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ECONOMIC ANALYSIS

Cancer Hospital Stockpiles: Strategizing for an Efficient and Sufficient Inventory List of Essential Items

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abstract

PURPOSE The COVID-19 pandemic has affected health care systems worldwide, resulting in critical shortages of essential items and materials. The available guidelines are of little use for cancer hospitals in low-income and low-middle–income countries. They have been designed for community hospitals serving in a centralized health care network. This study aimed to draft and field test a framework to establish a list of essential supplies that should be stockpiled for subsequent waves of the COVID-19 virus by a tertiary care cancer hospital in a low-middle–income country.

MATERIALS AND METHODS A model was formulated using the consumption trends during the peak month of the first wave of COVID-19 infection to compile a list of essential materials and supplies. Furthermore, costing analyses were conducted to determine the financial benefits of stockpiling.

RESULTS A proposed list of items to stockpile, including personal protective equipment, radiology supplies, laboratory reagents, medication, and oxygen, was shared with the hospital administration. However, the hospital administration only accepted the proposals for stockpiling personal protective equipment and oxygen.

CONCLUSION This paper provides a framework and strategies that cancer hospitals and health care systems can modify and use as per individual, institutional requirements and specifications for stockpiling essential items during the COVID-19 or other similar pandemics.

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INTRODUCTION

Cancer is a multifaceted disease characterized by plasticity and heterogeneity that progresses at genetic, phenotypic, and pathologic levels. It is recognized by the United Nations and WHO as a significant public health problem and considered to be a global health priority, particularly in low-income countries (LICs) and low-middle–income countries (LMICs). There are multiple challenges to cancer care, including limited access to care, scarce resources, affordability, and geographic barriers.

The COVID-19 pandemic has affected health care systems worldwide, resulting in critical shortages of essential items and materials, such as personal protective equipment (PPE), medication, laboratory reagents, and oxygen.[1,2] These shortages amplified the existing barriers to care in the LIC and LMIC, which resulted in a significant portion of patients suffering disruption in cancer care.[2]

The WHO, the US Department of Health and Human Services, and the Centers for Disease Control and Prevention have provided recommendations for preparedness goals for health care systems.[3-5] However, these are not specific to cancer hospitals. They lack the details needed to make decisions regarding the selection of items and quantities for the stockpile. Previously, investigators have used Delphi studies, involving experts from the field of emergency or disaster medicine, to determine types and quantities of PPE, medication, and other medical or clinical items that might be needed by a hospital during a disaster.[6] Mathematic algorithms (game theory models) and consumption records from prior flu-like pandemics (SARS, Spanish flu) have been used to predict surge levels and quantities needed to sustain care until supplies can be replenished.[7-10] All these have limitations, because of the inherent nature of the disease and because these calculations have been made for general or community hospitals, often in centralized health care networks. These guidelines and models are therefore less useful for cancer hospitals in low-income and low-middle–income countries, such as Pakistan, where many hospitals function in a disjointed, fragile, and decentralized health care network.

We aimed to develop a framework to establish a list of essential medical equipment, drugs, and other

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CONTEXT

Key Objective

Is there a calculation system available to determine the appropriate stockpile for a cancer hospital serving in a low-income or low-middle–income country?

Knowledge Generated

This manuscript describes a model that uses the unique consumption patterns of a cancer hospital serving in noncentralized health care networks to make strategic decisions on whether and what to stockpile.

Relevance

This model is adjustable and can be modified and used in accordance with individual institutional requirements, which the cancer hospitals can use to prepare for a pandemic.

materials that should be stockpiled for subsequent waves of the COVID-19 pandemic, or for other flu-like pandemics, by a tertiary care cancer hospital in a low-income or a low-middle–income country. Various strategies to help hospitals with the logistics of stockpiling were also evaluated and are discussed.

MATERIALS AND METHODS

Study Setting

This study was completed at Shaukat Khanum Memorial Cancer Hospital & Research Centre (SKMCH & RC), Lahore, Pakistan, a 195-bed, tertiary care cancer center where, each year, more than 200,000 patient encounters occur in an outpatient setting, 40,000 sessions of chemotherapy are delivered, and nearly 64,000 sessions of radiation therapy occur.

