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Impact of the COVID-19 pandemic on Emergency Department attendances and hospitalisation for Asthma and Chronic Obstructive Pulmonary Diseases (COPD) in Singapore

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Abstract

Introduction: The prolonged impact of COVID-19 pandemic on non-COVID respiratory diseases remains uncertain. The objective of this study was to determine its impact on asthma and COPD Emergency Department (ED) attendances and hospital admissions and compare to the pre-pandemic utilisation state.

Methods: This study identified all ED attendances and admissions with a discharge diagnosis of acute asthma or COPD exacerbation between 1st January 2015 and 31st December 2022 to the National Healthcare Group's hospitals from a central cluster electronic record database. Rates of ED attendances, admissions and all-cause mortality in these patients pre- and post-pandemic were compared.

Results: For asthma, the median number of all-cause ED visits per 10,000 patients reduced from 92.6 per week (2015-2019) to 58.6 per week (2020-2021), ($p < 0.001$). This remained sustained in 2022 (65.1 ED visits per 10,000), ($p < 0.001$). For COPD, the median number of all-cause ED visits per 10,000 patients fell from 204.5 per week (2015-2019) to 137.2 per week (2020-2021), ($p < 0.001$), and persisted in 2022 (151.0 ED visits per week), ($p < 0.001$). These occurred without increase in mortality or average length of hospital stay over the three-year period. With the end of pandemic, the utilisation trends for ED visits and hospitalisations returned to pre-pandemic levels.

Conclusion: There was a notable decrease in ED visits and admissions for obstructive airway diseases during COVID-19 pandemic without significant change in overall mortality and duration of hospital stay. Our study highlighted the potential of telemedicine and home monitoring to reduce unnecessary ED attendance and hospital admissions in the future.

Introduction

The COVID-19 pandemic has had significant impact on hospital admissions worldwide [1,2]. It caused a surge in hospital admissions due to the high number of COVID-19 cases, leading to a strain or even a breakdown on healthcare systems in countries [3]. However, it also led to a decrease in hospital admissions for non-Covid related illnesses due to fear of contracting the virus and restrictions on non-essential medical procedures [4,5]. Hospitals were overwhelmed due to a shortage of beds, medical supply such as oxygen and ventilators, and healthcare workers [6]. This led to a delay in diagnosis and treatment of many conditions, leading to a higher risk of complications, hospital length of stay and mortality [7].

The impact of COVID-19 on emergency department (ED) visits and hospital admissions has been felt worldwide to varying degrees [8]. It is uncertain how respiratory airway diseases such as asthma and Chronic Obstructive Pulmonary Disease (COPD) were impacted over a prolonged period, especially with the widespread adoption of public health measures, including social distancing, hand hygiene and wearing of face coverings. While emergency visits and hospital admissions of gastrointestinal bleeding, acute coronary syndrome and cancer were reported to be reduced during the Covid pandemic [9-11], it is uncertain how acute services utilisation has changed with the end of the pandemic and unwinding of public health measures.

We aimed to study the impact of COVID-19 on asthma and COPD attendances at the ED and hospital admissions over a 3-year period, and compared that with the pre-pandemic utilisation state. We also compared the Average Length of Hospital Stay (ALOS) and all-cause mortality for both conditions before, during and after the pandemic.

Methods

Asthma and COPD patients residing in the Central and North zones of Singapore were identified using the National Healthcare Group's (NHG) Chronic Disease Management System (CDMS) [12].

