Effects of Social Distancing Measures during the First Epidemic Wave of Severe Acute Respiratory Syndrome Infection, Greece

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Greece imposed a nationwide lockdown in March 2020 to mitigate transmission of severe acute respiratory syndrome coronavirus 2 during the first epidemic wave. We conducted a survey on age-specific social contact patterns to assess effects of physical distancing measures and used a susceptible-exposed-infectious-recovered model to simulate the epidemic. Because multiple distancing measures were implemented simultaneously, we assessed their overall effects and the contribution of each measure. Before measures were implemented, the estimated basic reproduction number (R_0) was 2.38 (95% CI 2.01–2.80). During lockdown, daily contacts decreased by 86.9% and R_0 decreased by 81.0% (95% credible interval [CrI] 71.8%–86.0%); each distancing measure decreased R_0 by 10%–24%. By April 26, the attack rate in Greece was 0.12% (95% CrI 0.06%–0.26%), one of the lowest in Europe, and the infection fatality ratio was 1.12% (95% CrI 0.55%–2.31%). Multiple social distancing measures contained the first epidemic wave in Greece.

Coronavirus disease (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), emerged in China in December 2019 (*1*) and by September 14, 2020, had spread worldwide, causing >28.6 million cases and >917,000 deaths (*2*). To suppress the epidemic curve, public health authorities needed to use the strongest possible mitigation strategies until effective therapies and vaccines are available. Central mitigation strategies include nonpharmaceutical interventions, such as travel-related restrictions, case-based, and social distancing interventions. Social distancing aims to decrease social contacts and reduce transmission (*3*).

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In Greece, the first COVID-19 case was reported on February 26, 2020 (*4*). Soon after, several social distancing, travel-related, and case-based interventions were implemented. A nationwide lockdown restricting all nonessential movement throughout the country began on March 23 (Figure 1). By the end of April, the first epidemic wave had waned, and withdrawal of physical distancing interventions became a social priority.

Despite an ongoing severe financial crisis and an older population, Greece has been noted as an example of a country with successful response against COVID-19 (*5*). However, given the resurgence of cases in Greece and other countries, careful consideration and close monitoring are needed to inform strategies for resuming and maintaining social and economic activities.

We describe a survey implemented during lockdown in Greece and assess the effects of physical distancing measures on contact behavior. We used these data and mathematical modeling to obtain estimates for the first epidemic wave in the country, during February–April 2020, to assess the effects of all social distancing measures, and to assess the relative contribution of each measure towards the control of COVID-19.

Materials and Methods

Social Contacts Survey

We conducted a phone survey during March 31–April 7, 2020, to estimate the number of social contacts and age mixing of the population on a weekday during the lockdown and on the same day of the week before the pandemic, during mid-January 2020, by using contact diaries (Appendix Figure 1, https://wwwnc.cdc.gov/EID/

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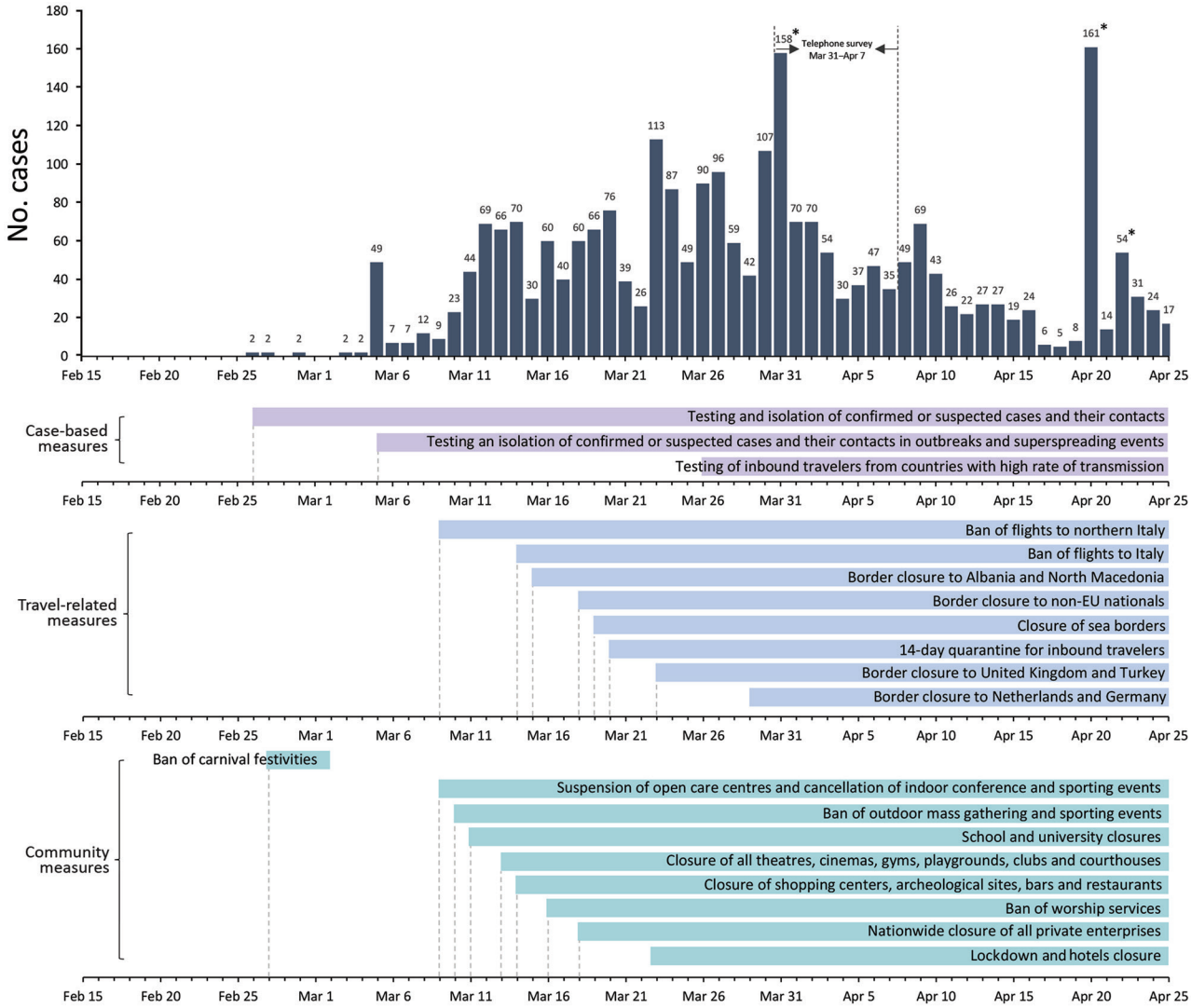

Figure 1. Daily number of coronavirus disease cases by date of sampling for laboratory testing (25) and timeline of key measures, Greece. Dates of telephone survey are indicated. Asterisks indicate spikes in the number of diagnosed cases at the end of March and late April that correspond to clusters of cases in 3 settings: a ship, a refugee camp, and a clinic. EU, European Union.

article/27/2/20-3412-App1.pdf). Participants provided oral informed consent. We defined contact as either skin-to-skin contact or a 2-way conversation with ≥3 words spoken in the physical presence of another person (*6*). For each contact, we recorded information on the contact person's age and location of the contact, such as home, school, workplace, transportation, leisure, or other. We planned to recruit 600 participants of all ages residing in Athens by using proportional quota sampling and oversampling among persons 0–17 years of age.

We estimated the average number of contacts for the prepandemic and lockdown periods. We defined 6 age groups to build age-specific contact matrices, adjusting for the age distribution of the population of Greece, by using socialmixr in R software (R Foundation for Statistical Computing, https://www.r-project.org).

Estimating the Course of the First Epidemic Wave and Assessing Effects of Social Distancing

To estimate the course of the epidemic, we first estimated the basic reproduction number (R_0), the average number of secondary cases 1 case would produce in a completely susceptible population in the absence of control measures. Then, we used social contacts matrices to assess the effects of physical distancing measures on R_0. Finally, we simulated the course of the epidemic using a susceptible-exposed-infectious-recovered (SEIR) model.

Estimating R_0

We estimated R_0 based on the number of confirmed cases with infection onset dates before the first social distancing measures were adopted, up to March 9, and accounted for imported cases. We used a maximum-likelihood method to obtain the R_0 and 95% CI, assuming that the serial interval distribution is known (*7*). We used the daily number of cases by date of symptom onset and inferred infection dates assuming an average incubation period of 5 days (*8*,*9*). We assumed a gamma distributed serial interval with a mean of 6.67 (SD 4.85) days, in accordance with other studies (*10*,*11*; D. Cereda et al., unpub. data, https://arxiv.org/abs/2003.09320). As a sensitivity analysis, we estimated R_0 assuming a shorter serial interval of 4.7 days (Appendix) (*12*).

Assessing Effects of Social Distancing on R_0

Primary social distancing measures implemented in Greece began on March 11. These measures and the dates implemented were closing all educational establishments on March 11; theatres, courthouses, cinemas, gyms, playgrounds, and nightclubs on March 13; shopping centers, cafes, restaurants, bars, museums, and archaeological sites on March 14; suspending services in churches on March 16; closing all private enterprises, with some exceptions, on March 18; and, finally, restricting all nonessential movement throughout the country on March 23 (Figure 1; Appendix Table 1).

