



Experimental Research

Assigning green hospitals during the COVID-19 pandemic assure continuous and safe resumption of surgical services

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ABSTRACT

Background: Coronavirus 19 pandemic impacted the health system with more pressure on the critical areas, leading to direct manpower working in the Operating Room to help treat this new problem by postponing elective surgical cases and affecting some urgent ones. However, elective surgical services start to recover by establishing one or more hospitals that deal with COVID-19 free patients (green hospital) in each area with a dedicated one to treat COVID19 cases. Our research shows if this model's application assures safe and continued recovery of surgical services to reach the level before the pandemic. This study aimed to explore if assigning a green hospital to assure safe and continuous resumption of surgical services during a pandemic.

Methods: This study used a multicenter, national, quasi-experimental, post-test-only control group design. All hospitals assigned at least one hospital as a green hospital (COVID-19 free hospital) in the northern areas of Saudi Arabia were included in the study. We also included Riyadh's large tertiary care hospital as a control none green hospital. We reported the number of surgical backlog in each city, the number of surgical cases performed, the percentage of OR utilization in each city and the percentage of COVID-19 cases to the number of ICU bed cases in each city.

Results: This study included green hospitals in five cities in the northern area of Saudi Arabia. Besides, we included one none large green hospital in Riyadh city as a control group. The median of weekly procedures in green hospitals was 101 (99, 109.5) in Alqurayat, 233 (194, 237) in Tabuk, 180 (162, 199) in Haill, 108 (90, 120) in Al Jawf and 257 (155, 313) in Northern Borders. The median of weekly procedures in the control hospital was 245 (215, 259). Green hospitals contributed to reducing the surgical backlog by a median percentage of 74% (38, 108) in Alqurayat, 25% (21, 26) in Tabuk, 8% (7, 9) in Haill, 81% (54, 91) in Al Jawf and 78% (72, 88) in Northern Borders. While in the control hospital was 8% (8, 9).

Conclusion: Implementing elective surgeries in green hospitals contributes to a continuous resumption of surgical services during the COVID-19 pandemic.

1. Background

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has spread worldwide, and the WHO declared a COVID-19 pandemic in March 2020 [1]. The pandemic of COVID-19 has globally disrupted routine hospital services. Many hospitals minimized elective surgery during the pandemic as a broader response to the COVID-19 pandemics

[2]. It was estimated that more than two million operations per week would be cancelled or postponed due to COVID-19 [2]. Surgical patients are a vulnerable group at risk of hospital exposure to SARS-CoV-2 transmission. They may be particularly prone to subsequent pulmonary complications and higher pulmonary rates [2]. Around half of the patients with perioperative SARS-CoV-2 infection encountered postoperative pulmonary complications [2]. SARS-CoV-2 postoperative

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complication was associated with a 23.8% mortality rate, compared with 2% without SARS-CoV-2 [2]. This created high thresholds for surgery during the COVID-19 pandemic compared to standard practice. Over this, it has proven challenging to resume elective surgery, with several million more procedures being delayed each month. As a response to this challenge, a dedicated COVID-free surgical pathway has been established to provide safe surgeries. This pathway successfully lowers pulmonary complication rates, SARS-CoV-2 infection rates and mortality; however, using this pathway may lead to a capacity reduction for other health conditions [3].

A “green hospital” or “COVID-19 free hospital” is another approach used to resume elective surgeries during the pandemic. This approach encompasses using COVID-19 free-buildings where there are no admitted patients with proven or suspected SARS-CoV-2 infection. Infection prevention and control guidelines for COVID-19 are strictly applied across this hospital model.

Assigning a green hospital during covid 19 pandemics may assure continuous and safe resumption of surgical services. We reported our experience in using a green hospital for performing surgical procedures in the northern regions of Saudi Arabia. This study aimed to assess the feasibility and surgical outcomes of resuming elective surgeries in a green hospital during the current COVID-19 pandemic and its possible implications for other future pandemics.