Stockpile and Essential Items

In this study, a stockpile was defined as the amount of equipment over and above the needs of the hospital during normal circumstances, assuming that there would be a surge in demand during a pandemic.

Essential items can be PPE, medication, oxygen, or reagents or supplies for laboratory and radiologic investigations. To establish the types of essential items to stockpile, consumption data for medical supplies for the peak month of the first wave of COVID-19 were reviewed and compared with a controlled pre-COVID timeframe of the same duration. Essential items were deemed to be those with $> 15\%$ increase in consumption or those that were specifically procured for the management of patients with COVID-19.

Quantities

The quantities of essential items required were calculated by determining the monthly excess consumption of each item. This value was divided by 30 (number of days in a month) to estimate the Calculated Daily Use (CDU) for each. A margin of 20% was added to the CDU to account for the pandemic's unpredictable nature and procurement delays, to provide the Anticipated Daily Use (ADU) of each item. Figure 1 summarizes the framework of this model. These calculations did not consider safety stocks or functional inventories normally in place to manage routine variations in demand, as part of the stockpile. Similarly, it was assumed that the current stockpile of the hospital was zero. June 2020 was used as the study month since this was the peak month for COVID-19 cases in Pakistan during the first wave of the pandemic and June 2019 was used as the control month.

For calculating the oxygen stockpile, the total consumption of oxygen during the peak (study) month was used for the calculation of CDU and ADU, with the goal being to maintain a hospital reserve for at least 15 days of COVID-19 level consumption.

Costing

The ADU of essential items was multiplied by the lead time (days required for procurement) to calculate the quantity of the item needed for the stockpile. For laboratory investigations, the quantities of each of the primary reagents (test kits, controls, and calibrators) required to carry out the test were determined, assuming that control and calibrator liquids were changed once a day.

All costs were calculated in Pakistani Rupees (PKR) and converted to US Dollars (USD) for this manuscript. At the time of analysis, 1 USD was equivalent to 163 PKR. For costing analyses, the tender prices for the year 2020-2021, which are fixed for a year, were used. Where an item had not been tendered, the average procurement cost from March 15 to May 30, 2020, was used.

For determining the cost difference of procuring essential items as needed (emergency buying) and purchasing prepandemic (tendered), we used prices provided by the hospital's Materials Management Department. For emergency buying, the average cost of items from March 15 to May 30, 2020, was used, and for the prepandemic purchase model, the tendered price of items was used. For items that were procured for the first time during the pandemic, the actual purchase price was used in both. If there was a difference of at least 5% between the cost of sourcing materials prepandemic and emergency buying,

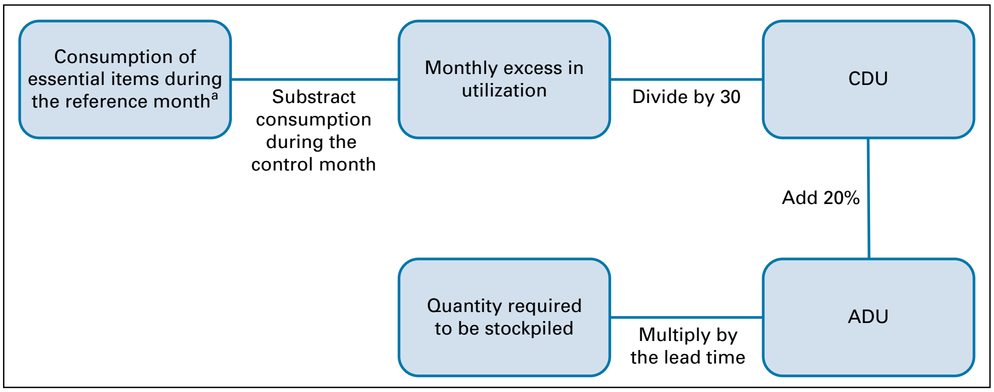

FIG 1. The framework, which was used to compile a list and quantities of items that should be stockpiled by the hospital, is shown. [a]Reference month is the month during which the hospital treated maximum number of COVID-19 cases. ADU, anticipated daily use; CDU, calculated daily use.

then an additional analysis of the cost of maintaining, rotating, and storing the stockpiles was carried out to calculate the overall cost of the prepandemic model.