We assessed the effects of these measures on R_0 through the social contact matrices obtained before and during lockdown, as used in other studies (*13*,*14*). For respiratory-spread infectious agents, R_0 is a function of the age-specific number of daily contacts, the probability that a single contact leads to transmission, and the total duration of infectiousness; thus, R_0 is proportional to the dominant eigenvalue of the social contact matrix (*15*). If the other 2 parameters did not change before and during social distancing measures, the relative reduction, δ, in R_0 is equivalent to the reduction in the dominant eigenvalue of the contact matrices obtained for the 2 periods (Appendix) (*14*,*16*). To account for a lower susceptibility for children than for adults, we introduced an age-dependent proportionality factor, s_i, measuring susceptibility to infection of persons in age group *i*, as in other studies (*13*,*17*). We performed the analysis using a conservative estimate for s_i, and considered the susceptibility among persons 0–17 years of age to be 0.34 compared with persons ≥18 years of age (Appendix Table 2) (*13*).

We estimated the relative reduction in R_0 in 2 periods: the period of initial measures until the day before lockdown (March 11–22), which included closure of schools, entertainment venues, and shops (reduction δ_1); and the period of lockdown (March 23–April 26) (reduction δ_2). Because we did not assess social contacts during the period of initial measures, we created a synthetic contact matrix by assuming no school contacts because of school closures, and a reduction in leisure and work contacts (*18*–*20*) (Appendix). To assess uncertainty, we performed a nonparametric bootstrap on contact data by participant to estimate the mean and 95% credible interval (95% CrI) of δ_1 and δ_2 (n = 1,000 bootstrap samples).

Simulating the Epidemic in Greece

We used a SEIR model to simulate the outbreak from the beginning of local transmission until April 26, 2020, the day before the originally planned date to ease lockdown measures. Susceptible persons (S) become infected at a rate β and move to the exposed state (E) as infected but not infectious. Exposed persons become infectious at a rate σ, and a proportion p will eventually develop symptoms (p = 80%) (*21*). To account for asymptomatic transmission during the incubation period, we introduce a compartment for infectious presymptomatic persons (I_{pre}). I_{pre} cases become symptomatic infectious (I_{symp}) cases at a rate of σ_s. We assumed that infectiousness can occur 1.5 days before the onset of symptoms (*22*–*24*). The remainder ($1 - p$) will be true asymptomatic or subclinical cases (I_{asymp}). We assumed that the infectiousness of subclinical cases relative to symptomatic cases was q = 50% (*24*). Symptomatic cases recover (R) at a rate of γ_s, and asymptomatic cases recover (R) at a rate of γ_{asymp} (Table 1; Figure 2; Appendix).

We derived the transmission rate β from R_0 and parameters related to the duration of infectiousness (Appendix). We incorporated uncertainty in R_0 by drawing values uniformly from the estimated 95% CI (2.01–2.80). We modeled the effect of measures by multiplying β by the parameters δ_1 and δ_2; in which δ_1 corresponds to the reduction of R_0 in the period of initial social distancing measures, where δ_1 was drawn from a normal distribution with a mean of 42.7% (SD 1.7%); and δ_2 corresponds to the reduction of R_0 during lockdown, for which δ_2 was drawn from a normal distribution of 81.0% (SD 1.6%) estimated from the bootstrap on the contact data. To account for the uncertainty in R_0, δ_1, and δ_2, we performed 1,000 simulations of the model and obtained median estimates and 95% CrIs.

We obtained the infection fatality ratio (IFR) and the cumulative proportion of critically ill patients by dividing the reported number of deaths and of

Table 1. Parameters of the susceptible-exposed-infectious-recovered model used to assess effects of social distancing measures during the first epidemic wave of coronavirus disease, Greece

Epidemiologic parameters	Value	Comments and references
R_0 (95% CI)	2.38 (2.01–2.80)	Estimated from data on the number of confirmed cases in Greece by accounting for imported cases and assuming gamma distributed serial interval with mean 6.67 days (SD 4.88 days) (D. Cereda et al., unpub. data, https://arxiv.org/abs/2003.09320) and aligned with other studies (*10*,*11*)
Latent period (1/σ)	3.5 days	Based on an average incubation time of ≈5 days (*8*,*9*) and assuming that infectiousness starts 1.5 days prior to the symptom onset (*22*–*24*)
Percentage (*p*) infected cases developing symptoms	80	From K. Mizumoto et al. (*21*), the estimated proportion of true asymptomatic cases was 20.6% assuming a mean incubation period of 5.5 days
Symptomatic cases		
Length of infectiousness before symptoms, d ($1/\sigma_s$)	1.5	(*22*–*24*)
Duration of infectious period from development of symptoms to recovery, d ($1/\gamma_s$)	4.5	To obtain a serial interval of ≈6 days (*8*,*9*)
True asymptomatic cases		
Infectiousness (*q*) of asymptomatic vs. symptomatic persons, %	50	(*24*)
Duration of infectious period until recovery ($1/\gamma_{asymp}$)	6 days	The same duration of infectiousness as for symptomatic cases = $1/\sigma_s + 1/\gamma_s$

critically ill patients (*25*) by the total number of cases predicted by the model. We used a lag of 18 days for deaths and 14 days for critically ill patients based on unpublished data on hospitalized patients from the National Public Health Organization in Greece. To validate our findings, we used a reverse approach; we applied a published estimate of the IFR (*26*) to the number of infections predicted by the model and compared the resulting cumulative and daily number of deaths to the observed deaths (Appendix Table 3).

Effects of Social Distancing Interventions

Because multiple social distancing measures were implemented simultaneously, to delineate the effects of each measure on R_0, we used information from the

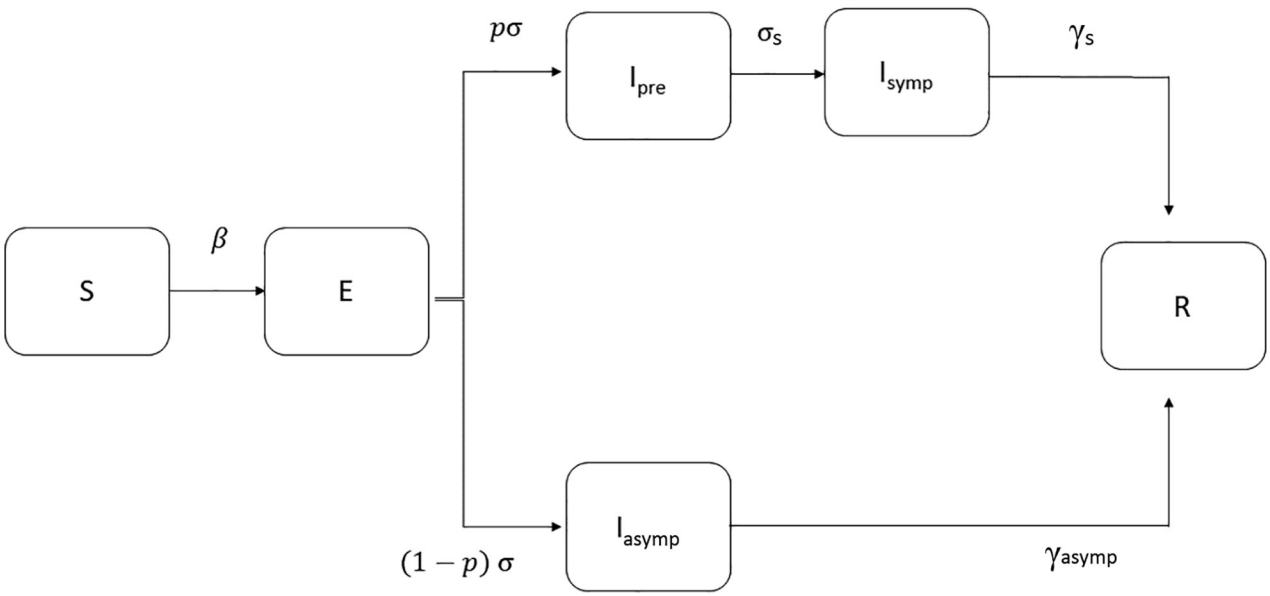

Figure 2. Modified susceptible-exposed-infectious-recovered (SEIR) model used to estimate the course of the first epidemic wave of coronavirus disease, Greece. Cases are classified into susceptible (S), exposed (E), infectious (I, which is divided into 3 conditions: I_{pre}, before developing symptoms, I_{symp} for clinically ill, or I_{asymp} for true asymptomatic), and recovered (R). We assumed that a proportion (*p*) of exposed cases will develop symptoms and that infectiousness can occur before the onset of symptoms. β is the rate at which persons become infected and move to E; exposed individuals become infectious at a rate σ and presymptomatic infectious cases develop symptoms at a rate σ_s; γ_{asymp} is the rate of recovery for asymptomatic persons; γ_s is the rate of recovery for symptomatic persons.

contacts reported on a regular weekday in January 2020 and mimicked the impact of each intervention by excluding or reducing subsets of corresponding social contacts (*16*,*17*,*19*,*20*) (Appendix). We also assessed scenarios with less disruptive social distancing measures (Appendix). In addition, we evaluated the increase in effective reproduction number (R_t) for varying levels of infection control measures (hand hygiene, use of facemasks, and maintaining distance ≥1.5 m) when social distancing measures are partially lifted after lockdown (Appendix).

Results

Social Contacts before and during Lockdown

In total, 602 persons provided contact diaries and reported 12,463 contacts before the pandemic and 1,743 during lockdown (Table 2). The mean daily number of contacts declined from 20.7 before to 2.9 during lockdown; when adjusted for the age distribution of the population, the reduction was 19.9 before and 2.6 during lockdown (86.9%).

We noted a change in age-mixing patterns in the contact matrices (Figure 3, panel A). In the prepandemic period, the diagonal of the contact matrix depicts the assortativity by age; participants tended to associate more with people of similar age (Figure 3, panel A). When social distancing measures were put into effect, the assortativity by age disappeared and contacts occurred mainly between household members (Figure 3, panels B–D).

