

A descriptive analysis of the impact of COVID-19 on Emergency Department attendance and visit characteristics in Singapore

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Abstract

Introduction: It is yet to be understood how COVID-19 impacted utilisation of Emergency Department (ED) services in Singapore. This study aimed to describe the changes in attendance of a single ED and corresponding patient visit characteristics and outcomes before and during the COVID-19 period.

Methods: In a single-centre retrospective cohort study, we used descriptive statistics to compare ED attendance, patient demographics and visit characteristics during the COVID-19 period (1 January – 28 June 2020) and its corresponding historical period in 2019 (2 January – 30 June 2019).

Results: Mean ED attendance decreased from 342 visits/day in the pre-COVID-19 period, to 297 visits/day in the COVID-19 period. This was accompanied by reductions in P1 visits and presentations in nearly every ICD-10-CM diagnosis category except for respiratory-related diseases. We also noted a shift in ED patient case-mix from 'Non-fever' cases to 'Fever' cases, likely giving rise to two distinct trough-to-peak visit patterns during the pre-Circuit Breaker and Circuit Breaker period. Average ED admission rate during the Circuit Breaker period (48.3%) was higher as compared to pre-Circuit Breaker period (40.7%), however average daily admission remained stable.

Conclusion: The COVID-19 pandemic caused a reduction in SGH ED attendances amongst patients with low-acuity conditions and those with highest priority for emergency care. This raises concern about treatment-seeking delays and possible impact on health outcomes. Our data provides insights that may be useful for ED crowd management planning in the post-COVID-19 era. There should be cautious use of ED admission rate as a metric in evaluating ED performance during an outbreak.

Introduction

It is yet to be understood how the coronavirus disease 2019 (COVID-19) impacted utilisation of Emergency Department (ED) services in Singapore. The resulting changes in the utilisation of medical services for non-COVID-19 emergencies and urgent health needs can lead to undesirable health consequences^{1,2}. They should be further investigated to formulate appropriate policy responses.

As with all outbreaks, the Emergency Department (ED) has been the primary portal of entry into hospitals for COVID-19 patients³⁻⁵. Despite the surge in suspected COVID-19 cases, there is global evidence to show that the Emergency Department (ED)'s overall daily attendance has declined⁶⁻¹¹. Several studies have reported significant reductions in visits associated with time-sensitive and life-threatening conditions such as acute myocardial infarction and stroke¹²⁻¹⁵. This reduction suggests either the decrease in incidence of diseases during the pandemic or a worrying trend of patients with acute medical conditions failing to seek critically needed hospital care^{13,16}.

The ED at Singapore General Hospital (SGH) saw Singapore's first COVID-19 case on 23 January 2020. Subsequently, rising numbers of unlinked infected cases prompted two major national interventions to curb the spread of COVID-19 in the community¹⁷. The first raising of the risk assessment of COVID-19 to Disease Outbreak Response System Condition (DORSCON) Orange¹⁸ on 7 February 2020 caused widespread fear and panic in the public¹⁹. The second was the implementation of Circuit breaker, a partial lockdown on public movement, on 7 April 2020, as Singapore observed the peak of daily incidence in April. While COVID-19 fatality rates in Singapore remain one of the lowest globally, the city-state nevertheless experienced huge spikes in infections. The local government was aggressive in public education efforts, encouraging residents to stay home and exercise social responsibility, which prevented hidden pockets of infected cases from affecting others in the community. The close coordination of different healthcare sectors at the national level allowed accessible public healthcare services even during the pandemic as definitive steps were taken to ensure that the healthcare system has sufficient capacity to care for clinically unwell patients at peak infection rates²⁰. At the time of

writing, the spread of COVID-19 has largely slowed down, and Singapore is undergoing the second phase of a three-phased approach to re-open the economy and resume social activities in a careful and calibrated manner²¹.

Nevertheless, it is not known whether Singapore has been spared from the global phenomenon of declining ED visits, despite having an effective national response to infection, prompt debunking of misinformation through various government communication channels and easy accessibility of healthcare services during the pandemic. With residents largely complying with social distancing measures in Singapore²², we speculate that a similar trend of decline in ED attendances for both non-emergent and acute life-threatening conditions would be observed. This descriptive study aimed to understand how attendance of a single ED and corresponding patient visit characteristics have changed during the COVID-19 period as compared to the pre-COVID-19 period, describing observed impact of COVID-19 on medical care, resource allocation and patient outcomes. We hypothesise that the impact of COVID-19 outbreak on the utilisation of ED healthcare services at the Singapore General Hospital (SGH) varies by patient demographics, acuity of illness and clinical reason for attendance.

Materials And Methods

Study design and setting

Singapore General Hospital (SGH) is one of Singapore's largest and oldest acute tertiary hospital with 1785 beds in total and its Emergency Department (ED) sees approximately 130,000 patients annually⁴.

In a retrospective study cohort, we compared and described SGH ED attendance, patient demographics and visit characteristics during the COVID-19 period (1 January – 28 June 2020) and its corresponding historical period in 2019 (2 January – 30 June 2019). The studied COVID-19 period was chosen as it represents the changes in ED attendance over the course of time, revealing trends specific to the Pre-Circuit Breaker period and Circuit Breaker period. The pre-Circuit-Breaker period includes both Pre-DORSCON-Orange and DORSCON Orange periods.

Data source and extraction

Routine and administrative data on ED attendances were extracted from the electronic health intelligence system (eHINTS) at SGH ED. Collected data fields were gender, age, nationality, ethnicity, mode of arrival, patient acuity category (PAC), disposition and clinical reason for attendance. This was a service evaluation study which did not require further ethical deliberation by SingHealth Centralised Institutional Review Board (CIRB Ref: 2020/2470).

Patient acuity category (PAC) triage system

The patient acuity category (PAC) triage system is used to assign ED patients a specific level of priority for medical attention based on the acuity and severity of their presenting complaints. The four main levels of PAC status are; Priority 1 (P1) for critically ill patients who require immediate resuscitation; Priority 2 (P2) for non-ambulant patients in stable condition and do not require resuscitation but must be initially treated in the hospital; Priority 3 (P3) for ambulant patients with acute symptoms which may be treated by ED physicians or primary care providers; Priority (4) for patients with non-emergent conditions which are more appropriately managed in primary health care setting. Febrile patients in different acuity categories were labelled as P1F, P2F and P3F and they share the same priority levels as their non-fever counterparts.

Study variables

Twelve disposition descriptions were condensed into two categories, admitted, or not admitted. Multiple categorical variables were created for age, nationality, ethnicity, mode of arrival, ED disposition and clinical reason for ED attendance.

Age was condensed into 8 categories – 0-10, 11-14, 15-24, 25-34, 35-44, 45-54, 55-64, ≥65. Twenty-two ethnicities were condensed into 4 categories – Chinese, Malay, Indian and Others. All nationalities were condensed into 2 categories – Singapore citizens and non-citizen. Fifteen modes of arrival were condensed into 3 categories – Non-ambulance, Singapore Civil Defence Force (SCDF) public ambulance and private ambulance.

SNOMED CT to ICD-10 Conversion for ED diagnosis

In our dataset, ED diagnoses were coded and classified according to the Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT). As International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) codes are oriented more for statistical data collection, SNOMED CT codes were converted to ICD-10-CM and mapped to twenty-one broad ICD-10-CM categories using the SNOMED CT to ICD-10-CM Map provided by the National Library of Medicine²³. Only the first matched ICD-10-CM code was kept in instances where multiple possible matches of ICD-10-CM codes to one SNOMED CT code.

Statistical analysis

ED attendance was reported as mean (and standard deviation and range). Variables with skewed distribution, such as age, was reported as median (and low and upper quartile, Q1 and Q3). The comparison of categorical variables between pre-COVID-19 and COVID-19 periods were tabulated as frequency reduction and percentage change. A sub-analysis comparing ED attendances and admission rates in different acuity categories during the pre-Circuit-Breaker period (1 January – 6 April 2020) and Circuit breaker period (7 April – 1 June 2020) was also tabulated. Weekly ED attendance and admission rate were plotted over time for clear visualisation of respective trends over various phases. Plotted attendance was stratified by febrile status and acuity categories. All data were de-identified before data processing and analysis in R software (v4.0.0)²⁴.