The hospital has a total oxygen storage capacity of 6,630.33 m^3 and pays for the actual volume of oxygen consumed. A costing analysis was performed to calculate the cost of increasing the oxygen storage capacity so as to ensure supply for 15 days of COVID-19 level consumption.

Final Decision

The proposed plan was presented to the hospital's management, which decided the essential items that the hospital would consider stockpiling.

RESULTS

Essential Medications

Dispensing trends for June 2019 and June 2020 were analyzed, identifying increased utilization of 39 items from June 2019 to June 2020. Thirteen drugs where increased utilization was < 15% were subsequently excluded from the list.

The mean increase in the utilization of essential drugs was 145.9%. Piperacillin sodium/tazobactam sodium had the least, and dexmedetomidine had the highest consumption, at 17.5% and 875.7%, respectively. Midazolam was calculated to have the highest ADU (101.6), and tiotropium with formoterol was found to have the lowest ADU (0.3). Lead times of 14 days for local medications and 48 days for imported medicines were used (Table 1).

Ten of the essential drugs were not part of the hospital formulary and had to be procured on a need-to-use basis so that the same cost was used for these medications in calculations for both scenarios. The prices of most drugs increased during the pandemic, most significantly for montelukast (555.4%) and vancomycin (99.1%; Table 2). The most prominent reductions in price were for nalbuphine (37.3%) and midazolam (10.9%). Overall, emergency buying for a medication stockpile would cost us PKR 1,711,292 (USD 10,499), whereas sourcing medications prepandemic would cost PKR 1,680,279 (USD 10,309). This is 1.8% less than the emergency buying model. Since the percentage difference between the two models was < 5%, further analyses were not performed.

Essential Radiologic Supplies

We experienced a surge in utilization for three radiologic studies during June 2020. These were standard posteroanterior radiographs of the chest and computed tomography (CT) scans of the thorax, with and without contrast. The percentage increase in posteroanterior chest radiographs and for CT scans of the thorax with contrast was < 15%, but there was a 66.7% increase in CT scans of the thorax *without* contrast. This is a digital modality and does not require any additional stock.

Essential Laboratory Reagents

Utilization of 13 essential laboratory tests increased during the peak month of the COVID-19 pandemic, although three of these were subsequently excluded as the percentage increase was < 15%. The mean increase in utilization was 663.4%, with the increase of 3,816.1% for the D-Dimer test and 553.3% for serum ferritin levels. The highest ADUs were for the polymerase chain reaction for COVID-19 (PCR-COVID-19) and for the coronavirus antibody test, at 520.1 and 134.5, respectively (Table 3). A lead time of 28 days was used for all primary reagents, except for the ferritin test, where a lead time of 42 days was used. Prices for primary laboratory reagents were stable during the pandemic and so sourcing a laboratory stockpile (prepandemic or emergency buying) would cost the hospital PKR 21,923,206 (USD 134,498). These results are summarized in Table 4.

PPE

The record of the type and quantities of PPE used in SKMCH&RC in June 2019 and June 2020 was reviewed to assess PPE use. Fourteen items of PPE were shortlisted, but two were excluded because the percentage increase was < 15%. Among the remaining 12, the mean increase in utilization was 634.7%. Sterile surgical gowns (1,105.6%) and plastic aprons (442.7%) had the highest increase in utilization. The highest ADUs were for surgical masks (2,548.6), plastic aprons (1,328), and face shields (949.7). Lead times of 14 days for local items and 28 days for imported items were

TABLE 1. The Consumption Differences and Daily Usages of Medications During June 2020 (sample month) and June 2019 (reference month)

