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Developing a Personal Protective Equipment Calculator During the COVID-19 Pandemic

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Brief Report

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Abstract

These days, because of the coronavirus disease (COVID-19) pandemic, we have faced a number of challenges and scarcities in Iran. Lack of personal protective equipment (PPE) is one of the most remarkable problems that can have damaging consequences on the health system. In this letter, we introduce software that can help hospitals manage their PPE in terms of purchasing, distributing, and predicting the future needs in different time intervals. The software has several distinctive features such as superior speed, cost management, managerial dashboard, a wide range of applicability, comprehensiveness, supply chain management, and quality appraisal. We hope that our findings can assist health authorities in planning and optimizing the use of PPE for the response to COVID-19, where the shortage of resources may occur due to supply chain issues.

In Iran, the growing prevalence of the COVID-19 pandemic has led to heavy workload and stress among the health care workforce. Furthermore, shortages of PPE caused many of them to become infected with the virus due to the high exposure. In fact, in this country, the same significant number of workers have been reported to be infected and died, signifying the necessity of proper management and protection.[1] As a result, the World Health Organization (WHO) mandated the proper use of PPE to slow the spread of the virus and decrease the rate of infection in health care settings. This obligation resulted in a high demand for such equipment in health care facilities.[2–4] Worldwide, such shortages are largely risky for medical staff and if not adequately resolved, frontline health workers will become infected and, consequently, the quality and quantity of available care will be affected negatively.[5]

However, accurately predicting the number of required PPE is challenging because having access to the needed data is somehow difficult. For example, having data about the infectious period, recovered or dead cases, contacts per person per day, the probability of infection per contact, and reproduction number in different regions of a country and at different times are among major challenges.[6] In addition to data limitations, the diverse consumption of PPE makes it difficult to convert the number of infected patients and hospitalizations into forecasts for PPE demand. To resolve the issue, in this study, we developed web-based software to forecast the consumption of PPE during the COVID-19 pandemic based on hospitalization information, the number of new admissions, the number of health care workers, the number of shifts per day, the number of PPE changes per shift, and number of contacts with COVID-19 patients per shift. This tool can be integrated with epidemiological models to extract information such as current cumulative COVID-19 cases, recovered or dead cases from these models. Furthermore, it provides an opportunity for users to estimate the number of required equipment for different time periods and provide weekly, bi-weekly, monthly, 6-month, and even annual reports to health officials. It is also able to calculate the number of required medical supplies for different health settings, including hospitals, primary health care providers, long-term care settings, and even emergency medical services. The model is dynamic and flexible due to considering different conditions relevant to the type of hospital or health system as it can input their own scenarios in terms of morbidity, mortality, and hospitalization rate. This tool also considers some of the scenarios that can reduce the number of required PPE, including extended use strategy, reuse strategy, and reducing the number of patient visits per shift. Furthermore, the tool takes into account those workers who are not involved in direct caregiving to patients, but they are also at risk of having exposure to suspected patients such as those working in admission and discharge units.

To develop the calculating software to forecast the required number of PPE, we followed 11 steps, depicted in Figure 1. First, we defined all hospital wards/departments in the portal and inserted personnel data (including an employee's name, job title, an employee's work

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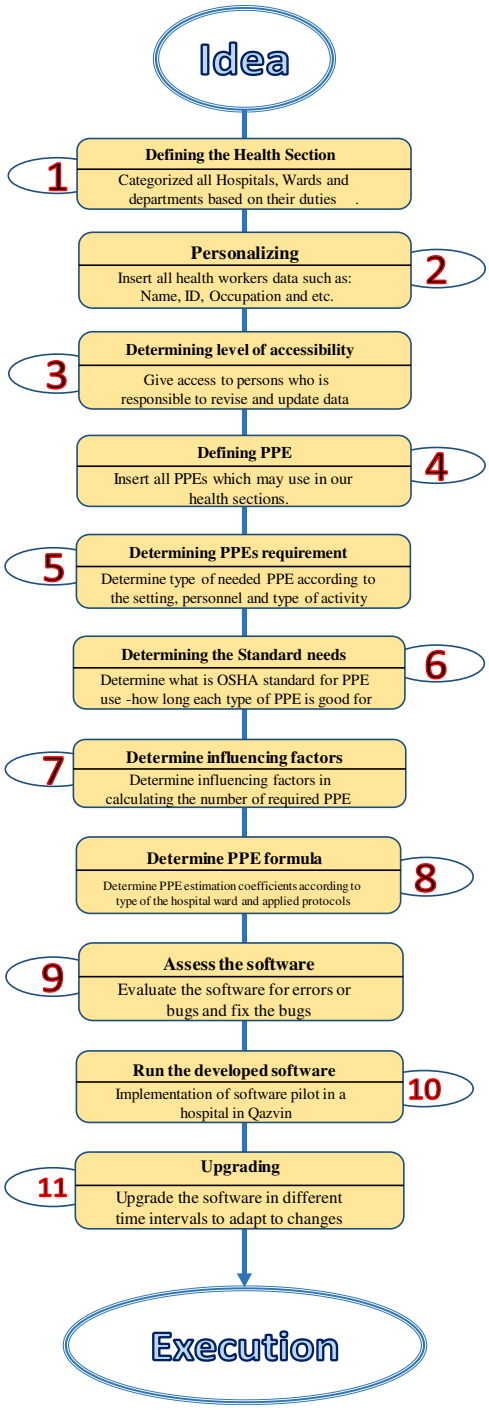