Results

ED visit records selected for analysis

Out of 120,209 ED visits records extracted, 1029 visit records outside of our study period were excluded. Further exclusion of 4072 duplicate records and 12 distorted records left us with 115,096 ED visit records for analysis; pre-COVID-19 period had 61,576 visit records; COVID-19 period had 53,520 visit records (**Figure 1**).

Patient demographics and visit characteristics

Table 1 shows the gross reduction in the number of ED visits at SGH across gender, ethnicity, age groups and Singapore citizens. The median (Q1, Q3) age during the pre-COVID-19 period and COVID-19 period was similar, with 56.0 (36.0-70.0) and 55.0 (35.0-70.0), respectively. Although there was proportional decline across age groups, we observed the largest percentage reductions in visits by children aged below 10 years (44.0%) and 11-14 years old (49.3%). While Singapore citizen ED attendance fell by 17.1% (41,099 vs 49,592 baseline), non-citizen ED attendance went up by 3.6% (12,421 vs 11,984 baseline), accompanied by a 3.7% increase in proportion (23.2% vs 19.5% baseline). Moreover, total numbers of SCDF (public) and private ambulance arrival increased, contributing to a 4.6% increase in proportion of ambulance arrivals (19.2% vs 14.6% baseline) during the COVID-19 period.

Table 1. SGH ED patient characteristics during the pre-COVID-19 period in 2019 and COVID-19 period in 2020.

Time periods studied	Pre-COVID-19 period	COVID-19 period	% change in ED attendances as compared to Pre-COVID-19 period
	2 Jan – 30 Jun 2019	1 Jan – 28 Jun 2020	
Total No. of ED visits	61576	53520	-8056 (-13.1%)
Mean ED attendance (SD, range)	342 (44.9, 277-427)	297 (31.8, 207-445)	
Demographics	N (%)	N (%)	
Gender			
Male	31707 (51.5%)	28942 (54.1%)	-2765 (-8.7%)
Female	29869 (48.5%)	24578 (45.9%)	-5291 (-17.7%)
Age (year)			
Median (Q1-Q3 ² , range)	56 (36-70, 0-106)	55 (35-70, 0-105)	
0-10	286 (0.6%)	216 (0.4%)	-170 (-44.0%)
11-14	213 (0.3%)	108 (0.2%)	-105 (-49.3%)
15-24	5172 (8.4%)	3970 (7.4%)	-1202 (-23.2%)
25-34	8448 (13.7%)	8407 (15.7%)	-41 (-0.5%)
35-44	7008 (11.4%)	6916 (12.9%)	-92 (-1.3%)
45-54	7856 (12.8%)	6757 (12.6%)	-1099 (-14.0%)
55-64	10736 (17.4%)	8884 (16.6%)	-1852 (-17.3%)
≥65	21757 (35.3%)	18261 (34.1%)	-3496 (-16.1%)
Missing	0	1	
Citizenship status			
Singapore Citizen	49592 (80.5%)	41099 (76.8%)	-8493 (-17.1%)
Non-Citizen	11984 (19.5%)	12421 (23.2%)	+437 (+3.6%)
Ethnicity			
Chinese	39663 (64.4%)	33137 (61.9%)	-6525 (-16.5%)
Indian	8034 (13.0%)	7605 (14.2%)	-429 (-5.3%)
Malay	6603 (10.7%)	5811 (10.9%)	-792 (-12.0%)
Others	7276 (11.8%)	6967 (13.0%)	-309 (-4.2%)
Visit Characteristics	N (%)	N (%)	
Mode of arrival			
Non-ambulance	52585 (85.4%)	43239 (80.8%)	-9346 (-17.8%)
SCDF ambulance	6432 (10.4%)	7384 (13.8%)	+952 (+14.8%)
Private ambulance	2559 (4.2%)	2897 (5.4%)	+338 (+13.2%)
Patient acuity category status ²			
P1	9049 (14.7%)	5336 (10.0%)	-3713 (-41.0%)
P2	33550 (54.5%)	28608 (53.5%)	-4942 (-14.7%)
P3	16874 (27.4%)	10486 (19.6%)	-6388 (-37.9%)
P4	345 (0.6%)	138 (0.3%)	-207 (-60.0%)
P1F	144 (0.2%)	178 (0.3%)	+34 (+23.6%)
P2F	714 (1.2%)	1138 (2.1%)	+424 (+59.4%)
P3F	900 (1.5%)	7636 (14.3%)	+6736 (+748.4%)
Disposition			
Admitted from ED	25422 (41.3%)	23422 (43.8%)	-2000 (-7.9%)
General ward (GW)	21958 (86.4%)	20000 (85.4%)	-1958 (-8.9%)
High dependency (HD) ward	1190 (4.7%)	872 (3.7%)	-318 (-26.7%)
Intermediate care area (ICA)	387 (1.5%)	231 (1.0%)	-156 (-40.3%)
Intensive care unit (ICU)	372 (1.5%)	302 (1.3%)	-70 (-18.8%)
Infectious Disease (ID)/ Isolation ward	857 (3.4%)	1891 (8.1%)	+1034 (+120.7%)
Unknown	658 (2.6%)	126 (0.5%)	-532 (-80.9%)
Not admitted	36126 (58.7%)	30054 (56.2%)	-6072 (-16.8%)
Missing	28	44	

²Overall, the mean number of daily ED visits (SD) during the studied COVID-19 period was lower than that during the pre-COVID-19 period. As compared to pre-COVID-19 period, there was a gross reduction in the number of SGH ED visits across gender, ethnicity, age groups and Singapore citizens during the COVID-19 period. In the same period, there was also a decline in ED attendances across all 'Non-Fever' triage groups (P1-P4), including the sickest patient group (P1). The decline in ED admissions was evident across all ward types except for the infectious disease or isolation wards during the COVID-19 period.

²Abbreviations: Q1: First quartile which represents 25th percentile value; Q3: Third quartile which represents 75th percentile value; P1: Priority 1; P1F: Priority 1 Fever; P2: Priority 2; P2F: Priority 2 Fever; P3: Priority 3; P3F: Priority 3 Fever; P4: Priority 4.

Two-phase ED attendance trend

Overall, the mean number of daily ED visits (SD) during the COVID-19 period was 297 (31.8), lower than that during the pre-COVID-19 period (342, 44.9) (**Table 1**). Within the COVID-19 period, the national tally of daily infected cases started relatively small during the pre-Circuit Breaker period (**Figure 2**). Thereafter, the tally rocketed to its highest during the Circuit Breaker period. **Figure 3** illustrates a two-phase ED attendance trend experienced at SGH ED within the COVID-19 period. The first phase and second phase represent visit trends during the pre-Circuit Breaker period and Circuit Breaker period, respectively.

First phase of ED attendance trend

Approximately one week before DORSCON Orange initiation (2 February – 8 February 2020, Week 6), there was a noticeable drop of 6.4% in weekly ED attendance (2144 vs 2291 baseline) as compared to the same week in 2019 (**Figure 3**). The initial downward trend in ED attendance was largely driven by the decrease in 'Non-Fever' visits (**Figure 4**). The

subsequent sharp returning of ED attendance (**Figure 3**) corresponded with the rising numbers of “Fever” visits (**Figure 4**), even though the national tally of daily infected cases was relatively low below a hundred (**Figure 2**). Weekly ED attendance peaked during the last week of March, almost reaching pre-COVID-19 numbers in the same week.

Second phase of ED attendance trend

SGH ED experienced its second fall in attendance where both number of ‘Fever’ and ‘Non-Fever’ visits were declining (**Figure 3, Figure 4**). The steepest drop occurred during 3 May - 9 May 2020 (Week 19), where a 27.4% dip in ED visits was observed relative to the same week in the pre-COVID-19 period (**Figure 3**). This time, the new low persisted over a longer period than what was observed in the pre-Circuit Breaker period, despite having record-breaking daily numbers of local infected cases (**Figure 2**). Nevertheless, as the nation was halfway through Circuit Breaker, we observed a slow and steady climb in SGH ED attendance that was visually distinct from the surge in the first phase (**Figure 3**). This gradual recovery coincided with the rise in total ‘Non-Fever’ visits and a relatively constant number of ‘Fever’ visits (**Figure 4**).

Following the end of Circuit Breaker and the start of a three-phased approach to resume activities safely, ED attendances continued to show signs of gradual recovery to baseline numbers (**Figure 3**).