R_0 and Effects of Social Distancing Measures

Before lockdown, the estimated R_0 was 2.38 (95% CI 2.01–2.80). During the first period of social distancing measures, in which schools, entertainment venues, and shops were closed, R_0 was estimated to decrease by 42.7% (95% CrI 34.9%–51.3%); under lockdown, R_0 decreased by 81.0% (95% CrI 71.7%–86.1%). Thus, the cumulative measures implemented during lockdown would have reduced R_0 to <1.0 even if the initial R_0 had been as high as 5.3 (95% CrI 3.5–7.2). Estimated R_t was 1.13 (95% CrI 1.38–1.61) during the period of the initial measures but was 0.46 (95% CrI 0.35–0.57) during lockdown (Figure 4, panel A).

Contribution of Each Social Distancing Measure

We assessed the effect of each measure separately and in combinations (Figure 5). During lockdown, the estimated reduction in R_0 attributed to each measure was 10.3% (95% CrI 5.2%–20.3%) for the decline in work contacts, 18.5% (95% CrI 10.7%–26.3%) for school closures, and 24.1% (95% CrI 14.8%–34.3%) for the decline in leisure activity contacts. Thus, each measure separately would have reduced R_0 to <1.0 if the initial R_0 had been as high as 1.11 for the decline in work contacts, 1.23 for school closures, and 1.32 for the decline in leisure activity contacts. A combination of measures could be effective if the initial R_0 had been as high as 1.78 for interventions reducing work and school contacts, 1.72 for reducing work and leisure contacts, and 1.43 for reducing school and leisure contacts.

We assessed alternative scenarios with less disruptive social distancing measures. A 50% reduction in school contacts, such as smaller class sizes; 20% in work contacts, such as teleworking for part of the population or rotating weekly schedules in which employees telework some days and work onsite other days; and 20% in leisure activities could reduce R_0 to <1.0 for initial levels as high as 1.32 (95% CrI 1.27–1.38). An even larger decline in leisure activities (50%) could successfully reduce an initial R_0 as high as 1.48 (95% CrI 1.35–1.62).

Finally, we assessed the increase in R_t when measures were partially lifted after lockdown. To mimic the measures implemented after lockdown in Greece, we assumed that contacts at work would return to

Table 2. Number of contacts on a weekday during lockdown, March 31–April 7, 2020, and on the corresponding day in January 2020 before the coronavirus disease epidemic in Athens, Greece

	Mid-January 2020			During lockdown		Reduction of reported
Covariate	Participants, no. (%)	No. (%)	Mean (95% CI)	No. (%)	Mean (95% CI)	contacts, %
Overall	602 (100.0)	12,463 (100.0)	20.7 (18.9–22.5)	1,743 (100.0)	2.9 (2.6–3.2)	86.0*
Sex						
M	295 (49.0)	6,218 (49.9)	21.1 (18.3–23.9)	934 (53.6)	3.2 (2.7–3.6)	85.0
F	307 (51.0)	6,245 (50.1)	20.3 (18.0–22.7)	809 (46.4)	2.6 (2.2–3.1)	87.1
Age, y						
0–4	20 (3.3)	386 (3.1)	19.3 (12.8–25.8)	53 (3.0)	2.7 (2.2–3.1)	86.3
5–11	58 (9.6)	2,020 (16.2)	34.8 (29.1–40.6)	168 (9.6)	2.9 (2.6–3.2)	91.7
12–17	83 (13.8)	2,758 (22.1)	33.2 (28.4–38.1)	275 (15.8)	3.3 (2.3–4.3)	90.0
18–29	74 (12.3)	1,316 (10.6)	17.8 (14.4–21.1)	361 (20.7)	4.9 (3.1–6.7)	72.6
30–64	209 (34.7)	4,852 (38.9)	23.2 (19.5–26.9)	529 (30.4)	2.5 (2.2–2.9)	89.1
≥65	158 (26.3)	1,131 (9.1)	7.2 (5.4–8.9)	357 (20.5)	2.3 (1.8–2.7)	68.4

*The reduction in the reported contacts becomes 86.9% after adjusting for the age distribution of the population of Greece.

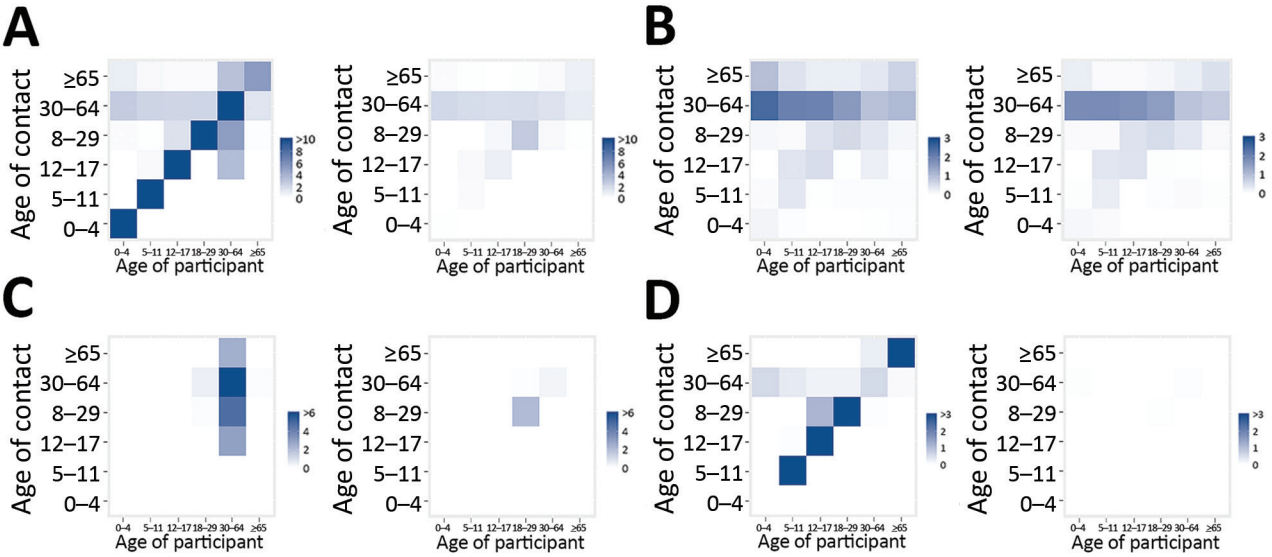

Figure 3. Side-by-side comparisons of age-specific contact matrices in Greece before the coronavirus disease pandemic (January 2020; left) and during lockdown (April 2020; right). A) All contacts; B) contacts at home; C) contacts at work; and D) contacts during leisure activities. Each cell represents the average daily number of reported contacts, stratified by the age group of the participants and their corresponding contacts. In panel A, the diagonal of the contact matrix corresponds to contacts between persons in the same age group, the bottom left corner of the matrix corresponds to contacts between school-age children, and the central part corresponds to contacts mainly in the work environment.

levels 50% lower than pre-pandemic, school to 50%, and leisure to 60%. For instance, class sizes were reduced 50% when schools reopened in May. Under this scenario, R_t would remain <1.0 assuming ≥20% reduction in susceptibility as a result of infection control measures, including hand hygiene, use of face masks, and maintaining physical distances ≥1.5 meters (Figure 6). Under milder social distancing measures, infection control policies would need to be much more effective (Appendix Figure 2).

Model Predictions on the Epidemic during February 15–April 26

By April 26, 2020, Greece had 2,517 diagnosed COVID-19 cases, 23.0% of which were imported, and 134 deaths (Figure 1) (25). The corresponding naive case-fatality ratio (CFR) was 5.3%. Based on our SEIR model, the cumulative number of infections during February 15–April 26 would be 13,189 (95% CrI 6,206–27,700) (Figure 4, panel B), which corresponds to an attack rate (AR) of 0.12% (95% CrI

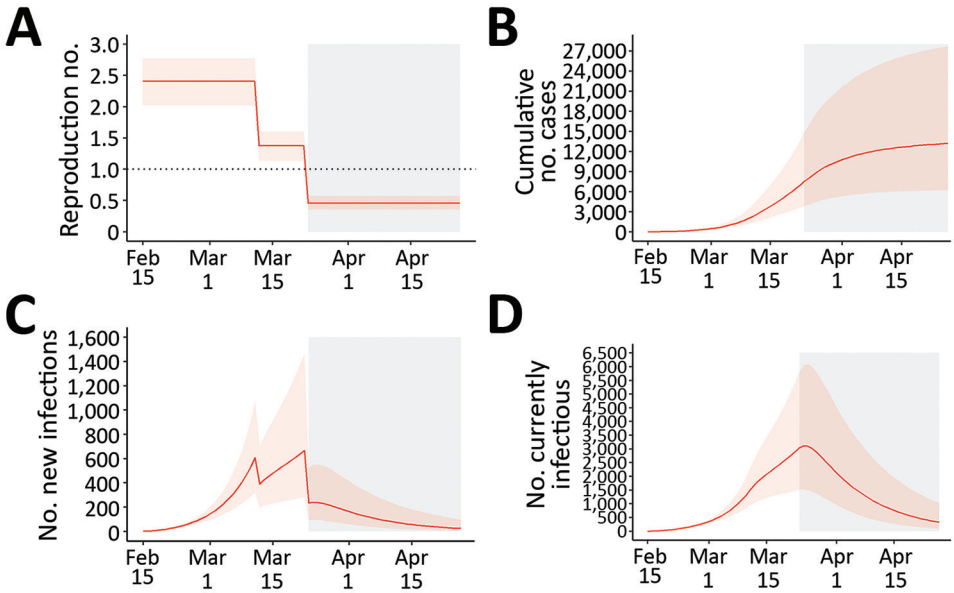

Figure 4. The first wave of the coronavirus disease epidemic in Greece (February 15–April 26, 2020), estimated from 1,000 susceptible-exposed-infectious-recovered (SEIR) model simulations. A) Effective reproduction number; B) cumulative number of cases; C) new infections; and D) number of infectious persons by date. Orange lines represent the median estimates, and the light orange shaded areas indicate 95% credible intervals. Gray areas indicate the period of restrictions of all nonessential movement in the country (i.e., lockdown).

