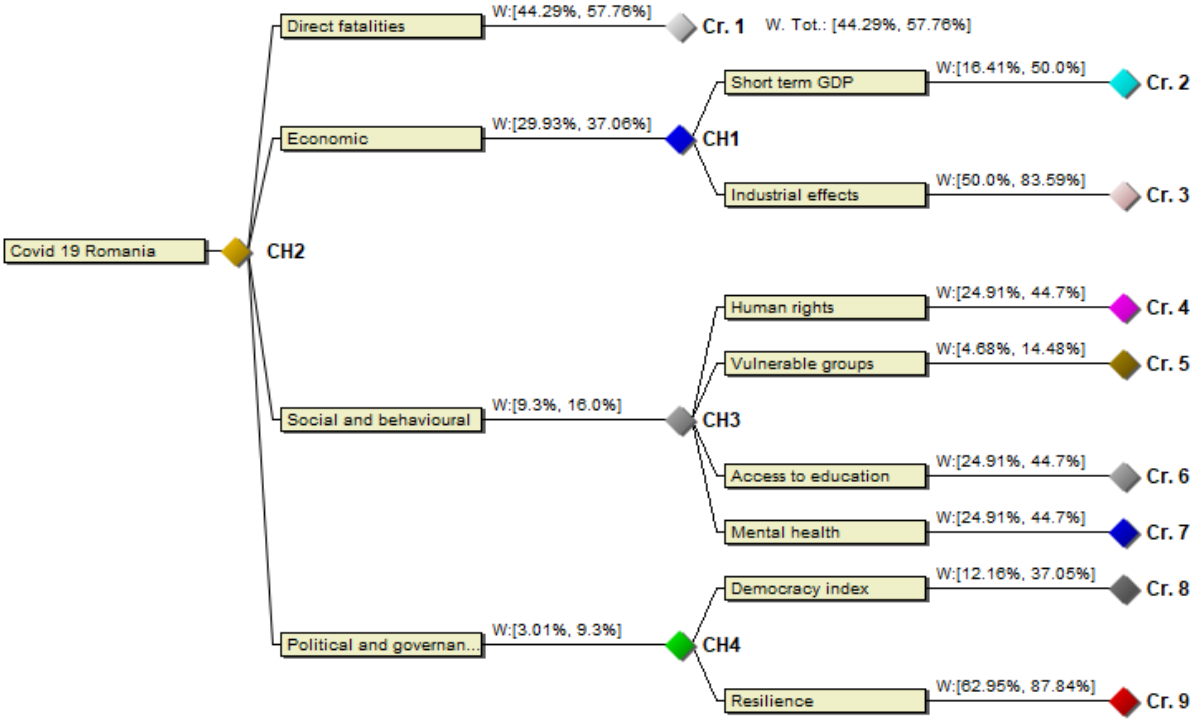

Figure 6. Criteria tree for Covid-19 response measures in Romania

We then again use the notation from[102] to represent the strength of the rankings between the criteria by introducing auxiliary variables x_i and we obtain the ranking w(fatalities) > x_1 > w(economy) > x_2 > w(social) > x_3 > w(political), denoting the weight of fatalities by w(fatalities) and so on. This theory behind the process is explained in detail in ibid. Using the more elaborated theory, we could considerably have refined the elicitation of the rankings between criteria, but such an analysis is beyond the scope of this article. Finally, for the alternatives, we have a mixture of interval estimates and a ranking.

[102] Komendantova N, Ekenberg L, Marashdeh L, Al-Salaymeh A, Danielson M, and Linnerooth-Bayer J. Are Energy Security Concerns Dominating Environmental Concerns? Climate (2018) 6:88. doi: https://doi.org/10.3390/cli6040088.

2.4. Aggregation and Evaluation

The multi-criteria decision problem is evaluated against the background information using the method described in Part II of the present report, Section 2.2. This means in this simple case, without sub-criteria, that we evaluate weighted averages of the figures involved, or, more precisely, equations of the format $E(M_j) = \Sigma w_i v_{ij}$, where w_i is the weight variable of criterion *i* and v_{ij} is the value variable of measure *j* under criterion *i*. The value $E(M_j)$ is computed by solving successive optimisation problems by the program DecideIT, implementing the ideas described in Part II, Section 2.2. The result of our example is provided in Figure 7.

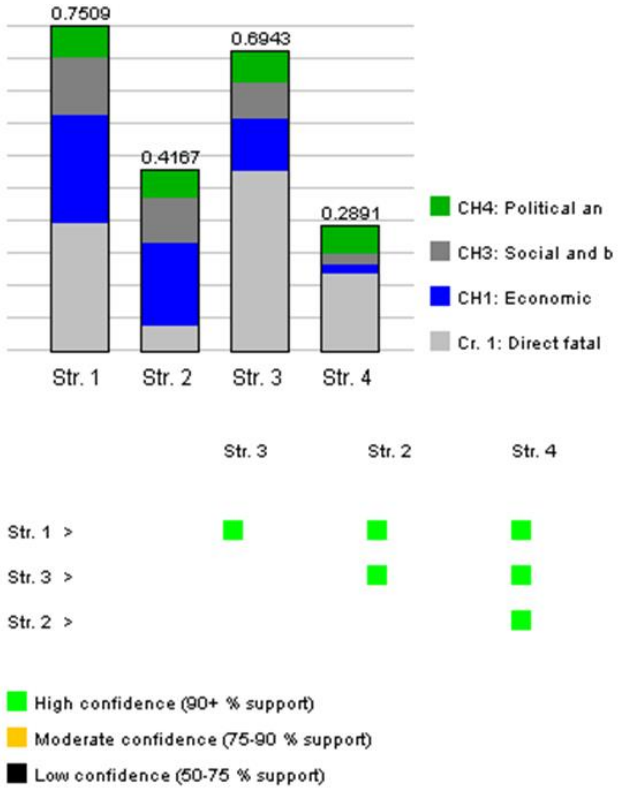

Figure 7. The result of the DecideIT evaluation showing ranking, the criteria contribution as well as the significance of the result

In the figure, the higher the bar for the measure, the better it is, given the background information. The bars also show how much each criterion contributes to the respective values, based on the possible ranges of the resulting weighted averages of the respective measures. Furthermore, the robustness of the opinions is colour-marked. Green means that there is a significant difference between the features and that there must be substantial changes in the input data for it to change. Yellow means that there is still a difference, but it is more sensitive to input data. Black means that there is no significant difference between the desirability of the measure. The confidence measure just the proportion of the volume under the resulting distribution as explained in Part II, Section 2.2. An extended explanation

of the semantics regarding the bars and the colour-markings is also provided in this reference[103].

In summary, the differences are all significant where L1 is the best strategy, followed by L3, L2 and L4. L1 is clearly the best option in this example. Furthermore, this result is quite robust. We can also note how this significantly differs from the uninformed intuitive rankings from the results of the questionnaire.

Needless to say, different data would affect the result. For instance, if we consider when all main criteria are unweighted, given the value ranges, the result would be the one in Figure 8. As can be seen from the figure, the ranking is unchanged, but the difference between L2 and L3 has decreased.

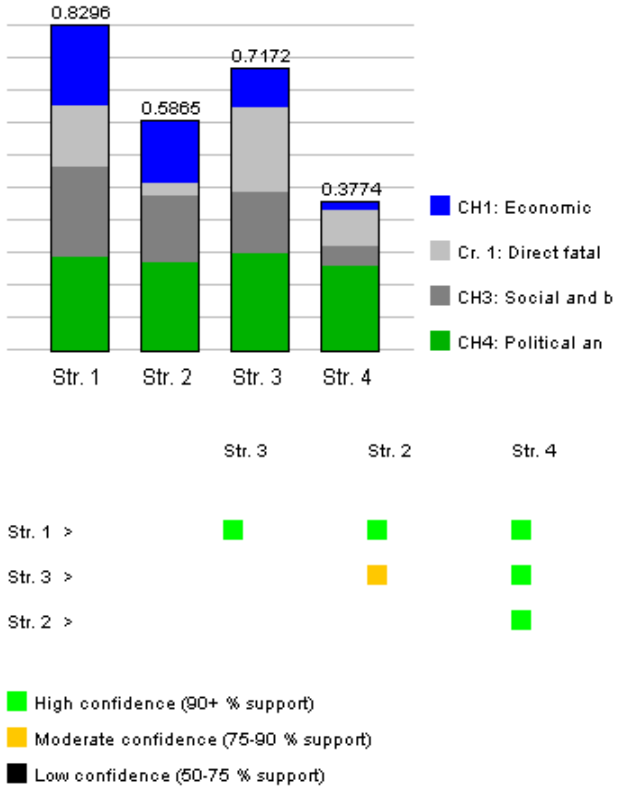

Figure 8. The result of the DecideIT evaluation when the criteria are considered to be equally important

Note again that our point here is not that this in any way provides a conclusive recommendation plan. Our purpose here is to demonstrate a methodology for solving such complex problems under large uncertainties in multi-stakeholder settings and to show as well that there are effective tools available for the quite elaborate calculations involved.

[103] Danielson M, Ekenberg L, Komendantova N, Al-Salaymeh A , Marashdeh L. "A Participatory MCDA Approach to Energy Transition Policy Formation,". In: de Almeida A, Ekenberg L, Scarf P, Zio E, Zuo MJ, editors. Multicriteria Decision Models and Optimization for Risk, Reliability, and Maintenance Decision Analysis - Recent Advances. Springer International Publishing (2020).

3. Jordan

Jordan was one of the top countries in the world which imposed full lockdown after the spread of the pandemic on the 14th of March 2020. The Covid-19 pandemic risk mitigation measures included pharmaceutical measures and case isolation, personal protective measures (stay home, hand washing, respiratory etiquette, clean frequently touched surfaces daily, wearing face masks) as well as the defence-first order with different imposed measurement; social distancing measures and restrictions on mobility: school closures, restaurants and large shopping centres closed. People could only go out only for their basic necessities. The lockdown lasted during the period from 18.03.2020 until 29.04.2020. On the 29th of April 2020 and until the 6th of June 2020 the Government of Jordan announced partial lockdown with extensive telework where it was possible. The movement between various regions of Jordan was restricted. This lockdown in Jordan heavily affected its economy. The daily workers were affected the most, followed by employees of the private sector.

During the summer, the number of Covid-19 cases declined, however, they started to increase sharply again in September 2020. The government of Jordan reacted with a full lockdown on Fridays and the introduction of e-learning in universities and schools. During this period all socioeconomic sectors in Jordan became affected including education, political, economic, social and health sectors. By the size of the population, Jordan ranks 11th in the Arab world.

The statistical data for this report were collected during the period of March 2020 until January 2021. Data were collected from various sources such as the database of the Ministry of Health and the World Bank as well as economic data on GDP and other economic parameters from the Department of Statistics.