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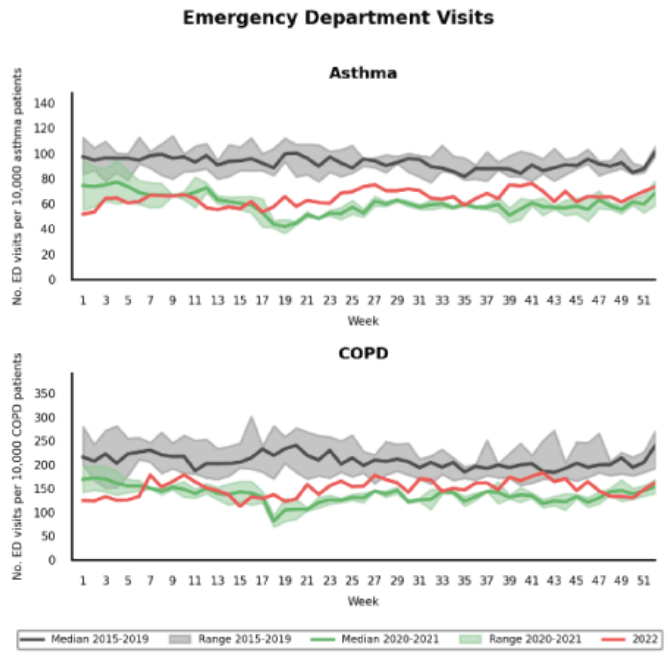

Figure 1: Number of all-cause ED visits among asthma and COPD patients.

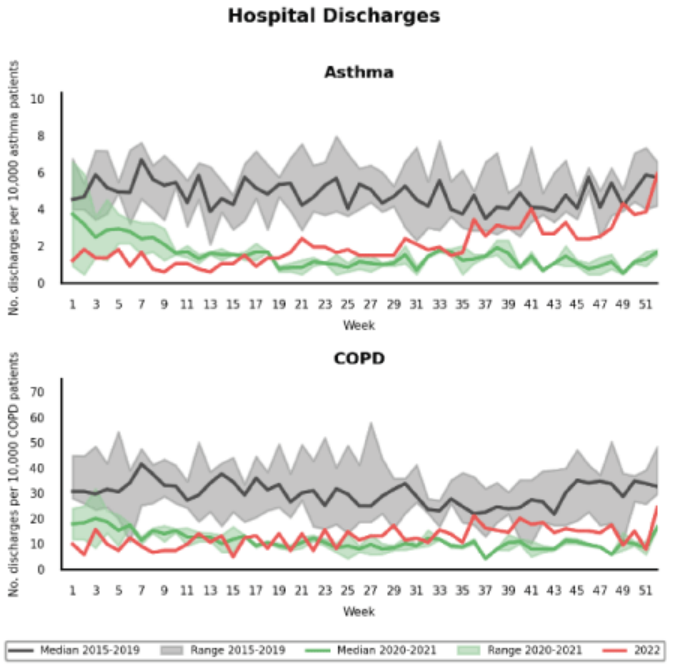

Figure 2. Number of asthma and COPD discharges among asthma and COPD patients

CDMS is a chronic disease registry that collects data on adults with chronic diseases such as diabetes mellitus, dyslipidaemia, hypertension, asthma, COPD, heart failure and chronic kidney disease. All emergency department (ED) attendances by asthma and COPD patients, as well as admissions with a discharge diagnosis of acute asthma exacerbation (ICD-10-AM J45-J46), or COPD exacerbation (ICD-10-AMJ41-J44), between 1st January 2015 and 31 December 2022 to the National Healthcare Group's hospitals (one of the three national healthcare clusters with two large hospital sites) were identified from a central cluster electronic record database. Average length of hospital stay and all-cause mortality within and outside the hospital was also obtained from the database.

The rates of ED attendances, hospital admissions and all-cause mortality by these asthma and COPD patients pre- and post-pandemic were compared using proportion test and average length of hospital stay using t-test. Data were analysed using STATA version 18.0 (StataCorp LP, College Station, TX, USA).

Results

There were a total of 39,946 to 65,735 asthma patients and 7,569 to 12,017 COPD patients residing in the Central and North zones of Singapore between 2015 to 2022. The mean age and its standard deviation for asthma and COPD patients in 2022 were 47.7 (SD = 22.0) years and 73.4 (SD = 12.4) years, respectively.