Medication	Difference in Consumption	Percentage Change (%)	CDU[a]	ADU[b]
Azithromycin injection 500 mg	70	45.2	2.3	2.8
Amikacin injection (all strengths) 500 mg[c]	114	—	3.8	4.6
Atropine injection 1 mg/mL	89	38	3	3.6
Cephazoline injection 1,000 mg	580	131.8	19.3	23.2
Cisatracurium injection 10 mg[c]	1,095	—	36.5	43.8
Dexmedetomidine injection 100 mcg/mL	613	875.7	20.4	24.5
Doxycycline 100 mg tablet/capsule	84	91.3	2.8	3.36
Enoxaparin injection 40 mg	674	33.4	22.5	27
Frusemide injection 20 mg	430	95.3	14.3	17.2
Hydrocortisone injection 100 mg	235	79.1	7.8	9.4
Imipenem/cilastatin injection 500 mg	236	62.3	7.87	9.4
Meropenem injection 500 mg[c]	237	—	7.9	9.5
Midazolam injection 5 mg/5 mL	2,539	111.8	84.6	101.6
Montelukast 10 mg tablet	1814	581.4	60.5	72.56
Nalbuphine injection 20 mg[c]	2,324	—	77.5	93
Norepinephrine injection 8 mg/4 mL	460	44.2	15.3	18.4
Piperacillin sodium/tazobactam sodium injection 4,500 mg	642	17.5	21.4	25.7
Ringer lactate 1,000 mL infusion	1,009	72.7	33.6	40.4
Salbutamol inhaler 100 mcg/dose	104	162.5	3.5	4.2
Sodium bicarbonate (8.4%) 20 mL[c]	767	—	25.6	30.7
Tiotropium/formoterol caps for inhalation[c]	7	—	0.2	0.3
Tocilizumab injection 200 mg[c]	10	—	0.3	0.4
Vancomycin injection 1,000 mg	112	72.7	3.7	4.5
Vitamin C 500 mg tablet[c]	341	—	11.4	13.6
Voriconazole injection 200 mg	58	87.9	1.9	2.3
Zinc syrup 20 mg/5 mL	59	25.1	2	2.4

[a]CDU (calculated daily usage) is the quantity of medicine required in excess in a month during a pandemic, divided by 30 (No. of days in a month).
[b]ADU (anticipated daily usage) for a given medicine is 120% of the CDU of that medicine.
[c]These items were not used in June 2019 (reference month).

used. The results for PPE stockpile analysis are summarized in Table 5.

The hospital procured three items (safety goggles, face shields, and hazardous material or hazmat suits) during the COVID-19 pandemic, which are not routinely used. For these items, the same unit price was used for both scenarios. All items of PPE, other than alcohol wipes and hand sanitizers, increased in price during the pandemic. The most significant change was noticed in the cost of N95 respirator masks (332.6%) and surgical masks (323.8%; Table 6).

Sourcing essential PPE using the prepandemic model would cost at least 15% less than the emergency buying model (PKR 6,916,818.8 or USD 42,428.3 against PKR 7,999,906.1 or USD 49,073). Approximately 1,000 square feet of space was required to store these items, so the average cost of maintaining, rotating, and storing the stockpile was calculated to be PKR 70 (USD 0.43)/square foot/month, with a monthly cost of PKR 70,000 (USD 430). The prepandemic purchasing model would remain cost-effective for the hospital for at least 15 months, after which the overall price of prepandemic purchasing would exceed that of the emergency buying model.

Oxygen

Figures for the hospital's oxygen consumption and storage capacity in June 2019 and June 2020 were reviewed to assess the need for enhancing storage. In June 2020, there was a surge of 89.2% in oxygen utilization. The CDU of oxygen utilization was 508.29, and the ADU was calculated to be 609.95. On the basis of usual reserves, this meant that the hospital would have a supply of oxygen, at this increased level of consumption, for 10.8 days. The lead time for liquid oxygen was 1-4 hours and 12-24 hours for cylinders. To maintain a reserve for 15 days, the hospital would need to increase its capacity by 2,518.9 m^3, which

TABLE 2. The Costing Analysis for the Medication Procurement During June 2020 (sample month) and June 2019 (reference month)