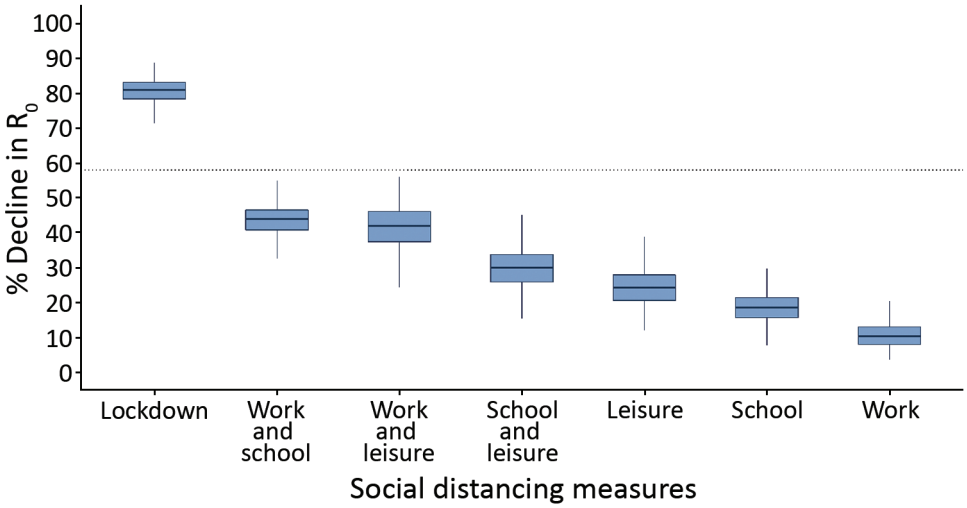

Figure 5. The percenage decline of R_0 associated with multiple social distancing measures during coronavirus disease lockdown in Greece and the relative contribution of each measure or combination of measures implemented. Boxplots demonstrate distribution of the estimated percent decline from nonparametric bootstrap on the social contacts data based on 1,000 bootstrap samples. R_0 reduction during lockdown was obtained by comparing social contacts data collected for April 2020 versus January 2020. The other estimates were derived by using the information from contact diaries in January 2020 corresponding to a regular school or work day and excluding or reducing subsets of social contacts at school, work, home, and leisure activities, based on observations during lockdown. Because contact with a particular person can take place in multiple settings, we assigned contacts at multiple locations to a single location by using the following hierarchical order: home, work, school, leisure activities, transportation, and other locations. Dotted line indicates the minimum reduction needed to bring R_0 from 2.38 to <1. Box top and bottom lines indicate 25th and 75th percentiles; horizontal lines within boxes indicate medians; whiskers indicate 25th/75th percentile plus 1.5 times the interquartile range. R_0, basic reproduction number.

0.06%–0.26%). The estimated case ascertainment rate was 19.1% (95% CrI 9.1%–40.6%). By the end of April, 25 (95% CrI 6–97) new infections per day and 329 (95% CrI 97–1,027) total infectious cases were estimated (Figure 4, panels C, D).

On the basis of the number of deaths and critically ill patients reported in Greece by April 26, and using the number of infections obtained from the model as denominator, we estimated the IFR to be 1.12% (95% CrI 0.55%–2.31%) and the cumulative proportion of critically ill patients to be 1.55% (95% CrI 0.75%–3.22%). As a validation, we estimated the number of deaths by applying a published age-adjusted estimated IFR to the number of infections predicted by the model (Appendix Table 3). The predicted number of deaths was 137 (95% CrI 66–279) compared with the reported number of 134 deaths (Appendix Figure 3). As a sensitivity analysis, we simulated the epidemic and calculated IFR and AR assuming a shorter mean serial interval of 4.7 days. We obtained similar results for the AR and the IFR as when the serial interval was 6.67 days (Appendix Figure 4).

Discussion

Greece and other countries managed to successfully slow the first wave of the SARS-CoV-2 epidemic early in 2020. Assessing the burden of infection and death in the population and quantifying the effects of social distancing was necessary because the stringent measures taken had major economic costs and restricted individual freedom. In addition, several countries, including Greece, began seeing COVID-19 cases increase after resuming economic activities and travel, indicating the need to reimplement some types of location-specific physical distancing measures.

We assessed the effects of social distancing by using a social contacts survey to directly measure participants' contact patterns during lockdown in a sample including children. To our knowledge, only 2 other diary-based social contacts surveys have been implemented during COVID-19 lockdown, 1 in China (*13*) and 1 in the United Kingdom (*14*); only the study from China included children. Our study had common findings with the other 2: a large reduction in the number of contacts, 86.9% in Greece, 86.4%–90.3% in China, and 73.1% in United Kingdom; and assortativity by age (i.e., contacts between people of the same age group) disappeared during lockdown and contacts were mainly among household members. Other studies have assessed the impact of social distancing indirectly by using contact data from prepandemic periods and assuming that interventions reduce social mixing in different contexts (*18*,*20*,*27*).

We estimated that R_0 declined by 81% and reached 0.46 during lockdown. This finding agrees with findings from a study pooling information from 11 countries in Europe, which also reported an 81% reduction in R_0 (*28*) and with estimates from China (*3*,*29*), the United Kingdom (76.2%; *14*), and France (77%; *30*). In our analysis, we assumed lower susceptibility among

children because of support from a growing body of evidence (*13*,*17*,*31*–*33*; K. Mizumoto et al., unpub. data, https://doi.org/10.1101/2020.03.09.20033142).

We further attempted to delineate the effects of each measure. For example, many countries, including Greece, instituted large-scale or national school closures (*34*). We estimated that each measure alone could reduce an R_0 of ≈1.1–1.3 to <1.0. Only multiple social distancing measures would be effective for reducing an R_0 at the initial level (2.38) observed in Greece. The finding concerning an 18.5% reduction in R_0 related to school closures agrees with recent studies suggesting that this measure likely is much less effective for COVID-19 than for influenza-like infections (*17*,*28*). Concerning the course of the epidemic after lockdown, moderately relaxing social distancing could be safe if ongoing infection control strategies are adopted; milder social distancing measures would demand stricter infection control policies.

By May 18, 2020, Greece had one of the lowest reported COVID-19 death rates in Europe, 15.2 deaths/1 million population (*35*) (Appendix Table 4). Our IFR estimate of 1.12% was similar to that anticipated for the population of Greece based on a published estimate adjusting for demography (*26*). In addition, the estimated AR of 0.12% (95% CrI 0.06%–0.26%) was one of the lowest in Europe (*28*,*36*). Other researchers have applied back calculation of infections from reported deaths (*28*), and the resulting infection AR was almost identical (0.13%) (*36*). Our estimate is further confirmed by a serosurvey in residual serum samples that identified 0.25% (95% CI 0.02%–0.50%) seroprevalence in Greece in April 2020 (*37*). The number of infectious cases subsided considerably towards the end of April; however, even during this period with low transmission levels, 2 local outbreaks were identified, 1 in a refugee camp and 1 in a private healthcare unit, thus increasing the number of diagnosed cases in the respective days (Figure 1). An increasing number of reports around the world suggest the significance of superspreading events (*38*–*41*), and caution should be exercised to prevent or recognize these events early.

The first limitation of our study was that, due to the absence of prepandemic data on social contacts, we asked respondents to report their contacts ≈2 months prior to the survey to ensure reports were not affected by increased awareness of the pandemic. Recall bias might be observed, although to what direction is not clear. A general limitation in contact diaries is that participants record a fraction of their contacts (*42*). However, biases in participant recall are difficult to quantify, especially for those with many contacts in different settings. For example, short-lived contacts and work contacts are more likely to be underreported (*42*). Thus, recall bias could be different among children and adults and in various settings. In addition, underreporting might have occurred before and during lockdown because of many social contacts before the pandemic or because participants were afraid to disclose contacts during lockdown. Second, the survey was conducted in a sample from the Athens metropolitan area and not from the whole country. However, no consistent relationship has been found between social contacts and urbanization (*43*). In addition, most (79%) of the population of Greece lives in urban areas, and Athens accounts for 35% of the population. Furthermore, the observed reduction of social contacts during lockdown was similar to other surveys (*13*,*14*). Third, estimated R_0 depends on the serial interval. Because no data from a local study of

