UNIVERSAL MASKING TO RESTART SOCIETY AND SAVE LIVES

COVID-19 Data, Simulations, Policy Recommendations

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This collective work grew out of a Kinnernet discussion group about COVID-19 initiated by Guy-Philippe Goldstein. All authors contributed to the overall design and writing. Additionally, Goldstein formulated overall study goals and analysed policy data, Morgunov ran the SEIR simulation and collected policy data, De Kai created the online interactive ABM simulation, Nangalia contributed with medical expertise and to the model design, and Rotkirch and De Kai first drafted the report.

Mask photos: Mia Ehrnrooth, AIM by Mia

As governments plan how to exit societal lockdowns, universal masking (mass face mask wearing) has rapidly emerged as one of the key non-pharmaceutical interventions for containing the spread of the COVID-19 pandemic. A growing body of evidence, ranging from clinical trials to the policy comparisons and new simulations presented here, suggests that universal masking as currently practiced in Asian countries significantly lowers rates of transmission.

Currently, the lowest recorded daily growth rates in COVID-19 infections are found in countries with a culture of mass face mask wearing, most of whom have also made mask wearing in public mandatory during the epidemic, and most of whom are not currently locked down. Supporting this correlational evidence, we provide a simulation of the effects of mass face mask wearing over time compared to effects of social distancing and lockdown. Simulation results indicate that without masking, lifting lockdown after nine weeks while keeping social distancing measures will risk a major second wave of the epidemic in 4-5 months' time. However, if four out of five citizens would start wearing cloth masks in public before the lockdown is lifted, the number of new COVID-19 cases could decline enough to exit lockdown and still avoid a second wave. If only every second person starts wearing a mask, infection rates would also decline substantially, if not fully enough to prevent the second wave of the epidemic.

We also offer a new interactive simulation of agent-based models showing how masking works.

This white paper shows the need for mass masking as an alternative to a continued lockdown scenario. For this strategy to be most effective, the vast majority of the population needs to adopt mask wearing immediately. When a well-timed "mouth-and-nose lockdown" accompanies the current "full body lockdown", we can lower both the human and economic costs of this pandemic.

1	Masking should be **mandatory or recommended for the general public** when in public transport and public spaces, for the duration of the pandemic.
2	Masking should be **mandatory for individuals in essential functions** (health care workers, social and family workers, the police and the military, and the service sector) and medical masks should be provided to them by employers.
3	Countries should aim to eventually **secure mass production** and availability of appropriate medical masks (without exploratory valves) for the entire population during the pandemic.
4	Until supplies are sufficient, **members of the general public should wear nonmedical fabric face masks** when going out in public and medical masks should be reserved for essential functions.
5	The authorities should **issue masking guidelines to residents and companies** regarding the correct and optimal ways to make, wear and disinfect masks.
6	The introduction of mandatory masking will benefit from being rolled out together with **campaigns**, citizen initiatives, the media, NGOs, and influencers in order to avoid a public backlash in societies not culturally accustomed to masking.

With Europe, several US states, and other countries' states having imposed strict measures of social distancing and restrictions on movement in March 2020, governments now seek a **sustainable pathway back towards eased social restrictions and a functioning economy.** Mass testing for infection and serological tests for immunity, combined with mass contact tracing, quarantine of infected individuals, and social distancing, are recommended by the WHO and have become widely acknowledged means of controlling the SARS-CoV-2 virus until a vaccine is available.

A growing body of evidence suggests that universal masking or face mask wearing is an additional essential tool in the COVID-19 mitigation toolkit. Masks indisputably protect individuals against airborne transmission of respiratory diseases. A recent Cochrane meta-analysis found that masking, handwashing, and using gowns and/or gloves can reduce the spread of respiratory viruses, although evidence for any individual one of these measures is still of low certainty.[1]

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MASKING PROTECTS YOUR COMMUNITY.

NOT JUST YOU.

Face masks work both ways. They can protect an infected person from spreading the virus (transmission). And they can limit how much the non-infected individual is exposed to the virus (absorption). Surgical masks most efficaciously reduce the emission of influenza virus particles into the environment in respiratory droplets. Comparing different mask materials, medical masks have been found to be up to three times more effective in blocking transmission compared to homemade masks.[2] Still, although masks vary greatly in their ability to protect, using any type of face mask (without an exploratory valve) can help decrease viral transmission.[3]

Masks may be especially crucial for containing the COVID-19 pandemic, since many infections appear to come from people with no signs of illness. For instance, around 48% of COVID-19 transmissions were pre-symptomatic in Singapore and 62% in Tianjin, China.[4] Furthermore, the SARS-CoV-2 virus is known to spread through airborne particles[5] and quite possibly via aerosolized droplets as well.[6,7,8,9] It may linger in the air for at least 30 minutes and travel up to 4.5 meters, or larger than the "safe distance" imposed by social distancing rules in public — the insight which prompted Chinese health authorities to encourage masks in early March.[10]