2. Methodology

This study used a multicenter, national, quasi-experimental, post-test-only control group design. All areas assigned at least one hospital as a green hospital (COVID-19 free hospital) were included in the study. Data were collected from the Ministry of Health (MOH) database. The green hospital is defined as COVID-19 free hospital. There was one specialized hospital assigned to take care of COVID-19 patients in each city. Other hospitals will be treated as green hospitals. Green hospitals encompass using COVID-19 free-hospitals where there are no admitted patients with proven or suspected SARS-CoV-2 infection. Infection prevention and control guidelines for COVID-19 are strictly applied across this hospital model following the “infection control precautions and recommendations for elective surgeries” from the Saudi Center for Disease Prevention and Control [4].

The study was conducted in the northern areas of Saudi Arabia. The north areas include multiple provinces: Tabuk, Ha'il, Al Jawf, and Northern Borders regions. As per 2019 statistics, the population in these regions is estimated at 2,595,762 people, representing around 7.6% of Saudi Arabia's population [5]. In 2019, the number of government hospitals in these regions was 50 Hospitals (48 MOH hospitals and two other governmental hospitals) with a total bed capacity of 7497 beds. The number of private hospitals in these regions was four hospitals with 256 beds [6]. The green hospitals were applied in Tabuk, Alqurayat, Haill, Al Jawf and Northern Borders cities. The institutional review board approved this study of King Fahad Medical City.

We reported the number of surgical backlogs in each city, the number of surgical cases performed and the percentage of OR utilization in each city and green hospitals. To recognize pandemic status in each city, we reported the percentage of COVID-19 cases to the number of ICU bed cases in each area. To evaluate the feasibility of resuming elective surgeries in green hospitals during the current COVID-19 pandemic, we compared their data with a large central tertiary care hospital in Riyadh city, which does not consider a COVID-19 free hospital (not a green hospital). Data was collected in the period from September 2020 till January 2021. This work complies with the STROCSS criteria (Strengthening the Reporting of Cohort Studies in Surgery) [7]. The research registration unique identifying number (UIN) is researchregistry7433 www.researchregistry.com/browse-the-registry#home/.

3. Results

This study included green hospitals in five cities in the northern area of Saudi Arabia. Besides, we included one none large green hospital in Riyadh city as a control group.

In Alqurayat city, the maximum surgical backlog was 542 cases, with the highest weekly procedures of 123 surgeries with a median and quartiles of 101 (99, 109.5). Green hospitals contributed a median percentage of 74% (38, 108) in reducing the surgical backlog. The highest percentage of COVID-19 cases to the number of ICU beds in Alqurayat was 15% during the study period.

In Tabuk city, the maximum surgical backlog was 1019 cases, with the highest weekly procedures of 274 surgeries with a median and quartiles of 233 (194, 237). Green hospitals contributed in the median percentage of 25% (21, 26) in reducing the surgical backlog. The highest percentage of COVID-19 cases to the number of ICU beds in Tabuk was 9% during the study period.

In Haill city, the maximum surgical backlog was 2598 cases, with the highest weekly procedures of 282 surgeries with a median and quartiles of 180 (162, 199). Green hospitals contributed in the median percentage of 8% (7, 9) in reducing the surgical backlog. The highest percentage of COVID-19 cases to the number of ICU beds in Haill was 15% during the study period.

In Al Jawf city, the maximum surgical backlog was 281 cases, with the highest weekly procedures of 131 surgeries with a median and quartiles of 108 (90, 120). Green hospitals contributed in the median percentage of 81% (54, 91) in reducing the surgical backlog. The highest percentage of COVID-19 cases to the number of ICU beds in Al Jawf was 11% during the study period.