3.1. Measures and criteria under evaluation

For Jordan, we used the same alternative measures for evaluation as in the Romanian case:

- Level 1: An unmitigated epidemic – a scenario in which no other action is taken except pharmaceutical measures and case isolation;
- Level 2: Mitigation adding to pharmaceutical measures and case isolation, public communication encouraging increased hygiene and personal protection, localized action (closing a school/workplace in case of a number of cases) - influenza epidemics protocol
- Level 3: Mitigation adding to pharmaceutical measures and case isolation, personal protective measures (stay home when sick, hand-washing, respiratory etiquette, clean frequently touched surfaces daily, wearing face masks), mild social distancing measures (large public gatherings banned, work from home where possible, social distancing recommended);
- Level 4: Suppression (lockdown) - pharmaceutical measures and case isolation, personal protective measures (stay home when sick, hand-washing, respiratory etiquette, clean frequently touched surfaces daily, wearing face masks), imposed social distancing measures and restrictions on mobility: school closures, restaurants and large shopping centres closed, ‘stay-at-home’ orders

We used a subset of criteria for which value estimates could be made, given the data availability, which was validated through stakeholder consultations, as described below in section 3.3:

3.2. Value estimates

3.2.1. Epidemiologic model results

The simulations of the measures' effects in containing the virus spread in Jordan below were made in AnyLogic 8, based on a data set that should be adjusted and adapted to different regions. As input, the model uses the Jordanian population divided into three age groups: 0–24, 25–64, and 65 years or older, according to national severity profiles (see Appendix 5). The number of days between being infected to becoming infectious are, on average, 5.1 days and the time being infectious 5.0. The model was fitted against the daily number of reported cases and fatalities, the distribution of cases and fatalities per age group, as well as the incidence rate until January 30, 2021, as reported by the Ministry of Health in Jordan[104]. Until the end of January 2021, 4,304 deaths from Covid-19 and 311,481 cases of infected people were recorded. The 14-day incidence rate at the beginning of February was 6.12, much lower than in the previous weeks. An infectivity parameter, a relative contact reduction, and the proportion of unreported cases were calibrated for each age-group. Unreported cases were assumed to be less infectious than reported cases, considering that these have milder symptoms. The contact profile changes three times during the simulation, and we have two periods with different infectivity and share of unreported. This baseline scenario was then used to simulate the various strategies of mitigation.

The results from the four alternative measures with their assumptions are provided in Figures 9-12 below, where the simulated results from December 31, 2019, to the end of 2021 are shown together with the actual reported cases by January 30th, 2021. Since our example uses values estimating the impact of various measures for the year 2020, in estimating direct fatalities we have summed the total of unreported infections in one year for scenarios 1-4 and then assumed an infection fatality rate of 0.23.

In the figures below, the red graphs show the number of simulated reported positive cases per day, and the blue ones, show the simulated unreported cases per day.

[104] https://corona.moh.gov.jo/en

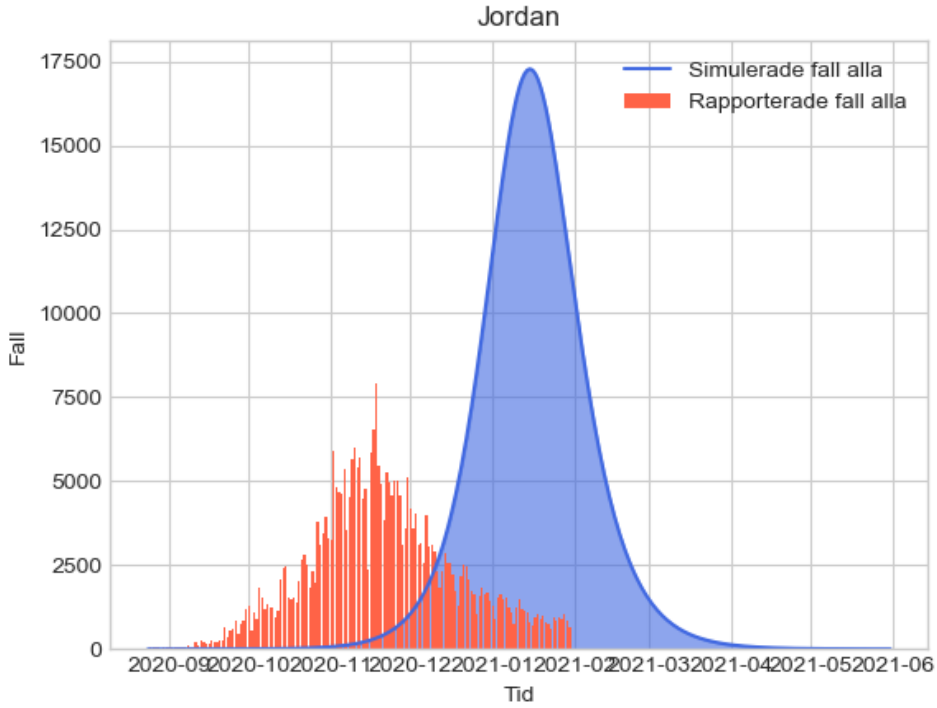

Figure 9. L1: Epidemiologic evolution without any social distancing measures. Estimated fatalities 2020 with 10% confidence interval: [18,648; 22,792]

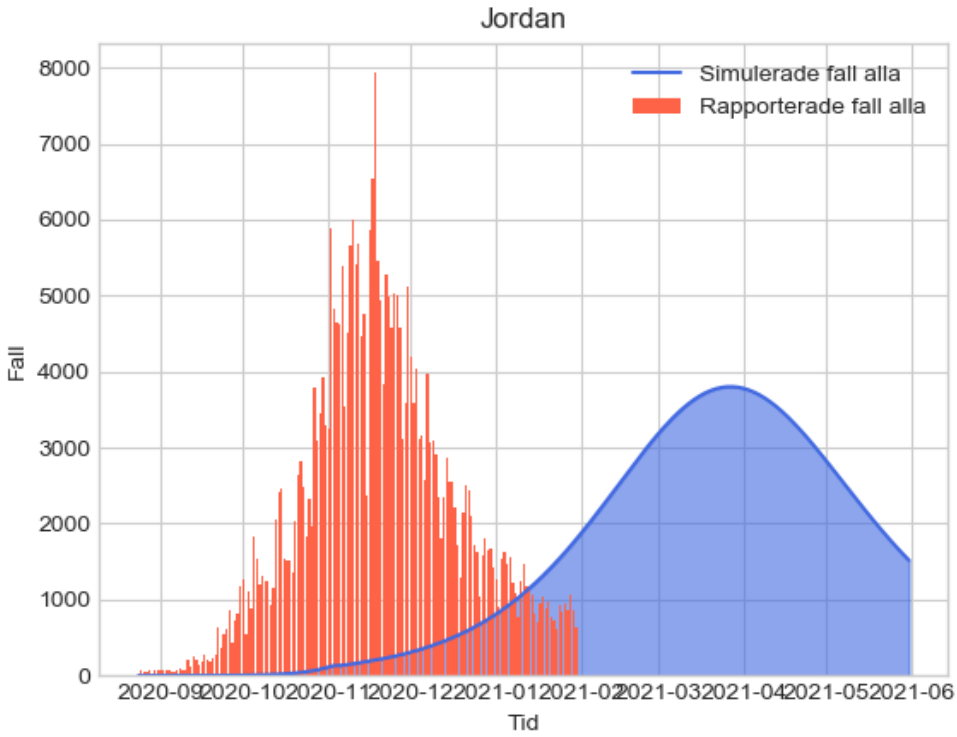

Figure 10. L2: Epidemiologic evolution without any social distancing measures. Estimated fatalities 2020, with 10% confidence interval: [15,800.4; 19,311.6]

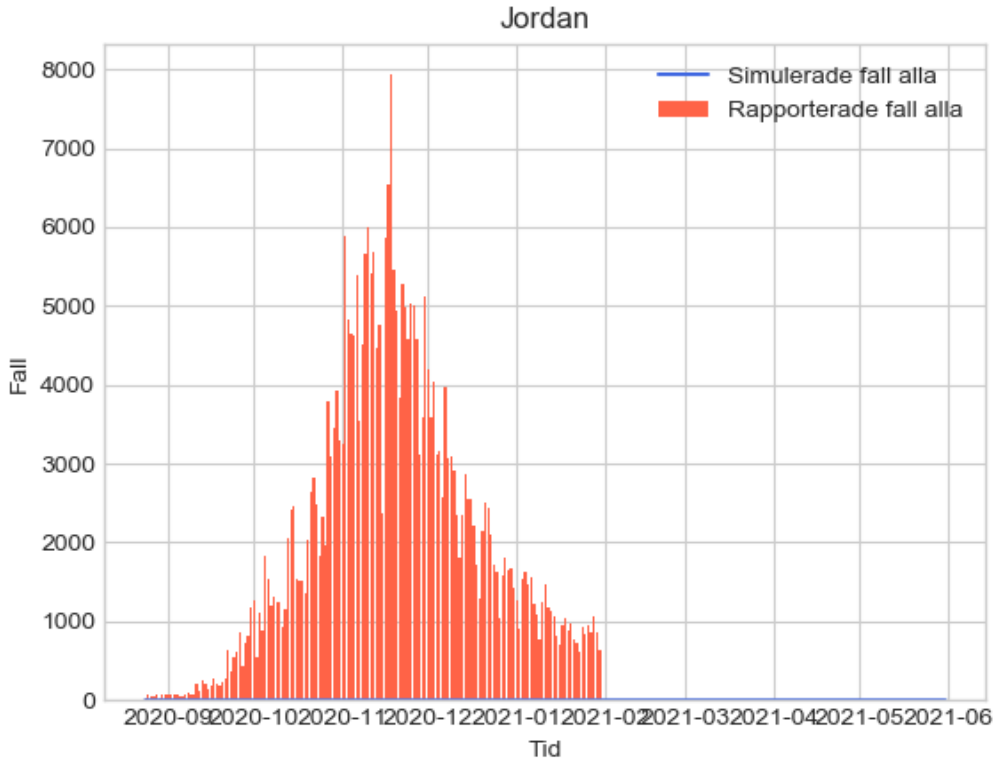

Figure 11. L3: Epidemiologic evolution without any social distancing measures. Estimated fatalities 2020, with 10% confidence interval: [11,216.7; 13,709.3]