Previous modelling studies indicate that masking can be an effective intervention strategy in reducing the spread of a pandemic.[11] Crucially, a high rate of masking (80% or more) may be needed in a population to provide efficient protection from influenza.[12] This is why masking needs to be universal and not restricted to individuals who think they may be infected. Furthermore, universal masking can reduce stigmatisation of ethnic groups, risk groups or the sick and contribute to public solidarity.[13]

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The move to universal masking has been driven by grassroots initiatives. In the era of social distancing, we are witnessing a remarkable cultural convergence in favour of masking as a low-cost and possibly high reward tool in the war against COVID-19.

CULTURAL CONVERGENCE ON UNIVERSAL MASKING

The Czech Republic was the first non-Asian country to embrace and impose mandatory universal masking on March 11. The Czech policy swiftly inspired various initiatives from citizens, journalists and scientists,[1,2,3,4,5,6,7] and created global movements such as #masks4all and #wearafuckingmask. Their arguments build on the ability of the COVID-19 virus to spread from pre- and asymptomatic individuals who may not know that they are infected, and to linger in airborne droplets.

Leading political and medical experts who early were advocated masking included Chinese CDC director-general Prof. George Fu Gao,[8] former FDA commissioner Scott Gottlieb and Prof. Caitlin Rivers of Johns Hopkins,[9] and the American Enterprise Institute's roadmap.[10] In early April a rapidly increasing number of governments from countries without a previous culture of mask wearing require or recommend universal masking including the Czech Republic, Austria and Slovakia. Additionally, public health bodies in the USA, France or New Zealand have moved toward universal masking recommendations (table on the next page).[11,12]

The WHO has issued guidelines discouraging the use of masks in the public.[13] In early April the WHO modified the guidelines, allowing self-made masks but rightly stressing the need to reserve medical masks for healthcare workers.[14,15] The policy shifts of the WHO and other CDCs reflect advances in our scientific understanding of this pandemic, and partly legitimize the altruistic "mask resistance" of civil society in this war against COVID-19.

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THE PLACES THAT BEST HANDLED COVID-19 ALL HAD UNIVERSAL MASKING

The universal masking movement has been triggered by the striking country comparison of COVID-19 cases. **The majority of regions that have so far best managed their outbreaks are masking cultures and include Taiwan, South Korea, Singapore, and Hong Kong.**

Indeed, most East Asian countries have a widespread culture of masking which has intensified during the COVID-19 outbreak. Masking in public is required in Taiwan, metropolitan areas in China such as Shanghai and Beijing (as well as Guangzhou, Shenzhen, Tianjin, Hangzhou, and Chengdu), Japan, South Korea, and other countries.[1]

Country or region	Daily growth	Reduction from peak	Masking culture?	Universal masking (date made mandatory or recommended)	Strict lockdown (mass home quarantine)
Macau	2.4%	96.0%	yes	Feb 19	
Beijing	3.6%	98.5%	yes	Feb 8	partial
Shanghai	3.7%	83.6%	yes	Feb 8	partial
Guangdong	5.0%	95.8%	yes	Feb 8	partial
Hong Kong	5.5%	69.8%	yes	Jan 15	
Taiwan	5.6%	85.0%	yes	Jan 27	
Singapore	6.8%	23.5%	yes	Jan 30 (sick) Apr 5 (all)	partial
Japan	9.1%	24.5%	yes	Mar 4	partial
Estonia	10.0%	69.4%			
Slovakia	11.3%	29.9%		Mar 24	
S Korea	11.6%	94.4%	yes	Feb 27	
Slovenia	12.0%	46.0%		Mar 19	
Malaysia	13.1%	38.2%			Mar 18
Australia	13.9%	77.7%			Mar 23
Finland	14.2%	27.3%			Mar 27
Hungary	14.3%	26.5%			Mar 28
Norway	14.5%	61.0%			Mar 12
Lithuania	15.5%	46.0%			Mar 16
Sweden	15.9%	17.2%			
Denmark	16.2%	20.3%			Mar 11
CZ	16.6%	36.8%		Mar 18	Mar 16
Israel	17.0%	54.9%			
Austria	17.0%	70.3%		Mar 31	Mar 16
Lux	17.0%	63.2%			
IT	17.2%	40.4%			Mar 9
NZ	17.2%	44.3%			Mar 26
CH	17.3%	45.8%			
ND	18.4%	16.6%			Mar 16
Pol	18.5%	17.5%			Mar 13
Belgium	18.5%	20.1%			Mar 18
Ire	18.6%	23.9%			Mar 12
Canada	18.7%	37.1%			
Germany	19.6%	36.0%			(only Bavaria)
France	20.2%	56.6%			Mar 17
Portugal	20.4%	27.1%			Mar 19
UK	20.4%	22.4%			Mar 24
US	21.6%	5.5%			Mar 19-24 (CA, NV, CT, IL, KS, MA, MI, NY, OR, WI)
Spain	21.9%	38.8%			Mar 14

Figure 1. Daily growth of confirmed cases, masking and lockdown policies in 38 selected countries. Universal masking was employed in every region that handled COVID-19 well.