Sub-group analysis of ED attendance by ‘Non-Fever’ and ‘Fever’ triage categories

Overall, ED attendances declined across all ‘Non-Fever’ triage groups (**Figure 5**). There were 4.7% and 7.8% reductions in the proportion of Priority 1 (P1) visits (10.0% vs 14.7% baseline) and Priority 3 (P3) visits (19.6% vs 27.4% baseline), respectively (**Table 1**). The proportion of P3 patients had the greatest decline over the COVID-19 period, reaching its lowest numbers during the Circuit Breaker phase (**Figure 5**). In contrast, **Table 1** demonstrates an increase in ED attendees across all ‘Fever’ triage groups. Of note, there was 8.5 times more (7636 vs 900 baseline) Priority 3 Fever (P3F) ED attendances during the COVID-19 period as compared to the Pre-COVID-19 period.

Clinical reason for ED attendance

Among 115,096 visit records, we excluded 2545 records (2.2%) with no documentation of diagnosis code in our analysis of diagnoses. The remaining 112,551 visit records had a total of 143,995 documented SNOMED CT diagnosis codes. Out of these, approximately 3000 documented diagnosis codes (2%) were not mapped to ICD-10 categories and these were excluded from our analysis.

The decline in ED attendance was accompanied by decreases in nearly every diagnosis category except for diseases of the respiratory system, which had a 9.8% increase in proportion of total recorded diagnoses (17.2% vs 7.4% baseline) (**Table 2**). The greatest reduction in proportion was seen in the diagnostic category that covers injury, poisoning and certain other consequences of external causes, with 2.6% reduction in proportion to total recorded diagnoses (9.9% vs 12.5% baseline).

Table 2: Frequency and proportion of diagnosis categories during the pre-COVID-19 period and COVID-19 period.

Time periods studied	Pre-COVID-19 period	COVID-19 period	% change in frequency as compared to Pre-COVID-19 period
	2 Jan – 30 Jun 2019	1 Jan – 28 Jun 2020	
Total No. of ED visits	61576	53520	
No. of ED visits with ≥1 recorded diagnosis	60166	52385	
Total No. of documented diagnoses	73545 (100%)	67444 (100%)	
ICD-10-CM Diagnosis categories ²	N (% total documented diagnoses)	N (% total documented diagnoses)	
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	19196 (25.5%)	16883 (24.5%)	-2313 (-12.0%)
Injury, poisoning and certain other consequences of external causes	9358 (12.5%)	6779 (9.9%)	-2579 (-27.6%)
Diseases of the musculoskeletal system and connective tissue	5932 (7.9%)	3995 (5.8%)	-1937 (-32.7%)
Diseases of the circulatory system	5810 (7.7%)	4723 (6.9%)	-1087 (-18.7%)
Diseases of the respiratory system	5594 (7.4%)	11842 (17.2%)	+6248 (+111.7%)
Diseases of the digestive system	4971 (6.6%)	4367 (6.4%)	-604 (-12.2%)
Diseases of the genitourinary system	3821 (5.1%)	3141 (4.6%)	-680 (-17.8%)
Certain infectious and parasitic diseases	3799 (5.1%)	3095 (4.5%)	-704 (-18.5%)
Endocrine, nutritional and metabolic diseases	2976 (4.0%)	2735 (4.0%)	-241 (-8.1%)
Diseases of the skin and subcutaneous tissue	2937 (3.9%)	2360 (3.4%)	-577 (-19.6%)
Diseases of the eye and adnexa	2493 (3.3%)	1805 (2.6%)	-688 (-27.6%)
Diseases of the nervous system	1265 (1.7%)	1074 (1.6%)	-191 (-15.1%)
Neoplasms	1227 (1.6%)	1069 (1.6%)	-158 (-12.9%)
Mental, Behavioral and Neurodevelopmental disorders	1012 (1.3%)	899 (1.3%)	-113 (-11.2%)
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	943 (1.3%)	860 (1.2%)	-83 (-8.8%)
External causes of morbidity	699 (0.9%)	636 (0.9%)	-63 (-9.0%)
Diseases of the ear and mastoid process	640 (0.9%)	537 (0.8%)	-103 (-16.1%)
Factors influencing health status and contact with health services	557 (0.7%)	405 (0.6%)	-152 (-27.3%)
Pregnancy, childbirth and the puerperium	220 (0.3%)	174 (0.3%)	-46 (-20.9%)
Congenital malformations, deformations and chromosomal abnormalities	62 (0.1%)	36 (0.1%)	-26 (-41.9%)
Certain conditions originating in the perinatal period	33 (0.0%)	29 (0.0%)	-4 (-12.1%)

¹The decline in ED attendance was accompanied by decreases in nearly every diagnosis category except for diseases of the respiratory system. The greatest reduction in proportion was seen in the diagnostic category that covers injury, poisoning and certain other consequences of external causes.

²Abbreviations: ICD-10-CM: International Classification of Diseases, Tenth Revision, Clinical Modification

Table 3: Frequency and proportion of diagnosis categories and severe diseases amongst P1 patients.

Time periods studied	Pre-COVID-19 period	COVID-19 period	% change in frequency as compared to Pre-COVID-19 period
	2 Jan – 30 Jun 2019	1 Jan – 28 Jun 2020	
Total No. of P1 visits	9049	5336	
No. of P1 visits with ≥1 recorded diagnosis	9012	5313	
Total No. of recorded diagnoses	11510 (100%)	7519 (100%)	
ICD-10-CM Diagnosis categories	N (% ED visits with ≥1 recorded diagnoses)	N (% ED visits with ≥1 recorded diagnoses)	
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	3286 (28.5%)	1737 (23.1%)	-1549 (-47.1%)
Injury, poisoning and certain other consequences of external causes	690 (6.0%)	490 (6.5%)	-200 (-29.0%)
Diseases of the musculoskeletal system and connective tissue	197 (1.7%)	80 (1.1%)	-117 (-59.4%)
Diseases of the circulatory system	2623 (22.8%)	1698 (22.6%)	-925 (-35.3%)
Diseases of the respiratory system	1515 (13.2%)	1442 (19.2%)	-73 (-4.8%)
Diseases of the digestive system	444 (3.9%)	280 (3.7%)	-164 (-36.9%)
Diseases of the genitourinary system	235 (2.0%)	183 (2.4%)	-52 (-22.1%)
Certain infectious and parasitic diseases	401 (3.5%)	225 (3.0%)	-176 (-43.9%)
Endocrine, nutritional and metabolic diseases	920 (8.0%)	638 (8.5%)	-282 (-30.7%)
Diseases of the skin and subcutaneous tissue	84 (0.7%)	51 (0.7%)	-33 (-39.3%)
Diseases of the eye and adnexa	183 (1.6%)	95 (1.3%)	-88 (-48.1%)
Diseases of the nervous system	217 (1.9%)	125 (1.7%)	-92 (-42.4%)
Neoplasms	248 (2.2%)	169 (2.2%)	-79 (-31.9%)
Mental, Behavioral and Neurodevelopmental disorders	94 (0.8%)	76 (1.0%)	-18 (-19.1%)
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	182 (1.6%)	89 (1.2%)	-93 (-51.1%)
External causes of morbidity	101 (0.9%)	91 (1.2%)	-10 (-9.9%)
Diseases of the ear and mastoid process	10 (0.1%)	8 (0.1%)	-2 (-20.0%)
Factors influencing health status and contact with health services	59 (0.5%)	30 (0.4%)	-29 (-49.2%)
Pregnancy, childbirth and the puerperium	12 (0.1%)	7 (0.1%)	-5 (-41.7%)
Congenital malformations, deformations and chromosomal abnormalities	7 (0.1%)	4 (0.1%)	-3 (-42.9%)
Certain conditions originating in the perinatal period	2 (0.0%)	1 (0.0%)	-1 (-50.0%)
Severe diseases			
Stroke	704 (6.1%)	516 (6.9%)	-188 (-26.7%)
Acute myocardial infarction	508 (4.4%)	440 (5.9%)	-68 (-13.4%)
ST elevation (STEMI) myocardial infarction	226 (2.0%)	187 (2.5%)	-39 (-17.3%)
Non-STEMI (NSTEMI)	282 (2.5%)	253 (3.4%)	-29 (-10.3%)
Other acute ischemic heart diseases	109 (0.9%)	95 (1.3%)	-14 (-12.8%)
Heart failure	337 (2.9%)	231 (3.1%)	-106 (-31.5%)
Cardiac arrest	92 (0.8%)	102 (1.4%)	+10 +(10.9%)
Paralytic ileus and intestinal obstruction without hernia	337 (2.9%)	277 (3.7%)	-60 (-17.8%)
Appendicitis	173 (1.5%)	157 (2.1%)	-16 (-9.2%)

[†]There was a gross decline in ED P1 visits for all diagnosis categories during the COVID-19 period as compared to pre-COVID-19 period. The presentations of several severe diseases such as stroke and acute myocardial infarction also declined during the same period. However, a higher proportion of P1 patients attended ED for respiratory-related presentations.