Emergency Department attendances and hospitalisation

There was a significant and sustained reduction in both asthma and COPD ED attendances and admissions during the pandemic years, 2020-2021 (Figures 1 and 2).

For asthma, the median number of all-cause ED visits per 10,000 asthma patients fell from 92.6 per week (year 2015-2019) to 58.6 per week (year 2020-2021), ($p < 0.001$). This reduction was sustained in year 2022 (65.1 ED visits per 10,000), ($p < 0.001$) when the peak of the COVID pandemic was receding. The median admissions into hospital per 10,000 asthma patients fell from 4.8 per week to 1.4 per week in 2020-2021 ($p < 0.001$). However, with the end of the pandemic and unwinding of public health measures in 2022 there was a rebound back to pre-pandemic levels from the second half of 2022 (with a median admission 4.1 per week in December 2022), Figure 2.

The patient demographics and status on arrival at the ED (before and during the pandemic) is shown in Table 1. The demographics and outcome for hospitalisation cases is shown in Table 2.

For asthma ED attendances, patients were older and there was a significantly higher mortality on arrival/in ED (0.35% vs 0.23%, p <

Table 1. Patient demographics and status on arrival at the ED (Asthma)

ED attendance	Asthma 2015-2019 (N = 129,067)	Asthma 2020-2021 (N = 40,610)	p
Age, mean (SD)	49.9 (22.4)	53.1 (21.9)	
0 to 39, n (%)	50,208 (38.9%)	13,766 (33.9%)	< 0.001
40 to 64, n (%)	39,107 (30.3%)	12,442 (30.6%)	(< 0.001)
65 and above, n (%)	39,752 (30.8%)	14,402 (35.5%)	
Gender, n (%)			
Male	69,129 (53.6%)	20,583 (50.7%)	< 0.001
Female	59,938 (46.4%)	20,027 (49.3%)	
Mortality on arrival/in ED, n (%)	300 (0.23%)	141 (0.35%)	< 0.001

Table 2. Patient demographics and outcome for hospitalized cases (Asthma)

Hospital Admission	Asthma 2015-2019 (N = 6,815)	Asthma 2020-2021 (N = 999)	p
Age, mean (SD)	56.6 (19.4)	59.0 (19.8)	
0 to 39, n (%)	1,516 (22.2%)	212 (21.2%)	< 0.001
40 to 64, n (%)	2,783 (40.8%)	359 (35.9%)	(0.001)
65 and above, n (%)	2,516 (36.9%)	428 (42.8%)	
Gender, n (%)			
Male	2,191 (32.1%)	330 (33.0%)	0.577
Female	4,624 (67.9%)	669 (67.0%)	
Use of Ventilator, NIV or intubation, n (%)	232 (3.4%)	49 (4.9%)	0.017
ICU admission, n (%)	168 (2.5%)	36 (3.6%)	0.032
Mortality during stay, n (%)	37 (0.54%)	6 (0.60%)	0.818
Readmission with 30 days, n (%)	558 (8.2%)	70 (7.0%)	0.200

Table 3. Patient demographics and status on arrival at the ED (COPD)

ED attendance	COPD 2015-2019 (N = 52,681)	COPD 2020-2021 (N = 16,781)	p
Age, mean (SD)	72.9 (11.7)	73.4 (11.7)	
0 to 39, n (%)	125 (0.2%)	75 (0.4%)	< 0.001
40 to 64, n (%)	13,230 (25.1%)	3,975 (23.7%)	(< 0.001)
65 and above, n (%)	39,326 (74.6%)	12,731 (75.9%)	
Gender, n (%)			
Male	40,415 (76.7%)	12,767 (76.1%)	0.090
Female	12,266 (23.3%)	4,014 (23.9%)	
Mortality on arrival/in ED, n (%)	342 (0.65%)	129 (0.77%)	0.100

Table 4. Patient demographics and outcome for hospitalized cases (COPD)

