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The impact of COVID-19 on emergency department attendance in an Australia hospital: a parallel convergent mixed methods study

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The impact of COVID-19 on emergency department attendance in an Australia hospital: a parallel convergent mixed methods study

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ABSTRACT

Objectives

The COVID-19 pandemic has changed the way people are accessing healthcare. The aim of this study was to examine the impact of coronavirus (COVID-19) on emergency department (ED) attendance for frequent attenders and to explore potential reasons for changes in attendance.

Design

This convergent parallel mixed methods study comprised two parts.

Setting

An interrupted time-series analysis evaluated changes in ED presentation rates; interviews investigated reasons for changes for frequent ED users in a culturally and linguistically diverse setting.

Participants

200 patients were interviewed, mean age 66 years (range 23-99).

Results

Interrupted time series analysis from 4868 eligible participants showed an instantaneous decrease in weekly ED presentations by 36% ($p<0.001$), with reduction between 45% and 66% across emergency triage categories. 32% did not know they could leave home to seek care with differences seen in English versus non-English speakers ($p<0.001$). 35% reported postponing medical care. There was a high fear about the health system becoming overloaded (mean 4.2 (±2) on 6-point scale). Four key themes emerged influencing health seeking behaviour: Fear and/or avoidance of hospital care; Use of telehealth for remote assessment; No fear or avoidance of hospital care; Not leaving the house for any reason.

Conclusions

This study demonstrated reduced emergency department use by a vulnerable population of previously frequent attenders. COVID-19 has resulted in some fear and avoidance of hospitals, but has also offered new opportunity for alternative care through telehealth.

Strengths and limitations of this study

- This study is the first to assess the impact of COVID-19 on the health seeking behaviours of people who had demonstrated a pattern of frequent attendance at the emergency department prior to the pandemic.
- More than 75% of participants in this study were from migrant or refugee backgrounds and more than 2/3 spoke a preferred language that was not English.
- The study seeks to understand reasons for changes in health seeking behaviour from the patient's perspective through interviews with a sub-sample of this population.
- A limitation is that study findings are from a single hospital network in Melbourne and results may not be generalizable to other hospital populations.

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Introduction

One of the unexpected indirect consequences of the COVID-19 pandemic has been delays in access to care for people with pre-existing chronic and complex health and psychosocial conditions. Leading health authorities have expressed concern that there will be a secondary wave of deaths arising from individuals who fail to access care in a timely way (1-3). Hospital emergency departments (EDs) play an important role in the provision of first line care for serious symptoms, illnesses and injuries that are less able to be managed in primary care, as well as for management of less serious health concerns. In Australia and globally there have been reports of significant reductions in ED presentations (1, 3), including up to a 50% reduction in trauma presentations (4), and up to a 30% reduction in presentation rates for stroke and acute myocardial infarction (AMI) (5, 6).

Frequent attenders to ED may be especially vulnerable to problems associated with COVID-19 enforced lockdowns. They are a heterogenous group with chronic and complex physical and/or mental health needs, substance abuse and psychosocial issues. They are more likely to be adversely affected by social isolation and are also at higher than average risk of contracting COVID-19 and having severe disease (7). Frequent users who also have low English proficiency are additionally at risk due to issues with understanding information (7). It is pertinent and timely to examine the drivers behind changes in the health seeking behaviours of this population, whom we consider to be a vulnerable group in the context of COVID-19.

The aims of this study were to (i) describe the impact of COVID-19 on ED attendance for frequent users with existing chronic and complex conditions in a culturally and linguistically diverse setting, and (ii) explore potential reasons for changes in attendance.

Methods

Design

A parallel convergent mixed methods design was used for this study consisting of an interrupted time series analysis to describe changes in service use pre-COVID-19 compared to during COVID-19 and interviews to explore reasons for changes in ED attendance.

Setting

Northern Health (NH) is the major provider of hospital services in the Northern Melbourne Metropolitan Region. Residents in the catchment are culturally diverse, originating from 165 countries, and speaking over 100 languages. The area has lower income, educational attainment and health literacy than Victorian state averages (8, 9). The catchment accounts for 10% of the Victorian population, however 1/3 of Victoria's COVID-19 cases were in this region at the height of the pandemic in Australia.

This study was approved by the NH Human Research Ethics Committee (LNR 64196).

