Title: Anticipating the N~~n~~eed for H~~h~~ealthcare R~~r~~esources F~~f~~ollowing the E~~e~~scalation of the COVID-19 O~~o~~utbreak in the Republic of Kazakhstan

Running title: ~~The h~~Healthcare R~~r~~esources in COVID-19

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Abstract

Background~~. ~~**:** The lack of advance planning in ~~the situation of ~~a public health emergency can lead to wasted~~waste of~~ resources and inadvertent loss of lives. This study is aimed at forecasting the needs for healthcare resources following the expansion of the coronavirus disease 2019 (COVID-19) outbreak in the Republic of Kazakhstan, ~~concerning ~~focusing on hospital beds, equipment, and the professional workforce ~~with considering ~~in light of the developing epidemiological situation and the data on resources currently available.

Methods~~. ~~**:** We constructed ~~the ~~a forecast model of the epidemiological scenario via the classic susceptible-exposed-infected-removed (SEIR) approach. The ~~WHO's ~~World Health Organization's COVID-19 Essential Supplies Forecasting Tool was used to evaluate the healthcare resources needed for the ~~nearest ~~next 12 weeks.

Results~~. ~~**:** Over the forecast period, there will be 104,713 hospital admissions due to severe disease and 34,904 hospital admissions due to critical disease~~, in total~~. This will require 47,247 beds for severe disease and 1,929 beds for critical disease at the peak of the COVID-19 outbreak. ~~Also, t~~There will also be high needs for all categories of healthcare workers and for both diagnostic and treatment equipment. Thus, ~~the country~~Kazakhstan faces the need for a rapid increase ~~of ~~in available healthcare resources and/or for finding ways ~~of their effective~~to redistribute ~~redistribution~~resources effectively.

Conclusion~~, ~~**:** Kazakhstan ~~is ~~will be able to reduce the rates of infections and deaths among its population by developing and following a consistent strategy targeting ~~the ~~COVID-19 in a number of inter-related directions.

서식 있음: 글꼴: 굵게

Keywords: COVID-19, Kazakhstan, forecast modeling, healthcare resources

Introduction

Many uncertainties originate from the possible scarcity of healthcare resources due to the rapid escalation of coronavirus disease 2019 (COVID-19), which is caused by a novel coronavirus (CoV) associated with severe acute respiratory syndrome (SARS) secondary to atypical pneumonia. This CoV belongs to the family *Coronaviridae* and is likely to be a zoonosis in nature, as it shares many similarities with SARS-CoV, which was spread to humans through palm civets and raccoon dogs ~~—~~as ~~the~~ incidental hosts [1]. COVID-19 emerged in Wuhan, China in December 2019 and quickly ~~unrolled~~ spread ~~over the globe~~globally, reaching the Republic of Kazakhstan ~~(the RK)~~ in March ~~,~~ 2020 [2].

~~Since 11~~ On March 11, 2020, the World Health Organization (WHO) declared COVID-19 a pandemic [3], and viral pandemics tend to present serious threats to healthcare systems by imposing extraordinary and sustained demands on them [4]. ~~In turn, t~~These demands can exceed the service capacity with regard to both inputs and outputs, undermining the availability of sufficient resources, infrastructure, technologies, and professional workforce. COVID-19 ~~brings~~ presents the enormous challenge of balancing between equality and equity for people in the distribution of risks and benefits. In view of the ~~scenario of~~ increasing frequency of COVID-19 cases among the country's population, there is an urgent need to evaluate best practices in order to optimize the use of available means and resources. This is particularly true for intensive care unit (ICU) beds and related equipment that are at imminent risk of unavailability. Thus, it is essential to establish clinical, technical, and ethical criteria to make the best use of ~~them~~ these resources in order to ensure the greatest possible benefits for COVID-19 patients [5].

Some international professional associations have argued that, since the pandemic is an exceptional situation, it must be managed in the same way as any crisis situation and requires measures of ~~"C~~conflict/ ~~and c~~Catastrophe~~"~~ or d~~D~~isaster m~~M~~edicine [6,7]. ~~For that~~However, to do so, solid technical and scientific criteria, strict ethical principles, and legal considerations must be taken into account. Besides, a fair allocation of available resources requires an ethical decision-making framework, which can be adapted and revised depending on the context of the developing situation. Healthcare systems and individual providers must be prepared to make the most of limited resources and to reduce the damage to people and society [5]. ~~Perhaps, t~~The weight of decisions about the allocation of available healthcare resources should not fall on the professionals who are in the "front line" of the epidemic and are already overburdened by the scenario that is ~~being deployed~~unfolding, experiencing ~~the~~ increased risks of failures

서식 있음: 글꼴: 기울임꼴

메모 [A1]: As a small background point, the abbreviation "RK" was removed here for the sake of consistency, since the text used a mixture of "RK," "Republic of Kazakhstan," and "Kazakhstan," and in principle if abbreviations like "RK" are introduced, they should be used consistently throughout. The options were therefore to either introduce "RK" and use it whenever Kazakhstan is being referred to, or to remove it and use "Republic of Kazakhstan" or "Kazakhstan." The latter option seemed to be best for promoting clarity, since not all readers of the paper will be familiar with the abbreviation "RK".

and professional stress. In contrast, healthcare providers need to be protected in this process, since they are fundamental to face the issue of the escalating outbreak [8].