Hospital Admission	COPD 2015-2019 (N = 7,616)	COPD 2020-2021 (N = 1,358)	p
Age, mean (SD)	73.5 (10.2)	74.6 (10.4)	
0 to 39, n (%)	6 (0.1%)	1 (0.1%)	< 0.001
40 to 64, n (%)	1,481 (19.4%)	265 (19.5%)	(0.996)
65 and above, n (%)	6,129 (80.5%)	1,092 (80.4%)	
Gender, n (%)			
Male	6,530 (85.7%)	1,086 (88.7%)	0.004
Female	1,204 (14.3%)	154 (11.3%)	
Use of Ventilator, NIV or intubation, n (%)	592 (7.8%)	157 (11.6%)	< 0.001
ICU admission, n (%)	208 (2.7%)	44 (3.2%)	0.281
Mortality during stay, n (%)	198 (2.6%)	26 (1.9%)	0.136
Readmission with 30 days, n (%)	1,724 (22.6%)	246 (18.1%)	< 0.001

0.001). We looked at age-specific mortality and found that only the 65 and above age group had statistically significant higher mortality on arrival and/or death within the ED. Among those requiring hospital admissions, there was more use of Non-Invasive Ventilation (NIV) or invasive (intubation) ventilation (4.9% vs 3.4%, p = 0.017) and more ICU admissions (3.6% vs 2.5%, p = 0.032). Age-specific analyses shows that both 0 to 39 and 40 to 64 age groups had statistically significant higher use of NIV or invasive (intubation) ventilation and ICU admissions during the pandemic. There was no difference in mortality during hospital stay, or readmission within 30 days.

For COPD, the median number of all-cause ED visits per 10,000 patients fell from 204.5 per week (year 2015-2019) to 137.2 per week (year 2020-2021), (p < 0.001). This reduction was sustained in year 2022 (151.0 ED visits per week), (p < 0.001). The median admissions into hospital per 10,000 patients fell significantly greater than ED attendances from 30.2 per week to 10.2 per week in 2020-2021 (p < 0.001). Compared with asthma, there was a more gradual rebound admission rate to pre-pandemic levels from the second half of 2022 (median 24.6 per week in the last week of 2022), Figure 2.

The patient demographics and status on arrival at the ED (before and during the pandemic) is shown in Table 3. The demographics and outcome for hospitalisation cases is shown in Table 4.

Patients attending ED were significantly older during the pandemic, but there was no significant difference in mortality on arrival/in ED. Similarly, patients admitted to hospitals were older during the pandemic period, with more patients requiring assisted ventilation- either NIV or invasive (intubation) ventilation (11.6 vs 7.8%, p < 0.001). Age-specific analyses show that this increase in patients requiring assisted ventilation only occurred for the 65 and above age group. There was no difference in ICU admission or mortality during stay.

Average Length of Hospital Stay (ALOS) and all-cause mortality

There was no significant change in ALOS (Asthma: 4.4 vs 5.0 days, 2015-2019 *vs* 2020-2021), p = 0.296, (COPD: 6.3 vs 6.8 days, 2015-2019 *vs* 2020-2021), p = 0.573, or overall all-cause mortality (Asthma: 2.2 vs 2.1 per week per 10,000 patients, 2015-2019 vs 2020-2021), p = 0.981, (COPD: 14.9 vs 13.7 per week per 10,000 patients, 2015-2019 vs 2020-2021), p = 0.818, for both conditions between the pre and pandemic periods, Supplementary Materials Figures 3 and 4.