Participants and procedure

Describing the impact of COVID-19 on ED attendance for frequent attenders

We used a case-finding algorithm developed by the Victorian Department of Health and Human Services: the HealthLinks prediction algorithm (supplementary material A) (10) to identify frequent ED attenders in 2019 who were predicted to continue their pattern of attendance. To determine the effect of COVID-19 on attendance we conducted an

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interrupted time series analysis (11). Weekly attendance data were separated into two phases: pre- impact (1st January 2019 to 16th March 2020) and post- COVID-19 (16th March to 30th September 2020). 16th of March was chosen as the impact date to reflect the timing of the declaration of a State of Emergency in Victoria. This included 63 weekly time points pre- and 28 time points post-impact. Based on the distribution of the data, a standard segmented linear regression model was chosen to describe whether COVID-19 impacted the (i) level and (ii) trend of weekly hospital presentations. A change in trend was investigated by introducing an interaction term between the week number and phase (pre vs post COVID-19). We expected an immediate effect of COVID-19, so a time-lag was not introduced between phases. Presentations to ED were observed to be lower in the two weeks surrounding 1 January 2019 and 2020. A sensitivity analysis was therefore used to investigate the seasonal effect of these dates on the overall results of the simpler, unadjusted model. Autocorrelation was investigated using the Durbin-Watson test.

Further inspection of the HealthLinks cohort was considered by stratifying patients by their most severe Australasian Triage Scale triage category over the study period, with a Wilcoxon signed-rank test used to test for change between the March 19th to September 22nd 2019 period and the March 17th to September 20th 2020 period. We also collected data on the top categories for which a change in presentation rate has been identified.

Exploring potential reasons for changes in attendance

Computer generated random sampling was used to select a representative sub-sample of 200 patients for interview from the HealthLinks cohort across age, gender and chronic and complex health conditions. A sample of 200 was considered above the required number to reach thematic saturation but would provide insight across a range of culturally and linguistically diverse groups (12). We employed stratified sampling to include limited English proficiency (LEP) patients from our top spoken languages (Arabic, Turkish, Italian, Assyrian/ Chaldean, Macedonian, Greek, Vietnamese, Punjabi, Mandarin, Persian, Nepali, Hindi and Urdu). Exclusion criteria were: inability to provide informed consent, speaking a language other than those in the top 10, hearing impairment impacting ability to participate in a telephone interview.

Telephone interviews were conducted from 6th July to 24th August 2020. All interviews were conducted by experienced researchers and an interpreter where required. Verbal consent was gained and an explanatory statement was mailed to participants. Participants could withdraw during and up to two weeks following participation. We used an interview guide that included both open- and closed-ended questions adapted from a World Health Organization survey (13). To address the study aims we analysed responses to the following questions:

1. Can you name the four reasons you are allowed to leave home during stage 3/ stage 4 restrictions? (binary)
2. Have you avoided/ postponed any appointments during COVID-19? (binary)
3. How worried are you about the health system being overloaded? (scale)
4. What is your understanding of what you can do to manage your health conditions at the moment? (open)

Responses to binary questions were presented as proportions and for the total sample size of 200 would infer an estimated maximum margin of error of +/- 6.2%. (for a sub-group of

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50, the margin of error increased to +/- 14%). Fear and worry were expressed as means ± standard deviation. Chi Square (and Fisher's Exact test when values <5) to assess whether responses differed for age (dichotomised to <65/ ≥ 65), gender (male/ female) or language (English/ non-English).

Open-ended responses were analysed using content analysis. Content analysis condenses text into small parts (described as 'meaning units'), which are labelled using pre-formulated coding rules which concisely describe the condensed text (14). Two independent researchers developed the meaning units and applied the coding. The level of agreement of the coders was measured using Cohen's Kappa, a statistical measure of inter-rater reliability (15). We considered a kappa-co-efficient of 0.7 or above sufficient evidence of demonstrably similar results on extracts from the data (15).

Results

Describing the impact of COVID-19 on ED attendance for frequent attenders

A total of 4,868 patients met the HealthLinks algorithm criteria for inclusion in the study. Of these, 4679 (96%) people presented to ED at least once between 1st January 2019 through to 21st September 2020. Figure 1 provides a plot for the interrupted time series analysis of weekly ED presentations. At the impact point of COVID-19, there was an immediate reduction in weekly ED presentations by 36% (p<0.001). There was also a further 1% reduction in presentations per week from the point of impact (p<0.001). The Durbin-Watson test indicated no evidence of autocorrelation. There was evidence of seasonality however this did not change the outcome of the simpler, unadjusted model (see supplementary material B and C for coefficients).