The lack of advance planning in ~~the situation of~~a public health emergency can lead to the waste of resources~~,~~ and inadvertent loss of lives, ~~and~~ as well as ~~jeopardize~~ jeopardizing the trust of the general public in medical services (9–11). This study is aimed at forecasting the needs for healthcare resources following ~~expansion~~ the escalation of the COVID-19 outbreak in the Republic of Kazakhstan, focusing on ~~concerning~~ hospital beds, equipment, and the professional workforce, ~~with considering~~ in light of the developing epidemiological situation and the data on resources currently available.

Materials and methods

Data sources

Currently, the Ministry of Health of the ~~RK~~Republic of Kazakhstan reports ~~on~~ all COVID-19 cases registered in the country through a special website maintained by the National ~~Centre~~ Center of Public Health [12]. In order to anticipate the need for health care resources, we built a real-time database from those data. ~~Also, we~~We also used the World Bank ~~(WB)~~ data on the population size in Kazakhstan, which equaled 18,654,000 people in 2020 [13], as well as on available healthcare resources. As for the latter, we ~~addressed~~ utilized the Republican Center for Health Development (RCHD) dataset to get information on the number~~s~~ of medical workforce in the ~~RK~~Republic of Kazakhstan [14]. ~~Besides, the d~~Data on available hospital beds in the country were also obtained from the RCHD [14], while the number of available beds in infectious disease units were extracted from the reports of the Ministry of Health, Kazakhstan [15].

Mathematical modeling

The classic ~~four~~4-compartmental ~~SEIR model:~~ susceptible (S) – exposed (E) – infected (I) – removed (R) (SEIR) model was utilized to estimate the spread of the COVID-19 outbreak in the ~~RK~~Republic of Kazakhstan [16]. The SEIR model categorizes the country's population into ~~four~~ 4 broad compartments: susceptible (those who can develop the disease of interest), exposed (those who are already infected but are asymptomatic), infected (those who are infected and present with symptoms and signs), and removed (those who are recovered or dead) [17]. We updated ~~the~~ an earlier published SEIR model on the COVID-19 outbreak in Kazakhstan [2] for the ~~nearest~~ next ~~twelve~~ 12 weeks, ~~with considering~~ incorporating the latest epidemiological data, and ~~including~~ included official data on the cumulative number of symptomatic and asymptomatic patients.

Thus, we ~~inputted~~ entered the following variables into the SEIR model: cumulative number of infected, which equaled 131,596 (including asymptomatic polymerase chain reaction [PCR]-positive patients); duration of the incubation period (5 days); duration of mild and asymptomatic infections (5 days); proportion of infections that are asymptomatic (30 %); proportion of infections that are severe (2 %); duration of severe infection (hospital stays), ~~that~~ which was estimated to be 10 days~~,~~; proportion of infections that are critical (2 %); duration of critical infections or ICU stays (15 days); death rate for critical infections (0.55 %); the country's population size (18,654,000); the maximum time of forecast (80 days); the transmission rate~~s:~~ for infections that are asymptomatic (0.5 days), mild infections (0.39 days~~);~~), severe infections (0.01 days~~);~~), and critical infections (0.01 days); R_0 (reproduction number) = 2.12; T_2 (doubling time) = 8 days; and r (number of contacts ~~number~~ a day) = 0.091.

~~For predicting~~To predict the number of COVID-19 cases in need of hospitalization versus healthcare capacity (number of "severe" and "critically" ill patients vs. the capacity of the healthcare system, ~~that~~ which is constrained or capped by inpatient bed availability in the whole country or by the availability of beds provided for COVID-19 patients), the construction of the classic SEIR model was followed by ~~the~~ analyses ~~on~~ of general hospital beds and the number of available beds for COVID-19 patients in the ~~RK~~Republic of Kazakhstan. We assumed that inpatient beds would be reserved solely for "severe" infections (symptomatic patients presenting with severe pneumonia associated with dyspnea, respiratory rate >30/min, blood oxygen saturation <93%, ratio of partial pressure arterial oxygen to fraction of inspired oxygen ~~(~~[PaO_2/FiO_2] <300~~)~~, and/or infiltrates exceeding 50 % of the lung volume) and "critical" infections (symptomatic patients with respiratory failure, septic shock, and/or multiple organ dysfunction or failure) [18].