Discussion

The impact of COVID-19 on hospital emergency department visits and admissions has been significant in this study. We report marked

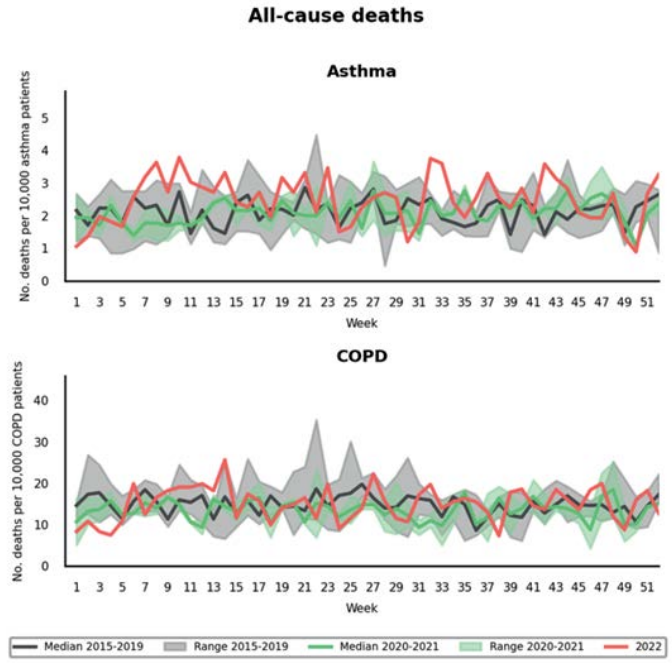

Figure 3. Average length of stay for asthma and COPD admissions among asthma and COPD patients.

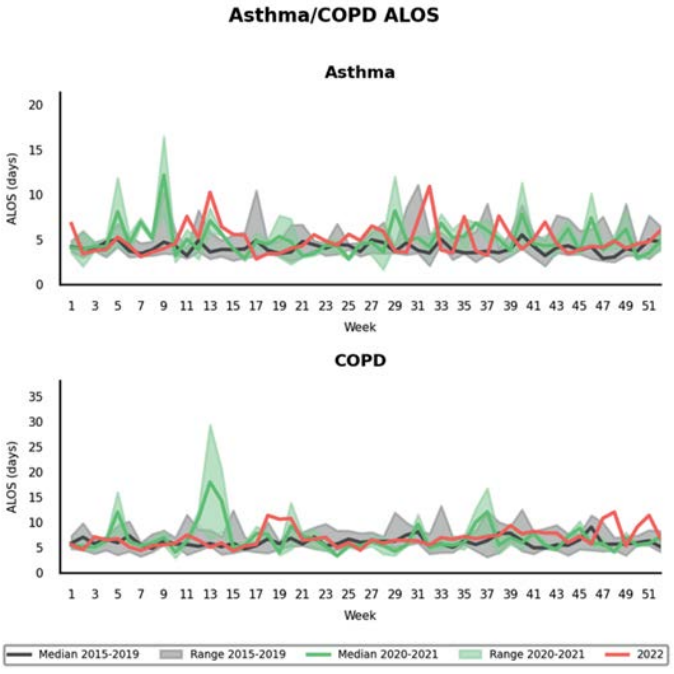

Figure 4. Number of within and outside hospital all-cause deaths among asthma and COPD patients.

reductions in asthma and COPD ED visits and admissions (greater than 50% reductions) during the two years of the Covid pandemic, from 2020-2021. This occurred without any change or increase in overall all-cause mortality, which is an important counter-balancing measure of clinical outcomes, as well as without any significant change in the ALOS.

For asthma however there was a higher mortality on arrival and/or death within the ED during the pandemic. This suggests either more patients with mild asthma are avoiding hospitals, leading to higher proportion of patients with severe asthma being seen at ED and thus a higher mortality, or there was a delay in presentation of asthma patients in general to the ED during the pandemic years. There was also more use of NIV or intubation (4.9% vs 3.4%, $p = 0.017$) and more ICU admissions (3.6% vs 2.5%, $p = 0.032$). For COPD admissions, there was more use of ventilation during the pandemic years- either NIV or intubation (11.6 vs 7.8%, $p < 0.001$). Again, all these suggest either a higher proportion of patients with more severe asthma or COPD, or more acute severely ill cases were seen in hospital during the pandemic period. However, without data on the severity of their asthma or COPD or the severity of their acute exacerbation on presentation to the hospital, we were not able to differentiate between these two possibilities in this study. Results on ALOS, mortality during stay and overall all-cause mortality was no different between pre- and during pandemic periods, suggesting that asthma and COPD patients were still adequately well managed during the pandemic period.