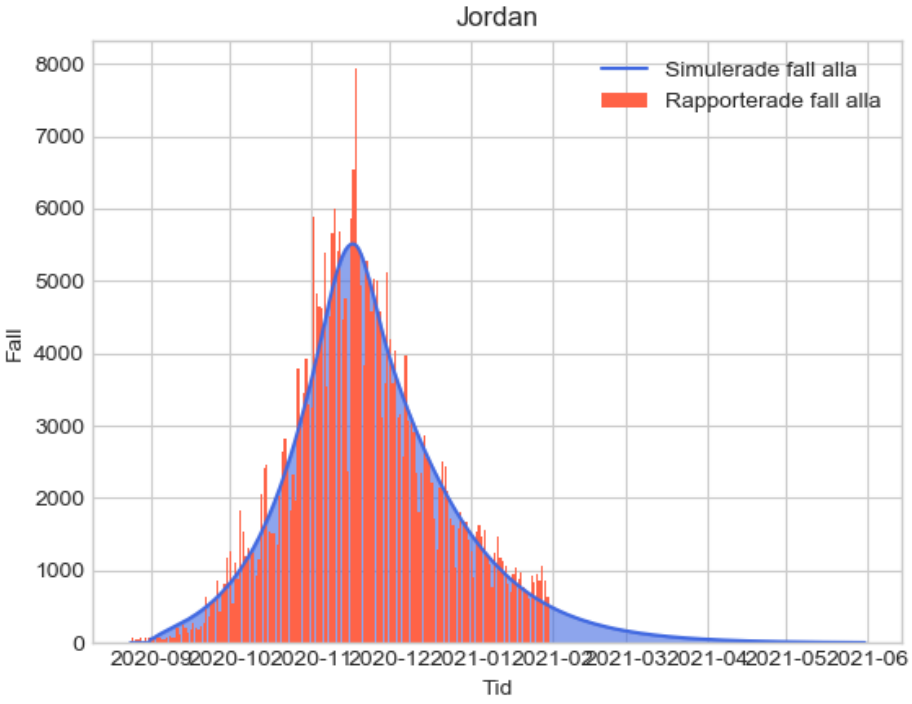

Figure 12. L4: Epidemiologic evolution without any social distancing measures. Estimated fatalities 2020, with 10% confidence interval: [7,434.9; 9,087.1]

Since the estimations do not take into consideration other factors such as improvements of treatments, regional patterns of spread and other variables, we used a 10% confidence interval for the total estimated fatalities.

3.2.2. Socioeconomic estimates

All schools, kindergartens and universities (private and public) were closed from the 15th March till the 22nd June for the spring semester of the academic year 2019/2020, impacting 2.37 million students. Schools moved to distance learning, televised lessons started to be broadcasted nationally, and digital platforms have been established to facilitate access to educational content and a new learning management system. The Ministry of Education announced the launch of the Darsak platform, an online education platform set up to host the new televised lesson content in Arabic by lesson and targeted grades 1st -12th. The summer semester of the academic year 2019/2020 also shifted to distance learning. Approximately 30 days have been lost from the last academic year, due to the establishment of a complete electronic education system for distance learning and teachers' union strikes[105,106].

At the beginning of the academic year 2020/2021, all students went to school while taking into consideration all safety instructions existing on the 1st of September 2020. Then schools that had registered Covid-19 cases had to close and teach through e-learning methods. After that, the pandemic risk management rules were issued to stop the education process at schools physically, all students except for 1st, 2nd, 3rd and 12th grades moving to distance learning. If there was any confirmed case of Covid-19 in a school, then this school had to move towards distance learning for 14 days. Starting from the 16th of October 2020, all schools shifted officially to distance learning for all grades. Also, universities moved to distance learning except for practical laboratories and clinical faculties. The beginning of the semester was postponed for 14 days, from the 27th of September 2020 to the 11th of October 2020.

The closures of schools brought a risk of an increased learning inequality and dropouts of pupils. According to the results of a survey run by the Ministry of education, only 30% of students nationwide had access to the televised materials, while only 70% of students were able to access the educational materials online via the official educational platforms. The majority of refugees are residing in urban areas, where over 85% are living below the poverty line. The measures taken to mitigate the pandemic are likely to exacerbate already existing educational inequalities.

Thus, we have calculated in terms of school days lost that 30 days were lost for 2.37 million students and 110 days for at least 30% of students were lost in 2020, who did not have access to online education.

Jordan's Human Development Index Value in 2020 was 0.723[107]. Since this depends on education indicators, but also on GDP for which reliable estimates were not available at the time of our evaluations, we took into consideration the country's risk class (medium) in the

[105] Roya News (7th Aug. 2020). Back to school: Shorter breaks and no morning assemblies. Available at: https://en.royanews.tv/news/21734/2020-08-07

[106] The Jordan Times (20th Aug. 2020). Private school enrolment drops by over 50 per cent. Available at: https://www.jordantimes.com/news/local/private-school-enrolment-drops-over-50-cent

[107] http://hdr.undp.org/en/content/table-1-human-development-index-and-its-components-1

INFORM Global Risk Index 2021, where there is an increased risk in socioeconomic vulnerability (3.6), but even more so in what concerns vulnerable groups (7.8). We estimate, therefore, that human development is most severely impacted by the highest stringency levels (Level 4), followed by Levels 3 and 2 where we estimate a moderate impact, the lowest impact on this indicator being estimated for measures that do not include social distancing (Level 1).

In what concerns mental health, we assumed levels of incidence increase based on reports on mental health for Level 4 (the real-life measures in Jordan)[108][109]: 79% of female Jordanians and 70% of male Jordanians reported their mental health being affected during the pandemic; 72.4% of the respondents to a national survey reported increased anxiety, irritability and anger, 67.5% sadness and depression, 62.5% fear. The respondents asked for a cancelation of the curfew. We assume that the more stringent the measures are in particular in reducing social mobility, the more the impact on mental health increases. Therefore, for Levels 1 and 2, the percentage of acute mental health cases due to Covid-19 is decreasing gradually for both genders.

The following values were used in the evaluation:

Table 2. The value estimates for the respective measure under each criterion

Criterion / Measure	DIRECT FATALITIES	SCHOOL DAYS LOST	HUMAN DEVELOPMENT	MENTAL HEALTH AND WELL-BEING
Level 1	Between 18,648 and 22,792	0	low	low
Level 2	Between 15,800 and 19,312	14-28	moderate	low
Level 3	Between 11,217 and 13,709	0	moderate	moderate
Level 4	Between 7,435 and 9,087	30-110	severe	severe

3.3. Co-creation process: stakeholders' rankings

For the co-creation process in Jordan, we used two web surveys using Google Forms, which were sent in November 2020 and January-February 2021, respectively. The first survey (see Appendix 6) aimed at obtaining stakeholders' input on the relevant criteria to be considered for the pandemic management in Jordan, the first question asking them to provide a criterion they considered of importance, aside from those that were discussed in the public sphere (health, education, financial aspects and well-being). A limited number of respondents (10 - 2 from the government, 6 from academia, 1 from the private sector and 1 from a non-

[108] Maqar (7th Aug, 2020), 68% of Jordanians became more nervous due to Corona. Available at: https://maqar.com/archives/426619

[109] Alrai (29th July, 2020). Corona affects the mental health of 79% of women and 70% of men. Available at: http://alrai.com/article/

governmental organization) filled in the questionnaire. The criteria added by them were: mental health for community (3 responses), health system capacity and well trained staff (matters which are not variables depending on social distancing measures, but rather offer a benchmark for the healthcare system coping capacity), social life (2 responses) and financial aspects and well-being. These responses were consistent with the criteria we identified.

After estimating the impacts of every scenario under consideration, for every criterion, a second survey was sent (see Appendix 7), this time with a much better response rate: we collected 78 responses, out of which 44 came from the education and research sector, 14 from the private sector, 10 from government, 8 from the healthcare system, and 2 from the non-governmental sector. Respondents were given our impact estimates for four criteria and for each criterion, they were asked to rank the measures according to their estimated effects. After seeing the impact estimates and ranking the measures, the stakeholders were asked again to rank the criteria according to their perception of the relative importance.

3.4. Aggregation and evaluation

The data aggregation in the Jordanian case can be found in Appendix 8. In the leftmost columns, the respondents' grades of the measures L1-L4 under the respective criterion, as well as the criteria grades, are shown. To the right of these, the corresponding CAR-values and weights can be found. Below the latter, the average values of the responses are shown together with the borders used for the analysis. The borders used for the analysis are the average values +/- the respective standard deviations to take into account the spread of the input data. Needless to say, these intervals could be widened in an arbitrary way if preferred, but one standard deviation seems to give a reasonable adequate representation of the values involved. The aggregated values are then used in the analysis as in a structured multi-criteria problem, but with the data spread taken into consideration as well.

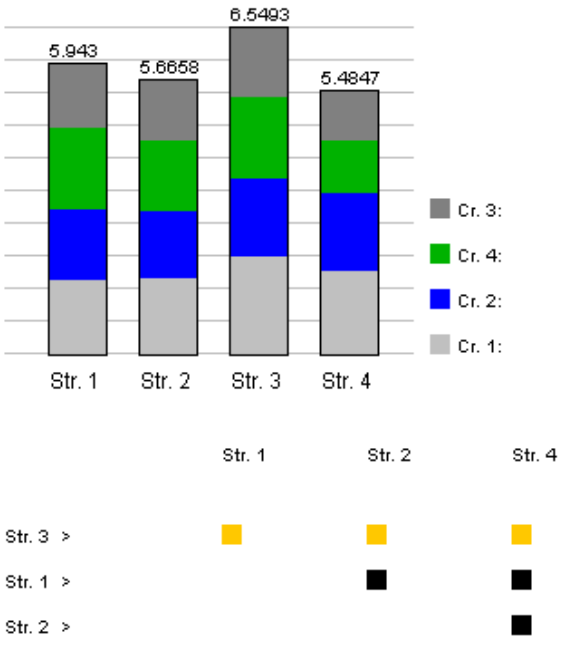

Figure 13. The result of the DecideIT evaluation showing ranking, the criteria contribution as well as the significance of the result

The multi-criteria decision problem is again evaluated against this background information using the method described in Part II, Section 2.2 of this report, i.e., the weighted averages of the figures taken from Appendix 8, using DecideIT. The result of our example is provided in Figure 13.

From the figure, we can see that L3 seems to be the best strategy to use in Jordan, with moderate confidence, followed by L1, L2 and L4.

PART IV: RECOMMENDATIONS AND DISSEMINATION

1. Policy recommendations

Crisis scenarios are indeed tremendously complex from a societal viewpoint and can result in highly undesirable side effects as well, which is why an approach cannot be restricted to a single criterion, such as fatality rate or financial short-term effects, but should rather be situated within a wider field of social shaping. The transformation of societal systems cannot be determined solely by any technological or economic assumed rationality. Rather, there is a wide range of social, political and institutional factors that interact in a systemic fashion and influencing their development. The acknowledgement of the multiple factors at stake in handling the crisis has more often than not been omitted from public communication, where public officials' statements mostly framed the problem unilaterally, basing their narratives on warnings coming from the medical and public health scientific community. The framework which we developed in our project can be used for the evaluation of different response measures which various countries took for mitigation and management of the Covid-19 pandemic emergency. In this report, we present a policy-formation and decision-support framework for managing the response to the SARS-CoV-2 pandemic and other future hazard scenarios, characterized by significant uncertainty. The framework can be implemented both during emergency preparedness and ongoing response, by relevant authorities and experts alike. Naturally, the more reliable data on relevant criteria to obtain evaluation results that have a higher degree of confidence, the better. However, the framework is supposed to be updated and correlated with data when such becomes available and the main point here is that without an adequate decision mechanism to aggregate and evaluate data, and without a stakeholder consultation process to establish the local priorities in mitigation response, epidemiologic data alone cannot automatically translate into appropriate policies. We thus recommend policy-makers at national and regional levels to use multi-criteria decision support tools and multi-stakeholder frameworks in deliberating upon actions, which are at least not sub-optimal, in current and future hazard scenarios. Needless to say, the framework should be regionally adapted and used, given differing socioeconomic conditions across a state, as well as in accordance with different spread patterns. This is one reason why the stakeholder consultation component is meaningful since different sociocultural groups can have different priorities for particular regions. Furthermore, local knowledge can be used to a larger extend. Obtaining regional socioeconomic data can pose some difficulties as it depends, among other things, on reporting protocols and chain effects with other regions. However, the set of criteria employed can be tailored to the needs in, and capabilities of, any region. Such an approach will probably also increase the understanding of various measures taken.