Forecasting the need for health care resources

After a strict quarantine was imposed across the country from March 19 ~~March till~~until mid-May 2020, its subsequent weakening was accompanied by the escalation of the COVID-19 outbreak, with a substantial increase in the number of infections and deaths. This returned the epidemic to the starting point and, for example, resulted in the shortening of T_2 (doubling time) from 10 to 7 days. The COVID-19 Essential Supplies Forecasting Tool (COVID-ESFT, version 2.0) [19] was used ~~for~~ to generate a forecast model~~ing~~

서식 있음: 아래 첨자

메모 [A2]: Reviewer comment: First of all, the outcome of the modeling study highly depends on which model researchers choose. As other studies reported, the asymptomatic transmission is already real, but the model would not be captured the part.

Reply: You are certainly right and we remade our modeling with account for asymptomatic transmission. These changes are reflected in revised tables 2-4 and figure 1. Also, we added the marked piece to Methods section.

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of the healthcare resources needed for the ~~nearest~~ next 12 weeks, beginning on ~~2~~ September 2, 2020. The COVID-ESFT helps to estimate the demand for essential supplies, including biomedical and diagnostic reagents and equipment, medical workforce, and infrastructure, based on a prior evaluation of COVID-19 patient numbers depending on their severity. The COVID-ESFT is best used for estimates over a short time period and does not take into account the already available resources, ~~that have to~~which must be factored in additionally. Clinical guidance, current practice, and international standards stand behind the assumptions for equipment and workforce needs, infrastructure required, and oxygen demands [19]. As the COVID-ESFT is not an epidemiological tool, we preliminarily constructed the SEIR model to ground our judgments ~~on~~regarding the need for healthcare resources. The variables needed for health~~-~~care resource planning were acquired from the statistical compilation issued by the RCHD and were entered into the model manually [14]. The list of available health care resources and underlying assumptions are presented in Table 1.

The Ministry of Health of the ~~RK~~Republic of Kazakhstan made a number of provisions for a timely and adequate response to the COVID-19 outbreak. These included the allocation of additional inpatient beds with ~~the~~ a maximum number of 20,000 [20]. To calculate the difference in the number of beds available for the COVID-19 response at its peak and the actual number of beds needed based on predictive modeling, we used the following formula:

*Percentage difference = (a/b-1)*100 %*, where "a" is a bigger number and "b" is a smaller number

Results

According to the mathematical model~~ing~~, over the forecast period there will be 104,713.7 hospital admissions due to severe disease and 34,904.55 hospital admissions due to critical disease~~, in total~~. This will require 47,247.75 beds for severe disease and 1,929.94 beds for critical disease at the peak of the COVID-19 outbreak. Out of the 20,000 beds allocated by the Ministry of Health, 11,336 will be occupied by severely ill patients and 664 will be occupied by critically ill patients. Thus, the expected shortage of beds for severe disease constitutes 35,912 or 316.79 % while that for critical disease constitutes 1,265.94 or 190.65 % (Table 2).

Figure ~~s~~ 1A depict~~ure~~s the number of all inpatient beds available in the country, including both governmental and private health care sectors, ~~with considering~~ according to the outbreak progression.

메모 [A3]: If possible, please revise the figure legend to read:

Figure 1. COVID-19 cases vs. healthcare capacity in the Republic of Kazakhstan: simulation-predicted number of severe and critical infections vs. the capacity of the health care system constrained by the availability of all inpatient beds in the Republic of Kazakhstan (A) and by the availability of inpatient beds reserved for COVID-19 patients (B) [16].

~~Dark~~ The dark red line is an outbreak forecast with no intervention measures being applied and the light red line represents the impact made by the introduction of quarantine measures. Both the dark red and light red lines present forecasts only for severe and critical cases, since mild and moderate cases are treated at the outpatient level ~~of care~~. ~~Grey~~ The gray dotted line displays the current number of all available inpatient beds (70,411), which is far beyond the need of severely and critically ill COVID-19 patients. According to the graph, the acute shortage of inpatient beds will start~~s~~ at day 46 th ~~day~~ of the forecast if no intervention measures are ~~being~~ applied and at day 73th ~~day~~ with the introduction of quarantine. Figure 1B depict~~ure~~s the number of inpatient beds available for COVID-19 treatment in Kazakhstan, based on the statement made by the Minister of Health. This number is equal to 20,000 and originates from the ~~reprofiling~~ repurposing of provisional hospitals ~~in~~ as infectious disease hospitals. In this case, the acute shortage of inpatient beds begins even earlier.