Medication	Quantity Required[a]	Cost (prepandemic model)[b]	Cost (emergency buying model)[b]	Percentage Difference (%)
Azithromycin injection 500 mg	40	4,800	6,672	39.0
Amikacin injection (all strengths) 500 mg[c]	64	2,937.6	2,937.6	0
Atropine injection 1 mg/mL[c]	1	877.5	877.5	0
Cephazoline injection 1,000 mg	325	35,750	41,583.8	16.3
Cisatracurium injection 10 mg[c]	123	193,915.7	193,915.7	0
Dexmedetomidine injection 100 mcg/mL[c]	344	172,543.5	172,543.5	0
Doxycycline 100 mg tablet/capsule	2	307.78	427.68	39
Enoxaparin injection 40 mg	189	143,057.9	154,103.04	7.7
Frusemide injection 20 mg[c]	5	1,045	1,045	0
Hydrocortisone injection 100 mg	132	6,468	9,018.24	39.4
Imipenem/cilastatin injection 500 mg	133	53,067	59,717	12.5
Meropenem injection 500 mg	133	59,717	66,234	10.9
Midazolam injection 5 mg/5 mL	143	150,042.8	133,705	–10.9
Montelukast 10 mg tablet	73	2,919.3	19,131.8	555.4
Nalbuphine injection 20 mg	131	68,950.5	43,230	–37.3
Norepinephrine injection 8 mg/4 mL	26	24,440	32,292	32.1
Piperacillin sodium/tazobactam sodium injection 4,500 mg	360	113,400	110,764.8	–2.3
Ringer lactate 1,000 mL infusion	29	30,508	28,768	–5.7
Salbutamol inhaler 100 mcg/dose	59	9,676	10,974	13.4
Sodium bicarbonate (8.4%) 20 mL[c]	1	8,562	8,562	0
Tiotropium/formoterol caps for inhalation	1	485.87	623.4	28.3
Tocilizumab injection 200 mg[c]	6	152,398.2	152,398.2	0
Vancomycin injection 1,000 mg	63	17,514	34,872.4	99.1
Vitamin C 500 mg tablet[c]	7	945	945	0
Voriconazole injection 200 mg[c,d]	112	423,584	423,584	0
Zinc syrup 20 mg/5 mL	33	2,366.76	2,366.76	0
Total		1,680,279.3	1,711,292.3	1.8

NOTE. A comparison between the prepandemic purchasing model and the emergency buying model is presented.

[a]Quantity required was calculated by multiplying anticipated daily usage (ADU) with the lead time of the medication. This was rounded off to the highest whole number.

[b]Given in Pakistani Rupee (PKR).

[c]These drugs were not part of the hospital formulary and had to be procured on a need-to-use basis so that the same cost was used for these medications in calculations for both models.

[d]All medicine had a lead time of 14 days, except for voriconazole injections (200 mg), which had a lead time of 48 days.

could be achieved by replacing one of the 3,000 m^3 liquid oxygen containers with a 6,000 m^3 container. The hospital Materials Management Department calculated the cost of replacing this cylinder to be PKR 1,700,000 (USD 10,430) after consulting with the hospital construction project office and the supplier. This would increase the hospital's reserves to 9,630.33 m^3, which would be sufficient for at least 15 days.

Final Decision

The data were presented to the hospital management, and, after deliberation, the proposals for investing in a stockpile for essential PPE and increasing oxygen storage capability were approved.

DISCUSSION

The purpose of this study was to develop and test a framework to establish a list of essential equipment, drugs, and other materials to be stockpiled by a tertiary care cancer hospital in a LIC or LMIC for the subsequent waves of the COVID-19 pandemic or other similar pandemics. A model was formulated, using our institution's unique consumption patterns, to determine a list of essential medical supplies, including oxygen and pharmaceutical

TABLE 3. The Consumption Differences and Daily Usages of Laboratory Tests During June 2020 (sample month) and June 2019 (reference month)