There is certainly a multitude of relevant aspects on the current crisis and the main purpose of this report has been to suggest what a framework for pandemic modelling, including epidemiological and socioeconomic factors, could look like, as well as to emphasise that such analyses should really be done, before, during and after a crisis, as a basis for evidence-based policymaking regarding pandemic situations and a learning opportunity. Representing complex scenarios in socioeconomic systems has the potential to inform policy formation processes and can decrease irrational decisions disturbed by a variety of cognitive and political biases as well as reducing the number of measures with insignificant effects or with highly undesirable side-effects. Since the current pandemic has primarily been considered a public health problem, strategies to mitigate the direct impact of Covid-19 upon the population have been persuasively communicated. Ethically justifiable use of narratives in science and evidence communication should, in principle, act for the common benefit and not "restrict an individual's autonomy to make decisions"[110]. Persuasion can be used where there is a high consensus that science "can justify the best course of action", in particular for emergency actions. However, the assumed best course of action must be carefully deliberated and motivated.

Our study provides a feasible methodology for structuring available – even if imprecise – evidence and preferences, which also serve as a support for publicly communicating the decision-making process. The long-term effects require sub-decisions as well, further complicating a naturally simplified analysis. For instance, macroeconomic policy actions and fiscal measures are critical to longer-term effects, something that the various types of austerity measures in the aftermath of the global financial crisis have emphatically highlighted, as well as to their effects on other criteria involved such as mental health[111,112] and the irrational growth of political populism and power abuse as well as distractions[113,114]. Furthermore, international comparisons are problematic due to the regional nature, as well as other factors, of the Covid-19 spread patterns. Therefore, comparisons between national strategies are very difficult to evaluate in a reasonable way and the strategies must be adapted to different countries according to the healthcare systems, demographics, telecommunication situations, authority trust and relations to social contracts, travelling patterns and so on. Therefore, again, a framework like this must be used with an awareness of national and regional conditions. The Covid-19 spread pattern furthermore emphasises that the model must be flexibly used and regionally adapted.

It is also difficult to adequately make trade-offs between different criteria, in particular when the stakes in many cases are high, but trade-offs must nevertheless be considered when handling such situations and it should be transparent which they are and how they affect the

[110] Dahlstrom MF, Ho SS. Ethical Considerations of Using Narrative to Communicate Science. Science Communication (2012) 34(5): 592–617. doi:10.1177/1075547012454597.
[111] Case A, Deaton A. Mortality and Morbidity in the 21st Century. Brookings Papers on Economic Activity (2017) 1:397-476. doi:10.1353/eca.2017.0005.
[112] Reeves A, McKee M, Stuckler D. Economic suicides in the Great Recession in Europe and North America. British Journal of Psychiatry (2014) 205(3):246-247. doi:10.1192/bjp.bp.114.144766
[113] Bor J. Diverging Life Expectancies and Voting Patterns in the 2016 US Presidential Election. American journal of public health (2017) 107(10):1560–1562. https://doi.org/10.2105/AJPH.2017.303945.
[114] The New York Times. Poland and Hungary Use Coronavirus to Punish Opposition (2020). https://www.nytimes.com/2020/04/22/world/europe/poland-hungary-coronavirus.html [Accessed April 26, 2020].

actual decision making, even if the trade-offs are not always clear[115]. As it now happens, these are often hidden, making it impossible to scrutinize the decisions that have been taken. For instance, the 70+ age group accounts for an overwhelming number of all deaths. Areas, even in reasonably wealthy countries or regions, having a higher proportion of first- and second-generation immigrants have been significantly more affected. How should this be considered compared to other effects? Should there be another type of precautionary measures and even society constructs so that particularly vulnerable and socially underprivileged groups are better protected when these types of events occur? In an international setting, such questions will be even more important in a variety of respects, not the least since many countries will suffer tremendously from the various socioeconomic side-effects of pandemics, exacerbating poverty and inequality, even aside from the much higher direct effects due to limited health care systems. These kinds of questions must be clarified in advance and well-anchored in the broader populations, another reason why transparent and deliberated policies should be analysed and in place beforehand to increase a general crisis resilience. To do this, there is a need for integrated methodologies and decision processes for how country strategies and action plans should be aligned with overall objectives and stakeholder perceptions and preferences. Deliberated strategies must be a prerequisite for policy formation and they should furthermore be developed together with the civil society in order to be better prepared for future crises.

In a deliberate design, stakeholders would be made more aware of the availability of different options regarding each of the pertinent hazards to their communities, as well as the impact of their preferences on risk management and on the broader society. This would probably facilitate improvements in resilience as well to future extreme hazard events, particularly in a multi-hazard context where it could deliver effective solutions for a multi-stakeholder planning approach and strengthen policy coherence by identifying management options, thereby contributing to more resilient regions. The management options can be communicated with stakeholders who could also be used to gather feedback about how they recognize these options and determine the possible opportunities and constraints from their viewpoint. The participatory approach of engaging different stakeholders would help to ensure the buy-in of stakeholders and encourage them to take on board the final results and raise the understanding for various measures, while still being aware of side-effects that are violating other fundamental societal effects. If this work could be undertaken, an applied framework would then define a blueprint for how crisis preparedness could be better carried out, implemented and scaled up.

2. Dissemination

The results of our research and the developed framework were described in the paper "*A Multi-Criteria Framework for Pandemic Response Measures"* which was submitted to Frontiers Public Health - Public Health Policy on the research topic: Strategic Narratives in Political and Crisis Communication: Responses to Covid-19. The paper is currently in review, received endorsement from three reviewers, and is waiting for the last one.

[115] Correia S, Luck S, Verner E. Pandemics Depress the Economy, Public Health Interventions Do Not: Evidence from the 1918 Flu. SSRN Electronic Journal (2020). doi:http://dx.doi.org/10.2139/ssrn.3561560.

A deeper insight on the results and their meaning for Romania was described in the paper "*Mitigating Cognitive and Behavioural Biases during Pandemics Responses",* submitted and accepted at the Group Decision and Negotiation (GDN) 2021 conference.

This project was acknowledged in two further papers:

Mats Danielson and Love Ekenberg, "A Framework for Categorising and Evaluating Tools for e-Democracy", DOI: 10.34190/EJEG.18.1.006

Mats Danielson, Love Ekenberg and Adriana Mihai, "A Multi-Criteria Approach to Analysing E-democracy Support Systems", chapter submitted for the 3rd edition of *Facebook Nation*, ed. Newton Lee.

The multi-criteria decision framework was presented at the following virtual events:

- Artificial intelligence, gender equality and involvement of women into decision-making processes. Workshop "Voices of women during the Covid-19 situation". Agha Khan University. Virtual, September 9, 2020.
- Systems analysis, policy and polycentric governance. VI International Conference on Management, Economics, Ethics, Technics – MEET 2020, Poland, October 20, 2020.
- Scientific cooperation to build bridges. Embassy of the Republic of Paraguay in Austria. November 11, 2020.

The results of the epidemiologic model, as well as the set of criteria and possible mitigation strategies for Botswana, were sent to and acknowledged by the Covid-19 Task Force within the Government of Botswana.

The results of the project will be described in the blog and disseminated at the homepage of Innovating Governance association, along with the following sets of **open data**:

- Epidemiologic model results with total estimated reported and unreported infections for Romania and Jordan, in Excel, which can be reused by applying different infection fatality rates (Appendices 8-11 for Romanian results, Appendices 12-15 for Jordan results);
- Criteria sets for the evaluation of mitigation measures

Appendices

Appendix 1. Input parameters epidemiologic model Botswana

- ✓ Infected (days): Number of days an individual is infected and infectious.
- ✓ Exposed (days): Number of days between an individual gets infected and becomes infectious.
- ✓ Infectivity 0-14: A parameter used to calibrate the risk of people in age-group 0-14 getting infected.
- ✓ Infectivity 15-64: A parameter used to calibrate the risk of people in age-group 15-64 getting infected.
- ✓ Infectivity 65+: A parameter used to calibrate the risk of people in age-group 65+ getting infected.
- ✓ Amplitude: The amplitude of the seasonality.
- ✓ Peak day: The day with the highest infectiousness during the year (in days from January 1).[116]
- ✓ Infectivity (% of infectiousness)
- ✓ The reduction in % of infectiousness for undetected, mild, severe, and critical cases.
- ✓ Population: The total population.
- ✓ % of the total population
    - 0-14: Age-group 0-14's share of the total population.
    - 15-64: Age-group 20-64's share of the total population.
    - 65+: Age-group 65+'s share of the total population.
- ✓ 0-14 RG: The share of people in age-group 0-14 who belongs to a risk-group.
- ✓ 15-64 RG: The share of people in age-group 15-64 who belong to a risk group.
- ✓ 65+ RG: The share of people in age-group 65+ who belong to a risk group.
- ✓ Quarantine (% of days infected): The % of the infected period for undetected, mild, severe, or a critical case in quarantine.
- ✓ Severity profile: The share of each age-group who are undetected, mild, severe or critically infected.
- ✓ Social distancing: Used to define social distancing policies for each age group, for one or two periods. Contact reductions can be defined within each age-group (upper row) and between each age-group (lower row).
- ✓ Contact reduction (%): The percentage that the contacts should be reduced by.
- ✓ Period (1 or 2): Checkbox used to enable the policy.
- ✓ Year (2020 or 2021): The year the policy should be enabled.
- ✓ Start day: The start day of the policy (day of year).
- ✓ End day: The end day of the policy (day of year).

[116] See https://www.medrxiv.org/content/10.1101/2020.02.13.20022806v1.full.pdf for Amplitude and Peak day.

Appendix 2. Stakeholder questionnaire Romania

Expertise / Field of work

Sector/industry: Government / Institute for public health / Medical facility / Public sector / Private sector / Academia / Non-governmental sector

1. For Romania, what would you consider to be an unacceptably high mortality caused by COVID-19?

□1,001-5,000	□5,001-10,000	□10,001-20,000	□20,001-50,000	□50,001-100,000	□100,001-1,000,000	□over 1,000,000

2. In your view, how serious is the risk of high mortality rates caused by COVID-19?

□very serious	□serious	□somewhat serious	□not very serious	□not serious at all

3. How likely do you think it is for the SARS-CoV-2 epidemic in Romania to have a high mortality rate, if left unmitigated?