The forecasted patient numbers and bed availability in Kazakhstan are presented in Table 3, according to which the demand for inpatient beds increases drastically following the growing numbers of severely and critically ill patients, reaching ~~the~~ its peak ~~at~~ in the second week of the forecast~~,~~ with a subsequent rapid decline. This reflects ~~the~~ a high need~~s~~ for all categories of healthcare workers, beginning from cleaners and caregivers and ending with the professional medical workforce (Table 3). ~~Besides, the~~The maximum demand for PCR testing, ~~that~~ which is considered obligatory for the confirmation of a COVID-19 diagnosis in the ~~RK~~Republic of Kazakhstan, follows ~~on~~ in the second week of the forecast with a relatively gradual decline due to a ~~reducing~~ decreasing number of COVID-19 patients. ~~The~~ A detailed specification of the forecasted need for treatment equipment according to the total expected caseload~~,~~ is presented in Table 4. As the actual number of available equipment in the country ~~is~~ has not been reported, it ~~could~~ may be assumed that it will be ~~needed~~ necessary to procure additional equipment to deal with spillover of an outbreak.

Discussion

This research was conducted to evaluate the needs for health~~-~~care resources following the expansion of COVID-19 outbreak in the Republic of Kazakhstan. The forecast was grounded on mathematical modeling of a rapidly developing epidemiological situation and used the WHO tool to anticipate the demands for hospital beds, equipment, and professional workforce. ~~Basically~~In essence, this research

메모 [A4]: Reviewer comment: In addition, the quarantine measure should be captured in this model. The imported cases of COVID-19 is associated with the chance to be infected. But, the model has not considered this part as well. The final result would be sound. But if authors consider the complexities in the real world dynamic, the model should be extensively modified.

Reply: Thank you. This is a very valid point. We captured the quarantine measures and remade our modeling. These changes are reflected in revised tables 2-4 and figure 1. Also, we amended the corresponding descriptions in Results section.

presents ~~the~~ internationally comparable data on the epidemiology of the COVID-19 outbreak, complementing an earlier publication on the promising effects of mass quarantine in ~~the country~~the Republic of Kazakhstan [2]. Still, ~~with an~~ after the early introduction of quarantine and other community protection measures, the decision was made to re-open the country ~~came to decision for re-opening~~ by mid-May, which was followed by a rapid escalation of ~~an~~ the outbreak with increasing numbers of deaths and~~,~~ severe and critical infections [21]. This required re-consideration of the outbreak scenario, ~~with~~ including the need to ~~making~~ estimate the~~estimates on~~ availability of health-care resources.

~~Probably, t~~The major finding of this study is that if the forecasted epidemic growth ~~will be implemented~~occurs in reality, the abundance of severely and critically ill patients will overwhelm the country's health care system very quickly, leaving no free hospital beds for other patients. This dictates the need ~~for acting in two~~to act in 2 different directions: reducing the number of new COVID-19 cases and optimizing the existing healthcare services to make them more fit ~~to~~ for the emerging situation [22]. ~~Perhaps,~~The endorsement of communitywide and personal protective measures ~~are~~ would perhaps be the best ~~strategies~~ strategy to reduce the number of new disease cases. As these measures are more effective ~~better acts~~ in combination, ~~such measures~~they should be repeatedly encouraged by both the country's officials and ~~the~~ opinion leaders. Timely identification and isolation of disease cases ~~better~~ works better ~~at~~ at the early stages of an outbreak and mass quarantine could be beneficial at any stage [23]. For more effective mode~~l~~lling of an outbreak forecast, ~~the~~ a deterministic SEIR compartment model with quarantine measures could be used, if these data are available [24]. As for optimization of health-care services, ~~different~~ various approaches could be implemented, including construction of new hospitals, re-profiling of existing hospitals for COVID-19 patients, and considering all patients as potential cases with subsequent treatment based on their clinical presentation [25].

~~There are other things~~Some other factors ~~that have to~~must be considered in the combat against the COVID-19 outbreak. Triage or sorting of patients is a common approach applied in ~~situations of~~ public health ~~emergency~~emergencies. Determining the priority of treatment based on the disease severity or infection risk imposed on other people requires the development of very accurate standard criteria. Triage ~~endorses~~ augments clinical and economic efficiency, safety, and availability of timely medical care [26]. Reverse triage is a way to reorient hospital resources to critically ill patients [27]. Emergency departments (EDs) of multidisciplinary hospitals, emergency medical services, and outpatient clinics are currently the

메모 [A5]: Reviewer comment: In the main text, the limitation of the model authors used was still vague.
- The author can reference this article to modenstrate the limitation of the model (Ryu S, et al. Estimation of the Excess COVID-19 Cases in Seoul, South Korea by the Students Arriving from China. IJERPH. 2020).

Reply: Thank you for your kind comment. We added the reference with explanation to Discussion section.

main places where sorting of COVID-19 patients takes place [28]. This situation is complicated by a very limited number of unified clinical guidelines or care protocols devoted to the ~~sorting~~ triage of patients with COVID-19 [29].