Table 1 provides an overview of the change in rates of ED presentations by triage category for the two time periods 19th March to 22nd September 2019 and 17th March to 20th September 2020 for the eligible cohort. There was a statistically significant difference in ED presentations across the two timeframes when stratified by triage category (p<0.001 for categories 1 to 4 and p=0.013 for category 5), with the largest decrease being seen for triage categories three and four (-62% and -66% respectively).

Table 1: ED presentations for Health Links patients by triage category

Category	*2019 total presentations	*2020 total presentations	% difference	P value
One (resuscitation)	195	102	-48%	<0.001
Two (emergency)	3488	1929	-45%	<0.001
Three (urgent)	3072	1169	-62%	<0.001
Four (semi-urgent)	339	114	-66%	<0.001
Five (non-urgent)	12	4	-67%	0.013

*Data date ranges: March 19th to September 22nd, 2019 and March 17th to September 20th, 2020

Table 2 provides an overview of the top 10 largest reductions in presentations by diagnostic categories. In terms of overall percentage change, the largest decrease in presentations was for viral infections. In raw numbers, the largest decrease was for chest pain.

Table2 : Top 10 diagnostic categories based on change for Health Links patients

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Category	*2019 total presentations	*2020 total presentations	% difference
Acute / Lower respiratory tract infection, chest	156	35	-78%
Renal colic	130	32	-75%
(Unknown) - People left before diagnosis	131	35	-73%
Collapse / Faint / Vasovagal attack / Micturition / syncope. Excludes Syncope caused by heat	114	34	-70%
Dizziness / Vertigo	146	47	-68%
Chest pain	815	339	-58%
Backache, unspecified	117	50	-57%
Abdominal / Flank pain / cramps / Intestinal Colic	541	256	-53%
Chronic obstructive pulmonary disease (COPD)	185	104	-44%
Congestive cardiac failure	168	100	-40%

*Data date ranges: March 19th to September 22nd, 2019 and March 17th to September 20th, 2020

Exploring potential reasons for changes in attendance

We approached 272 individuals to participate in the interviews before reaching our target of 200 participants (response rate 64%). Twenty-nine countries of origin and 11 languages were represented in the group. Mean age was 66 years (range 23 to 99) (supplementary material D).

Table 3 provides an overview of participants' understanding about restrictions, their health-seeking behaviours and their fear and worry about the health system. Only 66% of participants identified that they could leave home to seek medical care, with those speaking English 1.4 times more likely to report this than those with limited English proficiency ($p < 0.001$). Over one third of respondents (35%) reported they had postponed medical care since the pandemic began, however there were no significant differences between participants across age, gender or language. There was a high level of fear about the health system becoming overloaded, with the mean score on a 0 to 6 scale being 4.2 (±2). There was no difference in mean scores within levels of age, gender or language spoken.

Table 4 provides an overview of the content analysis for the question 'What is your understanding of what you are allowed to do to manage your health conditions at the moment?' Four key themes emerged from the data on influences on, or changes to, health-seeking behaviour. These were: Fear and/or avoidance of hospital care; Use of telehealth to connect to general practitioner (GP) for remote assessment; No fear or avoidance of hospital care; Not leaving the house for any reason. There was substantial to almost perfect agreement between the two raters on the first application of content analysis by two reviewers, with Kappa co-efficients ranging from 0.83 to 0.93.

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Table 3: Participants' understanding of restrictions, health-seeking behaviours and fear about the health system