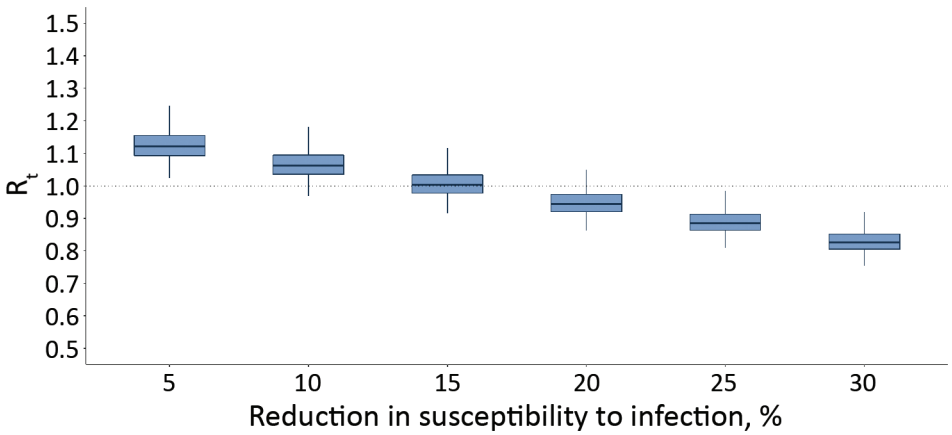

Figure 6. Estimated R_t after the partial lifting of social distancing measures at the end of the first coronavirus disease epidemic wave in Greece for varying effectiveness levels of infection control measures, such as hand hygiene, use of masks, maintaining social distances, in reducing susceptibility to infection. R_t during lockdown was 0.46. For the partial lifting of measures, we hypothesized a scenario in which contacts at work and school contacts will return to 50% lower than pre-epidemic levels and leisure activities will return to 60% lower than pre-epidemic levels. Dotted line indicates the threshold of R_t = 1. Boxplots of the distribution of the estimated Rt from nonparametric bootstrap on the social contacts data based on 1,000 bootstrap samples. Box top and bottom lines indicate 25th and 75th percentiles; horizontal lines within boxes indicate medians; whiskers indicate 25th/75th percentile plus 1.5 times the interquartile range. R_t, effective reproduction number.

infector–infectee pairs were available, the distribution of the serial interval was based on previous estimates (*10*,*11*; D. Cereda et al., unpub. data, https://arxiv.org/abs/2003.09320). The estimated R_0 aligned with estimates obtained in China (*44*) and Italy (*45*), and we accounted for the uncertainty in this value. We also repeated the analysis assuming a shorter serial interval (*12*), which resulted in a lower reproduction number. Fourth, in assessing the effect of each social distancing measure separately, we should note that an interrelation exists between the different measures and our approach might be an approximation. For example, school closure alone might result in increases in leisure contacts or decline in work contacts because parents need to be home with younger children. Fifth, as elsewhere, we assumed that changes in social contacts occur as soon as interventions take place, rather than gradually during lockdown dates (*28*), which could be valid for some interventions, such as school closure, but not for others. Finally, we did not consider case-based interventions that might have affected contacts, such as isolation of confirmed cases and quarantine of close contacts. In Greece, narrow testing criteria were applied beginning March 16 and elderly or severely ill persons, other high-risk groups, and healthcare personnel were tested but others were not; also, the testing capacity during March and April was low.

Overall, the social distancing measures Greece put in place in early March 2020 had a substantial impact on contact patterns and reduced R_0 to <1.0. By the end of April, the spread of COVID-19 was contained in Greece, and the country had one of the lowest ARs in Europe after the first pandemic wave. However, as social distancing and travel restrictions are relaxed, close monitoring of R_t is essential in order to adapt interventions over time without having to resort to stringent measures. Measuring social mixing patterns and adherence to infection control measures through repeated surveys can be additional tools for real-time monitoring of the epidemic potential in the months to come.

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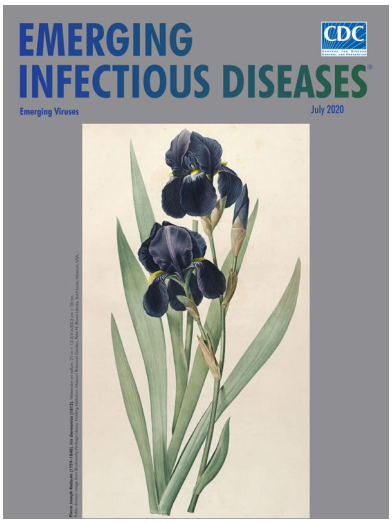

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Effects of Social Distancing Measures during the First Epidemic Wave of Severe Acute Respiratory Syndrome Infection, Greece

Appendix

Social Contacts Survey

During March 31–April 7, 2020, we conducted a survey of social contacts among persons in Athens, Greece. Proportional quota sampling based on age and sex was used and persons 0–17 years old were oversampled. Random digital dialing was used to reach the population and only 1 person in each household was asked to participate to the study. Trained staff administered questionnaires by telephone. Calls were placed between 10:00 AM–3:00 PM and 5:30 PM–9:30 PM (Appendix Figure 1).

Eligible participants had to be local resident of Athens, and to have lived ≥6 months in Athens during the past year, which was applicable only for respondents >2 years of age. Time and budget restrictions did not allow expansion of the survey outside Athens. However, Athens Metropolitan Area includes 3.83 million of the 10.8 million persons residing in Greece.

The questionnaire consisted of three sections: 1) general information, such as sex, age, educational level, household size, and age of household members; 2) a contact diary for a 24-hour period from 5:00 AM of the day before the interview to 5:00 AM the day of the interview or the previous Friday if the interview took place on Monday; and 3) a contact diary for the same day of the week in mid-January before the first cases were diagnosed in Europe.

Parental-proxy completion was used for all children 0–11 years of age and for children and adolescents 12–17 years of age if the parent did not consent to provide information on their own. More specifically, interviews of persons <18 years old were performed as follows: parents or guardians responded to the questionnaire on behalf of children 0–11 years old; for children

and adolescents 12–17 years of age, either the participant provided information on their own with parental informed consent, or parents provided information on behalf of the participant. For parental-proxy completion, parents were asked to collaborate with their child if the child was old enough to provide information.

In social contacts studies, children often are deliberately oversampled because of their important role in the spread of infectious diseases (*1*,*2*). In our survey, we oversampled children and adolescents 0–17 years of age because we wanted to be able to assess social contacts in various age groups (0–4, 5–11, 12–17) and to explore the impact of school closure.

Estimates Assuming a Shorter Serial Interval

We also estimated R_0 assuming a shorter serial interval with mean of 4.7 days and standard deviation of 2.9 days (*3*). Using a shorter serial interval, estimated R_0 was 1.85 (95% CI 1.56–2.17) compared with an estimated R_0 of 2.38 (95% CI 2.01–2.80) under a longer serial interval in the main analysis. In the susceptible-exposed-infectious-recovered (SEIR) model, we assumed a duration of infectiousness of 3 days rather than 4.5 days under a longer serial interval (Appendix Figure 4).

Assuming a shorter serial interval, estimated effective reproduction number (R_t) was close to 1 before the implementation of lockdown. Then during lockdown, R_t was 0.35 (95% CrI 0.27–0.44) assuming a serial interval of 4.7 days compared with 0.46 (95% CrI 0.35–0.57) under a serial interval of 6.67 days. The cumulative number of infections from the start of the epidemic until the end of the simulations period on April 26, was 12,423 (95% CrI 5,562–28,713) compared with 13,189 infections (95% CrI 6,206–27,700) under a longer serial interval. The cumulative number of infections corresponds to an AR of 0.11% (95% CrI 0.05%–0.27%) compared with 0.12% (95% CrI 0.06%–0.26%) assuming the longer serial interval. At the end of the simulations period, April 26, the median number of new infections per day was predicted to reach 2.5 (95% CrI 0.5–14.4) compared with 25 new infections per day (95% CrI 6–97) with the longer serial interval. On April 26, the median number of infectious cases in our model was 22 (95% CrI 5–101) compared with 329 infectious cases (95% CrI 97–1,027) assuming a longer serial interval.

Based on the number of deaths reported in Greece by April 26, we estimated the infection fatality ratio (IFR) by using the number of infections as denominator with a time lag of 18 days. Using this calculation, estimated IFR was 1.11% (95% CrI 0.49%–2.47%) compared with 1.12% (95% CrI 0.55%–2.31%) assuming a longer serial interval.

Assessing the Impact of Social Distancing Measures

Estimating the Relative Change in R_0 before and during Social Distancing Measures

The relative change (δ) in R_0 before and during social distancing measures is equivalent to the reduction in the dominant eigenvalue of the contact matrices obtained for the 2 periods and was calculated as follows (equation [1]):

$$\delta = 1 - \frac{\max eigenvalue\ (K_{during})}{\max eigenvalue\ (K_{pre})}$$

where the elements of the matrices K_{pre} and K_{during} are defined as $k_{ij,pre} = s_i c_{ij,pre}$ and $k_{ij,during} = s_i c_{ij,during}$ in which $c_{ij,pre}$ is the average number of contacts between persons in age group *i* with persons in age group *j* before the period of social distancing measures, $c_{ij,during}$ is the number of contacts during the period of social distancing measures, and s_i is the susceptibility to infection of an age-*i* person (i,j = 1,..6).

Estimating the Social Contacts Matrix during the Initial Measures

The first period of measures during March 11–22, included closure of schools, entertainment venues, and shops except from supermarkets, grocery stores, and pharmacies. Because we did not measure the reduction in contacts during this period, we used the information from the contacts reported on a regular weekday in January 2020 and mimicked the impact of these intervention by excluding school contacts and reducing contacts at work and leisure activities accordingly (*2,4–6*). Thus, we created a synthetic contact matrix by assuming that no school contacts took place because of school closures and that contact through leisure activities was reduced by 80% and work contacts reduced by 30% during lockdown as a result of these first measures. We accounted for a reduction in work contacts because a special purpose leave was provided to working parents with children enrolled in nursery schools and kindergarten or with children ≤15 years of age attending mandatory education schools. Contacts reported at multiple locations, such as contact with a person at school and leisure activities, were assigned to

a single location using the following hierarchical order: home, work, school, leisure activities, transportation, and other locations (*4*). Thus, the social contacts matrix for the first period of measures was as follows:

$$C_{inital\,measures} = C_{home} + (1 - f_1) \cdot C_{work} + 0 \cdot C_{school} + (1 - f_2) \cdot C_{leisure} + C_{transport} + C_{other}$$

where $C_{home}, C_{work}, C_{school}, C_{leisure}, C_{transport}, C_{other}$ were the matrices obtained from the contacts reported on a regular weekday before the pandemic in Greece in January 2020 and f_1, f_2 are the reduction in leisure and work contacts during the first measures.