The Australasian College for Emergency Medicine issued a clinical management guide for COVID-19 in EDs with limited resources that ~~underlines~~ emphasizes the importance of maintaining control and standards for infection prevention, ~~and the use of~~using personal protective equipment~~. ~~, ~~The guide emphasizes the importance of~~and establishing isolation zones and waiting areas to minimize the number of patients and to separate patients with respiratory symptoms from other~~ ones~~s. ~~Also, t~~There should also be ~~the~~ clear criteria for hospitalization, isolation, and patient discharge, and every hospital is recommended to introduce an isolation ward to minimize COVID-19 spread. The staff of EDs ~~has to~~must enable the timely identification of ~~those~~ patients who present with fever or respiratory symptoms and show signs of shock or respiratory distress in order to transport them to the ICU without delay [27]. The clinical guideline entitled "COVID-19 pandemic: triage for intensive-care treatment under resource scarcity" proposes ~~to~~ considering ~~a~~ the short-term prognosis as a decisive criterion for patient sorting in ICUs. According to this guideline, age alone should not be used as a criterion as this may cause discrimination against older people, but it should be taken into account on the basis of short-term prognosis, since older people are more likely to suffer from concomitant diseases [30].

As the COVID-19 pandemic continues to spread rapidly across the world, ICUs must be prepared for a large influx of patients and ~~be able~~ to withstand additional pressure imposed by ~~an~~ the outbreak on both patients and medical personnel [31,32]. For this, it is necessary to provide training for other healthcare professionals on how to deal with critically ill patients in need of resuscitation. ~~Also, it~~It is also important to enable the provision of mechanical ventilation and especially of extracorporeal membrane oxygenation (ECMO) to all critically ill patients with severe pneumonia, given the high effectiveness of these procedures. In many instances, this will require allocation of additional funds ~~for the~~to procure~~ment of~~ lacking equipment [33]. Clear threshold indicators should be developed for transferring critically ill patients to ECMO and mechanical ventilation, and steps should be taken to ensure the possibility of bronchoscopy with disposable bronchoscopes.

For the purpose of effective infection control in ICUs and in order to prevent~~ the~~ cross-contamination among healthcare workers, it is necessary to train~~ the~~ staff on how to use personal protective equipment and to provide ~~a~~ the possibility ~~of~~ for them to ~~taking~~ take a shower at the end of the working day. ~~Movement~~ The movement of medical personnel within and outside the department should be strictly limited. Although in an ideal scenario the team ~~goes~~ would go through a ~~two~~2-week observation period after the shift is over, this is not always possible in resource-poor settings, where healthcare workers stay on duty for prolonged time periods ~~having~~ with no chance for replacement. ~~Also, it~~It is also very important to pre-develop models of resuscitation scenarios with different specialists and to conduct ~~an~~ appropriate training [34].

~~Rapidly~~ The rapidly escalating COVID-19 outbreak poses many requirements ~~on~~ for the procurement of medicines, devices and equipment. ~~Also, it~~It is also necessary to make a sufficient number of beds available for patients with severe forms of the disease who need maintenance therapy and continuous monitoring of their vital functions and oxygen saturation by pulse oximetry or analysis of blood gas composition. All procedures should be carried out in a well-ventilated area (at least 12 air changes per hour and a controlled direction of air flow when using mechanical ventilation). The constant availability of oxygen and mechanical ventilation apparatus should be ensured, as well as a sufficient supply of sedatives for intubated patients [35].

Conclusion

In extreme conditions such as a global pandemic~~s~~, health care systems could be weakened to such an extent that they ~~would~~ may not be able to provide all necessary resources. In such situations, there is a need to increase rapidly the available resources or to find ways for ~~their effective~~to redistribute them effectively ~~redistribution~~. Even developed countries with the most advanced health care systems achieved only intermediate results in controlling ~~of~~ the COVID-19 outbreak. As compared to such countries, the health care system of Kazakhstan is less developed and it has started ~~facing~~ to face the consequences of significant relaxation of COVID-19~~-~~-focused communitywide protective measures. Still, Kazakhstan ~~is~~ will be able to reduce the rates of infections and deaths among its population by developing and following a consistent strategy targeting ~~the~~ COVID-19 in a number of inter-related directions.

Conflict of Interest statement

There is no conflict of interest to declare for any of the authors.

Author Contributions

Conceptualization: Semenova Yu, Glushkova N. Methodology: Pivina L, Ospanova D, Kuziyeva G. Formal analysis: Khismetova Z, Kushkarova A. Data curation: Auyezova A, Nurbakyt A. Software: Glushkova N. Validation: Ivankov A. Investigation: Kauysheva A. Writing – original draft preparation: Semenova Yu. Writing – review and editing: Semenova Yu, Glushkova N. Approval of final manuscript: all authors.