		Age			Gender			Language		
	Overall	**<65**	**≥65**	**P value**	**Male**	**Female**	**P value**	**English**	**Non-English**	**P value**
Four reasons to leave home – number correctly identified (%) (n= 200)			24 (20.2%)		33 (32.0%)	30 (30.9%)				
Work			86 (72.3%)		79 (77.5%)	79 (81.4%)				
Shopping	63 (31.5%)	39 (48.1%)	53 (44.5%)	<0.001	52 (51.0%)	45 (46.4%)	0.87	25 (29.4%)	38 (33.0%)	0.58
Exercise	158 (79.4%)	72 (90.0%)	74 (62.2%)	0.002	63 (61.8%)	68 (70.1%)	0.49	71 (84.7%)	86 (75.4%)	0.11
Attend medical	97 (48.7%)	44 (55.0%)	57 (71.3%)	0.15	32 (31.1%)	38 (39.2%)	0.52	45 (52.9%)	52 (45.6%)	0.31
	131 (65.8%)	57 (71.3%)		0.19			0.22	67 (78.8%)	64 (56.1%)	<0.001
Has postponed or avoided an appointment/s since the pandemic began (n=179)	70 (35.0%)	33 (40.7%)	37 (31.1%)	0.014	32 (31.1%)	38 (39.2%)	0.22	34 (40.0%)	36 (31.3%)	0.001
Fear and worry about the health system being overloaded on a scale from 0 to 6 with 0 being no fear and 6 being most fearful or worried you've ever been (n=171)	Mean 4.2 (SD 2)	4.4 (1.8) (n=78)	4.0 (2.2) (n=93)	0.48	4.1 (2.0) (n=85)	4.3 (2.1) (n=86)	0.37	4.3 (2.0) (n=81)	4.1 (2.1) (n=90)	0.54

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Table 4: What is your understanding of what you are allowed to do to manage your health condition?

Theme	Cohen's Kappa (p-value)*	Agreed final total responses n=175**	Example of responses
Fear/ Avoidance of hospital care	0.93 P<0.001	48 (27%)	Last night I had heart pain but I didn't go anywhere because I am scared. Would I go to the Northern [Hospital]? - no, because they have COVID-19. I am worried about going to the hospital because there are sick people and COVID people at the place and health professionals are among those that test positive for COVID.
Would be comfortable to call general practitioner for advice/ remote assessment	0.86 P<0.001	70 (40%)	Communicate on the phone instead. I think you're allowed to call local GP if you are unwell. They get your symptoms over phone. if very unwell, come in otherwise they provide advice over phone. Can get script easily by calling ahead and doing contactless pick up.
Would be comfortable to attend or call the hospital	0.83 P<0.001	53 (30%)	If I need to go to the hospital, I would just go. I'm not worried about going to the doctor or the hospital - they would tell me not to come in if they were worried. No of the restrictions apply if you are seeking medical help, you can use common sense to seek help. Even if the hospital is more than 5kms I'm not worried about going to the hospital. We have a great medical system and I have full faith in them.
Don't go out at all	0.93 P<0.001	8 (4%)	Don't leave house. Not allowed to go interstate, not allowed to leave home. Stay at home, not going to seek help.

** Kappa result is interpreted as follows: values ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement (Cohen ref). Kappa results following first round of coding are presented. P-values reflect a test against a minimum Kappa of 0.7.*

*** n=25 participants did not respond to these questions*

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Almost 1/3 of participants reported they would not attend the hospital for care for fear of contracting COVID-19. A further 1/3 reported no fear about coming to the hospital. 40% of participants reported use of telehealth as a first response to health issues. A small number of participants (4%) reported not leaving the house for any reason.

Discussion

This study provides both evidence of, and explanation for, a significant change in ED presentations in a group of patients with a history of frequent attendance prior to the COVID-19 pandemic. Weekly ED presentations fell by 36% and continued to fall by 1% per week following the declaration of a state of emergency in Victoria. Just over one third of participants reported actively avoiding the hospital, and these behaviours appear to be equally influenced by fear as well as better access and funding for remote care. Importantly, patients with low English proficiency were less likely to identify health care as one of the reasons they could leave home during the pandemic.

Fear and access to telehealth only partly explains the reduction in ED presentations for this cohort as reductions in attendance have occurred across all ED triage categories. Of particular concern is the reduction in presentations for acute cardiovascular events, a finding consistent with studies internationally (6, 16, 17). These studies agree that this stems from fear (6, 16, 17), along with a genuine reduction in events during the pandemic possibly due to a reduction in triggers such as air pollution, physical activity and acute emotional stress (6, 16-18).

The recent changes in funding arrangements that allow GPs to provide virtual care delivery appears to have been embraced by many of the interview participants, possibly improving access and reducing perceived need to attend an ED for care. For many conditions, telehealth allows individuals to be managed efficiently screened and treated, and is patient-centred, reducing patient costs associated with travel and waiting times (19). Policy changes that enhance the use of telehealth for chronic disease management may reduce disparities in access to care and improve outcomes among the most vulnerable populations (20).