ED admission

Overall, the total number of ED admissions decreased by 7.9% during the COVID-19 period (**Table 1**). The decline was evident across all ward types except for the infectious disease or isolation wards, which saw an increase of 4.7% in proportion of admitted patients (8.1% vs 3.4% baseline). The ED admission rate represents the fraction of ED visits that resulted in admission. The average ED admission rate during the pre-COVID-19 and COVID-19 periods were comparatively similar (43.8% vs 41.3% baseline). However, a closer look at weekly ED admission trend during the Circuit Breaker period revealed higher ED admission rates (**Figure 6**). The average ED admission rate was 48.3% during the Circuit Breaker period, higher than the average ED admission rate of 40.7% that was observed during the pre-COVID-19 period (**Table 4**). We noted a greater decline in average daily attendances of ‘Non-Fever’ triage groups during the Circuit Breaker period as compared to preceding months, but the average number of ED admissions per day remained unchanged. In contrast, average daily attendance of P3F patients increased slightly but a higher proportion of them were admitted during the Circuit Breaker period as compared to pre-Circuit Breaker period.

Table 4: Average ED attendance and average ED admission during the Pre-COVID-19, Pre-Circuit-Breaker and Circuit-Breaker periods.

Time periods studied	Pre-COVID-19 period 2 Jan – 30 Jun 2019 (180 days)			Pre-Circuit Breaker period 1 Jan – 6 Apr 2020 (97 days)			Circuit Breaker period 7 Apr –1 Jun 2020 (56 days)		
Triage categories	Average ED attendance per day	Average no. of ED patients admitted per day	Proportion of patients admitted (%)	Average ED attendance per day	Average no. of ED patients admitted per day	Proportion of patients admitted (%)	Average ED attendance per day	Average no. of ED patients admitted per day	Proportion of patients admitted (%)
P1	50.3	35.1	69.9%	31.2	23.8	76.4%	26.6	20.6	77.2%
P2	186.4	86.1	46.2%	165.8	81.0	48.9%	142.2	78.8	55.4%
P3	93.7	14.6	15.5%	71.6	11.1	15.5%	40.1	8.7	21.7%
P4	1.9	0.0	2.9%	1.0	0.0	2.1%	0.5	0.0	7.4%
P1F	0.8	0.7	81.9%	1.0	0.7	72.3%	1.2	0.9	73.8%
P2F	4.0	3.0	74.8%	6.0	3.4	57.7%	6.5	3.4	52.9%
P3F	5.0	1.7	34.8%	39.1	8.3	21.3%	49.8	16.4	33.1%
Total No.	61576	25422		30610	12449		14940	7217	
Average ED admission percentage (%)			41.3%			40.7%			48.3%

[†]The average ED admission percentage was higher during the Circuit Breaker period as compared to pre-COVID-19 period. There was a greater decline in average daily attendances of ‘Non-Fever’ triage groups (P1-P4) during the Circuit Breaker period as compared to preceding months, but the average number of ED admissions per day remained unchanged. Average daily attendance of P3F patients increased slightly but a higher proportion of them were admitted during the Circuit Breaker period as compared to pre-Circuit Breaker period.

Discussion

Key findings

Since the beginning of the COVID-19 outbreak, the overall number of SGH ED visits and admissions have dipped as compared to corresponding pre-COVID-19 period. There was also a proportional decline in visits for all diagnosis categories, except for complaints related to the respiratory system which more than doubled during the COVID-19 period. Notably, there were fewer visits and presentations for all diagnostic categories by SGH ED’s highest priority P1 group. This raises the concern whether there was any delay and failure in seeking necessary medical treatments which can translate to poorer health outcomes^{26,27}. Amidst the decline, we noted a shift in ED patient case-mix from ‘Non-fever’ cases to ‘Fever’ cases. This likely gave rise to the two-phase ED attendance trend that we observed at SGH ED, where each phase has its distinct trough-to-peak visit pattern. The first and second phase corresponds with the pre-Circuit Breaker and Circuit Breaker period, respectively. Lastly, the Circuit Breaker period had a higher average ED admission rate as compared to the pre-Circuit Breaker period. Between these two periods, the average number of ED patients admitted per day remained relatively unchanged, except for P3F patients. The Circuit breaker period, however, saw a greater decline in average daily ED attendance as compared to the pre-Circuit Breaker period.

Possible explanations for the two-phase ED attendance trend at SGH

The general decline in ED attendance was widely reported in several countries, including fewer visits for non-respiratory complaints^{6,9} and certain medical emergencies such as stroke and acute myocardial infarction^{1,13-15}. Here at SGH ED, we observed a similar trend with an overall decline in visits for non-fever and non-respiratory complaints, raising the concern that some patients needing emergency care were not seeking help at ED. With a large decrease in ED visits, one may expect the sickest patients (P1) to continue attending ED for unquestionably needed emergency care. Nevertheless, COVID-19’s impact on the ED attendance of P1-equivalent triage group seemed to vary by country. While two studies

reported no change in ED attendance of their sickest patient group^{28,29}, several other EDs observed a significant decline in visits of the same vulnerable group^{7,10,30}. Like most studies, SGH ED saw fewer life-threatening presentations and a decrease in both the number and proportion of P1 visits throughout the COVID-19 period. We speculate the following reasons that could have contributed to the overall decline in SGH ED attendance, even amongst the most urgent cases.

Some patients may have avoided SGH ED due to fear of burdening the healthcare system²² or contracting the dreadful virus in a public hospital that is screening and treating for COVID-19^{26,31}. Also, social distancing measures and a partial lockdown have likely led to lower incidences of common community infections and injuries related to work, sports, and road traffic accidents. It is also likely that the gradual expansion of COVID-19 screening and treatment capacity in Singapore have redirected patients from ED to alternative avenues. These avenues include community COVID-19 swab operations and isolation facilities, teleconsultation services and general practitioner (GP) clinics adequately equipped to manage patients with respiratory symptoms²⁰. Furthermore, the close collaboration between Singapore's public and private healthcare hospitals likely expanded treatment capacity for management of chronic medical ailments and non-life-threatening clinical conditions. Our data, however, cannot prove whether there has been a true decrease in the incidence of diseases, or whether patients are avoiding ED or seeking treatment elsewhere. Whether there was any delay and failure in seeking urgently needed treatments remains a major public health concern. Additional data and in-depth analysis are required to study the relative contributions of the aforementioned factors to the decline in ED attendance.