□very likely	□likely	□somewhat likely	□not very likely	□unlikely

4. What is, in your view, the most pressing problem in Romania brought by the SARS-CoV-2 pandemic?

5. In your view, which of the following non-pharmaceutical measures to contain the SARS-CoV-2 epidemic in Romania would be better? Drag the slider scale using the mouse to indicate the order of preferences.

- No other action is taken except for pharmaceutical measures and case isolation;
- Health system coordination, public communication encouraging increased hygiene and personal protection, case isolation and localized action (closing a school/workplace in case of a number of cases) - *influenza protocol*
- Health system coordination, public communication encouraging increased hygiene and personal protection, case isolation, mild social distancing measures (large public gatherings banned, work from home where possible, social distancing recommended) - *Sweden's policy*

- ❖ Health system coordination, public communication encouraging increased hygiene and personal protection, case isolation, mild social distancing measures (large public gatherings banned, work from home where possible, social distancing recommended), contact tracing involving publicly disclosed detailed location information of individuals that tested positive for COVID-19 - *South Korea's policy*
- ❖ Health system coordination, public communication encouraging increased hygiene and personal protection, case isolation, mild social distancing measures (large public gatherings banned, work from home where possible, social distancing recommended), complete physical isolation of the elderly from other age groups for 12 weeks - *Enhanced distancing for vulnerable groups*
- ❖ Health system coordination, public communication encouraging increased hygiene and personal protection, case isolation, strict social distancing measures (large public gatherings banned, work from home where possible, school and university closures, restaurants and shopping malls closures, restricted mobility) - *Lockdown*

6. Is there any other set of measures you believe would have been better than any of the ones described at Question 5? Briefly indicate what that would be.

7. Which are, in your view, the main concerns to be addressed by governmental responses to the SARS-CoV-2 pandemic? Drag the slider scale using the mouse to specify what has more priority for you:

i. Health and epidemiologic aspects

ii. Economic aspects

iii. Social and behavioural aspects

iv. Environmental aspects

v. Political and governance aspects

8. What health problems do you think are more important to limit during a SARS-CoV-2 epidemic in Romania? Drag the slider scale using the mouse to specify what should be a priority to address by mitigation actions:

i. Reducing the number of direct COVID-19 fatalities

ii. Reducing the number of indirect fatalities, caused by healthcare, economic or social problems brought by the epidemic

9. Which are, in your view, the most important economic aspects to be addressed in a pandemic response action? Drag the slider scale using the mouse to specify which issues have more priority for you:

i. The short-term costs of the pandemic

ii. Unemployment

iii. Taxes and budget

iv. Specific industries affected

v. Growing industries

10. Which are, in your view, the most important social aspects to be addressed in a pandemic response action? Drag the slider scale using the mouse to specify which issues have more priority for you:

i. Preserving human rights

ii. Protecting vulnerable groups

iii. Avoiding the increase of criminality rates

iv. Preserving mental health

v. Ensuring access to education and training

11. Which are, in your view, the most important political aspects to be addressed in a pandemic response action? Drag the slider scale using the mouse to specify which issues have more priority for you:

i. Reducing the risk of short-term governmental abuse

ii. Ensuring citizen approval of measures to be taken

iii. Maintaining or increasing trust in government

iv. Increasing resilience and preparedness for hazard events

12. What is your opinion on the following statements? Choose the option which is closest to your view.

□completely disagree	□somewhat disagree	□ I neither agree, nor disagree	□ somewhat agree	□completely agree

- The number of direct COVID-19 fatalities is more important than the effect of climate change and pollution on people's health in Romania.
- The number of direct COVID-19 fatalities is more important than unemployment levels in Romania.
- The number of direct COVID-19 fatalities is more important than mental health.
- The number of direct COVID-19 fatalities is more important than the risk of short-term governmental abuses.
- The number of direct COVID-19 fatalities is more important than ensuring access to education for children and young students.
- The number of indirect fatalities is more important than the citizen approval of governmental action in response to the pandemic.
- The short term costs of the measures taken by the government are more important than the citizen approval of governmental action in response to the pandemic.

- ❖ The protection of vulnerable groups is more important than the risk of short-term governmental abuses.
- ❖ The protection of vulnerable groups is more important than the economic impact on specific industries.
- ❖ The number of direct COVID-19 fatalities is more important than the preservation of human rights.

13. Which are the main sources you use for information on COVID-19 related issues? Select the frequency of use from 1 - most often, 2 - often, 3 - sometimes, 4 - rarely, 5 - never.

TV	□1	□2	□3	□4	□5
Radio	□1	□2	□3	□4	□5
Print newspapers	□1	□2	□3	□4	□5
National online news platforms	□1	□2	□3	□4	□5
International online news platforms	□1	□2	□3	□4	□5
Social media	□1	□2	□3	□4	□5
National institutional websites	□1	□2	□3	□4	□5
International institutions' websites	□1	□2	□3	□4	□5
Academic outlets	□1	□2	□3	□4	□5
NGOs	□1	□2	□3	□4	□5

14. How much do you trust the following sources of information? Select for each whether you have 1 - complete trust, 2 - some trust, 3 - little trust, 4 - very little trust, 5 - no trust.

TV	□1	□2	□3	□4	□5
Radio	□1	□2	□3	□4	□5
Print newspapers	□1	□2	□3	□4	□5
National online news platforms	□1	□2	□3	□4	□5
International online news platforms	□1	□2	□3	□4	□5
Social media	□1	□2	□3	□4	□5
National institutional websites	□1	□2	□3	□4	□5
International institutions' websites	□1	□2	□3	□4	□5
Academic outlets	□1	□2	□3	□4	□5
NGOs	□1	□2	□3	□4	□5

Appendix 3. Input parameters epidemiologic model Romania

Epidemiologic parameters:

1. Infected (days): Number of days an individual is infected and infectious. 5.0
2. Exposed (days): Number of days between an individual gets infected and becomes infectious. 5.1

Infectivity:

3. Infectivity (% of infectiousness): The reduction in % of infectiousness for asymptomatic, mild, severe, and critical cases. 50.0, 0.0, 0.0, 0.0

Total reported cases 3 January 2021: 643,559

Total deaths: 16,057
95.2% of deaths were of patients with comorbidities
84.7% of deaths were in the 60+ age group

- Total cases / age group:

0-19 years: 7%
20-59 years: 66%
60+ years: 27%

- Total deaths / age group:

0-19 years: 0%
20-59 years: 14%
60+ years: 86%

- Population size: 19,370,448

0-19 years: 4,063,856 - 20.98%

20-59 years: 10,354,630 - 53.46%

60+ years: 4,951,962 - 25.56%

- Incidence rate:

14-day case notification rate per 100 000 inhabitants: 253.08

14-day death notification rate per 100 000 inhabitants: 8.16

Cases and deaths per day, as well as ICU COVID-19 patients per day were taken from the European Center for Disease Control, COVID-19 datasets.

Other data sources for epidemiologic evolution and demography in Romania: National Institute of Public Health Romania and National Institute of Statistics

Appendix 4. Questionnaire results Romania - weights aggregation

See PDF document below.

Appendix 5. Input parameters epidemiologic modeling Jordan

Epidemiologic parameters:

Infected (days): Number of days an individual is infected and infectious. 5.0
Exposed (days): Number of days between an individual gets infected and becomes infectious. 5.1

Infectivity:

Infectivity (% of infectiousness): The reduction in % of infectiousness for asymptomatic, mild, severe, and critical cases. 50.0, 0.0, 0.0, 0.0

COVID-19 data JORDAN - 20 January 2021

- Population size: 10,806,000

0-24 years: 5,858,780
25-64 years: 4,548,530
65+ years: 398,690

- Total cases / age group:
- 0-24 years: 70,974
  25-64 years: 173,245
  65+ years: 15,143
- Total deaths / age group:

0-24 years: 33
25-64 years: 1,448
65+ years: 2,756

Appendix 6. First stakeholder questionnaire Jordan

See PDF document below.

Appendix 7. Second stakeholder questionnaire Jordan

See PDF document below.

Appendix 8. Questionnaire results Jordan - weights aggregation

See PDF document below.

Appendices 9-12. Romania epidemiologic evolution - results all

See separate Excel files.

Appendices 13-16. Jordan epidemiologic evolution - results all

See separate Excel files.

Appendix 4. Questionnaire results Romania - weights aggregation

		MEASURES				NORMALISED			
Timestamp	date	L1	L2	L3	L4	L1	L2	L3	L4
#1139	06/18/2020 - 18:19	7	9	12	4	0,375	0,625	1	0
#1141	06/18/2020 - 20:06	1	4	7	8	0	0,429	0,857	1
#1142	06/21/2020 - 17:37	1	3	9	7	0	0,25	1	0,75
#1143	06/21/2020 - 18:18	0	0	0	6	0	0	0	1
#1144	06/23/2020 - 12:46	6	11	11	9	0	1	1	0,6
#1146	06/24/2020 - 10:03	3	12	3	12	0	1	0	1
#1147	06/24/2020 - 10:48	5	9	3	11	0,25	0,75	0	1
#1148	06/24/2020 - 14:33	0	11	0	0	0	1	0	0
#1149	06/25/2020 - 12:07	3	6	14	12	0	0,273	1	0,818
#1153	07/03/2020 - 10:42	3	6	14	8	0	0,273	1	0,455
#1154	07/04/2020 - 11:14	10	0	0	0	1	0	0	0
#1155	07/06/2020 - 20:49	0	9	1	12	0	0,75	0,083	1
#1156	07/06/2020 - 22:38	0	14	14	0	0	1	1	0
#1158	07/09/2020 - 12:32	2	0	0	0	1	0	0	0

DecideIT	Midpoint	0,1875	0,5249	0,4957	0,5445
DecideIT	Lower hull	0,0000	0,1276	0,0000	0,0931
DecideIT	Upper hull	0,5503	0,9223	0,9996	0,9958

Appendix 6. First stakeholder questionnaire Jordan

Covid-19 Questionnaire

You have been selected to participate in this research as a stakeholder in choosing measures to prevent the spread of the SARS-CoV-2 virus. The present study aims to develop and apply a multi-criteria and participatory model for the decision-making process, in conditions of increased uncertainty, regarding the management of the current pandemic. Our goal is to support decision-makers' response to future "waves" of the COVID-19 pandemic as well as of other possible pandemics in the future.

This is a part of the European Union-funded project from European Open Science Cloud EOSC, Covid-19 Fast Track Funding led by Innovating Governance, a non-profit organisation in Vienna, Austria, whose team consists of international researchers affiliated with numerous prestigious academic institutions. Find out more about us here: https://www.igovernance.eu/about.