The relative change in R_0 was then estimated from equation [1] by using the contacts c_{ij} from the corresponding social contacts matrices $C_{inital\,measures}$ and C_{pre}.

Effects of Each Measure Implemented during Lockdown

To assess the impact of each measure separately, we estimated the reduction in R_0 by using the social contacts matrix before the pandemic and the synthetic matrix corresponding to each measure or combination of measures. For example, to estimate the impact of school closures, we compared the original matrix with social contacts reported on a regular weekday (C_{pre}) to the matrix resulting from the sum of home, work, leisure, transportation, and other contacts, excluding contacts in the school setting. The resulting synthetic contact matrix for school closure became

$$C_{school\,closure} = C_{home} + C_{work} + 0 \cdot C_{school} + C_{leisure} + C_{transportation} + C_{other}$$

Similarly, the impact of closing restaurants, coffee shops, cinemas, and other venues was estimated by reducing the subset of leisure contacts data by a proportion *f*. The synthetic contact matrix became

$$C_{reduction\,leisure} = C_{home} + C_{work} + C_{school} + (1 - f) \cdot C_{leisure} + C_{transportation} + C_{other}$$

This approach was used to assess the impact of a combination of measures, for example school closure and reduction in contacts at work, because they were measured during lockdown.

Effects of Milder Measures in Reducing Transmission during the First Wave

We assessed the impact of a theoretical scenario with less disruptive social distancing measures. A reduction of 50% in school contacts, such as classes split in half, combined with 20% teleworking and 20% reduction in leisure activities, results in the following contact matrix:

$$C_{mild\,measures} = C_{home} + (1 - 0.20) \cdot C_{work} + (1 - 0.50) \cdot C_{school} + (1 - 0.20) \cdot C_{leisure} + C_{transportation} + C_{other}$$

Effects of Lifting Measures Post Lockdown for Varying Effectiveness of Infection Control Measures

We assessed scenarios in which lockdown measures were partially lifted. As a result, the number of contacts increase but they do not return to the pre-epidemic levels. We hypothesized a scenario (scenario 1) in which contacts at work and school would return to levels that are 50% lower than prepandemic levels and leisure activities are 60% lower. The rational for this scenario is based on the following selected measures implemented post lockdown in Greece:

• High schools opened in mid-May and primary schools opened in June. Class sizes were reduced by half with a maximum of 15 students per classroom, desks were spaced 1.5 meters apart, and breaks were staggered to allow for physical distancing.

• Retail stores opened on May 11 with restrictions on the number of persons per square meter.

• Cafes, restaurants, and bars opened on June 1 with only outdoor spaces and restrictions on the number of people allowed per table.

Apart from scenario 1 (work reduced 50%, school 50%, leisure activities 60%.), we also assessed 2 scenarios with milder social distancing measures concerning the number of contacts post lockdown: scenario 2 involved work and leisure activities reduced by 20%, school by 50% and scenario 3 involved having all contacts are near prepandemic levels with just 20% reduction.

In each scenario, we applied the following methodology. The corresponding social contacts matrix for the period after lockdown is denoted as C_{post} and C_{during} is the contact matrix during lockdown. The resulting increase in R_t can be assessed as follows:

$$1 - \frac{\max eigenvalue\ (K_{post})}{\max eigenvalue\ \ (K_{during})}$$

where the elements of the matrices K_{post} and K_{during} are defined as $k_{ij,post} = hs_i c_{ij,post}$ and $k_{ij,during} = s_i c_{ij,during}$ in which $c_{ij,post}$ and $c_{ij,during}$ are the average number of contacts between persons in age group *i* with persons in age group *j* post and during lockdown, and s_i is the susceptibility to infection of an age *i* person (*i*,*j* = 1,..6). We assumed that post lockdown

susceptibility to infection is reduced by a fraction (1 – h) as a result of intensive infection control measures, including hand hygiene, use of facemasks, and maintaining distances ≥1.5 m. We assumed the same reduction for all age groups.

We did not account for infection control measures during lockdown because contacts during that period occurred mostly within households. In addition, some measures, such as the use of fabric facemasks by the general public, were not recommended during lockdown in Greece. During the period of lifting lockdown measures, public health officials strongly recommended use of fabric facemasks by the general public and government officials made use of facemasks mandatory on public transportation and in crowded public spaces. To account for the efficacy of measures, such as keeping distances, and the possible impact of others, such as use of masks (*7*,*8*), we assumed a 5%–30% reduction in susceptibility (i.e., *h* ranging between 0.70–0.95) (Figure 6). This reduction corresponds to the efficacy and the adherence to these measures.

Under the scenarios with the milder social distancing measures (work and leisure contacts return to levels 20% below pre-epidemic, and school contacts are 20%–50% lower than pre-epidemic levels), infection control measures would need to reduce susceptibility to infection by 45%–50% (i.e., higher efficacy and adherence would be needed) (Appendix Figure 2).

Susceptible-Exposed-Infectious-Recovered (SEIR) Model

According to the model, susceptible persons (S) become infected at a rate, β, and move to the exposed state (E). At this point they are infected but not infectious. Exposed persons become infectious at a rate, σ, and a proportion, *p*, and will eventually develop symptoms. To account for asymptomatic transmission during the incubation period, we introduced a compartment for infectious cases who have not developed symptoms yet (I_{pre}). These persons develop symptoms at a rate, σ_s (I_{symp}). The remainder (1 – *p*) will be true asymptomatic or subclinical cases (I_{asymp}). We assumed that the infectiousness of these subclinical cases relative to symptomatic is *q*. Symptomatic cases recover (R) at a rate, γ_s, and asymptomatic at a rate, γ_{asymp}. Only cases in compartments I_{pre}, I_{symp}, and I_{asymp} are assumed to be infectious. The transitions between the compartments of the model are described by the following set of equations:

Susceptible, $\frac{dS}{dt} = -\delta_t \cdot \beta \cdot \left(q \cdot I_{asymp} + I_{pre} + I_{symp}\right) \cdot \frac{S}{N}$

Exposed, $\frac{dE}{dt} = \delta_t \cdot \beta \cdot \left(q \cdot I_{asymp} + I_{pre} + I_{symp}\right) \cdot \frac{S}{N} - \sigma \cdot E + \text{import}$

Infectious before developing symptoms, $\frac{dI_{pre}}{dt} = p \cdot E \cdot \sigma - \sigma_s \cdot I_{pre}$

Infectious and symptomatic, $\frac{dI_{symp}}{dt} = \sigma_s \cdot I_{pre} - \gamma_s \cdot I_{symp}$

Infectious and true asymptomatic (subclinical cases), $\frac{dI_{asymp}}{dt} = \left(1 - p\right) \cdot E \cdot \sigma - \gamma_{asymp} \cdot I_{asymp}$

Recovered, $\frac{dR}{dt} = \gamma_s \cdot I_{symp} + \gamma_{asymp} \cdot I_{asymp}$

The parameter β is estimated through R_0 from the following equation:

$$\beta = \frac{R_0}{(1-p)q\frac{1}{\gamma_{asymp}} + p(\frac{1}{\sigma_s} + \frac{1}{\gamma_s})}$$

To incorporate the impact of social distancing in the model, the infection rate β was multiplied by the parameter δ_t (t = 1,2) corresponding to the reduction of R_0 in 2 periods of social distancing measures. We considered 2 major periods of social distancing measures: March 11–22, the period of initial measures including closure of schools, restaurants, shopping centers, cinemas, etc. until the day before lockdown, and March 23–April 27, the period of lockdown. Based on the social contacts data, we estimated not only the reduction in the total number of contacts but also in the number of contacts at work, home, school, and leisure activities during lockdown. Thus, we modeled the relative reduction in R_0 in the 2 periods of social distancing measures, as described in the manuscript and Appendix.

We assumed that local transmission initiated on February 15, 2020 because the earliest reported date of symptom onset among locally infected cases was February 20. In our model, we seeded 1 symptomatic case in the population at day 0 (February 15th) and further seeded the epidemic by 700 imported cases over the first 40 days. This assumption was based on the ≈500

imported cases diagnosed by April 7 in Greece and taking into account unreported asymptomatic imported cases (*9*).

As a sensitivity analysis, we obtained model predictions assuming that asymptomatic and symptomatic persons are equally infectious (q = 100%) and the results were similar. For example, the cumulative number of infections from the start of the epidemic until the end of the simulation period was 13,066 (95% CrI 6,012–27,112) assuming q = 100% compared with 13,189 infections (95% CrI 6,206–27,700) assuming q = 50%.

Infection Fatality Ratio (IFR) and Comparison of Observed Deaths to Model Predictions

To validate our findings, we used a reverse approach; we applied a published estimate of the IFR (*10*) to the number of infections predicted by the model and compared the resulting number of deaths (cumulative and daily number) to the observed.

We adjusted the IFR estimate by Verity et al (*10*) to account for nonhomogeneous attack rates across age groups, as proposed elsewhere (*11*), and for the age distribution of the population of Greece. To account for the lower ARs among younger persons (12–14 years of age), we multiplied the age-specific IFR for persons 0–9 and 10–19 years of age by 1/0.34, where 0.34 is the relative susceptibility to infection of these age groups compared to adults (*12*). The corrected age specific IFRs were then combined to produce an overall IFR adjusting for the age distribution of the population in Greece (Appendix Table 3). To validate the model, we applied this IFR to the total number of infections predicted by the model and assumed a lag of 18 days between infection and death to compare the predicted number of deaths to the cumulative number of reported deaths (Appendix Figure 2).