Based on detected cases from Jan 23 to Apr 10 for the top countries/regions per GDP per capita in Asia, Europe, and the Americas, starting once 30 cases have been detected. Percentage of reduction from peak growth rates is calculated as the average number of new cases Apr 6-10, divided by the average of the three peak numbers of new daily cases. Sources: John Hopkins, Wikipedia, VOA News, Quartz, Straits Times, South China Morning Post, ABCNews, Time.com, Channel New Asia, Moh.gov.sg, Reuters, Financial Times, Yna.co.kr, Nippon.com, Euronews, Spectator.sme.sk

On the other hand, countries which have adopted mass testing, tracking and quarantining, but lack a universal masking culture, have not yet seen a clear reduction in COVID-19 transmission rates. Although these correlations may be due to underlying unobserved factors, they call for further enquiry into the effects of masking. A recent macro-level regression analysis by economists at Yale University, taking into account masking cultures and times of country COVID-19 policy responses, estimated that growth of COVID-19 rates only half that of mask wearing countries — the growth rate of confirmed cases is 18% in countries with no pre-existing mask norms and 10% in countries with such norms, while the growth rate of deaths is 21% in countries with no mask norms and 11% in countries with such norms. The authors note that such a 10% reduction in transmission probabilities could correspond to a per capita gain of $3,000-6,000 per each additional cloth mask (!), and that the economic benefits of each medical mask for healthcare personnel could be substantially larger.[2]

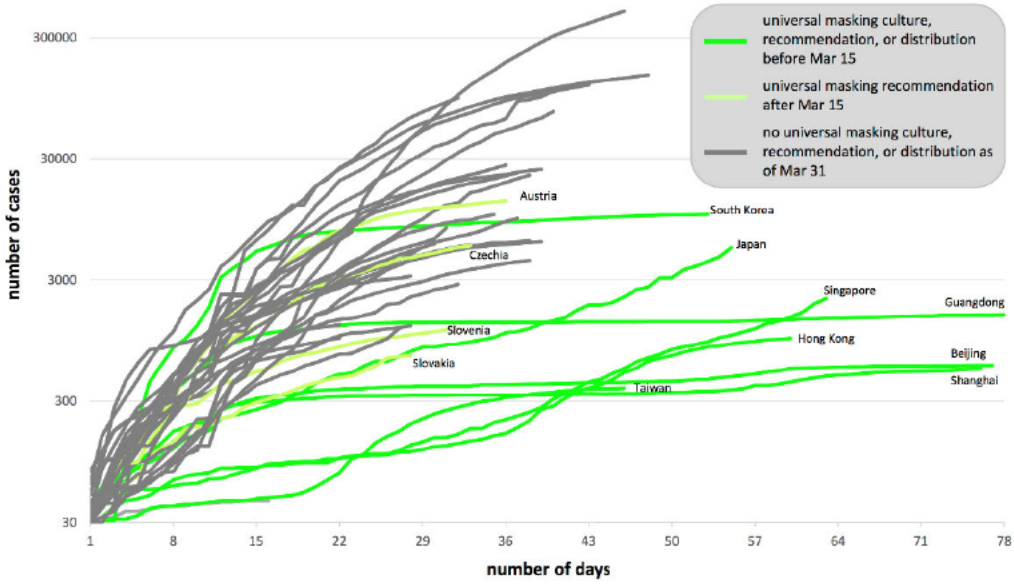

Figure 2. Two views of the impact of universal masking on epidemic control. Masking is nearly perfectly correlated with lower daily growth or strong reduction from peak growth of COVID-19. Percentage of reduction from peak growth rates is calculated as the average number of new cases Apr 6-10, divided by the average of the three peak numbers of new daily cases.

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NEW SIMULATION: UNIVERSAL MASKING IS PREFERABLE TO STRICT LOCKDOWNS

Building on the insights above, we simulated the relative impact of masking compared to the two main other societal non-pharmaceutical interventions, lockdown and social distancing.