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Table 1. Healthcare resources available in the Republic of Kazakhstan

Input variable	Number (number of beds/cases)	Data source, specification
Health care staff		
Number of ~~healthcare workers~~HCWs	208,510	Statistical compilation of ~~*~~RCHD [14]. This figure does not account for dentists.
Proportion of ~~healthcare workers~~HCWs available for COVID-19 response	0.7	Out of all HCWs in the country, including laboratory staff
Number of HCWs per bed	2.96	There are 70,441 hospital beds in the ~~‡RK~~Republic of Kazakhstan with exclusion of nursing care beds, rehabilitation beds, palliative care beds, and psychiatric beds. Three shifts per day are needed. The number of ~~^~~HCWs per bed = 208,510/70,441=2.96
Number of caretakers per bed	1	One per patient by default
Number of ~~ambulanciers~~ ambulance technicians per bed	0.03	Based on 1 ambulance per 100 bed hospital with 2 operators (driver + ~~ambulancier~~ambulance technician) There are 2,218 ambulances in the ~~‡RK~~Republic of Kazakhstan (including specialized and non-specialized ambulances) ~~Ambulanciers~~ Ambulance technicians per bed = 2,128 / 70,441= 0.03
Number of beds in infectious disease units	20,000	60 ~~%~~% utilization (Ministry of Health, ~~‡RK~~Republic of Kazakhstan, 2020) [20]
Proportion of hospital beds available for critically ill patients.	0.02	100 ~~%~~% utilization (Ministry of Health, ~~‡RK~~Republic of Kazakhstan, 2020) [20]
Infrastructure		
Number of #ICU beds per hospital	9	Out of 788 hospitals in the country, 557 are government-owned and the rest are private. The overall number of beds is 70,441. Number of beds per hospital = 70,441 / 788 = 89.39 We assume that 10 ~~%~~% of beds in any hospital could be reprofiled to #ICU beds = 89.39*0.1= 8.94. Thus, there are 9 #ICU beds per hospital.
Beds per 1000 population	3.78	Statistical compilation of ~~*R~~RCHD [14]. Country population = 18,654,000 Beds per 1000 population = 70,441 /18,654,000*1000 = 3.78
Consultations		
Number of consultations per ~~^~~HCW per day, on an average	20	We assume that on an average, a doctor and a nurse consult 40 patients per day each.
Lab operation		
Number of lab staff in the country	12,511	Statistical compilation of ~~*R~~RCHD [14].
Proportion of lab staff available for COVID-19 response	0.67	Lab staff in the country, the proportion of lab staff in the country that could be used empirically for the COVID-19 response.
Number of tests run by each lab per day	400	Based on 2 machines with throughput of 200 tests per day, by default
Number of lab staff per lab	3	Based on current known staffing models by default
General information on the country's health care workers		
Number of doctors	72,877	Statistical compilation of ~~*R~~RCHD [14]
Number of nurses and midwives	175,705	Statistical compilation of ~~*R~~RCHD [14]
Number of ~~^~~HCWs treating hospitalized COVID-19 inpatients	0.55	Based on calculations in the model of inpatient vs. outpatient staff needs
Proportion of ~~^~~HCWs responsible for screening and triaging of COVID-19 suspects	0.15	Based on calculations in model of inpatient vs. outpatient staff needs
Number of ~~^~~HCWs for outpatients	8,780	Statistical compilation of ~~*R~~RCHD [14] We assume that this category is covered by general practitioners available in the ~~‡RK~~Republic of Kazakhstan

HCWs, healthcare workers; ~~*~~RCHD ~~–~~, Republican Center for Health Development; COVID-19, coronavirus disease 2019;~~^HCWs – Health care workers; ‡RK – Republic of Kazakhstan;~~ #ICU, intensive care unit. ~~– Intensive Care Unit~~

메모 [오전1]: "Ambulancier" is not a commonly used English word; "emergency medical technician" (https://en.wikipedia.org/wiki/Emergency_medical_technician) could be another option, but "ambulance technician" is probably clearest for international readers from countries with a wide range of medical systems.

메모 [오전2]: Should this be "together"? "Each" would imply that a doctor sees 40 patients and a nurse sees 40 patients, resulting in a total of 40 * 2 = 80. "Together" or "jointly" would yield 40 / 2 = 20, which would align with the column to the left. Please double-check.

Table 2. Total COVID-19 cases and inpatient admissions due to COVID-19 over the forecast period by bed availability in ~~the country~~the Republic of Kazakhstan (beginning ~~02~~ September 2, 2020)

Disease severity	Total number of cases (based on forecast calculations, uncapped by hospital bed availability)	Total number of hospital admissions over forecast period (capped by bed availability)	Maximum number of beds provided for COVID-19 response at peak (with assumption that all ~~country~~ beds in the country could be occupied)	Maximum number of beds currently available for COVID-19 response (at peak occupancy)	Difference between available and needed number of beds for COVID-19 response
	698,091.1	12,000	49,177.69	20,000.0	N (%)
Mild	279,236.4	*n/a	n/a	n/a	n/a
Moderate	279,236.4	n/a	n/a	n/a	n/a
Severe	104,713.7	11,336	47,247.75	11,336	35,912 (316.79)
Critical	34,904.55	664	1,929.94	664	1,265.94 (190.65)

*n/a – not applicable

COVID-19, coronavirus disease 2019.