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Appendix Table 1. Main control measures implemented in Greece during the coronavirus disease pandemic, February 26–March 29, 2020

Start date, 2020	Description
Feb 26	Testing and isolation of confirmed or suspected cases and their contacts
Feb 27	Ban of carnival festivities
Mar 5	Testing and isolation of confirmed or suspected cases and their contacts in outbreaks and superspreading events
Mar 9	Ban of flights to northern Italy
Mar 9	Suspension of open care centers and cancellation of indoor conferences and sporting events
Mar 10	Ban of outdoor mass gatherings and sporting events
Mar 11	School and university closures
Mar 13	Closure of all theatres, cinemas, gyms, playgrounds, clubs, and courthouses
Mar 14	Ban of flights to Italy
Mar 14	Closure of shopping centers, archeological sites, bars, and restaurants
Mar 15	Border closure to Albania and North Macedonia
Mar 16	Ban of religious services
Mar 18	Border closure to non-European Union nationals
Mar 18	Nationwide closure of all private enterprises
Mar 19	Closure of sea borders
Mar 20	14-day quarantine for inbound travelers
Mar 23	Border closure to United Kingdom and Turkey
Mar 23	Ban of all intra- and inter-city movements across country (complete lock down)
Mar 23	Hotel closures
Mar 26	Testing of inbound travelers from countries with high rate of transmission
Mar 29	Border closure to the Netherlands and Germany

Appendix Table 2. Literature estimates concerning the relative susceptibility to severe acute respiratory syndrome coronavirus 2 infection by age*

Reference and data	Relative susceptibility to infection, odds ratio (95% CI)
Zhang et al. (*12*); 7,375 contacts from 114 clusters; age, y	
0–14	0.34 (0.24–0.49)
15–64	Referent
≥65	1.47 (1.12–1.92)
Jing et al. (*13*); 2,075 contacts of 212 primary cases in 195 unrelated clusters; age, y	
0–19	0.27 (0.13–0.55)
20–59	0.80 (0.53–1.19)
≥60	Referent
Li et al. (*14*); 392 household contacts of 105 index patients; age, y	
0–17	0.18 (0.06, 0.54)
≥18	Referent

*Although reference *12* and *13* do not use exactly the same age categories, we note that in Jing et al. (*13*), the odds ratio of infection for persons 0–19 years of age versus persons 20–59 years of age is 0.34 (0.27/0.80), which is similar to that estimated by Zhang et al. (*12*) for the comparison of persons 0–14 years of age vs. persons 15–64 years of age.

Appendix Table 3. Infection fatality ratio adjusted for the age distribution of the population and relative susceptibility to infection by age, Greece*

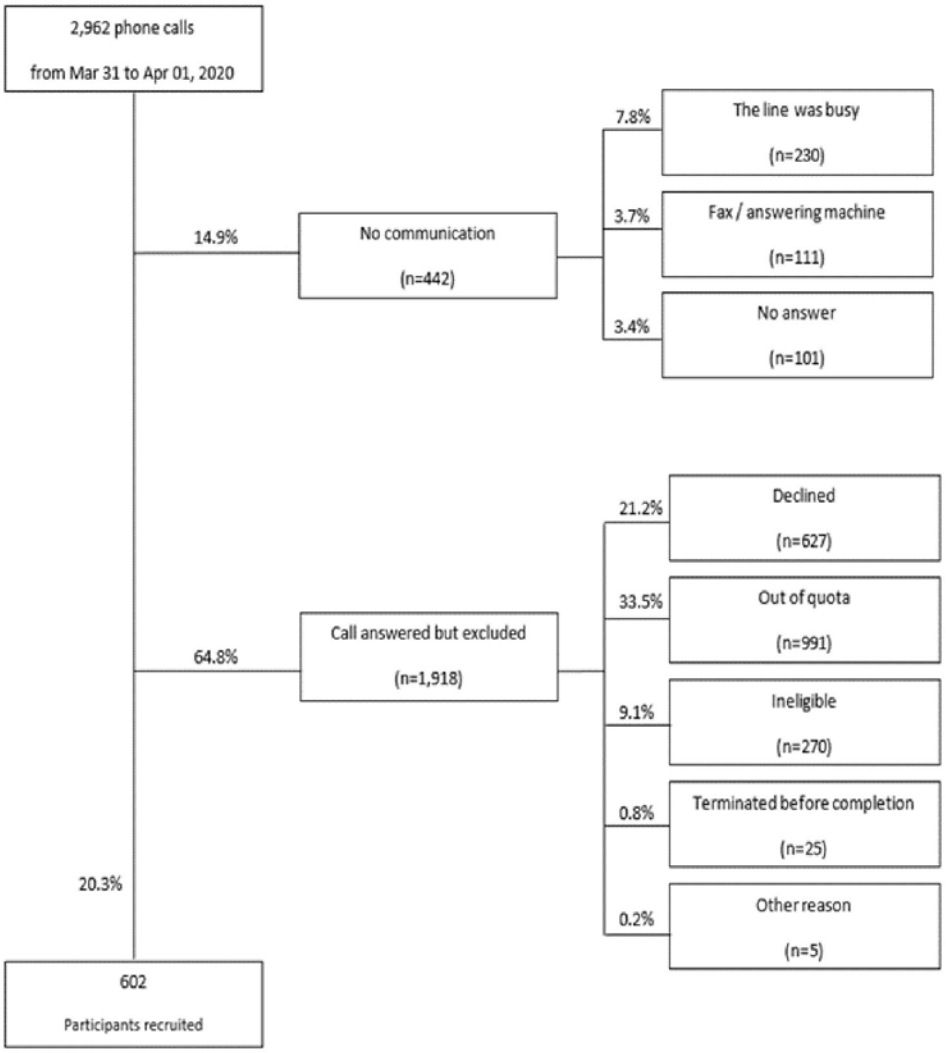
Age group, y	No. Greece	IFR, % (*10*)	Relative susceptibility†	Adjusted IFR, %‡	IFR standardized for the age distribution of the population in Greece, %§
0–9	1,049,839	0.00161	0.34	0.00474	1.14 (0.62–2.19)
10–19	1,072,705	0.00695	0.34	0.02044	
20–29	1,350,868	0.0309	1	0.0309	
30–39	1,635,304	0.0844	1	0.0844	
40–49	1,581,095	0.161	1	0.161	
50–59	1,391,854	0.595	1	0.595	
60–69	1,134,045	1.93	1	1.93	
70–79	1,017,242	4.28	1	4.28	
≥80	583,334	7.80	1	7.80	

*IFR is based on published estimates from Verity et al. (*10*). IFR, infection fatality ratio.
†Relative susceptibility to infection based on Zhang et al. (*12*).
‡IFR adjusted for age susceptibility.
§The lower and upper limits were calculated using the upper and lower bounds of the age specific IFR provided by Verity et al. (*10*).

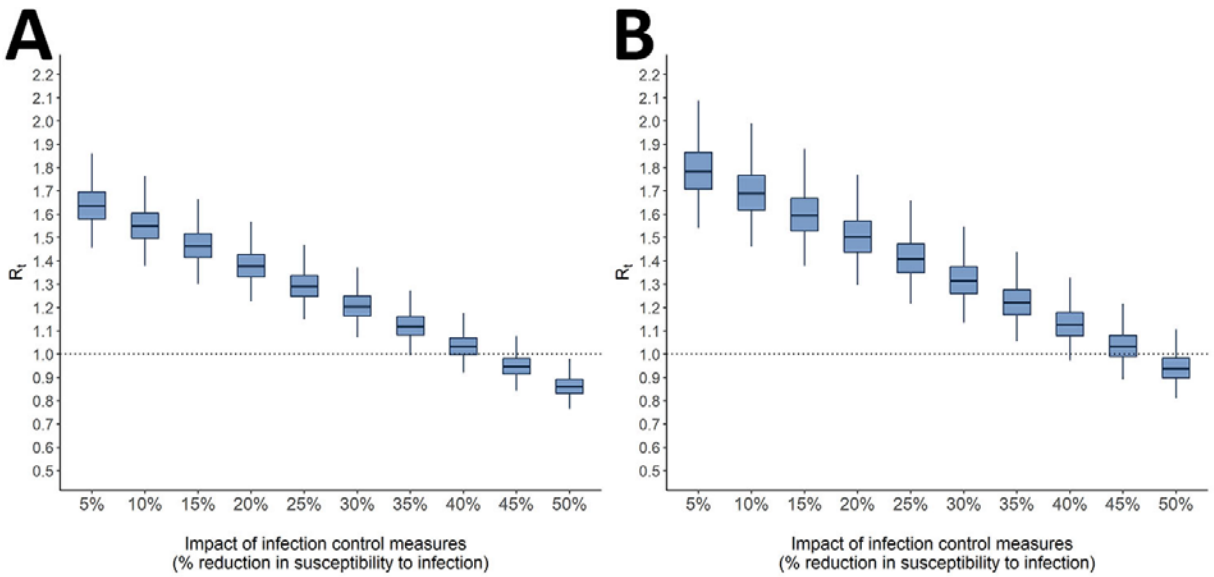
Appendix Table 4. Number of coronavirus disease deaths per million population in Europe by May 18, 2020*