In the United Kingdom (UK), patients with asthma and COPD were considered at increased risk of dying from COVID-19 and were subject to UK Government shielding advice [13]. This was not done in Singapore. During the pandemic, various studies have also observed a lower occurrence of patients with asthma and COPD amongst hospitalised COVID-19 cases [14-16]. It was postulated that universal mask wearing and social distancing may reduce community transmission of common respiratory viral infections, leading to reductions in viral-induced exacerbations of both diseases [15]. Fear of contracting the virus could also lead to a decrease in hospital admissions for both conditions, leading to a delay in presentation and poorer outcomes, such as increase in mortality or ALOS [16].

Our data provides evidence that simple public health measures such as mask-wearing, social distancing, and hand hygiene to reduce community transmission of respiratory viral infections may be useful in reducing exacerbations of both asthma and COPD. These simple measures were implemented community-wide from February 2020 in Singapore [17]. There was a short 6-week 'lockdown' period from April-June 2020 which was lifted on 2 June 2020, with progressive relaxation of social distancing [5]. Compulsory mask wearing in public places was maintained until February 2023 [18]. With public adherence to such simple measures, it is possible to reduce unscheduled healthcare utilization for these airway diseases, as shown by our study. A similar but shorter effect was seen and reported during the SARS pandemic in 2003 [19,20]. With the end of the pandemic and lifting of public health measures, we saw the acute utilisation pattern of asthma and COPD going back to pre-pandemic levels. This rebound effect was more pronounced for asthma compared with COPD and occurred earlier from mid-2022.

To the best of our knowledge, this is the first study to demonstrate the changes in asthma and COPD ED utilisation and hospitalisation before, during and after the Covid pandemic. Previous studies have shown that ED admissions reduced significantly for non-Covid illnesses [8,13-16], but we are the first study to analyse the 3-year longitudinal data in these two common respiratory conditions which constitute a major clinical load in ED and acute hospitals. Our study is unique to show that asthma and COPD admissions remained consistently low throughout the pandemic period, yet there were no significant differences in ALOS and overall mortality throughout the COVID-19 pandemic from early 2020 to mid-2022, irrespective of different waves of Covid variants. There was a small but significant increase in number of death-on-arrival asthma cases (0.1%, 2.1 per week per 10,000 patients) which might be due to delayed presentation. This is likely related to the reluctance to attend hospital or clinic visits in a timely manner during the period of pandemic. Better home monitoring and implementation of tele consultation for higher risk cases should avoid this excess in mortality.

The current study suggests that the marked reduction in asthma and COPD ED attendance and hospital admissions did not result in an increase in ALOS nor overall mortality. There are two potential implications of this observation. First, many of the asthma and COPD admissions in the pre-Covid times could be prevented by simple public health measures such as wearing surgical masks and keeping social distance even outside of the pandemic period. These measures would reduce common viral and even bacterial infections that lead to exacerbations of asthma and COPD leading to hospitalization and fatal complications. On the other hand, it could also imply that a certain proportion of patients with asthma and COPD exacerbation attending ED and/or admitted to hospital may actually be possible to be taken care at home without hospitalization, if home monitoring and teleconsultation can be effectively implemented. Overall, these observations highlight the importance of exploring effective strategies to manage chronic respiratory conditions to reduce the burden on the healthcare system, in particular ED visits and hospital admissions.

Home monitoring of asthma and COPD is one valuable approach to reduce unnecessary ED attendance and hospital admissions. Home monitoring typically involves the use of ambulatory devices that measure patients' lung function, oxygen saturation, and other vital signs [21]. These devices assist and enable asthma and COPD patients to develop skills in the early detection of deterioration or exacerbation of their clinical progress [22-24]. This provides a window of opportunity for treatment and intervention in a timely manner, reducing the burden on the ED unit and minimising hospitalisations.

