Public events and delayed flight restrictions were the turning point of the COVID-19 mitigation policy of Israel

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Abstract

Background:

Since its emergence the impact of COVID-19 has been profound, and the public health challenge seem to be the most serious regarding respiratory viruses since the 1918 H1N1 influenza pandemic. In the absence of effective vaccine or biomedical treatment, the basic rules of public health measures have not changed, namely public distancing and personal hygiene.

Methods:

In this study we present the results of epidemiological data analysis and modelling of one month since the onset of the outbreak in Israel. The data analyzed in this study was obtained from the epidemiological investigation reports that were released by the Israeli Ministry of Health. In addition to data analysis, we present an expended deterministic compartment model and simulations of disease outbreak scenarios emphasizing quarantine and isolation policies given their efficiency.

Results:

We analyze and discuss an abrupt change from controlled epidemic regime (effective reproduction number R_0 of the order of half) to an exponential growth regime ($R_0 = 2.18$) in light of the actual policy-makers decisions and public behavior in Israel. We further discuss three different modeled scenarios of quarantine efficiency: high-efficiency, medium-efficiency, and low-efficiency.

Conclusions:

Israel early lessons show that there is no allowance to compromise with the directive of social distancing. Even before the onset of the pandemic in Israel, fine-tuned but determined early decisions were taken by policy makers to control flight arrival from Covid-19 affected regions and to limit public gatherings. These measures

66 have effectively decreased the value of the effective reproductive number (R_0) in the

67 first two weeks. Our analysis show that one particular holyday in Israel has shifted the

68 occurrence curve from controlled regime to exponential growing regime. This

69 outcome suggests that even a short lapse in public responsiveness can have a dramatic

70 effect on public health during pandemic outbreaks.

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1. Introduction

75   Since its emergence the impact of COVID-19 has been profound, and the

76 public health challenge seem to be the most serious seen in a respiratory virus since

77 the 1918 H1N1 influenza pandemic (Soper 1919). In this study we present the results

78 of epidemiological data and modelling of one month since the onset of the outbreak in

79 Isreal, addressing public events occurring during this period and the sensitivity to a

80 number of public health measures focusing on social distancing (quarantine and

81 isolation).

82   The epidemiological data studied, consisting of 381 laboratory confirmed

83 COVID-19 cases, has been obtained from the epidemiological investigation reports

84 that were released by the Israeli Ministry of Health (Israeli Ministry of Health, 2020).

85   In addition we present an extended deterministic SEIR (Susceptible, Exposed,

86 Infectious, and Recovered) model to simulate disease outbreak scenarios. In

87 particular, the model includes quarantine of asymptomatic suspected population

88 (exposed) and isolation of symptomatic and infectious patients. The model takes into

89 account the efficiency of the quarantine and isolation measures. We discuss three

90 different quarantine efficiency scenarios: high-efficiency, medium-efficiency, and

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91   low-efficiency. The resulting analysis from the epidemiological cases data are

92   discussed in light of public events and compared to model simulations. We analyze

93   and discuss an abrupt change from controlled epidemic regime to an exponential

94   growth regime in light of policy makers decisions and public behavior.

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2. Methods

97   The dynamics of spread of epidemics as well as the quanrentine-isolation

98   policy of Israel was modeled using the SEQIJR model (e.g. Gumel, et al., 2004). This

99   is a deterministic compartmental model which allows the implicit inclusion of

100   biological epidemiological phases (including incubation period) as well as

101   governmental interventions such as quarantine and their actual efficiency of

102   implementation. A successful a posteriori implementation of this model to the

103   transmission dynamics and control of the SARS epidemics in Toronto, Hong Kong,

104   Singapore and Beijing is given in Gumel, et al., 2004. The model consists of a system

105   of 7 dynamical equations and 15 parameters. For details of the model and its

106   parameters see the online supplementary information.

107   The data analyzed in this study was obtained from the epidemiological

108   investigation reports that were released by the Israeli Ministry of Health (Israeli

109   Ministry of Health, 2020). From the total of 883 PCR laboratory confirmed COVID-

110   19 cases we analyzed the 384 cases that were investigated epidemiologically. This

111   allowed us to separate the imported cases (travelers arriving from abroad) from the

112   locally infected cases. The data spans over the first month of the COVID-19 outbreak

113   in Israel, beginning in February 21st 2020 and going until March 20th. We further note

114   that during the examined period the number of PCR tests performed rose daily,

115   reaching 1869 at the end of the period. However the proportion of positive tests

116   remained approximately the same, as 7.9% (Israeli Ministry of Health, 2020).