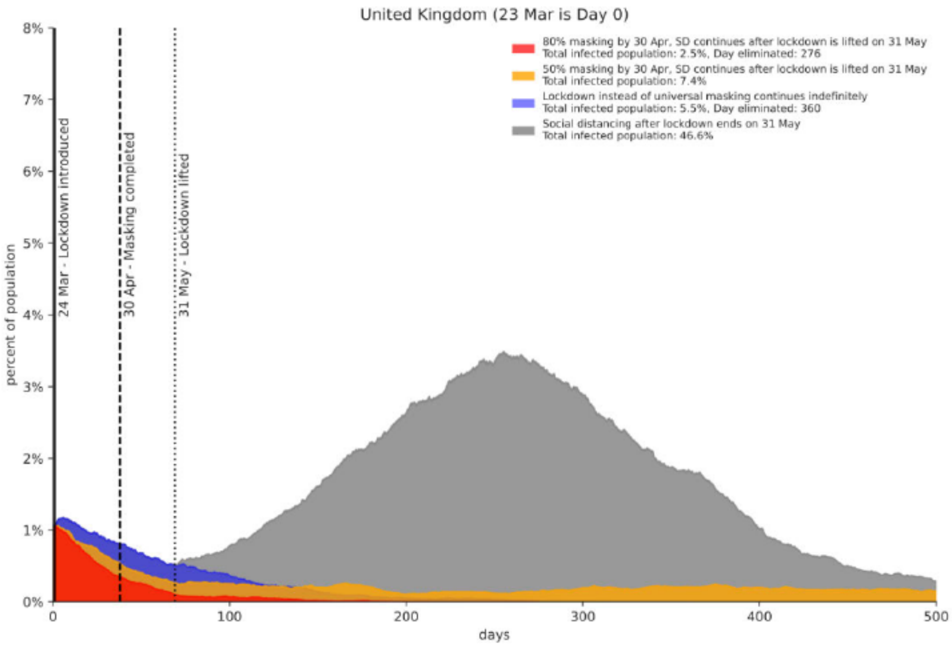


Figure 3. Simulation results for a representative scenario: universal masking at 80% adoption (red) flattens the curve significantly more than maintaining a strict lockdown (blue). Masking at only 50% adoption (orange) is not sufficient to prevent continued spread. Replacing the strict lockdown with social distancing on May 31 without masking results in unchecked spread.

Our model suggests a **clear impact of universal masking.** Without masking, but even with continued social distancing in place once the lockdown is lifted, the infection rate will increase and almost half of the population will become affected. This scenario, rendered in grey in Figure 3, would potentially lead to over a million deaths in a population the size of the UK. A continued lockdown, illustrated in blue colour, does eventually result in bringing the disease under control after around 6 months. However, the economic and social costs of a “full body lockdown” will be enormous, which strongly supports finding an alternative solution. In our models, social distancing and masking at both 50% and 80% of the population — but no lockdown