In addition to self-monitoring, telemedicine can strengthen the benefits of remote monitoring of chronic airway diseases. With the use of telemedicine, patients can receive personalised post-discharge care, follow-up visits and medical advice from healthcare professionals remotely during their rehabilitation [25,26]. Delivering healthcare remotely improves the accessibility to healthcare services and acts as a platform to equip patients with self-management skills and prevent the deterioration of diseases, especially during the COVID-19 pandemic [27]. Telemedicine consultations can also improve the quality of life and provide counselling to patients on their health conditions in a patient-centred approach during patients' home care [28]. Nevertheless, in order to fully harness the potential of this upstream and preventative approach, addressing challenges related to technology integration, data privacy, and healthcare provider training is essential [29]. By investing in home monitoring solutions, healthcare systems can move towards a more patient-centric and proactive approach to managing asthma and COPD.

There is a possible argument that delays in ED presentation and hospital admissions may increase the risk of worsened clinical outcomes for asthma and COPD patients. Our study suggests that

more severely ill cases were seen for both asthma and COPD in hospital during the pandemic period, yet there was no increase in ALOS and overall mortality. Therefore, the decision to provide home care or hospital care should be made carefully, and only a selected group of lower-risk asthma or COPD patients experiencing residual symptoms should be discharged home for continual care. The selection criteria for hospital-to-home or hospital-at-home should be developed through in-depth analysis of clinical (e.g. requiring use of long-term corticosteroids, previous ICU care and home oxygen, etc) and biophysiological parameters (e.g. oximeter, FEV1/FVC reading at ED, inflammatory markers, clinical features, etc) that reflect the severity of their disease exacerbation. Moreover, one of the primary advantages of home monitoring and telemedicine is the ability to detect early signs of exacerbations. Fluctuations in lung function, oxygen saturation levels, or symptom patterns can indicate an impending exacerbation of asthma or COPD, which can identify high-risk patients at home. By ensuring timely alerts and maintaining communication with healthcare providers, it is possible to promptly implement intervention strategies, which can help mitigate the severity of exacerbations [22-24]. This allows patients to seek medical advice promptly, ensuring timely intervention and care to prevent disease deterioration. Incorporating more comprehensive evaluation parameters and potentially utilising machine learning models in future studies may be able to improve the ability to triage patients to appropriate home care or hospital care. As clinic and ED attendance and hospital burden is continuing to rise globally, any strategy that can reduce the overburdening of the healthcare system would be valuable.

In summary, the COVID-19 pandemic has had a significant impact on hospital admissions worldwide, putting tremendous strain on healthcare systems. Despite a marked and sustained reduction in both asthma and COPD utilisation of acute hospital services during the pandemic, we found no increase in mortality or change in the ALOS for either condition. Cases that were admitted during the pandemic were more severe, requiring NIV, intubation or ICU care. With the end of the pandemic, the utilisation trends for both ED visits and hospitalisations returned to pre-pandemic levels. Our findings may not be applicable to other countries that have experienced different pandemic scenarios. Moving forward, further research is essential to investigate effective methods to reduce avoidable ED attendance and hospital admission for asthma and COPD exacerbations, with home monitoring and telemedicine playing an important role in this effort.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Human/Animal Ethics Approval Declaration

Not applicable for this study as only retrospective, de-identified and aggregated data were used. This is in accordance with our cluster's IRB policy.

Clinical Impact

- This study demonstrates the changes in asthma and COPD emergency department (ED) and hospitalisation utilisation before, during and after the Covid pandemic.
- The findings underscore the potential avoidable disease burden in this population.

Clinical Implications

- The study reveals the need of telemedicine and home-monitoring in reducing unnecessary ED visits and hospitalisation in Singapore.

This study explores strategies to reduce the burden of chronic respiratory diseases on the healthcare system in Singapore.

Tweetable Abstract

COVID-19 reduced ED visits for obstructive airway diseases. Telemedicine and home monitoring can play a role in preventing admissions in the future.

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