117   The incidence curve was modelled as a fit to an exponential growth function

118   (de Silva, et al., 2009; Zhao, et al., 2020). Several serial interval distributions that

119   were estimated for COVID-19 were examined (Nishiura, et al., 2020; Tapiwa, et al.,

120   2020; Zhao, et al., 2020).

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122   3. Results

123   The dynamics of epidemic spread in Israel in terms of daily reported

124   confirmed cases is shown in fig. 1. There are two distinct regimes in the curve. The

125   first ended in March 8, 2020 in which the number of daily new cases was constantly

126   less than 5. The second period, from March 9, 2020 is characterized by a delayed rise

127   in the daily number of new cases (due to incubation period), which resembles to an

128   exponential growth (red line, in figure 1). Although, most of the examined period

129   was dominated by new cases of travelers arriving from abroad, near the end of the

130   period, the number of daily local infections exceeded the number of travel associated

131   cases.

a)
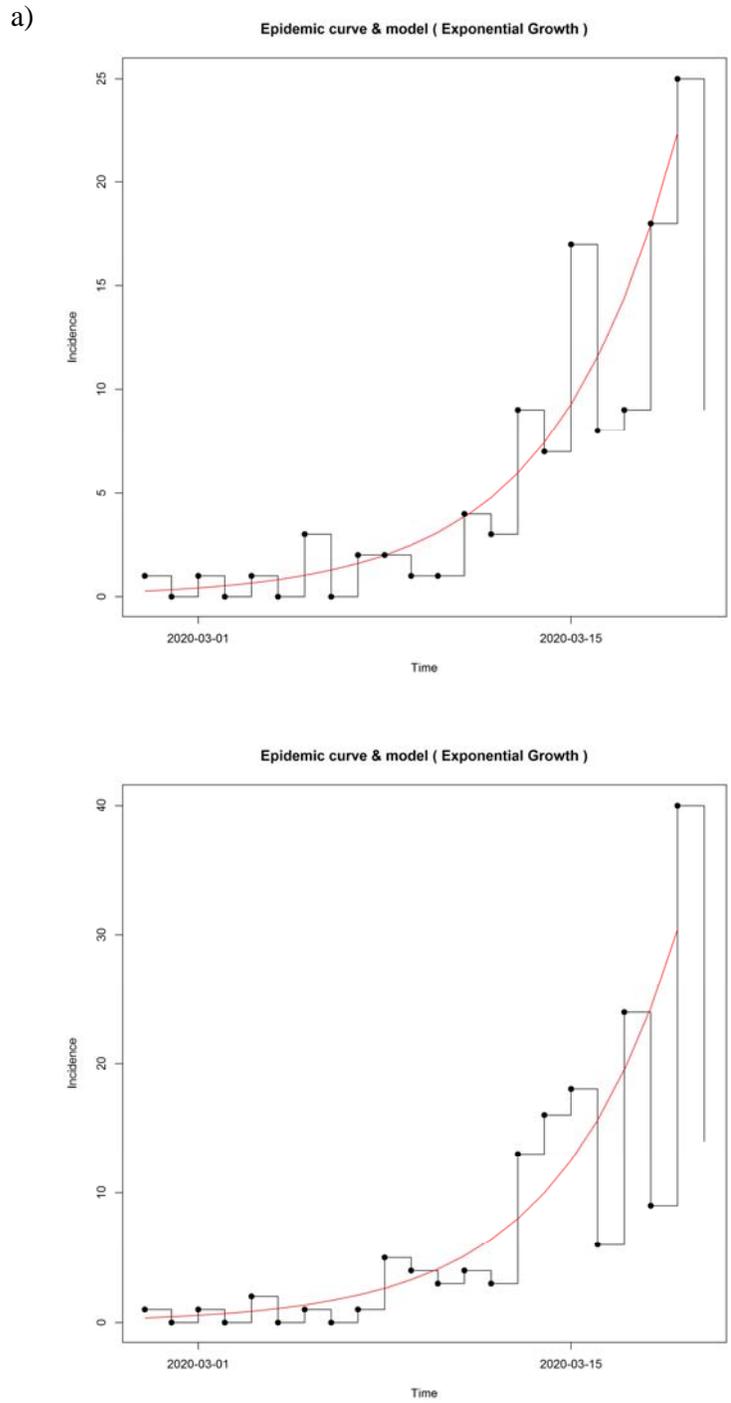
132   FIG. 1. Daily reported confirmed COVID-19 cases in Israel: a) cases of

133   travelers arriving Israel from abroad; b) cases infected locally

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135   The effective reproduction number, R_0, was estimated for the daily new cases

136 data of the first month of the COVID-19 epidemic. The lowest estimated R_0 was 2.08

137 (95%CI 1.92-2.5) for the Gamma distributed serial interval with mean 4.4 and SD 3

138 days (Zhao, et al., 2020). The highest estimate was 2.37 for the Gamma distributed

139 serial interval with mean 5.2 and SD 2.8 days (Tapiwa, et al., 2020). The mean R_0

140 overall the serial interval distributions examined, was 2.185.