Laboratory Test	Difference in Consumption	Percentage Change (%)	CDU[a]	ADU[b]
D-dimer	1,183	3,816.1	39.4	47.3
Fibrinogen degradation product	16	84.2	0.5	0.6
Ferritin	1,018	553.3	33.9	40.7
CRP (quantitative)	1,492	383.6	49.7	59.7
CRP-HS	4	200	0.1	0.2
LDH—serum	346	84.4	11.5	13.8
Lactate	206	48	6.9	8.2
Ammonia	55	137.5	1.8	2.2
Procalcitonin[c]	80	—	2.7	3.2
PCR COVID-19[c]	13,003	—	433.4	520.1
Coronavirus antibody test (SARS-CoV-2)[c]	3,363	—	112.1	134.5

Abbreviations: CRP, C-reactive protein; CRP-HS, C-reactive protein highly sensitive; LDH, lactate dehydrogenase; PCR, polymerase chain reaction.
[a]CDU (calculated daily usage) is the tests conducted in excess in a month during a pandemic, divided by 30 (No. of days in a month).
[b]ADU (anticipated daily usage) for a laboratory test is 120% of the CDU of that test.
[c]These items were not used in June 2019 (reference month).

and laboratory material, for stockpiling. The proposed list of essential items necessary for developing a stockpile for PPE, laboratory reagents, medications, and oxygen, together with quantities required, was presented to the hospital administration, which agreed with proposals for maintaining a stockpile for PPE and expanding oxygen reserves only.

Stockpiling large quantities of supplies is a financial and storage challenge. On the basis of our calculations, if we stockpile medications, PPE, and pathologic reagents and materials, while also increasing our oxygen reserves, there will be an additional fixed cost of approximately PKR 32.3 million (USD 200,000). In addition, a monthly cost of PKR 70 (USD 0.43)/square foot will be incurred for stock rotation, storage, and maintenance, for a 200 bed-hospital such as ours. We estimated that we would need at least 1,000 square feet of space to store a stockpile of this size. The financial cost of sourcing essential items can be reduced by implementing the prepandemic purchasing model. The costing analysis for the PPE stockpile, for example, indicated a saving of 15.7% by sourcing the items prepandemic. This purchasing model has additional costs for maintaining, rotating, and securing the stockpile, and storage space is also required. The emergency purchasing model, although more expensive, allows the hospital to allocate funds only when needed and does not require additional storage space, maintenance, or rotation costs. However, with the latter approach, essential items might not always be available in times of need.

Likewise, because of the inherent nature of pandemics, the adequacy of materials available at the time of need (emergency buying) might not always be appropriate. During the study period, the hospital encountered situations where the PPE reserves were nearly exhausted because of increased usage and delays in the procurement process. The hospital compensated by securing essential items from local vendors, who were new entrants in manufacturing PPE. Initially, there were a few problems with the quality of the PPE provided, such as fluff formation in surgical masks and sterility issues with surgical gowns. However, these were initial teething problems, which were quickly resolved as local vendors developed and improved the manufacturing process.

A hospital can only function if health care workers (HCWs) can deliver care to their patients. Adequate and timely availability of PPE for HCWs allows them to carry out their duties unhindered, reducing the likelihood of infection, enhancing emotional, psychologic, and physical well-being, and helping to reduce job-related stress, burnout, and fatigue.[11,12] During the first wave of the COVID-19 pandemic, HCWs at many hospitals across the world refused to work without appropriate PPE.[13] Most items of PPE have a relatively long shelf life, and their storage and maintenance needs are not as stringent as those for medication and laboratory reagents, thus allowing for lower running and maintenance costs. Storage space requirements are fairly modest, and we were fortunate to have space available. For institutions with limited space, renting storage space, or sharing it with another institution, is a possible alternative. It is also possible to limit the quantity of PPE needing to be stored by considering reuse of items such as isolation gowns, hazmat suits, face masks, and respirators, for which guidelines now exist,[14–16] thus reducing storage space for, and costs of, PPE.