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Table 3. The forecasted patient numbers, bed availability, and need for health care workers in Kazakhstan by week (beginning 02 September 2, 2020)

Health care resource	Required Each Week	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12
Inpatient	Total number of severe cases needing beds (unconstrained by bed availability)	35,622.09	36,639.98	19,211.85	7,722.236	3,124.234	1,331.135	587.4432	264.0811	119.7831	54.56021	24.89996	11.37387
	Total number of severe patients admitted and in a bed (capped by bed availability)	11,336	11,336	11,336	7,722.236	3,124.234	1,331.135	587.4432	264.0811	119.7831	54.56021	24.89996	11.37387
	% Available beds for severe patients that are occupied	1	1	1	0.681213	0.275603	0.117425	0.051821	0.023296	0.010567	0.004813	0.002197	0.001003
	Total number of critical cases needing beds (unconstrained by bed availability)	18,453.83	24,087.36	18,617.28	8,978.029	3,615.49	1,485.123	639.5259	283.8414	127.9547	58.11445	26.48672	12.09128
	Total number of critical patients admitted and in a bed (capped by bed availability)	664	664	664	664	664	664	639.5259	283.8414	127.9547	58.11445	26.48672	12.09128
	% Available beds for critical patients that are occupied	1	1	1	1	1	1	0.963141	0.427472	0.192703	0.087522	0.03989	0.01821
Inpatient	Total number of health care workers	35,520	35,520	35,520	24,823.26	11,213.17	5,905.598	3,631.829	1,621.851	733.3041	333.517	152.1046	69.45684
	Total number of cleaners	6,000	6,000	6,000	4,193.118	1,894.117	997.5673	613.4845	273.9613	123.8689	56.33733	25.69334	11.73257
	Total number of ambulance personnel	360	360	360	251.5871	113.647	59.85404	36.80907	16.43768	7.432137	3.38024	1.541601	0.703954
	Total number of biomedical engineers	240	240	240	167.7247	75.76469	39.90269	24.53938	10.95845	4.954758	2.253493	1.027734	0.469303
Screening/ Triage	Total number of health care workers	1,594	1,639	860	346	140	60	27	12	6	3	2	1
Laboratories	Total number of lab staff required	167	167	167	167	167	167	167	167	167	167	167	167
	Total number of cleaners	56	56	56	56	56	56	56	56	56	56	56	56

Table 4. The forecasted need for treatment equipment for COVID-19 patients in Kazakhstan (Total total expected caseload over forecast period, : 698,091.1 cases)

Purpose	Detailed specification	Number of items needed
Status monitoring	Infrared thermometer	269.66
	Pulse oximeter (adult + pediatric probes)	12,000.00
	Patient monitor, multiparametric with ECG, with accessories	664.00
	Patient monitor, multiparametric without ECG, with accessories	2,834.00
Oxygen therapy	Oxygen source (i.e., concentrator, cylinder, or pipe supply)	12,000.00
Airway mManagement and iIntubation	Laryngoscope (direct or video type)	442.67
Mechanical ventilation	Patient ventilator, intensive care, with breathing circuits and patient interface	442.67
Non-invasive ventilation	CPAP, with tubing and patient interfaces, with accessories	110.67
	High Flow Nasal Cannula, with tubing and patient interfaces	110.67
Iv infusion	Electronic drop counter, IV fluids	11,336.00
	Infusion pump	2,834.00
Blood chemistry	Blood gGas aAnalyzser, portable with cartridges and control solutions	134.83
Imaging	Ultrasound, portable, w/ transducers and trolley	134.83
IcuICU	Drill, for vascular access, w/accessories, w/transport bag	134.83
	Electrocardiograph, portable with accessories	134.83
	Suction pump	3,498.00
Oxygen therapy	Bubble humidifier, non-heated	12,469.60
	Tubing, medical gases, int. diam. 5 mm	300.00
	Flow splitter, 5 flowmeters 0-2 L/min, for pediatric use	300.00
	Flowmeter, Thorpe tube, for pipe oxygen 0-15 L/min	219.12
	Filter, heat and moisture exchanger (HMEF), high efficiency, with connectors, for adult	3,821.29
Imaging	Conductive gel, container	96.50
Oxygen delivery devices	Catheter, nasal, 40 cm, with lateral eyes, sterile, single use; different sizes: 10 Fr, 12 Fr, 14 Fr, 16 Fr, 18 Fr	2,618.99
	Nasal oxygen cannula, with prongs, adult and pediatric	31,498.50
	Mask, oxygen, with connection tube, reservoir bag and valve, high-concentration single use (adult)	31,498.50
	Venturi mMask, with percent O_2 lLock and tubing (adult)	31,498.50
Airway management & and intubation	Compressible self-refilling ventilation bag, capacity > 1500 mL, with masks (small, medium, large)	221.33
	Airway, nasopharyngeal, sterile, single use, set with sizes of: 20 Fr, 22 Fr, 24 Fr, 26 Fr, 28 Fr, 30 Fr, 32 Fr, 34 Fr, 36 Fr	2,573.26
	Airway, oropharyngeal, Guedel, set with sizes of: No. 2 (70 mm), No. 3 (80 mm), No. 4 (90 mm), No. 5 (100 mm)	2,573.26
	Colorimetric eEnd tTidal CO_2 detector single use (adult)	2,573.26
	Cricothyrotomy, set, emergency, 6 mm, sterile, single use	442.67
	Endotracheal tube introducer	2,573.26
	Tube, endotracheal	2,573.26
	Laryngeal mask airway (LMA)	2,573.26
	Lubricating jelly - for critical patient gastro-enteral feeding and airway management & and intubation	96.50