Unlike the surge in ED attendance and number of 'Fever' visits that we saw during pre-Circuit Breaker period (First phase), ED attendance declined even as daily infected cases hit record-breaking numbers during the Circuit Breaker (Second phase). During the first phase where daily counts of newly infected community cases were relatively low, the shift in ED patient case-mix from 'Non-fever' cases to 'Fever' cases may be contributed by suspected COVID-19 cases seeking testing and treatment at the ED, as well as patients seeking care for flu-like symptoms for fear that they have contracted the COVID-19 virus³². As compared to pre-COVID-19 period, the percentage change in 'Fever' and 'Non-fever' visits and respiratory-related diagnoses during the COVID-19 period was likely an overestimation due to modified triage thresholds at ED. Patients who met suspect case criteria for COVID-19 were likely triaged as 'Fever' cases and given a respiratory-related primary diagnosis, no matter how mild their respiratory symptoms were or even if their chief complaint was of a non-respiratory nature³³. This was to facilitate the prompt placement of such patients in specific acute respiratory inpatient wards upon admission. This contrasts with the pre-COVID-19 period, where such patients with mild respiratory symptoms or non-respiratory presenting complaints were less likely to be given a respiratory-related diagnosis and the 'Fever' triage category mainly functioned to isolate patients with suspected conditions that were highly transmissible, such as pulmonary tuberculosis, measles, chicken pox and herpes zoster⁴. Amidst the rise in 'Fever' visits during the first phase, the overall number of 'Non-Fever' visits fell and this decline persisted into the Circuit Breaker period (Second phase). On the contrary, the surge in number of infected cases during Circuit Breaker (Second phase) was largely restricted to the densely occupied migrant worker dormitories, rather than the community^{4,34}. The prompt gazettement of these dormitories as isolation areas, general compliance to social distancing measures, rapid contact tracing and systematic screening for COVID-19 have likely stemmed any widespread infection to the community. Moreover, the scaling up of community medical facilities and services during the Circuit Breaker (Second phase) allowed quicker testing and housing of clinically well COVID-19 patient³⁴. These measures likely gained traction throughout Circuit Breaker and prevented an overwhelming number of 'Fever' visits to SGH ED, which partially explains the persistent nadir of ED attendance observed during the first half of Circuit Breaker.

In the second half of the Circuit Breaker, the recovery in 'Non-Fever' visits may be due to the delay in seeking treatment, resulting in more severe presentations that required emergent care and admission from ED. It may also be attributed to better public perception of the local COVID-19 situation and the declining number of new cases in the community. These may have quelled the public's fear of contracting the virus in the community and hospital settings.

Possible explanations for ED admission rate trends at SGH

The ED admission rate is one of several ED key performance indicators at SGH and it is dependent on ED attendance, the number of patients admitted from the ED and the patient case-mix unique to SGH. It is worth noting that SGH ED is likely to have higher than average ED admission rates as compared to other typical EDs during COVID-19 period due to its position in the largest tertiary hospital in Singapore³⁵. During peacetimes, a consistent trend in ED attendance allows the reliable use of ED admission rate to reflect inpatient bed needs of ED patients. This rate, however, can be misleading during a pandemic.

Existing few studies have reported temporal associations between declining ED attendance and rising ED admission rates during the COVID-19 period^{36,37}. At SGH ED, we observed obvious variability in the average ED admission rates between the pre-Circuit Breaker period (First phase) and Circuit Breaker period (Second phase). Although the overall number of patients admitted from the ED were the same in both periods, the trough of ED attendance persisted longer during the Circuit Breaker period (Second phase) as compared to the pre-Circuit Breaker period (First phase). These numbers gave rise to a higher average ED admission rate during the Circuit Breaker period despite the need for the same number of hospital beds. Our findings suggest that the admission rate should be distilled down to its components for evaluation. It is possible that the average acuity of presenting illness has increased across triage groups, necessitating a higher proportion of patients admitted. Further analysis of ED resource utilisation and life-saving interventions may tell us the severity of conditions that these patients presented to ED with. Another possible implication could be related to the change in protocol to admit suspected COVID-19 cases or patients with respiratory symptoms, who would otherwise be typically discharged during the pre-COVID-19 period. This included admitting patients who had difficulty self-isolating to Acute Respiratory Infection and isolation wards to reduce community spread.

Implications

The first implication of our findings was the possible delay in P1 patients seeking life-saving interventions at ED. The decline in SGH ED attendance might also be attributed to reduced incidence of disease in the community or a diversion towards alternative treatment avenues. Additional data and further exploration of the factors above are needed to conclude whether there was a true delay in seeking necessary treatments and explore the reasons behind it. The delay of emergent care and chronic care might lead to increased morbidity and mortality in the community, and potentially increased the need for hospital care. Further exploration of the issues above may help to identify key targets of interventions for better health outcomes. Secondly, the sole use of ED admission rate may not reflect inpatient bed needs reliably during a pandemic. The analysis of ED admission trends should also include admitted ward types and a good understanding of ED workflow and protocols during the COVID-19 period. Thirdly, the pandemic presents timely opportunities for policymakers to understand how some ED patient groups can be managed appropriately outside of ED for better management of ED crowding in a post-COVID-19 era.

Future studies

The COVID-19 pandemic is still showing no signs of abating globally and the resurgence of outbreaks, as seen in many other countries, is inevitable as Singapore reopens its borders. A deeper understanding on the pandemic's indirect impact on patient outcomes and the overall demand for emergent care across the nation is needed. As Singapore eased from social interaction mitigation measures in a stepwise manner, further studies on patients presenting to the ED during this period are needed to fully understand the health implications of the COVID-19 outbreak. It is also essential to explore public perceptions on seeking treatment at ED during the COVID-19 period. Moreover, the prediction of a post-COVID-19 peak rebound in 'Non-Fever' visits will facilitate informed decision-makings in resource allocation. It will be useful to have a whole-system model in the future which estimates the healthcare resources needed for health systems to adapt rapidly

in various outbreak scenarios. This tool will inform policy responses and minimise the impact of an evolving outbreak on Singapore's health systems' outcomes.

Limitations

As this was a single-centre study based on SGH's patient profile, and the analysis was performed using data collected from SGH's eHINTS-ED database, our findings may not be generalisable to other EDs in Singapore and we do not know whether more or less patients are seeking treatment at other hospitals. Although this study was not able to prove causation due to the nature of a descriptive analysis, our findings provide first insights on how ED utilisation at SGH has changed across different subperiods of the COVID-19 pandemic, laying out important questions and implications that future studies should address.

Another limitation of our study lies in our diagnosis dataset. As our dataset did not allow differentiation between primary and secondary diagnoses for each ED visit, all documented diagnoses were studied, and the proportion of each diagnosis category was analysed as a percentage of total number of documented diagnoses. Consequently, the results may have under-represented some diagnosis categories as there were more documented diagnoses than ED visits, or over-represented some diagnosis categories if secondary diagnoses were concentrated in those categories. Nevertheless, the broad conclusion remains that the frequency of nearly every diagnosis category has declined and the number of respiratory-related presentations have gone up during the COVID-19 period. Also, we were not able to map 3000 SNOMED CT codes to ICD-10, which represent 232 unique SNOMED CT diagnosis. However, these were fairly distributed across multiple diagnosis categories. As such, their exclusion will not likely alter the general conclusions of this study.

Conclusion

The COVID-19 pandemic caused a large decline in ED attendances at SGH, even amongst those with highest priority for emergency care. This raises the concern whether patients were delaying critically needed treatment at ED, and whether this has resulted in poorer health outcomes. Moreover, the use of ED admission rate as a key performance indicator during a pandemic can be misleading and the individual components of admission rates should be scrutinised before making any evaluation on inpatient bed needs. Lastly, this descriptive analysis revealed distinct ED visit trends across different time periods. A deeper understanding of how patients are utilising healthcare services across different healthcare institutions will provide policymakers useful insights on how ED crowding can be better managed in the post-COVID-19 era.

Abbreviations

COVID-19: Coronavirus disease 2019

CIRB: SingHealth Centralised Institutional Review Board

DORSCON: Disease Outbreak Response System Condition

ED: Emergency Department

eHINTS: Electronic Health Intelligence System

ICD-10-CM: International Classification of Diseases, Tenth Revision, Clinical Modification

PAC: Patient Acuity Category

P1: Priority 1

P2: Priority 2

P3: Priority 3

P4: Priority 4

P1F: Priority 1 Fever

P2F: Priority 2 Fever

P3F: Priority 3 Fever

Q1: First quartile which represents 25th percentile value

Q3: Third quartile which represents 75th percentile value

SGH: Singapore General Hospital

SCDF: Singapore Civil Defence Force

SNOMED CT: Systematized Nomenclature of Medicine Clinical Terms

Declarations

Ethics approval and consent to participate

This was a service evaluation study which did not require further ethical deliberation by SingHealth Centralised Institutional Review Board (CIRB Ref: 2020/2470).

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Ms Lim MQ, Prof Ong MEH, Asst Prof Siddiqui FJ, Assoc Prof Liu N and Asst Prof Saffari SE contributed to the study design. Mr Lian SWQ helped with the extraction of anonymised patient data. Asst Prof Siddiqui FJ, Assoc Prof Liu N, Asst Prof Saffari SE, Mr Lian SWQ and Ms Sim NS assisted in data cleaning. Ms Lim MQ performed all data analysis,

statistical analysis, and manuscript preparation. Asst Prof Saffari SE, Asst Prof Siddiqui FJ and Assoc Prof Liu N provided their guidance on descriptive analysis. All authors made substantial contributions to result interpretation and critical revision of the manuscript.