Participation in this study is voluntary, and the duration of completing the questionnaire is 1-5 minutes. The answers provided will be anonymous unless you wish to be recognized as an expert in our subsequent publications, in which case please confirm your option by e-mail to adriana.mihai@lls.unibuc.ro. Innovating Governance will retain the data provided only for their processing and interpretation, without distributing them to third parties. The results of this questionnaire will be presented publicly only in the form of useful analyses and interpretations for the decision-making model.

Continuing and completing this questionnaire is your consent for the collection, storage, and processing of the information you provide by Innovating Governance.

For any questions about this research or technical issues of the questionnaire, please contact us at the address mentioned. Thank you for your participation and interest.

Authors:
Dr. Adriana Mihai, IG and University of Bucharest
Prof. Dr. Love Ekenberg, IG, Stockholm University and the International Institute of Applied Systems Analysis (IIASA)
Dr. Nadejda Komendantova, IG and IIASA
Dr. Tobias Fasth, IG and Stockholm University

* Required

1. 1. What sector or industry are you currently working in? *

Mark only one oval.

- Government
- Healthcare
- Other public institutions
- Private sector
- Academia
- Non-governmental organization

2. 2. Typical criteria that are considered to be relevant in managing the pandemic are: direct and indirect fatalities (due to restricted healthcare given the extra burden on the health system), effects on education, financial aspects and well-being. In the text field below, add ONE further criterion you consider of importance to take into consideration. *

_____

Ranking Criteria

According to your perception of their relative importance, rank the criteria from 1 to 9 below. For instance, if a criterion has rank 9, it is more important than a criterion with rank 8, which in turn, is significantly more important than a criterion with rank 5, etc. Several criteria can have the same importance rank.

3. Direct fatalities *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10

4. Indirect fatalities *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10

5. Impacts on economy *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

6. Impacts on education *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

7. Well-being *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

8. Your suggested criterion *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Thank you for your contribution!

9. If you want to receive the report after finalisation, please write your email below. The email will not be linked to your answers in the report.

_____

10. Thank you for responding this questionnaire. If you want to add anything or have further questions or comments, you can use the text box below or email: adriana.mihai@lls.unibuc.ro.

Appendix 7. Second stakeholder questionnaire Jordan

Questionnaire COVID-19

You have been selected to participate in this research as a stakeholder in choosing measures to prevent the spread of the SARS-CoV-2 virus. The present study aims to develop and apply a multi-criteria and participatory model for the decision-making process in pandemic responses, in conditions of increased uncertainty.

The study includes 2 rounds of consultations with stakeholders, the first round being undertaken in November 2020. Participation in this study is voluntary, anonymous, and the duration of completing the survey is 1-5 minutes.

This consultation is a part of a project funded by European Open Science Cloud EOSC, Covid-19 Fast Track Funding, and led by Innovating Governance, a non-profit organization in Vienna, Austria, whose team consists of international researchers affiliated with numerous prestigious academic institutions. Find out more about us here: https://www.igovernance.eu/about.

Innovating Governance will retain the data provided only for their processing and interpretation, without distributing them to third parties. The results of this questionnaire will be presented publicly only in the form of useful analyses and interpretations for the decision-making model.

Continuing and completing this questionnaire is your consent for the collection, storage, and processing of the information you provide by Innovating Governance.

For any questions about this research or technical issues of the questionnaire, please contact us at adriana.mihai@lls.unibuc.ro. Thank you for your participation and interest.

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The University of Jordan
Dr. Nadejda Komendantova, IG and IIASA
Dr. Tobias Fasth, IG and Stockholm University

* Required

1. In what activity sector are you currently working? *

Mark only one oval.

- ◯ Government / Public administration
- ◯ Healthcare / social care system
- ◯ Education and research
- ◯ Non-governmental sector
- ◯ Private sector
- ◯ Other: _____

Ranking measures

The different measures which can be taken to mitigate the SARS-CoV-2 epidemic in Jordan can be pharmaceutical and non-pharmaceutical. The present study analyzes 4 different types of mitigation strategies, summed up in the following sets of measures:

MEASURES 1: only pharmaceutic measures (treatments, vaccination)
MEASURES 2: pharmaceutic measures, temporary school and workplace closures
MEASURES 3: pharmaceutic measures, social distancing recommended
MEASURES 4: pharmaceutic measures and social distancing imposed (lockdown)

Any chosen set of mitigation measures impacts various areas of life, which include health, education, human development, mental health and wellbeing. The project team has estimated the impact of every measure set above upon each of these areas in Jordan, for 2020-2021.

1. Which measure set do you think is better if you take into consideration their estimated effects on DIRECT FATALITIES? Please rank the measure sets from the worst (1) to the best (10).

MEASURE SETS	IMPACT: DIRECT FATALITIES*
MEASURES 1	Between 18,648 and 22,792
MEASURES 2	Between 15,800 and 19,312
MEASURES 3	Between 11,217 and 13,709
MEASURES 4	Between 7,435 and 9,087

*based on epidemiologic modelling, demographic and epidemiologic data from statistical reports published by the Ministry of Health, Jordan

2. Measures 1 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

3. Measures 2 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

4. Measures 3 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

5. Measures 4 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

2. Which measure set do you think is better if you take into consideration their estimated effects on EDUCATION? Please rank the measure sets from the worst (1) to the best (10).

MEASURE SETS	IMPACT: SCHOOL DAYS LOST
MEASURES 1	0
MEASURES 2	14-28
MEASURES 3	0
MEASURES 4	30-110*

*based on reports from the Ministry of Education, 30 days for 2.37 million students and 110 days in 2020 for at least 30% of students, who did not have access to online education

6. Measures 1 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

7. Measures 2 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

8. Measures 3 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

9. Measures 4 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

3. Which measure set do you think is better if you take into consideration their estimated effects on HUMAN DEVELOPMENT? Please rank the measure sets from the worst (1) to the best (10).

MEASURE SETS	IMPACT: HUMAN DEVELOPMENT*
MEASURES 1	low
MEASURES 2	moderate
MEASURES 3	moderate
MEASURES 4	severe

*see Human Development Index 2020 and Jordan's high socio-economic and group vulnerability, cf. INFORM Global Risk Index 2021

10. Measures 1 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

11. Measures 2 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

12. Measures 3 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

13. Measures 4 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

4. Which measure set do you think is better if you take into consideration their estimated effects on MENTAL HEALTH AND WELL BEING? Please rank the measure sets from the worst (1) to the best (10).

MEASURE SETS	MENTAL HEALTH AND WELL-BEING*
MEASURES 1	low
MEASURES 2	low
MEASURES 3	moderate
MEASURES 4	severe

*progressive decline with social mobilty reduction; lockdown and quarantine affected 79% females, 70% males, according to Nama Center for Opinion Polls

14. Measures 1 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

15. Measures 2 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

16. Measures 3 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

17. Measures 4 *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

Ranking criteria

According to your perception of their relative importance, rank the criteria from 1 to 9 below. For instance, if a criterion has rank 9, it is more important than a criterion with rank 8, which in turn, is significantly more important than a criterion with rank 5, etc. Several criteria can have the same importance rank.

18. Direct fatalities *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

19. School days lost *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

20. Human development *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

21. Mental health and well-being *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Thank you for your participation!

22. Thank you for your time. For any questions or comments, please use the text box below or send us an email at adriana.mihai@lls.unibuc.ro.