A reduction in cardiovascular events may also be due to a genuine decrease in events due to social distancing and isolation. A reduction in circulating viruses has led to fewer exacerbations of existing airways disease and the associated elevation of pro-inflammatory biomarkers that leads to cardiovascular events (21). This is supported by research that demonstrates that influenza vaccination is associated with reduced risk of stroke (22) and that rates of AMI increase during influenza season (22). There have been no deaths from influenza recorded in Australia in 2020 – this compares to 310,000 hospitalisations and over 900 deaths in 2019 (23). It is therefore plausible that the reduced pro-inflammatory burden on homeostasis in vulnerable patients has led to reduced rates of stroke and AMI during the pandemic.

Frequent attenders to the ED account for disproportionately high health care costs. Research has focused on methods for 'diverting' patients away from EDs to primary care services with mixed success (24). COVID-19 has provided a catalyst where large

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scale adoption and mainstreaming of telehealth has been tested (25). Our research suggests that frequent attenders are adopting telehealth, and that they are capable of changes to their health-seeking behaviour if health systems are designed and provided in a way that adequately supports them. Further research is required to determine whether these observed changes are sustainable post-COVID-19. In addition, longer term studies examining excess morbidity and mortality for patients who have forgone ED care during the pandemic is required.

One of the strengths of this study is the mixed methods design. The content analysis provides some explanation for the reduction in presentations to the ED for frequent attenders during COVID-19. A limitation is that study findings are from a single hospital network in Melbourne and results may not be generalisable. In addition, the interview cohort focused on only the top 10 most spoken languages at NH and some important groups with low representation may not have been captured. Importantly, reductions in ED presentation both in terms of rates and diagnostic categories at NH appear in line with what has been seen at other hospitals in Victoria (26) and internationally (6, 27). Data on this cohort's use of GP services are not available and we can only hypothesise, based on their interview responses, that they have more readily interacted with their GP's during this time.

Conclusion

This study demonstrated reduced ED use by a group of previously high attenders. COVID-19 has necessitated a rapid pivot towards readily accessible, remotely provided health care outside of the hospital. In this way, COVID-19 has been a driver towards achieving what multiple complex interventions could not. A reduction in physiological stress, putatively brought about by home isolation and exposure to fewer viral infections, might reduce inflammatory burden and therefore reduce cardiovascular events, leading to fewer high acuity ED presentations.

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Figure legend: The vertical dashed line is at the 16th of March coinciding with commencement of the Victorian State of Emergency. The x axis values represent year and week within that year. E.g. 2019-40 represents the 40th week in 2019. The dashed blue line represents the expected trajectory of ED presentations if COVID-19 pandemic had not occurred.

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Data Sharing Statement
De-identified participant data from this research will be shared upon reasonable request with the corresponding author.

Author Contributions
The author and overall design was conceived by RLJ, AB and AS and operationalised by RLJ and CB. RLJ, CB, NC, DA, HM, YC, AG and TH conducted the data collection. AS, AG, MT, RLJ and PC conducted the quantitative analysis and BL, CH, AT and AB conducted the qualitative analysis. RLJ wrote the first draft of the manuscript and all authors contributed to the analysis strategy and all drafts. All authors contributed to the interpretation for the results. All authors critically reviewed the manuscript and approved the final version.

Competing interest statement
All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three year, no other relationships or activities that could appear to have influenced the submitted work.

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Patient and public involvement

This project was reviewed by an ethics committee that included consumer representatives that were able to provide feedback on methods (including interview questions). All participants were patients of Northern Health. There was no other patient or public involvement in this research.