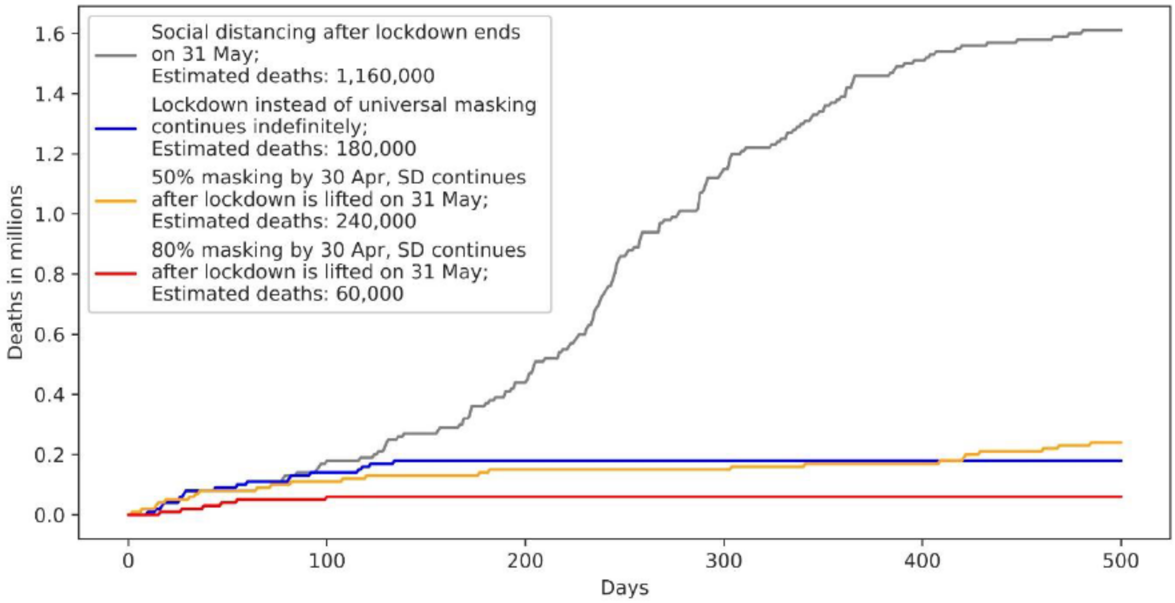


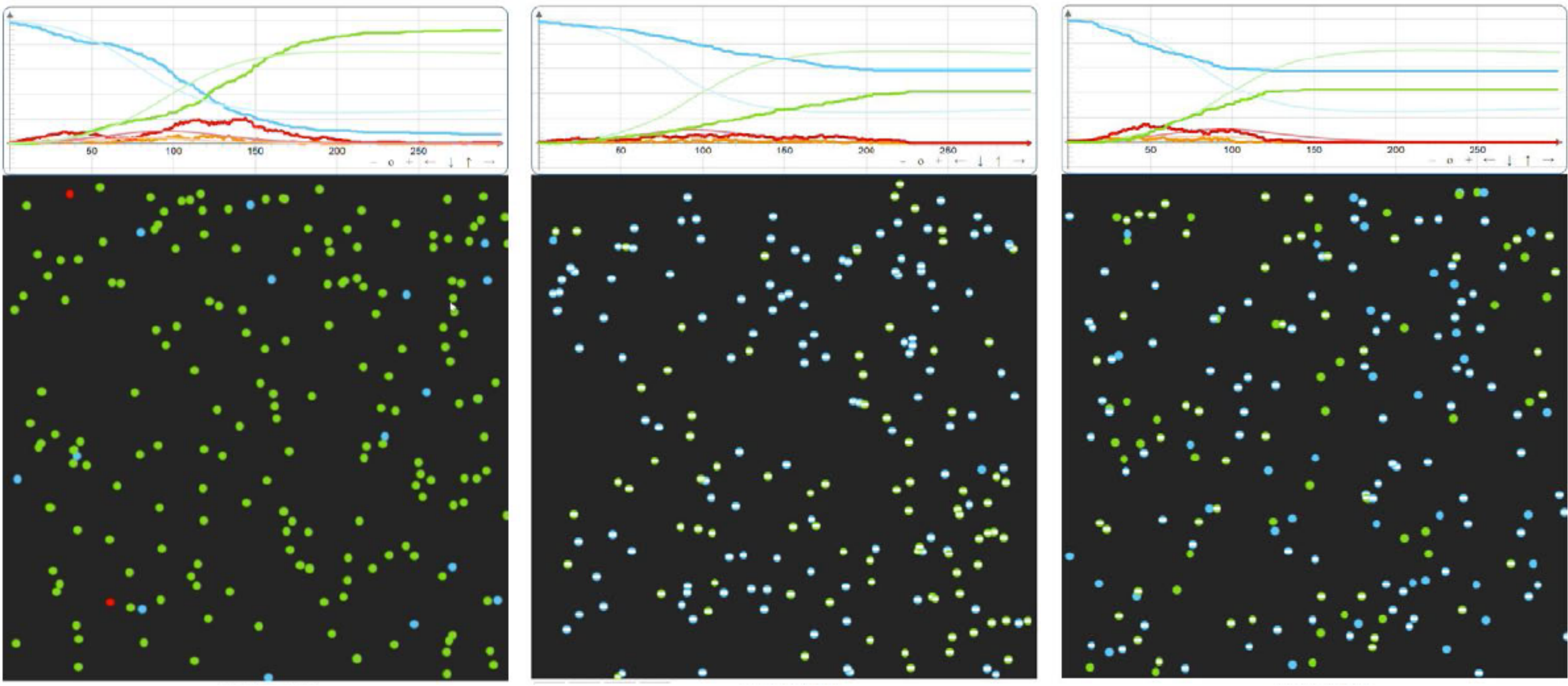
Figure 4. Simulation results for a representative scenario: universal masking at 80% adoption (red) results in 60,000 deaths, compared to maintaining a strict lockdown (blue) which results in 180,000 deaths. Masking at only a 50% adoption rate (orange) is not sufficient to prevent continued spread and eventually results in 240,000 deaths. Replacing the strict lockdown with social distancing on May 31 without masking results in unchecked spread.

beyond the end of May — result in substantial reduction of infection, with 80% masking eventually eliminating the disease.