Oxygen has low maintenance and storage costs, but many institutions saw critical shortages of oxygen during the first wave of the COVID-19 pandemic.[17,18] Our framework suggested augmenting the reserves in our hospital by

TABLE 4. The Costing Analysis for the Primary Reagents Required for Conducting Laboratory Tests During June 2020 (sample month) and June 2019 (reference month)

Laboratory Test	Primary Reagents	Quantity Required[a]	Cost (prepandemic model)[b]	Cost (emergency buying model)[b]	Percentage Difference (%)
D-dimer	D-dimer test kit	14	350,000	350,000	—
FDP	FDP plasma kit	1	44,619	44,619	—
Ferritin[c]	Ferritin kit	9	547,128	547,128	—
CRP	CRP latex	6	523,950	523,950	—
CRP-HS	CRP-HS reagent	1	48,685	48,685	—
	Control	1			
LDH—serum	LDH reagent	3	55,200	55,200	—
Lactate	Lactate reagent	2	39,700	39,700	—
Ammonia	Ammonia	2	458,460	458,460	—
	Calibrator	1			
	Abnormal control	1			
	Normal control	1			
Procalcitonin[c]	Procalcitonin kit	6	411,174	411,174	—
	Procalcitonin calibrator	2			
	Procalcitonin control	1			
PCR COVID-19[c]	Reagent	2	16,559,100	16,559,100	—
	Transport media	2			
	Negative control	73			
	Swab kit	14,564			
Coronavirus antibody test (SARS-CoV-2)[c]	Control	3	2,885,190	2,885,190	—
	Anti-SARS-CoV-2	38			
Total			21,923,206	21,923,206	0

NOTE. A comparison between the prepandemic purchasing model and the emergency buying model is presented.

Abbreviations: CRP, C-reactive protein; CRP-HS, C-reactive protein highly sensitive; FDP, fibrinogen degradation product; LDH, lactate dehydrogenase; PCR, polymerase chain reaction.

[a]Quantity required was calculated by multiplying anticipated daily usage (ADU) with the lead time of the reagent. This number reflects the number of packs or boxes required. The number of tests that can be conducted using a single box or pack of kit or reagent varied. The total sum was rounded off to the highest whole number.

[b]Given in Pakistani Rupee (PKR).

[c]All reagents had a lead time of 28 days, except for ferritin kit, which had a lead time of 42 days.

approximately 3,000 m^3, ensuring a supply of oxygen at enhanced COVID-19 consumption levels for 15 days. This would cost approximately PKR 1.7 million (USD 10,429.4). Our oxygen supplier increased production significantly, which meant that any shortfalls in the future were unlikely. The hospital was therefore able to negotiate an agreement with the vendor, which guaranteed us an enhanced supply of oxygen, in the event of enhanced future need.

The hospital administration rejected the proposal for stockpiling laboratory reagents because of the prohibitively high cost since many of these items require special storage conditions and are highly perishable. All the primary reagents for the essential laboratory tests are imported, and by the time they reach the hospital, they often have a short residual shelf life. Most tests that saw a surge in demand during the pandemic were uncommonly performed before this, and high levels of wastage of such reagents were also a concern. Local vendors ensured adequate provision of such supplies throughout the first wave and assured us that they would continue to meet the demand for reagents during any subsequent waves of disease.

The hospital administration decided against stockpiling medication since we did not experience any critical shortages of medication during the first wave of infection, as most essential medicines were locally manufactured. Additionally, there was no financial advantage to stockpiling since the difference in cost using the two models was minimal.

An alternate approach to calculating the surge in the usage of essential materials during a pandemic can be carried out by comparing patient encounters. In June 2019, there were 11,598 outpatient encounters, 2,938

TABLE 5. The Consumption Differences and Daily Usages of PPE During June 2020 (sample month) and June 2019 (reference month)

Medication	Difference in Consumption	Percentage Change (%)	CDU[a]	ADU[b]
N95 mask with an exhalation valve[c]	1,400	—	46.7	56
N95 mask[c]	632	—	21.1	25.3
Surgical mask	63,715	355	2,123.8	2,548.6
Safety glasses[c]	12	—	0.4	0.5
Face shield[c]	23,743	—	791.4	949.7
Surgical gown	19,901	1,105.6	663.4	796
Hazmat suit[c]	624	—	20.8	25
Plastic apron	33,200	442.7	1,106.7	1,328
Shoe cover[c]	1,000	—	33.3	40
Hand sanitizer	2,696	136	89.9	107.8
Surface disinfectant[c]	51	—	1.7	2
Alcohol surface wipes[c]	930	—	31	37.2

Abbreviation: PPE, personal protective equipment.