141   The SEQIJR model solutions are characterized by 3 locally stable equilibrium

142 points in parameters space. These refer to the following regimes or types of dynamics

143 of epidemic spread: controlled (decaying), flattened, uncontrolled (baseline SEIR

144 model; further details can be found in the supplementary material). In this study we

145 simulated three scenarios, the first corresponding to the first equilibrium and two

146 corresponding to the second:

147   1. A controlled high-efficiency quarantining (decaying green curve in

148   Fig. 2). This regime is characterized by an early entry of asymptomatic

149   suspected population to home quarantine. Moreover we assume the

150   infectiousness in home quarantine is one sixth compared to free

151   asymptomatic. The efficiency of isolation is 70%.

152   2. A flattened for medium-efficiency quarantining (purple curve in Fig.

153   2). This regime is characterized by a late entry of asymptomatic

154   suspected population to home quarantine. Moreover we assume the

155   infectiousness in home quarantine is one third compared to free

156   asymptomatic. The efficiency of isolation is 70%.

157   3. A flattened for low-efficiency quarantining (light-blue curve in Fig. 2).

158   This regime is characterized by a late entry of asymptomatic suspected

159   population to home quarantine. Moreover we assume the

160   infectiousness in home quarantine is similar to free asymptomatic. The

161   efficiency of isolation is 30%.

162   As discussed above, the dynamics of epidemic spread in Israel until March 8, 2020

163   corresponds to the controlled regime characterizes with   (green curve in Fig.

164   2). On the other hand after March 8, 2020 the regime corresponds to the flattened

165   regime with low-efficiency quarantining and   .
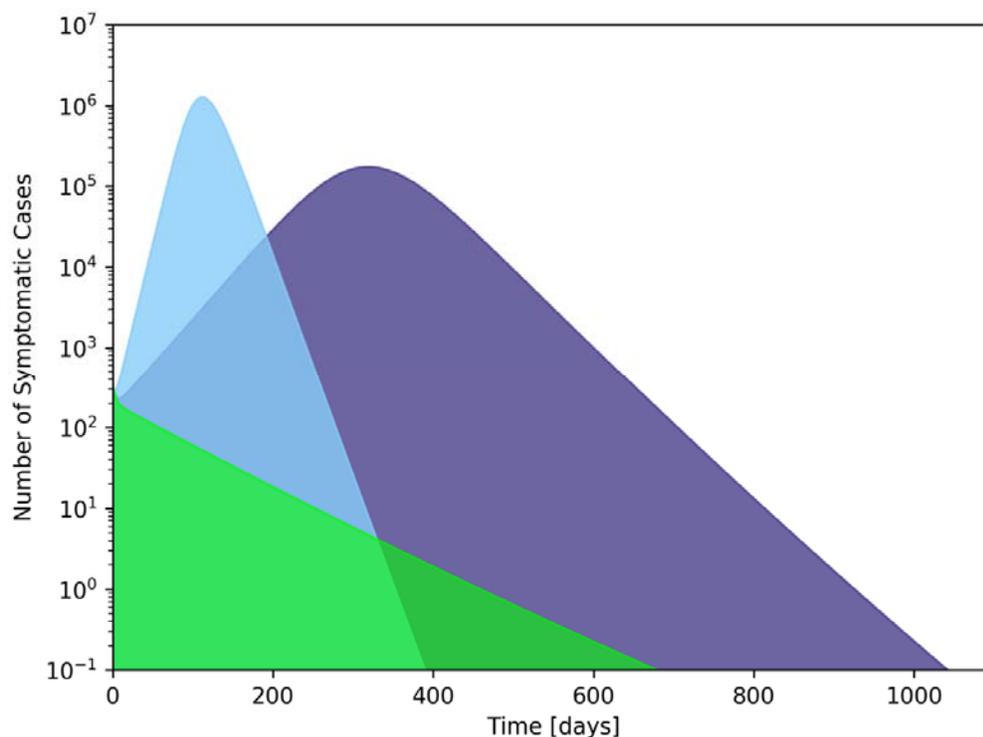
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167   FIG. 2. Total number of symptomatic cases in Israel from SEQIJR model

168   simulations for 3 scenarios: green – high-efficiency quarantining, purple – medium-

169   efficiency quarantining, light-blue – low-efficiency quarantining.