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Figures

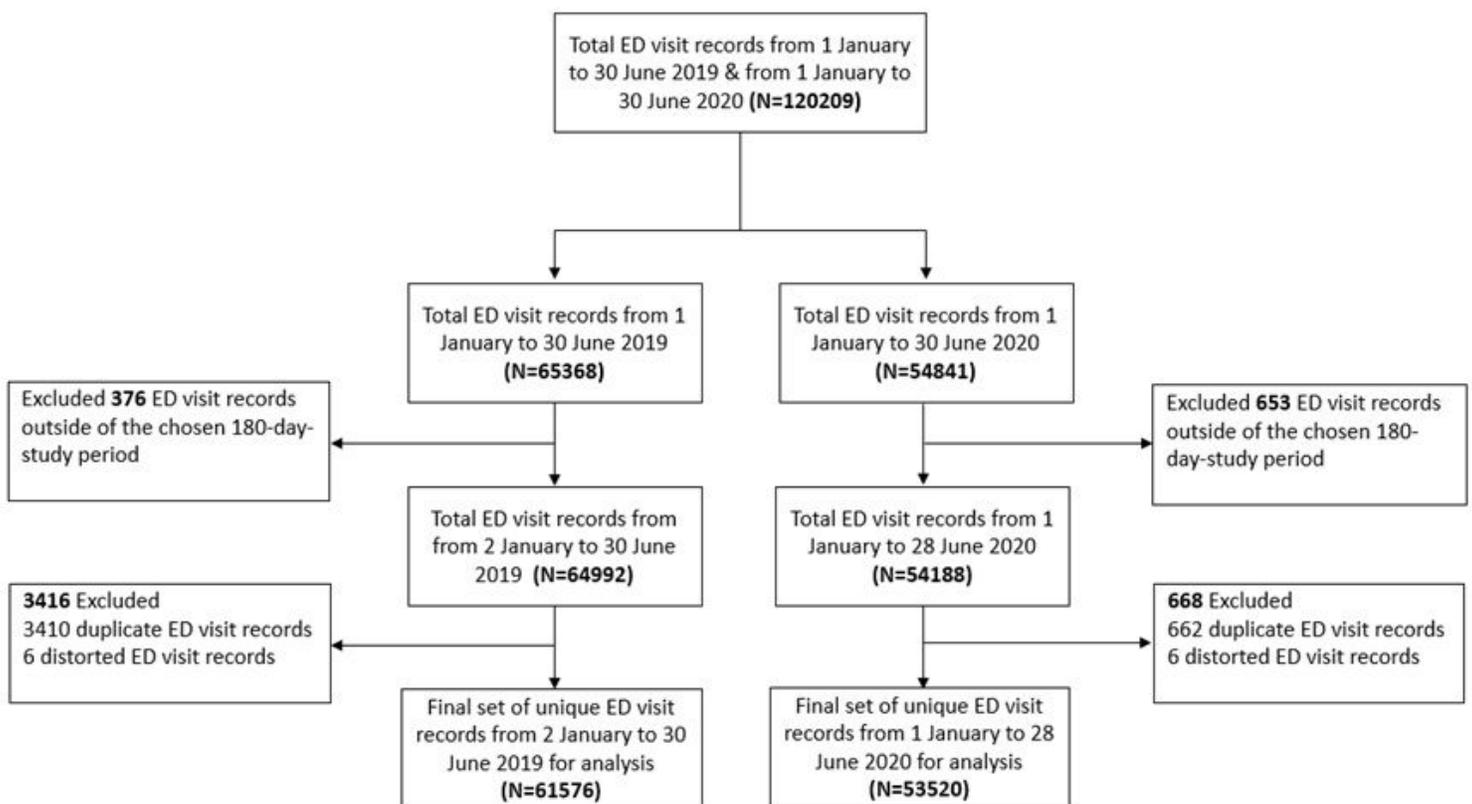


Figure 1

Flowchart depicting study selection process of ED visit records for analysis. Abbreviations: ED: Emergency department; N: number of records.

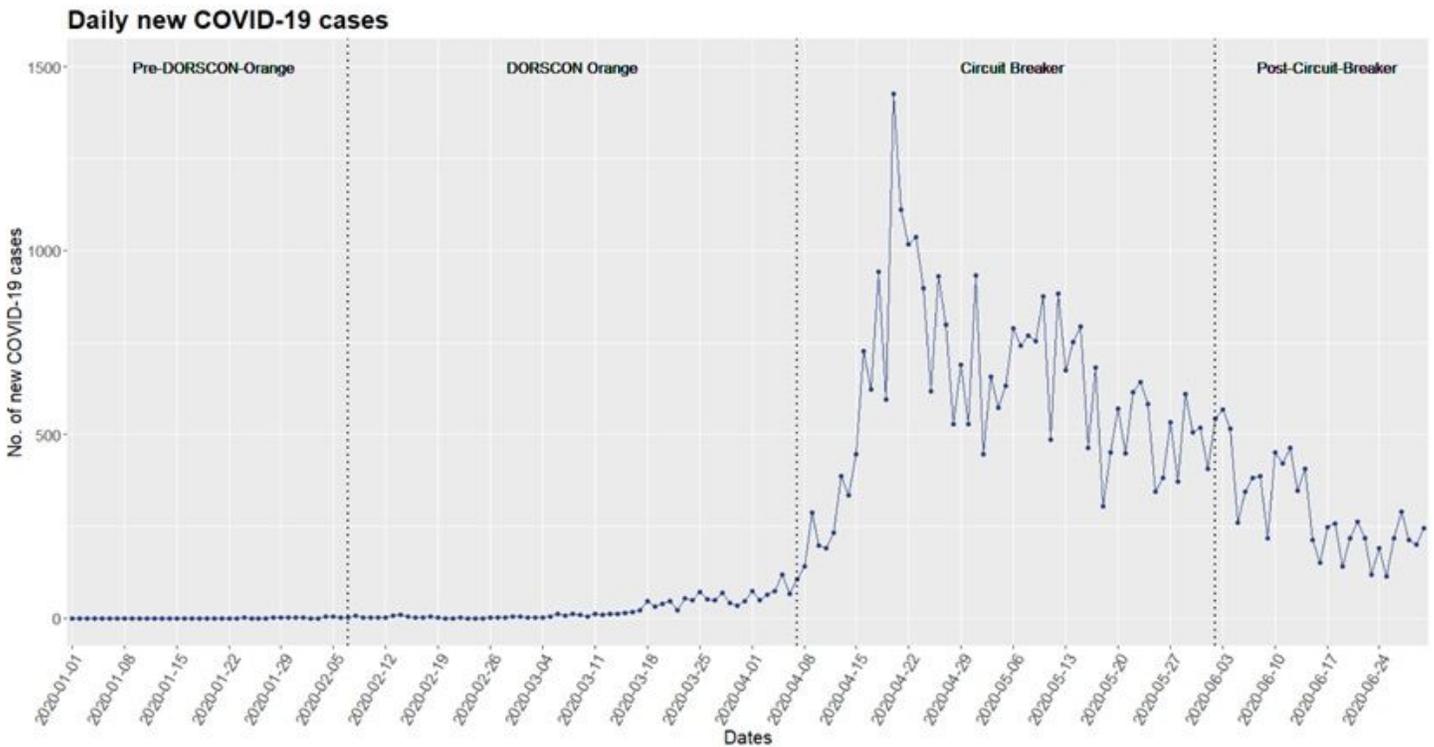


Figure 2

An illustration of the trend of daily newly infected cases in Singapore. Source: Ministry of Health (MOH) Singapore, Past updates on COVID-19 (Coronavirus disease 2019) local situation, 202025. National tally of daily infected cases reached its highest during the Circuit Breaker period and declined progressively thereafter.