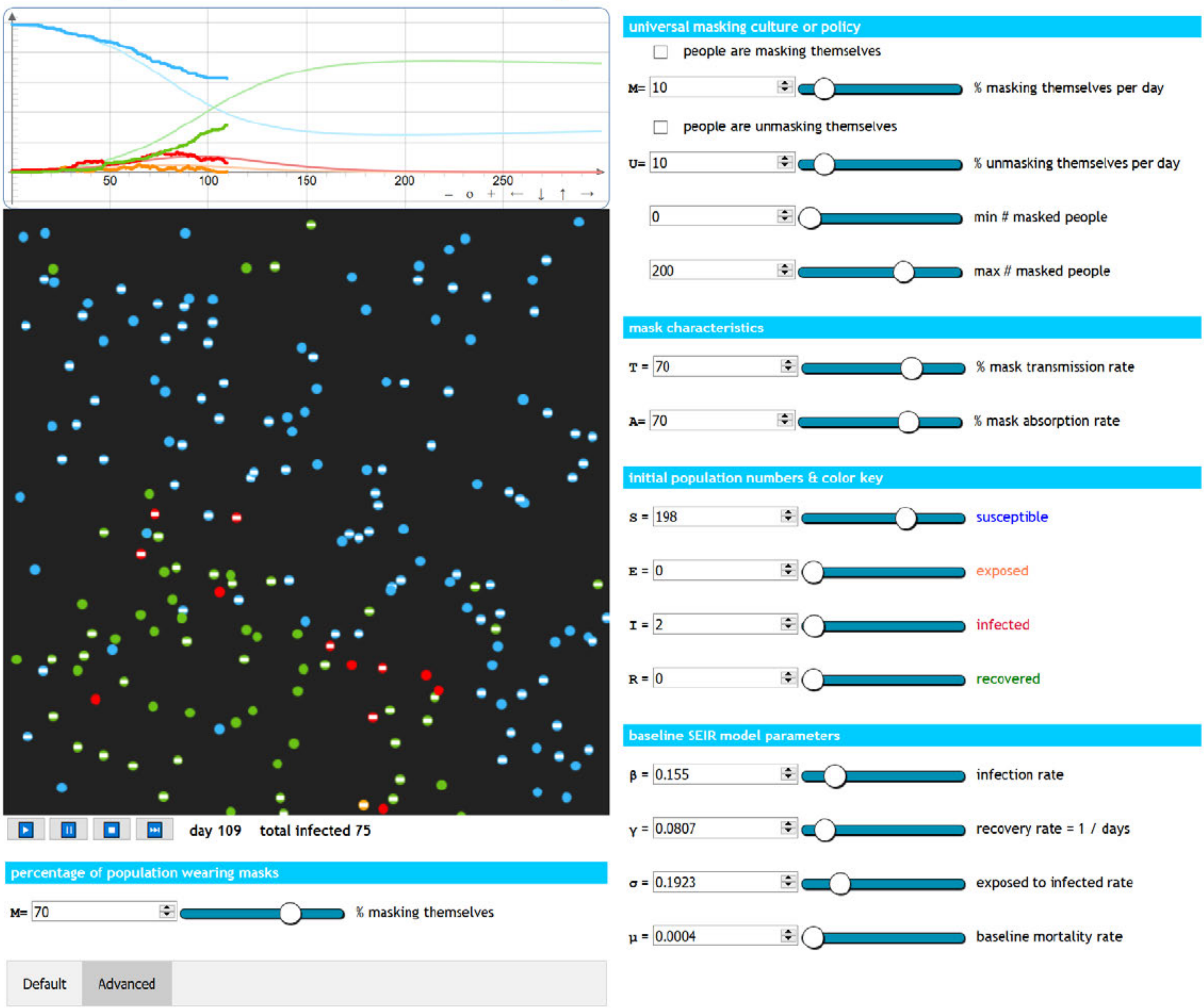
The simulation was fitted to the current timeline in many Western countries, with a lockdown imposed March the 24th (day 1) and planned to be lifted on May 31st. Universal masking is introduced in April. The simulation continues for 500 days from day 0, or around 17 months.

These modelling results support the need for mass masking as an alternative to continued lockdown scenario. For this strategy to be most effective, the vast majority of the population needs to adopt mask wearing immediately.

We implemented SEIR dynamics on a stochastic dynamical network with a heterogeneous population. We assumed an initial infected population of 1% and modelled the assumed effects of social distancing, lockdown, and universal masking over time on the rates of infection in the population. In the model, *social distancing* was defined as the degree distribution of the contact network of an individual. *Lockdown stringency* was modelled considering no stringent lockdown (i.e. only social distancing) or stringent lockdown by setting the probability of individuals coming into contact with those outside of their immediate network. Assuming that individuals have around 13 contacts in normal everyday life, social distancing will reduce this to 4 and lockdown to only 2, for other parameters and details see the Appendix. A gradual increase in *mask wearing* was modelled using a linear increase in the proportion of individuals randomly allocated with a rate of transmission reduced by a conservative factor of 2. The period of time over which the mask wearing went from 0 to maximum % was set to 10 days. 50% and 80% maximum values were considered. All models were built using the SEIRS+ package (https://github.com/ryansmcgee/seirsplus) v0.0.14; for model parameters and details see the Appendix.