Figure 1. The flowchart of developing the PPE software.

location, etc.) using the portal and human resource management database of the university. To ensure the accuracy of entered data, the heads of each hospital department were asked to verify and confirm the information of their personnel. Then we defined each user access right to portal objects and determined what type of data should be inserted by eligible users to create the database required to use formulas. In the next step, we determined what types of PPE are required based on the hospital ward, personnel, and type of their activities.[7] Since the usability time of PPE can affect their estimation, we reviewed Occupational Safety and Health Administration (OSHA) standards to extract needed data.[8] The calculation of required PPEs was done for each of the equipment separately in order to comply with the standards regarding their duration of usability and other requirements that must be considered in the calculation.

Table 1. Factors affecting the PPE requirements in health centers

Approach	Type of PPE	Influencing factors in calculating required PPE
Staffing based consumption	Surgical mask N95/FFP2/FFP3	- Number of hospitalized patients per month - Number of shifts per day - Number of patients per provider - Number of shifts each PPE is used
Contact based consumption	Gloves	- Number of hospitalized patients per month - Number of daily contacts per patient - Number of patient contacts before discarding a PPE
Contact based consumption	Face shield	- Number of procedures that are likely to generate aerosols, blood, fluid, or secretion per personnel per month - Number of staff encountering with aerosol generating procedures (AGP), or those generating blood, fluid, or secretion per month
Staffing based consumption	Reusable gown	- Number of hospitalized patients per month - Number of shifts per day - Number of patients per provider - Number of shifts each PPE is used
Contact based consumption	Disposable gown	- Number of hospitalized patients per month - Number of daily contacts per patient - Number of patient contacts before discarding a PPE

To define formulas, we reviewed the literature and used the experts' opinion not only to determine the influencing factors on PPE estimation but also to define mathematical relationships between variables. Furthermore, to attain data, we reviewed patient records to determine the average number of contacts each of the staff has with their patients in a particular period of time. We also interviewed physicians, nurses, and other clinical staff to gain necessary information. Evidence affirmed that there are 2 distinguishable types of PPE consumption: first, "contact-based consumption," which depends on the number of contacts workers have with COVID-19 patients and the second called "staffing based consumption," which is irrespective of the number of patient contacts.[9] Table 1 depicts the variables used to estimate the required number of PPE for clinical workforce. In the following, we presented an example of a calculation formula defined for estimating the number of required gloves for a clinical hospital ward. To do so, we exported epidemiological data about the number of COVID-19 cases over a period of time based on 2 factors of clinical attack rates and disease doubling times. Then, based on the disease severity, the percentage of infected patients who were admitted to a hospital in a monthly basis was identified. Afterward, the number of hospitalized patients per month was multiplied by an average number of monthly contacts of health workforce per patient, and the obtained result was divided by the number of patient contacts before discarding the PPE.

Number of required PPE per month = $(\beta*3)/\alpha$

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Table 2. Assigned coefficients according to the type of clinical ward and implemented strategies

Factors		Coefficient
Type of clinical ward	Caring COVID-19 patients	1.2
	Caring non- COVID-19 patients	1
Reuse/extended use of PPE	Yes	0.8
	No	1
Plastic window as a supportive strategy	Yes	0.8
	No	1
Caring for COVID-19 patients as a single cohort	Yes	0.8
	No	1

β: *Number of hospitalized patients per month*

3: Average number of monthly contacts of health workforce per patient

α: Number of patient contacts before discarding the PPE

The total demand for PPE in a hospital can be calculated through summing the estimated PPE demand across all clinical personnel working in all clinical wards.

Finally, the estimated number of required PPE obtained from the previous step was multiplied by the assigned coefficients according to the type of clinical ward and strategies implemented to optimize the use of PPE in hospital settings. For example, using strategies to reduce the use of PPE such as a plastic window, use of reusable PPE, or extended use of PPE in contingency and crisis situations were among main influencing factors (Table 2). With reference to a set of valid guidelines and asking clinicians to estimate the degree to which the number of patient encounters can be reduced in a situation where we face a shortage of PPE, appropriate coefficients were assigned. We also asked clinical staff about the frequency of PPE use under normal circumstances, shortages, and a major crisis. There are some interventions that can minimize the use and need for PPE through protecting health care staff from exposure to the COVID-19 virus. For example, using physical barriers such as plastic windows can be applied in places such as triage or screening areas, the registration desk, and at the pharmacy. Furthermore, giving care to confirmed COVID-19 patients in the same room can facilitate extended use of PPE. Even designating a particular group of health workforce only for COVID-19 patients can make extended use of PPE possible in contingency or crisis conditions.[7]

We hope that our findings can assist health authorities in planning and optimizing the use of medical supplies, including PPE, where the shortage of resources may occur due to supply chain issues.

Author contributions. All authors have read and reviewed the manuscript for submission.

Conflict(s) of interest. The authors declare no conflicts of financial interest.

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