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Letter to the Editor

Adaptation of the 'Assembly Line' and 'Brick System' techniques for hospital resource management of personal protective equipment, as preparedness for mitigating the impact of the COVID-19 pandemic in a large public hospital in India



Sir,

The COVID-19 pandemic had a slow start in India due to strict restrictions and screening imposed on foreign travel, but by the first week of March 2020, it was clear that the surgical store of our hospital needed to rapidly ramp up its inventory of personal protective equipment (PPE), well ahead of an anticipated increased transmission. PPE items provided by our regular vendors were not available as complete kits. In addition, some important items such as coveralls were not being routinely procured. Logistical delays from the nationwide lockdown, financial constraints such as fluctuating pricing and demands for advance payment as well as regulatory pressure due to caps imposed on purchase quantity and pricing, made it difficult to procure PPE. The supply chain disruption consequent upon limited supply of raw material with manufacturers and export bans imposed by other countries added to the complexity of the issue. Managing the supply chain of PPE in this scenario was difficult and made it necessary to evolve new systems and guidelines to mitigate these conditions.

Our hospital responded by bringing together a team consisting of hospital administrators, microbiologists and clinicians. An equitable model for appropriate use of PPE in various healthcare settings was created, which also reassured and boosted the morale of healthcare workers. It was decided to assemble PPE kits in house from piecemeal purchases of individual items of appropriate quality. An assembly line was put in place where components of the PPE kit were added in sequence until the final completed product was packed and ready for distribution. The processes adopted involved the following principles.

1. Widening of sourcing: the reputation of our institute, large size of advance orders and extensive reach available from previous history of purchases allowed us to attract a choice

- of vendors. A few components not routinely available in adequate numbers, such as hood caps and long shoe covers, were custom-made by reliable manufacturers.
2. Repurposing available resources: the patient waiting hall was reconfigured to become the staging area for incoming vendor inventory (Figure 1). Data Entry Operators and Patient Care Coordinators were enlisted as assembly-line workers. Faculty members volunteered to be assembly-line supervisors.
3. Creating a matrix of patient care areas and their PPE needs (Table 1): the hospital was being redesigned to manage COVID-19 and non-COVID-19 patients in physically separate buildings. Level-1 PPE kits were used in non-COVID-19 areas including wards, general labs and other areas handling non-COVID-19 patients or their samples. Level-2 PPE kits were assembled from components appropriate for screening areas and wards for COVID-19 patients. Components in these were selected based on availability in larger numbers, greater comfort when worn in hot summer temperatures for prolonged periods and greater ease of donning and doffing. Level-3 PPE kits were designed for wards and intensive care units (ICUs) managing COVID-19 patients. The same kits were also used for ICUs and operating rooms (OR) managing non-COVID-19 patients. The kit was composed of an N95 mask suitable for prolonged wear under a face-shield, which would maintain an airtight fit when worn with goggles which might have spectacles under them. Other components were sourced from original manufacturers. Donning and doffing required around 30 min with assistance.
4. The "Brick System": in the Indian armed forces, a 'Brick System' has been in vogue since the colonial era. A brick is an operationally self-contained box for a manpower-based unit. It is typically used in inventory management of the personal kit issued to each fighting unit and also used by the United Nations Peace Keeping Forces (The UN Brick) [1]. The system also envisages different types of kits required at different levels. This method was modified by a hospital administrator having previous experience in the Indian Army Medical Corps. The number of beds in a given medical unit and the human resources needed to operationalize it were considered a functional unit. The number of PPE kits required per day was ascertained. For laboratories, the monthly requirement was considered. The requisite number of in-house PPE kits for the various wards were then assembled into one brick (a carton) and supplied to that unit on a daily basis. The brick system aids in inventory management by rationalizing the indents, keeping track of future requirements and projecting the purchasing of

Table I

Levels of personal protective equipment (PPE) according to the matrix that was made

Level	Level I	Level II	Level III
PPE Kit	General use kits (non-COVID areas)	Coverall- based PPE kits	Bio-safety coverall-based kits
Components	Coverall-based PPE kits Surgical gown + N-95 mask + goggles + gloves	Coverall + hood + N-95 mask + goggles + long shoe covers + gloves	Bio-safety coverall + N-95 mask + goggles + long shoe covers + gloves
Type of patient care area	Non-COVID areas	COVID wards	COVID ICU & HDU

HDU, high-dependency unit; ICU, intensive care unit.



Figure 1. The patient waiting hall was utilized for assembly of the PPE kits and the Data Entry Operators and Patient Care Coordinators helped in assembling.

components far ahead of time. Bricks of varying sizes and levels help in rationing of PPE between different wards based on differentiating essential and elective patients. Availability of smaller bricks helps in downsizing of certain wards in terms of patient admissions or rostering of healthcare workers based on PPE availability.

Computerized records of each brick helps with storage, retrieval, issue and consumption patterns.

5. Preparing for the surge: keeping the system ready for all eventualities, based on reports from other countries [2], disinfection and reuse scenarios were envisaged. Modifications to a number of hospital rooms were carried out

for disinfection of different kit components, if found necessary in the future. Hydrogen-peroxide-vapour-based disinfection rooms [3,4] appropriate for N95 masks, Tyvec suits and other difficult-to-procure components of the PPE kits were created for in-house needs as well as for field units as might be required if a surge in the number of cases takes place.

Optimization and efficiency of the supply chain system is an essential component of repurposing a general hospital for an epidemic or pandemic. A surge is likely of both COVID-19 and non-COVID-19 patients in our hospital due to easing of travel restrictions. Being ahead of the curve regarding PPE requirements can not only balance the purchasing of different components of a PPE kit, but also reduce the stress levels and boost the confidence of healthcare workers. The latter is already visible after undertaking the above measures.

Conflict of interest statement

None declared.

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