In Northern Borders city, the maximum surgical backlog was 542 cases, with the highest weekly procedures of 424 surgeries with a median and quartiles of 257 (155, 313). Green hospitals contributed in the median percentage of 78% (72, 88) in reducing the surgical backlog. The highest percentage of COVID-19 cases to the number of ICU beds in Northern Borders was 14% during the study period.

For the control hospital in Riyadh city, the maximum surgical backlog in the hospital was 3039 cases, with the highest weekly procedures of 278 surgeries with a median and quartiles of 245 (215, 259). Green hospitals contributed in the median percentage of 8% (8, 9) in reducing the surgical backlog. The highest percentage of COVID-19 cases to the number of ICU beds in the hospital was 7% during the study period.

More results are shown in [Tables 1 and 2](#).

4. Discussion

In this study, we reported our experience in using a green hospital for performing surgical procedures in the northern regions of Saudi Arabia. We assessed the feasibility of resuming elective surgeries in a green hospital during the current COVID-19 pandemic.

Our results revealed that performing elective surgeries in green hospitals is feasible and successfully reduces the surgical backlog list. We compared the results of performing elective surgeries in green hospitals in the northern regions of Saudi Arabia with a large none green central tertiary care hospital in Riyadh city. We found that performing elective surgeries in green hospitals could be more feasible in reducing the surgical backlog than performing them in the control hospital despite the differences in the capacities.

The studies that evaluated applying green hospitals during COVID-19 are limited. A prospective study assessed using a COVID-19 free-hospital concluded that this model could represent a safe setting for elective surgery during the pandemics. They reported only one case with COVID-19 with no patients developed pulmonary complications [8]. A similar approach using a free COVID-19 surgical pathway involves complete separation of the operating rooms, critical care unit, and in-patient ward of patients with COVID-19 was evaluated in an

Table 1
Surgical backlog, OR utilization and COVID-19 situation per city.

City	Periods	Surgical backlog in the city	OR utilization in the city	Number of weekly procedures in green hospitals	OR utilization in the green hospitals	Percentage of COVID-19 cases to the number of ICU beds cases in the city
Alqurayat	W1	NA	13%	NA	NA	0%
	W2	480	28%	0	0%	3%
	W3	542	28%	111	20%	4%
	W4	337	28%	98	29%	9%
	W5	263	28%	123	46%	3%
	W6	116	20%	101	87%	15%
	W7	84	63%	108	129%	15%
	W8	75	63%	100	133%	4%
	W9	111	57%	82	74%	0%
Tabuk	W1	836	9%	180	22%	7%
	W2	926	14%	235	25%	7%
	W3	979	14%	265	27%	8%
	W4	975	14%	274	28%	9%
	W5	1019	14%	207	20%	9%
	W6	919	14%	237	26%	6%
	W7	947	19%	233	25%	6%
	W8	982	19%	194	20%	6%
	W9	910	21%	189	21%	5%
Haill	W1	1989	16%	135	7%	15%
	W2	2598	17%	147	6%	12%
	W3	2583	17%	177	7%	8%
	W4	2590	17%	200	8%	9%
	W5	2546	17%	282	11%	11%
	W6	2214	19%	189	9%	4%
	W7	230	38%	180	8%	4%
	W8	2314	38%	199	9%	5%
	W9	1382	41%	162	12%	4%
Al Jawf	W1	154	11%	73	47%	4%
	W2	160	21%	86	54%	9%
	W3	281	21%	90	32%	8%
	W4	161	21%	131	81%	7%
	W5	159	21%	109	69%	11%
	W6	101	23%	108	107%	4%
	W7	142	26%	120	85%	4%
	W8	107	26%	97	91%	4%
	W9	139	30%	127	91%	0%
Northern Borders	W1	285	25%	310	109%	14%
	W2	241	25%	257	107%	9%
	W3	356	25%	313	88%	4%
	W4	501	25%	385	77%	8%
	W5	542	25%	424	78%	6%
	W6	218	18%	155	71%	6%
	W7	194	25%	139	72%	6%
	W8	178	25%	142	80%	2%
	W9	254	23%	173	68%	3%
Riyadh Tertiary Care Hospital (control group)						
	W1	NA	NA	NA	NA	NA
	W2	3039	NA	258	8%	7%
	W3	2917	NA	259	9%	6%
	W4	2876	NA	276	10%	7%
	W5	2825	NA	278	10%	7%
	W6	2837	72%	245	9%	4%
	W7	2846	72%	215	8%	4%
	W8	2836	72%	222	8%	4%
	W9	2851	72%	81	3%	4%
	W10	2890	72%	184	6%	6%