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Figure 1: Total ED presentations per week for Health Links cohort

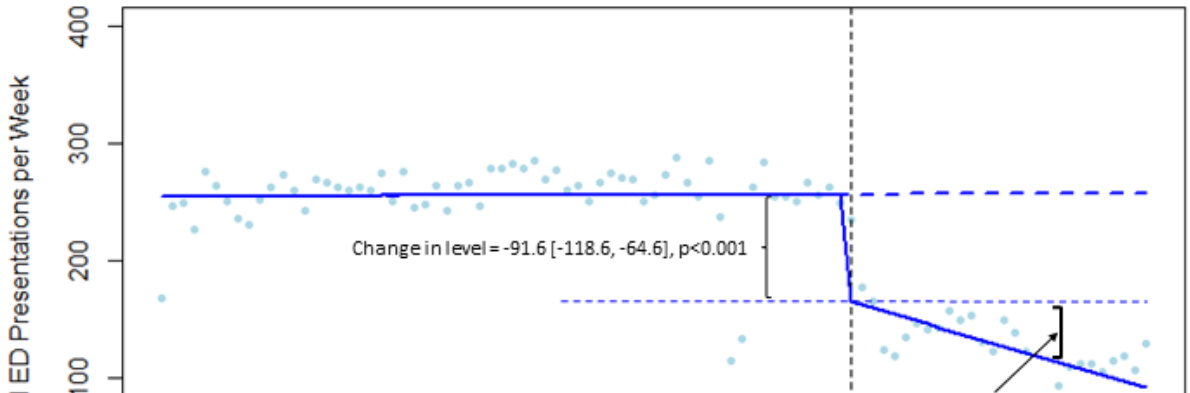

Figure legend: The vertical dashed line is at the 16th of March coinciding with commencement of the Victorian State of Emergency. The x axis values represent year and week within that year. E.g. 2019-40 represents the 40th week in 2019. The dashed blue line represents the expected trajectory of ED presentations if COVID-19 pandemic had not occurred.

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Supplementary material A: Criteria used for Health Links prediction algorithm

- Age
- Number of unplanned admissions in the past six months
- Number of emergency department visits in the past three months
- Hospital stay being caused by selected chronic progressive condition(s) and multiple co-morbidities such as asthma, kidney disease, chronic obstructive pulmonary disease, rheumatoid arthritis, hepatitis
- Smoking status
- Place of residence (residential aged care or private residence).

Each criterion provides a weighted value and inclusion into Health Links is triggered once a points threshold is reached. A strong correlation has been demonstrated between the observed and expected proportions of frequent users, and the model has been found to accurately identify patients who will be admitted three or more times in the following 12 months 32% of the time .

Supplementary material B: Coefficients of segmented interrupted time series analysis (note, data is centred around COVID impact)

term	Coefficiant	std.error	p.value	Lower CI	Upper CI
(Intercept)	256.390	7.738	<0.001	241.009	271.770
Week	0.025	0.210	0.907	-0.393	0.442
Covid Phase	-91.567	13.587	<0.001	-118.574	-64.560
Week : COVID Phase (Interaction)	-2.742	0.740	<0.001	-4.213	-1.270

Supplementary material C: Coefficients of segmented interrupted time series analysis adjusted for season (note, data is centred around COVID impact)

term	Coefficient	std.error	p.value	Lower CI	Upper CI
(Intercept)	264.549	5.323	<0.001	253.967	275.132
Week	0.096	0.143	0.505	-0.189	0.380
Covid Phase	-99.727	9.274	<0.001	-118.163	-81.290
Season	-123.535	12.222	<0.001	-147.831	-99.240
Week : COVID Phase (Interaction)	-2.813	0.503	<0.001	-3.814	-1.812

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Supplementary material D: COM-VID study demographic characteristics for Health Links eligible cohort and subsample of interview participants

	Interview participants (n = 200)	Health Links eligible cohort 2019 (n = 4,868)
Age (SD)	66.4 (15.6)	66.9 (17.5)
Gender Male Female	103 (52%) 97 (49%)	2,282 (47%) 2,586 (53%)
Spoken Language English Speaking Non-English Speaking	85 (43%) 115 (58%)	3,454 (71%) 1,414 (29%)
Primary Language Southern European (Italian, Greek, Turkish, Maltese, Macedonian) West Asian/ Middle Eastern (Arabic, Assyrian/ Chaldean Neo-Aramaic, Persian) East, South and South-East Asia (Hindi, Urdu, Punjabi, Mandarin, Vietnamese, Nepalese)	 54 (27%) 43 (22%) 19 (9%)	 901 (19%) 295 (6%) 59 (1%)

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5 - 6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4 - 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4 - 6
Bias	9	Describe any efforts to address potential sources of bias	5 - 6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-7 and tables
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5-7
		(b) Indicate number of participants with missing data for each variable of interest	

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		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	4-8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(*b*) Report category boundaries when continuous variables were categorized	6-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6-8
Discussion			
Key results	18	Summarise key results with reference to study objectives	7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	7-8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	MJA portal

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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The impact of COVID-19 on emergency department attendance in an Australia hospital: a parallel convergent mixed methods study

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ABSTRACT

Objectives

The COVID-19 pandemic has changed the way people are accessing healthcare. The aim of this study was to examine the impact of coronavirus (COVID-19) on emergency department (ED) attendance for frequent attenders and to explore potential reasons for changes in attendance.