Appendix 8. Questionnaire results Jordan - weights aggregation

		DIRECT FATALITIES				SCHOOL DAYS LOST				HUMAN DEVELOPMENT				MENTAL HEALTH WELLBEING				CRITERIA RANKING			
Timestamp	In what activity sector are y	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4	Direct fa	School (	Human (	Mental h
2-18-2021 23:34:48	Education and research	5	6	7	9	9	6	8	6	9	7	8	6	9	8	7	5	10	8	6	7
2-18-2021 23:50:27	Education and research	2	3	3	3	10	2	10	1	10	5	5	1	9	9	5	1	9	8	9	8
2-18-2021 23:53:16	Education and research	9	8	10	9	6	10	7	2	9	8	8	7	8	7	8	8	9	10	8	10
2-18-2021 23:53:54	Education and research	8	5	9	6	8	6	9	6	9	6	6	3	8	7	6	4	6	4	6	7
2-18-2021 23:56:46	Education and research	5	6	5	7	5	6	6	5	6	6	5	5	6	6	6	5	6	6	4	5
2-19-2021 0:01:10	Education and research	6	5	6	7	5	7	5	6	6	6	5	5	5	6	5	5	6	6	5	7
2-19-2021 0:02:05	Non-governmental sector	7	8	6	7	6	7	8	8	8	7	8	7	7	7	7	7	7	7	8	7
2-19-2021 0:05:15	Education and research	5	6	7	8	9	7	5	1	5	6	6	8	5	5	7	9	10	9	9	9
2-19-2021 0:06:05	Education and research	10	7	9	6	9	6	8	9	8	9	7	9	9	7	8	10	7	10	10	9
2-19-2021 0:06:30	Healthcare / social care sys	9	9	9	9	9	9	10	10	8	8	9	10	7	5	8	6	8	9	8	9
2-19-2021 0:13:29	Government / Public admin	3	4	4	4	4	3	4	4	3	4	4	3	4	4	3	4	3	3	3	3
2-19-2021 0:15:20	Education and research	8	7	9	6	3	4	6	10	4	5	4	7	5	5	8	5	4	6	8	8
2-19-2021 0:21:04	Education and research	10	8	6	4	3	8	3	9	3	5	6	8	3	4	6	8	9	8	7	7
2-19-2021 0:24:28	Education and research	5	4	8	10	5	4	9	5	9	6	5	2	10	9	6	4	7	10	8	5
2-19-2021 0:39:13	Education and research	5	5	5	5	1	5	1	5	8	6	6	9	8	8	8	9	4	1	1	8
2-19-2021 0:55:14	Government / Public admin	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2-19-2021 0:59:30	Private sector	4	3	2	1	1	3	2	4	1	2	3	4	2	1	3	4	10	10	10	10
2-19-2021 1:01:38	Education and research	4	5	7	9	3	7	5	2	9	6	4	2	9	7	4	2	9	4	3	4
2-19-2021 1:33:16	Education and research	6	6	5	5	9	7	8	9	8	8	8	8	7	8	8	9	7	8	8	7
2-19-2021 1:45:20	Education and research	1	6	7	10	1	1	10	1	1	1	10	1	1	1	10	1	10	8	9	9
2-19-2021 2:13:27	Education and research	3	4	9	1	9	2	8	1	8	6	8	2	8	7	6	10	9	8	6	8
2-19-2021 4:58:48	Education and research	10	8	7	6	8	6	5	7	6	8	9	6	6	7	8	5	9	7	7	7
2-19-2021 5:13:59	Education and research	6	6	10	7	6	8	6	8	7	7	7	5	6	6	6	3	8	10	9	9
2-19-2021 5:33:53	Education and research	3	4	6	8	4	6	3	6	5	4	3	10	1	8	4	9	7	8	7	4
2-19-2021 6:34:25	Education and research	2	5	10	2	2	3	9	2	2	2	6	1	1	4	10	1	4	7	8	8
2-19-2021 6:41:34	Education and research	5	8	9	10	8	8	10	7	8	9	10	1	7	8	10	3	8	9	6	9
2-19-2021 6:43:25	Education and research	7	8	9	4	10	8	10	6	10	7	7	4	10	7	5	1	8	6	5	4
2-19-2021 7:47:52	Education and research	3	6	7	8	2	5	5	8	3	5	5	7	7	7	5	3	9	5	6	8
2-19-2021 8:21:42	Education and research	7	5	4	2	9	7	5	2	9	5	5	1	8	8	5	2	9	7	6	6
2-19-2021 8:27:10	Education and research	7	8	9	10	7	7	10	5	7	7	9	6	7	6	8	4	8	7	6	9
2-19-2021 8:53:00	Government / Public admin	3	3	8	8	3	3	8	3	3	3	8	3	3	3	8	3	9	9	9	9
2-19-2021 8:57:03	Education and research	7	8	9	10	7	7	10	5	7	7	9	6	7	6	8	4	8	7	6	9
2-19-2021 9:08:38	Education and research	7	9	4	10	6	8	4	10	5	9	4	6	4	2	9	4	9	7	5	8
2-19-2021 9:45:12	Private sector	4	4	5	6	1	2	1	10	1	5	5	10	1	1	6	10	5	6	6	6
2-19-2021 9:58:45	Education and research	9	8	8	7	1	5	1	8	5	9	9	4	3	3	7	8	5	9	8	8
2-19-2021 10:07:08	Education and research	6	8	8	4	5	8	8	4	8	8	8	4	8	8	8	4	10	6	8	8
2-19-2021 10:19:53	Education and research	3	6	8	10	4	4	9	5	3	9	9	10	7	4	7	3	8	10	9	8
2-19-2021 10:20:36	Government / Public admin	3	3	8	8	3	3	8	3	3	3	8	3	3	3	8	3	9	9	9	9
2-19-2021 10:23:10	Education and research	5	6	6	5	4	8	3	6	5	5	7	5	5	6	6	7	9	7	7	7
2-19-2021 10:39:17	Education and research	9	7	6	1	10	7	7	1	9	8	7	1	10	9	6	1	9	8	8	8
2-19-2021 10:58:56	Education and research	8	6	4	2	10	7	10	4	8	6	6	1	9	9	5	1	10	7	6	10
2-19-2021 11:00:55	Education and research	9	7	7	7	9	9	7	9	9	8	8	9	7	6	7	9	9	9	8	7
2-19-2021 11:26:53	Early retired from gov. Rega	7	5	7	6	3	4	3	4	5	5	4	5	5	4	5	5	6	9	8	7
2-19-2021 12:40:42	Healthcare / social care sys	1	1	5	10	1	10	1	1	1	5	5	10	1	1	5	10	9	5	9	9
2-19-2021 12:53:00	Private sector	10	4	10	1	1	10	1	10	5	5	5	5	8	8	5	1	6	4	5	5
2-19-2021 13:02:06	Government / Public admin	9	9	9	9	8	8	8	8	7	8	9	8	8	8	8	8	8	7	7	9
2-19-2021 13:06:26	Private sector	4	3	2	1	2	6	3	2	4	3	7	3	6	4	2	1	4	3	8	4
2-19-2021 13:18:33	Healthcare / social care sys	1	1	1	1	4	4	4	4	7	7	7	7	8	8	8	8	9	9	9	9
2-19-2021 13:28:40	Private sector	10	8	3	1	10	5	9	1	10	9	8	1	10	9	4	2	8	8	6	5
2-19-2021 13:40:21	Private sector	8	8	7	8	8	8	7	7	9	8	8	8	7	7	8	7	8	7	9	9
2-19-2021 13:48:49	Healthcare / social care sys	1	1	1	1	10	10	10	10	9	9	9	9	10	10	10	10	9	8	10	10
2-19-2021 13:49:23	Private sector	5	7	8	10	9	4	5	4	5	5	4	10	10	5	4	1	5	8	8	9
2-19-2021 14:07:56	Private sector	3	3	2	4	5	4	4	3	3	4	6	3	6	4	6	3	3	6	4	5
2-19-2021 14:10:43	Education and research	6	5	4	5	5	4	7	6	4	7	5	6	4	5	4	4	5	4	5	4
2-19-2021 15:23:26	Government / Public admin	10	10	10	10	7	7	8	7	7	7	6	8	7	7	6	8	10	10	10	10
2-19-2021 15:24:06	Retirement	10	10	8	1	10	10	10	1	10	10	9	1	10	10	10	1	9	1	1	1
2-19-2021 15:32:35	Education and research	2	3	5	7	7	3	8	2	9	4	6	2	8	6	9	2	9	7	7	8
2-19-2021 16:18:20	Private sector	1	4	6	10	9	4	9	1	10	3	5	1	9	4	9	1	9	10	8	9
2-19-2021 16:41:56	Private sector	8	9	7	5	8	7	9	6	6	8	6	5	8	7	6	5	8	6	5	9
2-19-2021 17:25:32	Education and research	1	3	4	5	2	2	2	2	5	4	3	3	3	2	4	4	5	10	6	8
2-19-2021 17:47:45	Private sector	7	8	9	8	7	6	8	6	8	7	6	7	8	7	9	7	6	7	7	6
2-19-2021 20:02:57	Education and research	5	3	8	5	4	5	2	7	4	3	4	9	4	3	4	4	8	9	7	6
2-19-2021 21:39:17	Education and research	5	6	7	10	5	9	7	2	6	7	8	4	9	9	10	6	10	6	7	8
2-19-2021 22:22:05	Healthcare / social care sys	3	5	7	8	9	3	8	1	8	2	8	1	10	3	9	1	10	8	6	8
2-19-2021 22:28:10	Government / Public admin	1	2	10	10	8	5	9	3	9	5	9	1	9	7	7	2	5	9	9	9
2-20-2021 0:35:44	Private sector	4	7	9	2	10	6	9	1	2	3	8	1	10	4	9	1	9	7	8	6
2-20-2021 10:22:47	Private sector	8	3	10	1	7	2	8	1	3	6	6	1	5	5	2	1	8	6	4	5
2-20-2021 10:32:15	Education and research	1	1	1	5	1	1	1	8	1	1	1	7	1	1	1	7	3	5	6	7
2-20-2021 11:19:51	Non-governmental sector	1	3	9	6	6	4	7	1	4	5	5	2	8	7	6	1	8	8	8	9
2-20-2021 11:51:55	Education and research	8	3	10	2	6	7	2	9	5	4	10	2	5	4	10	2	9	8	8	9
2-20-2021 12:13:02	Education and research	1	1	1	10	1	1	1	10	1	1	1	10	1	1	1	10	8	10	9	7
2-20-2021 21:52:03	Government / Public admin	9	9	10	9	9	9	9	9	9	9	10	10	10	9	10	9	9	9	9	9
2-20-2021 22:06:02	Education and research	7	5	9	1	7	5	9	1	7	5	9	1	7	5	9	1	5	8	9	9
2-20-2021 22:10:50	Private sector	3	6	10	7	10	5	10	4	8	6	6	6	10	10	7	6	8	10	7	5
2-23-2021 8:01:07	Education and research	8	6	10	1	8	6	10	1	8	6	10	1	10	8	6	1	10	8	7	9