[a]CDU (calculated daily usage) is the number of PPE dispensed in excess in a month during a pandemic, divided by 30 (No. of days in a month).

[b]ADU (anticipated daily usage) for a PPE is 120% of the CDU of that item.

[c]These items were not used in June 2019 (reference month).

chemotherapy sessions, and 4,242 radiation therapy sessions. In June 2020, by comparison, there were 12, 951 outpatient consultations, 2,466 chemotherapy sessions, and 3,293 radiation therapy sessions. The overall difference in all patient encounters between these two periods was < 0.5%. However, this alone cannot be used as a surrogate for the daily usage of essential materials. The HCW, on the basis of clinical practice guidelines, will probably use more PPE than usual, and there will also be a surge in usage of PPE in nonclinical departments, such as reception staff and radiographers, as well as by technicians operating radiation, laboratory, and radiology machinery.

This study has some limitations. We did not review the utilization of clinical medical equipment such as syringes, catheters, dressing materials, and so forth, bedding; waste

TABLE 6. The Costing Analysis for the Personal Protective Equipment Procurement During June 2020 (sample month) and June 2019 (reference month)

Medication	Quantity Required[a]	Cost (prepandemic model)[b]	Cost (emergency buying model)[b]	Percentage Difference (%)
N95 mask with an exhalation valve[c]	1,568	219,520	950,835.2	332.6
N95 mask[c]	708	141,600	251,552.4	77.2
Surgical mask	35,681	149,860.2	635,121.8	323.8
Safety glasses[d]	7	1,915.9	1,915.9	0
Face shield[d]	13,297	1,400,174.1	1,400,174.1	0
Surgical gown	11,145	945,096	1,894,538.6	100.5
Hazmat suit[d]	350	241,570	241,570	0
Plastic apron	18,592	120,848	251,735.7	107.7
Shoe cover	560	1,848	3,080	66.7
Hand sanitizer[c]	3,020	2,261,980	1,279,543.8	–43.5
Surface disinfectant[c,d]	58	193,198	193,198	0
Alcohol surface wipes[c]	1,042	1,238,208.6	895,640.7	–27.7
Total		6,915,818.8	7,998,906.1	15.7

NOTE. A comparison between the prepandemic purchasing model and the emergency buying model is presented.

[a]Quantity required was calculated by multiplying anticipated daily usage (ADU) with the lead time of the item. This was rounded off to the highest whole number.

[b]Given in Pakistani Rupee (PKR).

[c]A lead time of 28 days was used. For rest of the items, a lead time of 14 days was used.

[d]These items were not procured by the hospital in 2019 and had to be procured on a need-to-use basis, because of which the same cost was used for these items in calculations for both models.

management supplies; or body bags and shrouds needed for the handling of dead bodies. During a pandemic, a hospital may experience a surge in the utilization of any or all of these items and so it might be beneficial to perform a similar analysis of the utilization of, and possible stockpiling of, such items. Our analysis did not address the feasibility of enhancing food, water, and fuel reserves to sustain care during a disaster. In this model, we have recommended using the most extended period of lead time to estimate quantities required for the stockpile. This obviously increases the volume of stock to be stored, but freight delays are not uncommon in situations such as a pandemic, and this should help to protect hospital operations in such situations.

The main feature of the model described here is that it uses the unique consumption patterns of a single cancer institution in a low-middle–income country, unlike prior models that have been designed for community hospitals in high-income countries. Often, such countries have a centralized health care network, with pooled purchasing, where strategic decisions with regard to stockpiling may be made at a governmental level. Our model is adjustable and can be modified and used in accordance with individual institutional requirements. We believe that our model, and our experience in developing it, will stand others in good stead when planning for subsequent waves of the COVID-19 pandemic, or other similar pandemics, and in making strategic decisions as to whether, and what, to stockpile.

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AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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Open Payments is a public database containing information reported by companies about payments made to US-licensed physicians (Open Payments).

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