Interactive Agent-Based Model Visualization for COVID-19 Masking



TRY THIS NEW INTERACTIVE SIMULATION: AGENT-BASED MODELS SHOW HOW MASKING WORKS

The exponential effect of masking can be counterintuitive.[1] We have constructed a new interactive simulation model to demonstrate how masks can significantly reduce virus spread, even if they are nonmedical or homemade.

To gain a more concrete feel for how masks impact the dynamics of virus spread, try the interactive visualization at http://dek.ai/masks4all

The interactive simulator implements an individual agent-based model (ABM), in contrast to compartmental models which group undifferentiated individuals into large aggregates (like in the above SEIR simulation).

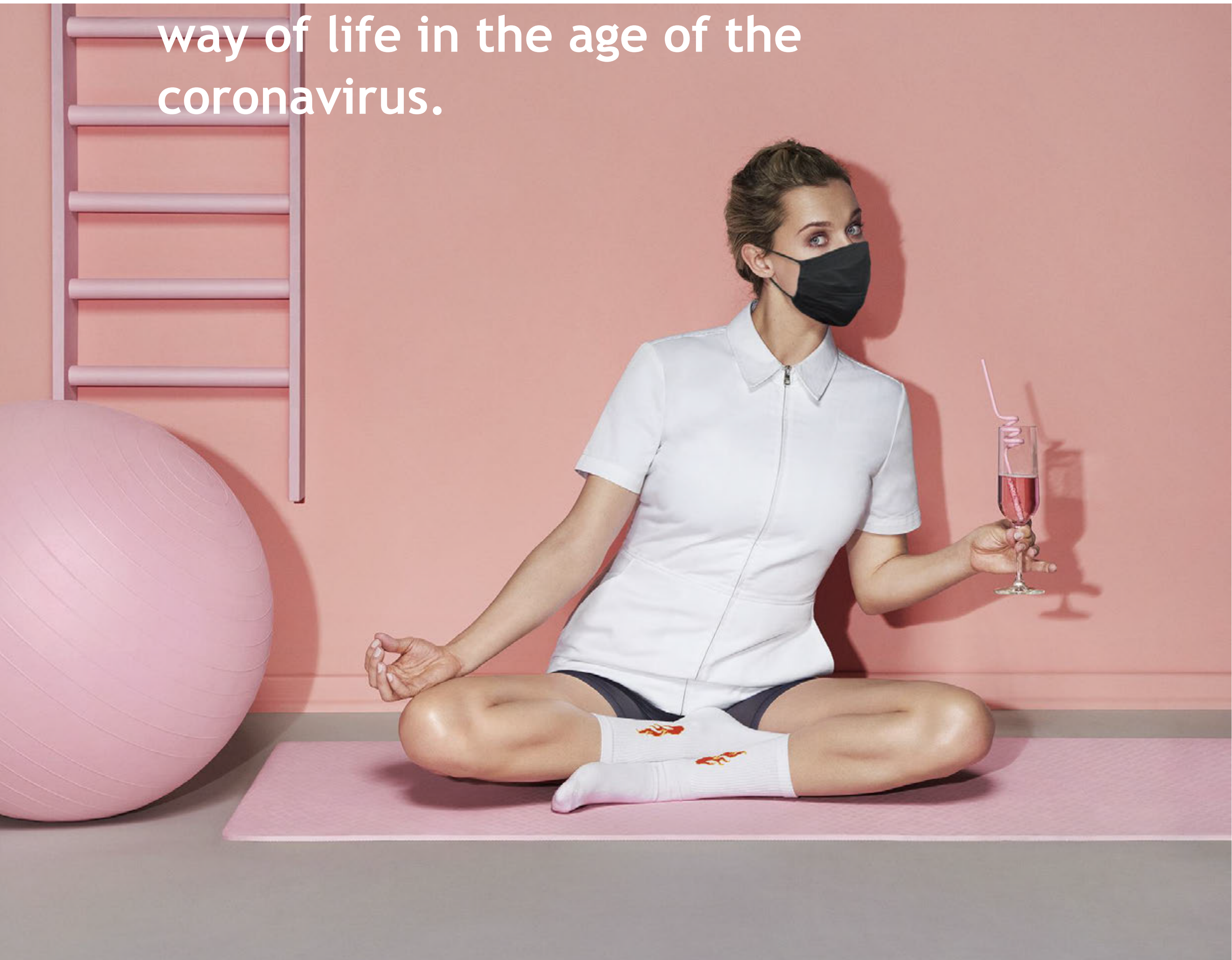
Each moving dot represents an individual agent, who may become exposed to the virus through proximity to other agents who are infectious. Blue dots are healthy susceptible agents, orange dots are exposed agents, red dots are infected agents, and green dots are recovered agents. A dot with a white rectangle on it represents an agent who is wearing a mask.