	DIRECT FATALITIES				SCHOOL DAYS LOST				HUMAN DEVELOPMENT				ENTAL HEALTH AND WELL BEIN				WEIGHTS			
Timestamp	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4	L1	L2	L3	L4	W1	W2	W3	W4
2-18-2021 23:34:48	0	0,25	0,5	1	1	0	0,667	0	1	0,333	0,667	0	1	0,75	0,5	0	0,5021	0,2343	0,1004	0,1632
2-18-2021 23:50:27	0	1	1	1	1	0,111	1	0	1	0,444	0,444	0	1	1	0,5	0	0,3333	0,1667	0,3333	0,1667
2-18-2021 23:53:16	0,5	0	1	0,5	0,5	1	0,625	0	1	0,5	0,5	0	1	0	1	1	0,2000	0,3429	0,1143	0,3429
2-18-2021 23:53:54	0,75	0	1	0,25	0,667	0	1	0	1	0,5	0,5	0	1	0,75	0,5	0	0,2500	0,1000	0,2500	0,4000
2-18-2021 23:56:46	0	0,5	0	1	0	1	1	0	1	1	0	0	1	1	1	0	0,3429	0,3429	0,1143	0,2000
2-19-2021 0:01:10	0,5	0	0,5	1	0	1	0	0,5	1	1	0	0	0	1	0	0	0,2333	0,2333	0,1333	0,4000
2-19-2021 0:02:05	0,5	1	0	0,5	0	0,5	1	1	1	0	1	0	1	1	1	1	0,2000	0,2000	0,4000	0,2000
2-19-2021 0:05:15	0	0,333	0,667	1	1	0,75	0,5	0	0	0,333	0,333	1	0	0	0,5	1	0,4000	0,2000	0,2000	0,2000
2-19-2021 0:06:05	1	0,25	0,75	0	1	0	0,667	1	0,5	1	0	1	0,667	0	0,333	1	0,0870	0,3478	0,3478	0,2174
2-19-2021 0:06:30	1	1	1	1	0	0	1	1	0	0	0,5	1	0,667	0	1	0,333	0,1667	0,3333	0,1667	0,3333
2-19-2021 0:13:29	0	1	1	1	1	0	1	1	0	1	1	0	1	1	0	1	0,2500	0,2500	0,2500	0,2500
2-19-2021 0:15:20	0,667	0,333	1	0	0	0,143	0,429	1	0	0,333	0	1	0	0	1	0	0,0750	0,1750	0,3750	0,3750
2-19-2021 0:21:04	1	0,667	0,333	0	0	0,833	0	1	0	0,4	0,6	1	0	0,2	0,6	1	0,4444	0,2593	0,1481	0,1481
2-19-2021 0:24:28	0,167	0	0,667	1	0,2	0	1	0,2	1	0,571	0,429	0	1	0,833	0,333	0	0,1837	0,4898	0,2449	0,0816
2-19-2021 0:39:13	1	1	1	1	0	1	0	1	0,667	0	0	1	0	0	0	1	0,2188	0,0781	0,0781	0,6250
2-19-2021 0:55:14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0,2500	0,2500	0,2500	0,2500
2-19-2021 0:59:30	1	0,667	0,333	0	0	0,667	0,333	1	0	0,333	0,667	1	0,333	0	0,667	1	0,2500	0,2500	0,2500	0,2500
2-19-2021 1:01:38	0	0,2	0,6	1	0,2	1	0,6	0	1	0,571	0,286	0	1	0,714	0,286	0	0,6269	0,1418	0,0896	0,1418
2-19-2021 1:33:16	1	1	0	0	1	0	0,5	1	1	1	1	1	0	0,5	0,5	1	0,1667	0,3333	0,3333	0,1667
2-19-2021 1:45:20	0	0,556	0,667	1	0	0	1	0	0	0	1	0	0	0	1	0	0,4000	0,1333	0,2333	0,2333
2-19-2021 2:13:27	0,25	0,375	1	0	1	0,125	0,875	0	1	0,667	1	0	0,5	0,25	0	1	0,4000	0,2500	0,1000	0,2500
2-19-2021 4:58:48	1	0,5	0,25	0	1	0,333	0	0,667	0	0,667	1	0	0,333	0,667	1	0	0,5000	0,1667	0,1667	0,1667
2-19-2021 5:13:59	0	0	1	0,25	0	1	0	1	1	1	1	0	1	1	1	0	0,1333	0,4000	0,2333	0,2333
2-19-2021 5:33:53	0	0,2	0,6	1	0,333	1	0	1	0,286	0,143	0	1	0	0,875	0,375	1	0,2600	0,4000	0,2600	0,0800
2-19-2021 6:34:25	0	0,375	1	0	0	0,143	1	0	0,2	0,2	1	0	0	0,333	1	0	0,0702	0,2281	0,3509	0,3509
2-19-2021 6:41:34	0	0,6	0,8	1	0,333	0,333	1	0	0,778	0,889	1	0	0,571	0,714	1	0	0,2174	0,3478	0,0870	0,3478
2-19-2021 6:43:25	0,6	0,8	1	0	1	0,5	1	0	1	0,5	0,5	0	1	0,667	0,444	0	0,5021	0,2343	0,1632	0,1004
2-19-2021 7:47:52	0	0,6	0,8	1	0	0,5	0,5	1	0	0,5	0,5	1	1	1	0,5	0	0,4598	0,0920	0,1494	0,2989
2-19-2021 8:21:42	1	0,6	0,4	0	1	0,714	0,429	0	1	0,5	0,5	0	1	1	0,5	0	0,5217	0,2174	0,1304	0,1304
2-19-2021 8:27:10	0	0,333	0,667	1	0,4	0,4	1	0	0,333	0,333	1	0	0,75	0,5	1	0	0,2727	0,1818	0,1091	0,4364
2-19-2021 8:53:00	0	0	1	1	0	0	1	0	0	0	1	0	0	0	1	0	0,2500	0,2500	0,2500	0,2500
2-19-2021 8:57:03	0	0,333	0,667	1	0,4	0,4	1	0	0,333	0,333	1	0	0,75	0,5	1	0	0,2727	0,1818	0,1091	0,4364
2-19-2021 9:08:38	0,5	0,833	0	1	0,333	0,667	0	1	0,2	1	0	0,4	0,286	0	1	0,286	0,4317	0,2014	0,0863	0,2806
2-19-2021 9:45:12	0	0	0,5	1	0	0,111	0	1	0	0,444	0,444	1	0	0	0,556	1	0,1429	0,2857	0,2857	0,2857
2-19-2021 9:58:45	1	0,5	0,5	0	0	0,571	0	1	0,2	1	1	0	0	0	0,8	1	0,0800	0,4000	0,2600	0,2600
2-19-2021 10:07:08	0,5	1	1	0	0,25	1	1	0	1	1	1	0	1	1	1	0	0,4688	0,0938	0,2188	0,2188
2-19-2021 10:19:53	0	0,429	0,714	1	0	0	1	0,2	0	0,857	0,857	1	1	0,25	1	0	0,1481	0,4444	0,2593	0,1481
2-19-2021 10:20:36	0	0	1	1	0	0	1	0	0	0	1	0	0	0	1	0	0,2500	0,2500	0,2500	0,2500
2-19-2021 10:23:10	0	1	1	0	0,2	1	0	0,6	0	0	1	0	0	0,5	0,5	1	0,5000	0,1667	0,1667	0,1667
2-19-2021 10:39:17	1	0,75	0,625	0	1	0,667	0,667	0	1	0,875	0,75	0	1	0,889	0,556	0	0,4000	0,2000	0,2000	0,2000
2-19-2021 10:58:56	1	0,667	0,333	0	1	0,5	1	0	1	0,714	0,714	0	1	1	0,5	0	0,3960	0,1287	0,0792	0,3960
2-19-2021 11:00:55	1	0	0	0	1	1	0	1	1	0	0	1	0,333	0	0,333	1	0,3429	0,3429	0,2000	0,1143
2-19-2021 11:26:53	1	0	1	0,5	0	1	0	1	1	1	0	1	1	0	1	1	0,1091	0,4364	0,2727	0,1818
2-19-2021 12:40:42	0	0	0,444	1	0	1	0	0	0	0,444	0,444	1	0	0	0,444	1	0,3125	0,0625	0,3125	0,3125
2-19-2021 12:53:00	1	0,333	1	0	0	1	0	1	1	1	1	1	1	1	0,571	0	0,4000	0,1333	0,2333	0,2333
2-19-2021 13:02:06	1	1	1	1	1	1	1	1	0	0,5	1	0,5	1	1	1	1	0,2593	0,1481	0,1481	0,4444
2-19-2021 13:06:26	1	0,667	0,333	0	0	1	0,25	0	0,25	0	1	0	1	0,6	0,2	0	0,1569	0,0980	0,5882	0,1569
2-19-2021 13:18:33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0,2500	0,2500	0,2500	0,2500
2-19-2021 13:28:40	1	0,778	0,222	0	1	0,444	0,889	0	1	0,889	0,778	0	1	0,875	0,25	0	0,3750	0,3750	0,1563	0,0938
2-19-2021 13:40:21	1	1	0	1	1	1	0	0	1	0	0	0	0	0	1	0	0,2000	0,1143	0,3429	0,3429
2-19-2021 13:48:49	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0,2000	0,1143	0,3429	0,3429
2-19-2021 13:49:23	0	0,4	0,6	1	1	0	0,2	0	0,167	0,167	0	1	1	0,444	0,333	0	0,0800	0,2600	0,2600	0,4000
2-19-2021 14:07:56	0,5	0,5	0	1	1	0,5	0,5	0	0	0,333	1	0	1	0,333	1	0	0,1091	0,4364	0,1818	0,2727
2-19-2021 14:10:43	1	0,5	0	0,5	0,333	0	1	0,667	0	1	0,333	0,667	0	1	0	0	0,3333	0,1667	0,3333	0,1667
2-19-2021 15:23:26	1	1	1	1	0	0	1	0	0,5	0,5	0	1	0,5	0,5	0	1	0,2500	0,2500	0,2500	0,2500
2-19-2021 15:24:06	1	1	0,778	0	1	1	1	0	1	1	0,889	0	1	1	1	0	0,7500	0,0833	0,0833	0,0833
2-19-2021 15:32:35	0	0,2	0,6	1	0,833	0,167	1	0	1	0,286	0,571	0	0,857	0,571	1	0	0,4444	0,1481	0,1481	0,2593
2-19-2021 16:18:20	0	0,333	0,556	1	1	0,375	1	0	1	0,222	0,444	0	1	0,375	1	0	0,2333	0,4000	0,1333	0,2333
2-19-2021 16:41:56	0,75	1	0,5	0	0,667	0,333	1	0	0,333	1	0,333	0	1	0,667	0,333	0	0,2989	0,1494	0,0920	0,4598
2-19-2021 17:25:32	0	0,5	0,75	1	1	1	1	1	1	0,5	0	0	0,5	0	1	1	0,0862	0,5172	0,1379	0,2586
2-19-2021 17:47:45	0	0,5	1	0,5	0,5	0	1	0	1	0,5	0	0,5	0,5	0	1	0	0,1667	0,3333	0,3333	0,1667
2-19-2021 20:02:57	0,4	0	1	0,4	0,4	0,6	0	1	0,167	0	0,167	1	1	0	1	1	0,2727	0,4364	0,1818	0,1091
2-19-2021 21:39:17	0	0,2	0,4	1	0,429	1	0,714	0	0,5	0,75	1	0	0,75	0,75	1	0	0,5021	0,1004	0,1632	0,2343
2-19-2021 22:22:05	0	0,4	0,8	1	1	0,25	0,875	0	1	0,143	1	0	1	0,222	0,889	0	0,4688	0,2188	0,0938	0,2188
2-19-2021 22:28:10	0	0,111	1	1	0,833	0,333	1	0	1	0,5	1	0	1	0,714	0,714	0	0,0625	0,3125	0,3125	0,3125
2-20-2021 0:35:44	0,286	0,714	1	0	1	0,556	0,889	0	0,143	0,286	1	0	1	0,333	0,889	0	0,4364	0,1818	0,2727	0,1091
2-20-2021 10:22:47	0,778	0,222	1	0	0,857	0,143	1	0	0,4	1	1	0	1	1	0,25	0	0,5021	0,2343	0,1004	0,1632
2-20-2021 10:32:15	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0,0863	0,2014	0,2806	0,4317
2-20-2021 11:19:51	0	0,25	1	0,625	0,833	0,5	1	0	0,667	1	1	0	1	0,857	0,714	0	0,2000	0,2000	0,2000	0,4000
2-20-2021 11:51:55	0,75	0,125	1	0	0,571	0,714	0	1	0,375	0,25	1	0	0,375	0,25	1	0	0,3333	0,1667	0,1667	0,3333
2-20-2021 12:13:02	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0,1818	0,4364	0,2727	0,1091
2-20-2021 21:52:03	0	0	1	0	1	1	1	1	0	0	1	1	1	0	1	0	0,2500	0,2500	0,2500	0,2500
2-20-2021 22:06:02	0,75	0,5	1	0	0,75	0,5	1	0	0,75	0,5	1	0	0,75	0,5	1	0	0,0702	0,2281	0,3509	0,3509
2-20-2021 22:10:50	0	0,429	1	0,571	1	0,167	1	0	1	0	0	0	1	1	0,25	0	0,2449	0,4898	0,1837	0,0816
2-23-2021 8:01:07	0,778	0,556	1	0	0,778	0,556	1	0	0,778	0,556	1	0	1	0,778	0,556	0	0,4364	0,1818	0,1091	0,2727
DecideIT Midpoint	0,4523	0,4782	0,6781	0,5680	0,5280	0,5081	0,6414	0,4111	0,5537	0,5102	0,6154	0,3609	0,6456	0,5022	0,6690	0,3549	28,8840	24,5867	21,4208	25,1085
DecideIT Lower hull	0,0059	0,1220	0,3224	0,1021	0,0918	0,1117	0,2154	0,0000	0,1126	0,1401	0,2077	0,0000	0,2186	0,0973	0,3130	0,0000	13,9853	13,2709	11,7332	14,0528
DecideIT Upper hull	0,8988	0,8345	1,0000	1,0000	0,9642	0,9044	1,0000	0,8890	0,9947	0,8804	1,0000	0,8307	1,0000	0,9070	1,0000	0,8306	42,8693	37,8576	33,1540	39,1613