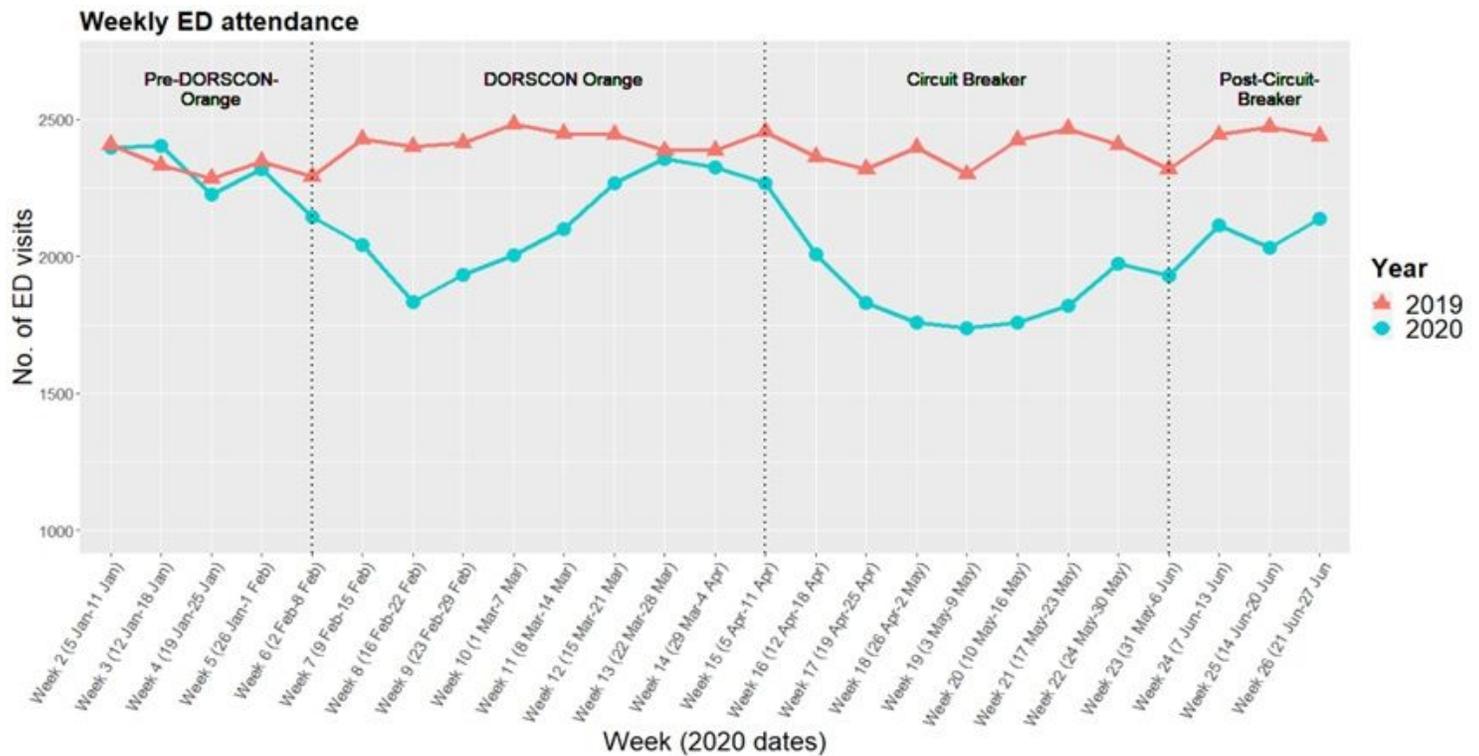


Figure 3

Weekly SGH ED attendance between the studied COVID-19 period and its corresponding historical pre-COVID-19 period. 1Weekly ED attendance during the studied COVID-19 period remained persistently below that of pre-COVID-19 period. A two-phase ED attendance trend was experienced at SGH ED within the studied COVID-19 period in 2020, where the first phase and second phase represent visit trends during the pre-Circuit Breaker period and Circuit Breaker period, respectively. 2Epi-weeks were used for plotting and only completed epi-weeks 2 to 26 of each studied period were included in this figure.

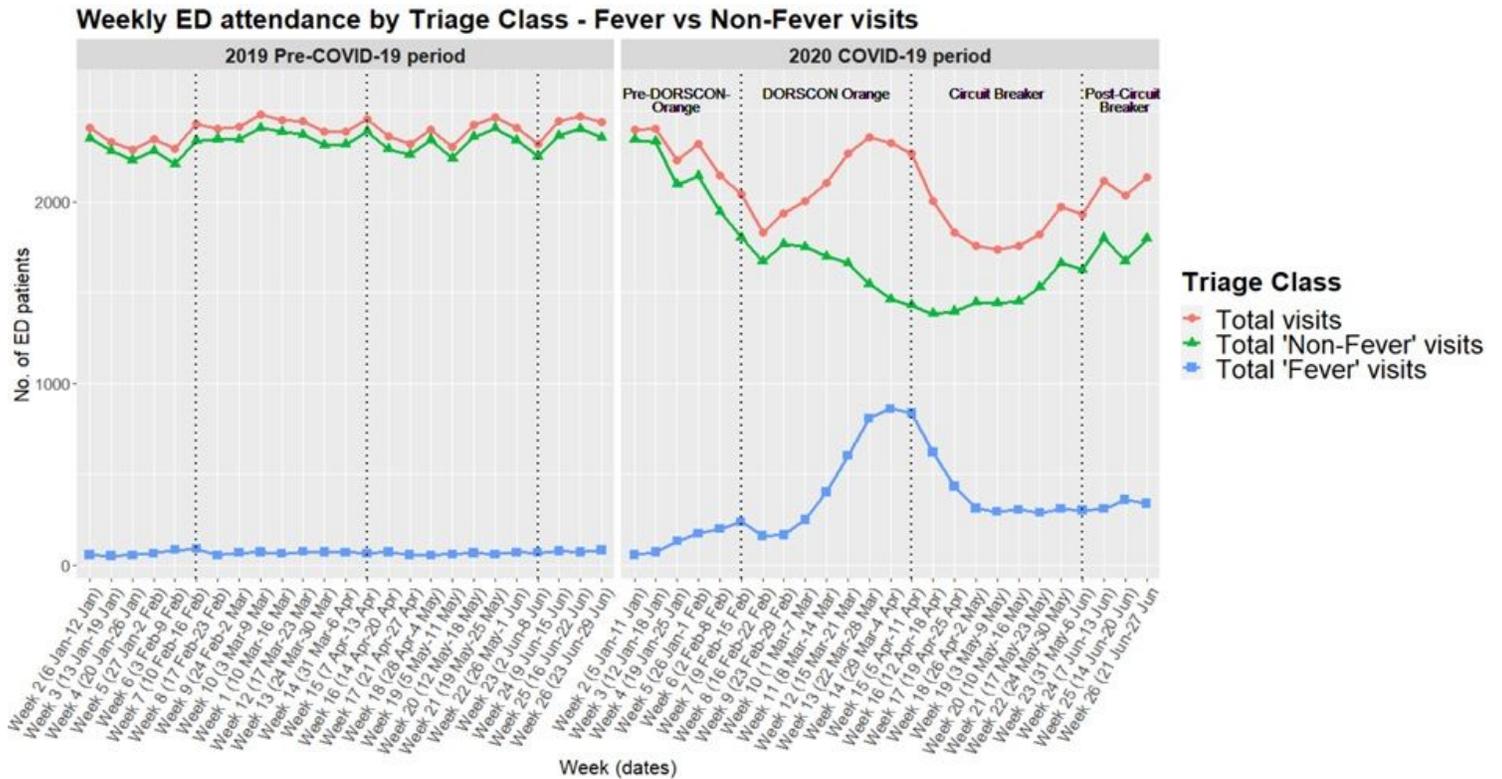


Figure 4

Weekly ED attendance trend of 'Non-Fever' and 'Fever' triage groups during pre-COVID-19 and COVID-19 periods. During DORSCON Orange period, the initial downward trend in total ED visits was largely driven by the decrease in 'Non-Fever' visits and the subsequent sharp returning of ED attendance corresponded with the rising numbers of total "Fever" visits. During Circuit Breaker period, there was a decline in attendance of both 'Non-Fever' visits and 'Fever' visits. Midway through the Circuit Breaker period, gradual recovery in total ED visits was observed as total 'Non-Fever' visits numbers rose while total 'Fever' visits numbers remained relatively constant. Epi-weeks were used for plotting and only completed epi-weeks 2 to 26 of each studied period were included in this figure.