Slider controls allow playing with various scenarios: whether masking is used, the adoption rate of masking, virus transmission and absorption rates through masks of varying quality, as well as other modelling parameters such as the initial numbers of susceptible, exposed, infected, or recovered agents.

Figure 5. Try this interactive visualization that simulates how COVID-19 spreads under different masking scenarios via an individual agent-based model (ABM).

[1] De Kai (2020). The disastrous consequences of information disorder erupting around COVID-19: AI is preying upon our unconscious cognitive biases. Boma COVID-19 Summit, 23 Mar 2020. http://dek.ai/unbias

Together with mass testing for infection and serological tests, tracking and quarantining diagnosed cases, and social distancing measures, universal masking shows us the way towards a sustainable way of life in the age of the coronavirus.



TO CONCLUDE: UNIVERSAL MASKING NEEDS BROAD SUPPORT AND CLEAR GUIDELINES

We urge governments and international bodies who have not yet done so to consider masking as one of the key tools in population policy after the COVID-19 lockdowns and until the virus is under control. The analysis presented here supports recent studies,[1] suggesting that the effectiveness of universal masking is comparable to that of social distancing or a societal lockdown with closed workplaces, schools, and public spaces and limited geographical mobility. The results from our simulation help explain the dynamics behind the perplexing advantage in the Asian experience of tackling COVID-19 compared to the situation elsewhere.

The effectiveness of universal masking in a given population is likely to depend on the type of masks used, the acceptance of masking in the population, the level of contagion of the virus, and what other interventions have been applied. From this perspective, the Central European experience will be highly informative, since it represents the first major shift to universal masking in a formerly non-masking culture. The effects of this pioneering intervention on infection rates and fatalities will appear only in the forthcoming weeks, although Slovakia and Slovenia are currently showing early indications of progress (see Figure 2 above). In any case, they illustrate that a country with no prior history of mask wearing in public may rapidly change course, and quickly adopt masks as a non-stigmatised — even street smart — way to express caring and solidarity in the community.

The medical and social risks of increased infections need to be countered by proper advice in the public domain. Some studies do indicate negative effects of cloth mass use, for instance, higher risks of infection due to moisture retention, reuse of cloth masks and poor filtration, in comparison to medical masks.[2] There are also concerns that lay individuals may use both medical and/or cloth and paper masks incorrectly. Masking techniques and norms need to be taught with targeted information to different demographics, just as proper handwashing and social distancing techniques have been taught.

[1] E.g., Abaluck, J., Chevalier, J., Beinecke, W., Christakis, N. A., Forman, H., Kaplan, E. H., Ko, A., Vermund, S. H. (2020). *The Case for Universal Cloth Mask Adoption & Policies to Increase the Supply of Medical Masks for Health Workers*. White paper, April 1 2020.

[2] MacIntyre, C Raina, Holly Seale, Tham Chi Dung, Nguyen Tran Hien, Phan Thi Nga, Abrar Ahmad Chughtai, Bayzidur Rahman, Dominic E Dwyer, and Quanyi Wang (2015). A cluster randomised trial of cloth masks compared with medical masks in healthcare workers. *BMJ open* 5(4): e006577.

APPENDIX

SEIR models were built using SEIRS+ package v0.0.14 (https://github.com/ryansmcgee/seirsplus). Unless stated otherwise, default parameters for COVID-19 from the example notebooks in the package GitHub repository were used (listed below for convenience).

Default parameters. β=0.155, σ=1/5.2, γ=1/12.39, μ_D=0.004, μ_0=0, ν=0, ξ=0. Initial infected population ($init_I$) was set to 1%, all others 0%. The size of the total population was set to 67,000 (a factor of 1,000 from the population of the UK). This describes a SEIR model with best estimates for COVID-19 dynamics.

Social distancing and lockdown. Social distancing was described by the degree distribution of the contact network of an individual. Default interaction networks were used, constructed as Barabasi-Albert graphs with m=9 and processes using the package function custom_exponential_graph with different scale parameters. Normal graph (scale=100) with mean degree 13.2, distancing graph (scale=10) with mean degree 4.1 and lockdown graph (scale=5) with mean degree 2.2. Furthermore, lockdown stringency was modelled using the locality parameter p, which was set to 0.02 during lockdown and 0.2 during social distancing phases.

Mask wearing. A gradual increase in mask wearing was modelled using a linear increase in the proportion of individuals randomly allocated with a reduced β parameter. The factor by which β was reduced was conservatively set to 2. The period of time over which the mask wearing went from 0 to maximum % was set to 10 days. 50% and 80% maximum values were considered.

Date fitting. The progression in the number of deaths was used to fit the model to an approximate calendar date representing Day 0. For the UK, this corresponded to Mar 23.

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