international multicenter cohort study conducted by the COVIDSurg collaborative [3]. The study showed that the COVID-free surgical pathway demonstrated lower pulmonary complication rates, SARS-CoV-2 infection rates, and lower mortality rates than hospitals with no defined pathway [3]. However, COVID-19-free surgical pathways can reduce capacity for other health conditions [3]. Applying green hospitals demonstrated that this approach is safe and feasible for elective surgeries without interruption for other health services.

Study results should be interpreted in light of their strengths and limitations. To our knowledge, this study is the first multicenter study

that examined the feasibility of implementing green hospitals for elective surgeries. Besides, evaluating the effect of the application of green hospitals in surgical backlog due to the COVID-19 pandemic was not studied before in the region. This study's limitation includes the quasi-experimental design's known weaknesses, such as lack of randomization, limiting its ability to conclude causal association. Further, this study did not compare the surgical outcomes such as pulmonary complications, SARS-COV infection and mortality. Measuring these outcomes and controlling for possible confounders are recommended for future studies.

Table 2

Summary of surgical backlog and OR utilization per city.

	Maximum surgical backlog number	The accumulated number of weekly procedures in green hospitals	Median of weekly procedures in green hospitals	OR utilization in the green hospitals (accumulated)	Median of OR utilization in the green hospitals (accumulated)
Alqurayat	542	723	101 (99, 109.5)	518%	74% (38, 108)
Tabuk	1019	2014	233 (194, 237)	214%	25% (21, 26)
Haill	2598	1671	180 (162, 199)	77%	8% (7, 9)
Al Jawf	281	941	108 (90, 120)	657%	81% (54, 91)
Northern Borders	542	2298	257 (155, 313)	750%	78% (72, 88)
Riyadh Tertiary Care Hospital (control group)	3039	2018	245 (215, 259)	71%	8% (8, 9)

5. Conclusion

Implementing elective surgeries in COVID-19 free hospitals (green hospitals) had contributed to a continuous resumption of surgical services during the COVID-19 pandemic and reduced the surgical backlog. Performing elective surgeries in green hospitals could be considered as a response to the COVID-19 and future pandemics.

- Ethical approval and consent to participate

The institutional review board at King Fahad Medical City gave ethical approval for this study. We used primary data collected by the research team.

- Consent to publish

Not Applicable.

- Availability of data and materials

All data generated and/or analyzed during this study included in this published article. The data are available from the corresponding author upon request.

- Competing interests

The authors declare that they have no competing interests.

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- Authors' contributions

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Ethical approval

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Author contribution

Y.Aalshareef. and K.A. wrote the manuscript with input from Y. A. All the authors contributed to sample preparation., S.A. and Y.A. collected the data.Y.Alassiri. performed the calculations and designed the tables, Y.A. supervised the project, Both Y. Aalshareef. and S.A. contributed to the final version of the manuscript, All authors provided feedback and helped shape the research, analysis and manuscript, Y. Aalshareef: Yassir AlShareef, S.A: Sami AlShammary, Y.A: Yacoub Abuzied, Y. AlAsseri: Yahya AlAsseri, K.A: Khalid AlQumaizi.

Please state any conflicts of interest

None.

Registration of research studies

1. Name of the registry: None
2. Unique Identifying number or registration ID: None
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): None

Guarantor

None.

Consent

None.

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