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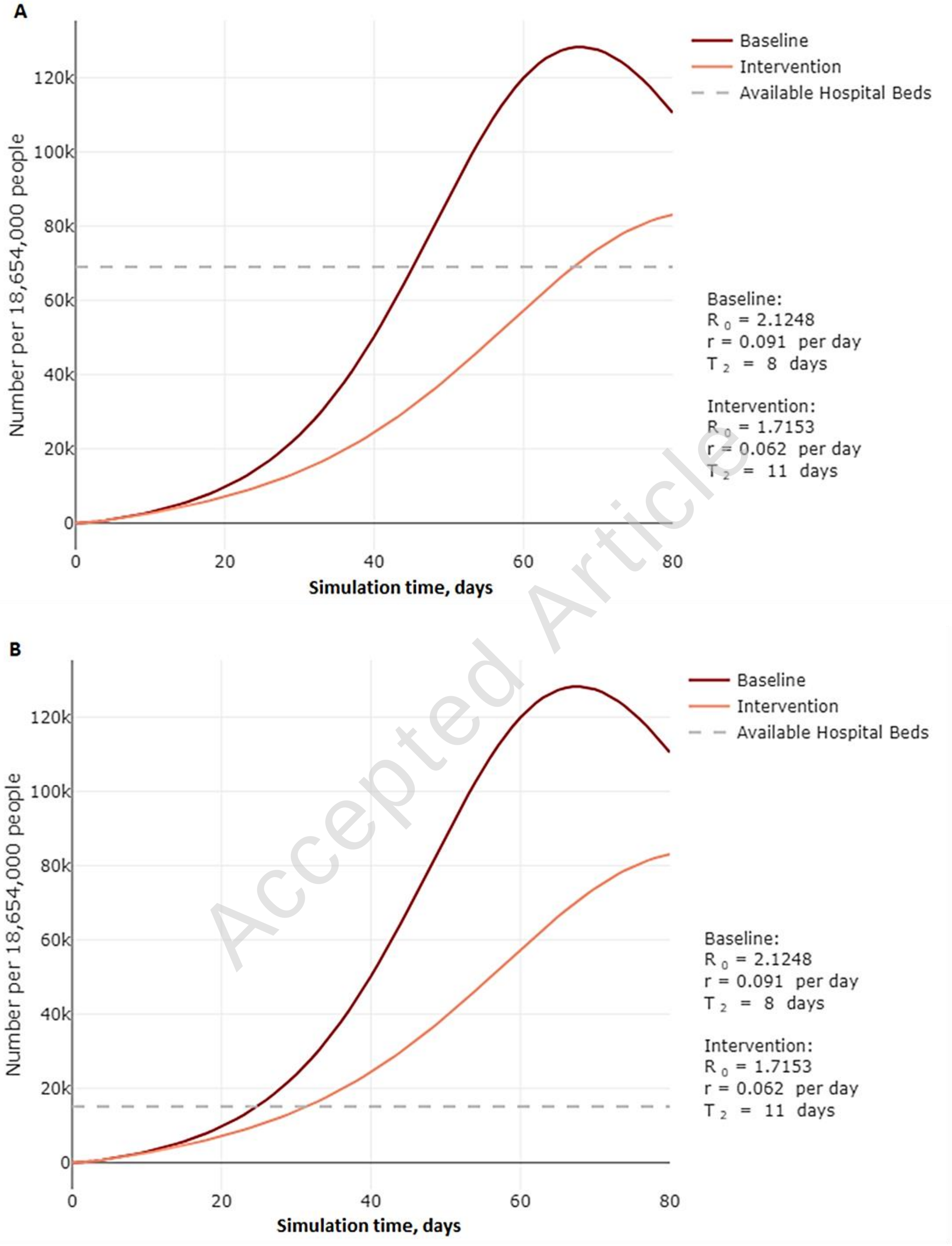

Figure 1. COVID-19 Cases vs. Healthcare Capacity: simulation predicted number of "severe" and "critical" infections vs. the capacity of health care system constrained by availability of all inpatient beds in the country (A) and by availability of inpatient beds reserved for COVID-19 patients (B) [16]