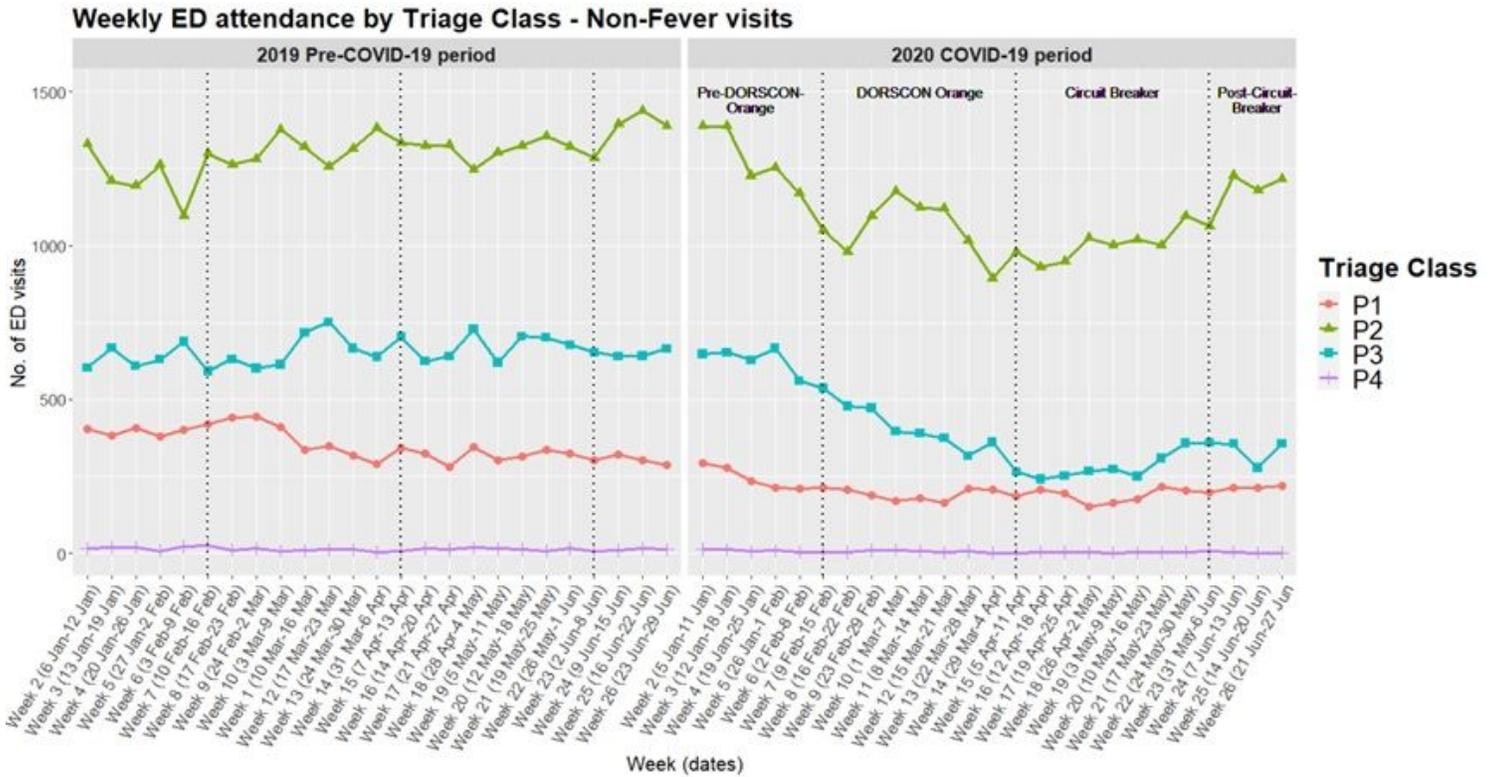


Figure 5

Weekly ED attendance trend for each 'Non-Fever' triage group during the pre-COVID-19 and COVID-19 periods. The number of 'Non-Fever' visits across all 'Non-Fever' triage groups (P1-P4) declined during the COVID-19 period as compared to corresponding pre-COVID-19 period. The proportion of P3 patients had the greatest decline over the COVID-19 period, reaching its lowest numbers during the Circuit Breaker phase. Epi-weeks were used for plotting and only completed epi-weeks 2 to 26 of each studied period were included in this figure.

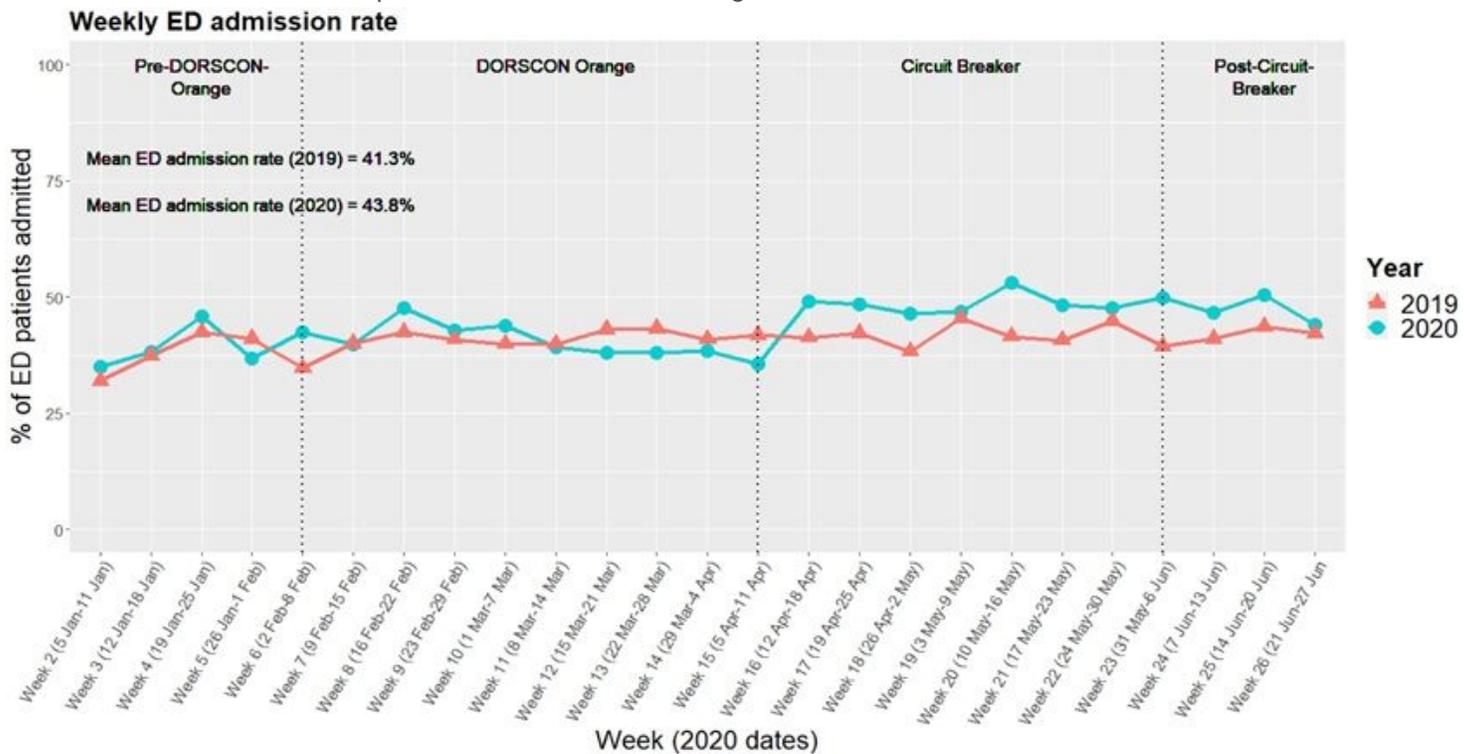


Figure 6

Weekly ED admission rate across time during the pre-COVID-19 period and COVID-19 period. The ED admission rate represents the fraction of ED visits that resulted in admission. The average ED admission rates in both periods were comparatively similar (43.8% vs 41.3% baseline). However, a closer look at weekly ED admission trend during the Circuit Breaker period revealed higher ED admission rates than corresponding period in 2019. Epi-weeks were used for plotting and only completed epi-weeks 2 to 26 of each studied period were included in this figure.