Country or territory	Population, 2018	Total deaths	Deaths/million population
San Marino	33,785	41	1,213.56
Belgium	11,422,068	9,052	792.5
Andorra	77,006	51	662.29
Italy	60,431,283	31,908	528
United Kingdom	66,488,991	34,636	520.93
France	66,987,244	28,108	419.6
Sweden	10,183,175	3,679	361.28
The Netherlands	17,231,017	5,680	329.64
Ireland	4,853,506	1,543	317.91
Isle of Man	84,077	24	285.45
Jersey	106,800	27	252.81
Guernsey	63,026	13	206.26
Switzerland	8,516,543	1,602	188.1
Luxembourg	607,728	107	176.07
Monaco	38,682	5	129.26
Portugal	10,281,762	1,218	118.46
Germany	82,927,922	7,935	95.69
Denmark	5,797,446	547	94.35
Austria	8,847,037	629	71.1
Moldova	3,545,883	211	59.51
Romania	19,473,936	1,097	56.33
Finland	5,518,050	298	54
Slovenia	2,067,372	104	50.31
North Macedonia	2,082,958	101	48.49
Estonia	1,320,884	63	47.7
Hungary	9,768,785	462	47.29
Norway	5,314,336	232	43.66
Bosnia and Herzegovina	3,323,929	132	39.71
Serbia	6,982,084	230	32.94
Iceland	353,574	10	28.28
Czechia	10,625,695	298	28.05
Liechtenstein	37,910	1	26.38
Poland	37,978,548	925	24.36
Croatia	4,089,400	95	23.23
Armenia	2,951,776	60	20.33
Lithuania	2,789,533	56	20.08
Russia	144,478,050	2,631	18.21
Belarus	9,485,386	165	17.4
Kosovo	1,845,300	29	15.72
Bulgaria	7,024,216	110	15.66
Greece	**10,727,668**	**163**	**15.19**
Montenegro	622,345	9	14.46
Cyprus	1,189,265	17	14.29
Malta	483,530	6	12.41
Ukraine	44,622,516	514	11.52
Albania	2,866,376	31	10.82
Latvia	1,926,542	19	9.86
Slovakia	5,447,011	28	5.14
Azerbaijan	9,942,334	39	3.92
Georgia	3,731,000	12	3.22
Faroe Islands	48,497	0	0
Gibraltar	33,718	0	0
Holy See	1,000	0	0

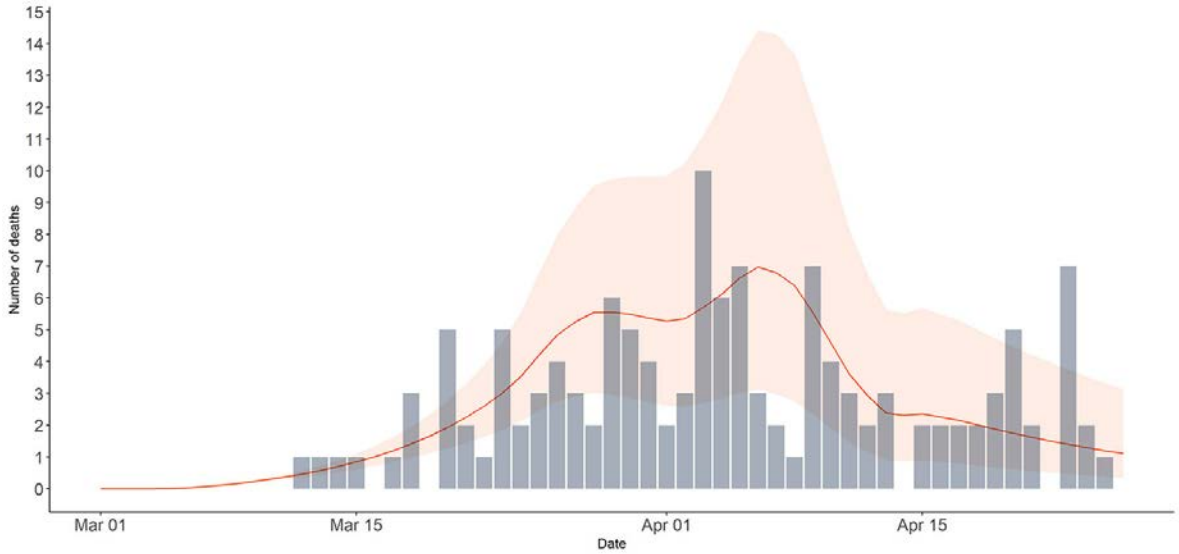
*Using data from European Centre for Disease Prevention and Control (*15*). Countries are listed from highest to lowest death rate. Bold text indicates Greece's lower death rate compared with other countries.



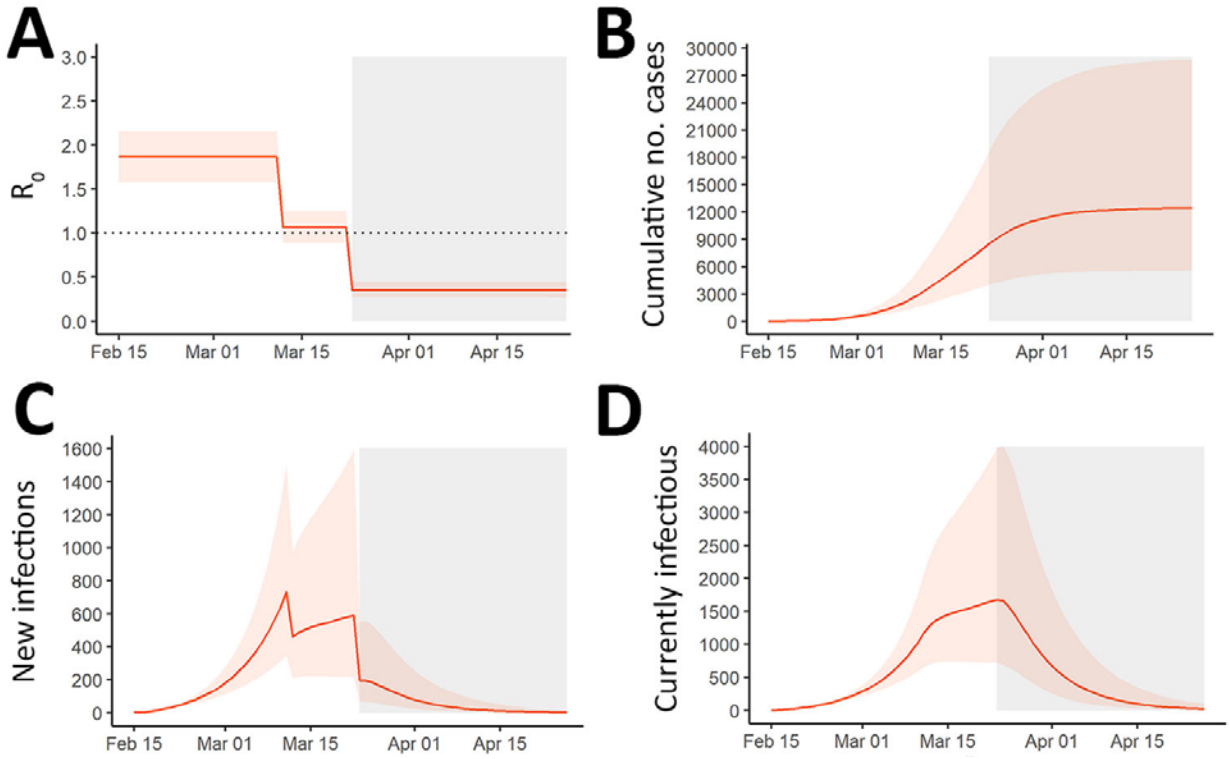
Appendix Figure 1. Flow chart of the recruitment process for a social contacts survey used to assess effects of social distancing measures during the first epidemic wave of severe acute respiratory syndrome coronavirus 2, Greece.



Appendix Figure 2. Estimated R_t after the partial lifting of social distancing measures at the end of the first SARS-CoV-2 wave in Greece. We assumed varying effectiveness levels of infection control measures (e.g., hand hygiene, use of masks, keeping distances) in reducing susceptibility to infection. R_t during lockdown was 0.46. For the partial lifting of measures, we hypothesized 2 additional scenarios: A) Contacts at work, return to levels that are 20%, school to 50%, and leisure activities to 20% below pre-epidemic levels; and B) contacts at work, school, and leisure activities all return to levels that are 20% below pre-epidemic levels. R_t, effective reproduction number; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.



Appendix Figure 3. Observed number of deaths per day compared with model estimates for the first epidemic wave of SARS-CoV-2, Greece. Gray bars indicate observed number of deaths; orange line indicates median; and orange shading indicates 95% CrI range of the model estimates. We used a published estimate of the infection fatality ratio (IFR) (*10*) adjusted for nonhomogenous attack rates by age and for the age distribution of the population of Greece (IFR = 1.14%; Appendix Table 3). The estimated number of deaths was obtained by applying this IFR to the total number of infections predicted by the model assuming a delay of 18 days from infection to death. Locally weighted smoothing was applied to the model estimates in the graph. The observed number of deaths was obtained from epidemiological surveillance data (*9*). SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.



Appendix Figure 4. Estimates for the first wave of the SARS-CoV-2 epidemic assuming a shorter serial interval (mean 4.7 days) in a SEIR model for Greece, February 15–April 26, 2020. Model estimates for A) Effective reproduction number; B) cumulative number of cases; C) number of new infections; and D) current number of infected persons. Solid orange line represents median estimates; light orange shaded areas indicate 95% credible intervals from 1,000 simulations of the SEIR model. Gray zone indicates estimates during lockdown, the period in which all nonessential movement in the country was restricted. SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; SEIR, susceptible-exposed-infected-recovered.