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4. Discussion

172   Israel has begun early its mitigation policy against the COVID-19 epidemic.

173   From the beginning of February, it was decided: to close all border passages (via land,

174   sea and air) to people that are not Israeli citizens or resident that have visited China

175   recently; to stop all direct flights from Israel to China and to require Israeli citizens

176   returning from China or that were in touch with a confirmed COVID-19 patients to a

177   14 days home quarantine. A short while later, the quarantine requirement was

178   expanded to other Asian countries. The first COVID-19 patients in Israel were two

179   passengers that returned from the "Diamond Princess", in 21 and 23 of February.

180   They entered directly to hospital isolation. A week later, a passenger from Italy was

181   diagnosed as a COVID-19 patient, and Italy was added to the list of countries that

182   require 14 days quarantine.

183   The quarantine-isolation policy succeeded in keeping the rate of daily new

184   cases small, up until March 9th. Then, 4 days later, a sudden change of regime has

185   occurred, which was manifested by the distinct change of the epidemic curve of Israel

186   towards exponential growth. March 15th marks the first time that the daily new cases

187   of locally infected were higher than the new travel associated cases.

188   The timing of this abrupt change is not of coincidence. Regarding the cases

189   arriving from abroad, a requirement for home quarantine affecting all travelers

190   arriving began on Match 9th. Moreover, during the period between March 9th to 11th a

191   Jewish holiday, Purim, was celebrated. This holiday is characterized by big parades

192   organized by local municipalities, as well as religious gatherings and privately

193   organized parties. Although authorities cancelled the public parades, many privately

194   organized and religious crowding had occurred. Regrettably, these drove Israel from a

195   controlled, mitigated regime to an exponential growth, as described in the results

196   section. Therefore, despite its intense efforts, Israel's effective R_0 for the period

197   ending in March 20th stands on around 2.185, slightly smaller than the R_0 of 2.6-3.2

198   estimated for the republic of Korea and Italy, for the period ending in March 5th.

199 Such abrupt transition based on social behavior emphasizes the fragility of mitigation

200 policies.

201   We therefore emphasis the importance of early fine-tuned but intense

202 directives for social distancing and isolation measures. This study clearly

203 demonstrates the lesson learned from the Israeli policy, that even a short lapse in

204 public responsiveness can have a dramatic effect on public health during pandemic

205 outbreak.

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References

210   1. Israel Ministry of Health. Information on confirmed patients and COVID-19

211   press releases. https://govextra.gov.il/ministry-of-health/corona/corona-

212   virus/spokesman-messages-corona/. Accessed Mar 22, 2020.

213   2. De Silva UC, Warachit J, Waicharoen S, Chittaganpitch M. 2009. A

214   preliminary analysis of the epimemiology of Influenza A(H1N1)v virus

215   infection in Thailand from early outbreak data. *Eurosurveillance*: **14**(31).

216   3. Nishiura H, Linton NM, Akhmetzhanov AR. 2020. Serial interval of novel

217   coronavirus (COVID-19) infections. *International Journal of Infectious*

218   *Diseases* DOI: 10.1016/j.ijid.2020.02.060

219   4. Zhao S, Gao D, Zhuang Z, Chong MKC, Cai Y, Ran J, Cao P, Wang K, Lou

220   Y, Wang W, Yang L, He D. 2020. Estimating the serial interval of the novel

221   coronavirus disease (COVID-19): A statistical analysis using the public data in

222   Hong Kong from January 16 to February 15, 2020. preprint is under

223   consideration at Infectious Diseases of Poverty. DOI: 10.21203/rs.3.rs-

224   18805/v1

225   5. Tapiwa G, Cecile K, Dongxuan C, Andrea T, Christel F, Jacco W, Niel H.

226   2020. Estimating the generation interval for COVID-19 based on symptom

227   onset data. medRxiv preprint DOI: 10.1101/2020.03.05.20031815

228   6. Gumel AB, Ruan S, Day T, Watmough J, Brauer F, van den Driessche P,

229   Gabrielson D, Bowman C, Alexander ME, Ardal S, Wu J, Sahai BM.

230   Modelling strategies for controlling SARS outbreaks. Proc Biol Sci. 2004;

231   **271**(1554):2223-32. doi:10.1098/rspb.2004.2800

232   7. Soper GA. 1919. The lessons of the Pandemic. *Science* **49**(1274): 501-506.

233   DOI: 10.1126/science.49.1274.501

234   8. Zhuang Z, Zhao S, Lin Q, Cao P, Lou Y, Yang L, Yang S, He D, Xiao L.

235   2020. Preliminary estimating the reproduction number of the coronavirus

236   disease (COVID-19) outbreak in Republic of Korea and Italy by 5 March

237   2020. medRxiv preprint DOI: https://doi.org/10.1101/2020.03.02.20030312

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