Design

This convergent parallel mixed methods study comprised two parts.

Setting

An interrupted time-series analysis evaluated changes in ED presentation rates; interviews investigated reasons for changes for frequent ED users in a culturally and linguistically diverse setting.

Participants

A total of 4,868 patients were included in the time-series. A sub-group of 200 patients were interviewed, mean age 66 years (range 23-99).

Results

Interrupted time series analysis from 4868 eligible participants showed an instantaneous decrease in weekly ED presentations by 36% ($p<0.001$), with reduction between 45% and 66% across emergency triage categories. 32% did not know they could leave home to seek care with differences seen in English versus non-English speakers ($p<0.001$). 35% reported postponing medical care. There was a high fear about the health system becoming overloaded (mean 4.2 (±2) on 6-point scale). Four key themes emerged influencing health

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seeking behaviour: Fear and/or avoidance of hospital care; Use of telehealth for remote assessment; No fear or avoidance of hospital care; Not leaving the house for any reason.

Conclusions

This study demonstrated reduced emergency department use by a vulnerable population of previously frequent attenders. COVID-19 has resulted in some fear and avoidance of hospitals, but has also offered new opportunity for alternative care through telehealth.

Strengths and limitations of this study

- This study is the first to assess the impact of COVID-19 on the health seeking behaviours of people who had demonstrated a pattern of frequent attendance at the emergency department prior to the pandemic.
- More than 75% of participants in this study were from migrant or refugee backgrounds and more than 2/3 spoke a preferred language that was not English.
- The study seeks to understand reasons for changes in health seeking behaviour from the patient's perspective through interviews with a sub-sample of this population.
- A limitation is that study findings are from a single hospital network in Melbourne and results may not be generalizable to other hospital populations.

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Introduction

One of the unexpected indirect consequences of the COVID-19 pandemic has been avoidance of care for people with pre-existing chronic and complex health and psychosocial conditions. Leading health authorities have expressed concern that there will be a secondary wave of deaths arising from individuals who fail to access care in a timely way (1-3). Hospital emergency departments (EDs) play an important role in the provision of first line care for serious symptoms, illnesses and injuries that are less able to be managed in primary care, as well as for management of less serious health concerns. In Australia and globally there have been reports of significant reductions in ED presentations (1, 2), including up to a 50% reduction in trauma presentations (4), and up to a 30% reduction in presentation rates for stroke and acute myocardial infarction (AMI) (5, 6).

Australia is a multicultural country, with almost 30% of Australians born overseas and over 200 languages spoken (7). Residents of the northern suburbs of Melbourne are more culturally diverse than the Australian average, with more than 40% of residents born overseas (8). The area has lower income, educational attainment, and health literacy than Victorian state averages (8-10). Approximately 10% of Victorias population live in the northern suburbs of Melbourne, however 1/3 of Victoria's COVID-19 cases were located in this area at the height of the pandemic, reflecting the greater vulnerabilities to COVID-19 experienced in this community.

Frequent attenders to ED may be especially vulnerable to problems associated with COVID-19 enforced lockdowns. They are a heterogenous group with chronic and complex physical

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and/or mental health needs, substance abuse and psychosocial issues. They are more likely to be adversely affected by social isolation and are also at higher-than-average risk of contracting COVID-19 and having severe disease (11). Frequent users who also have low English proficiency are additionally at risk due to issues with understanding information and applying it to their situation (11). It is pertinent and timely to examine the drivers behind changes in the health seeking behaviours of this population, whom we consider to be a vulnerable group in the context of COVID-19.

The aims of this study were to (i) describe the impact of COVID-19 on ED attendance for frequent users with existing chronic and complex conditions in a culturally and linguistically diverse setting, and (ii) explore potential reasons for changes in attendance.

Methods

Design

A parallel convergent mixed methods design was used for this study consisting of; an interrupted time series analysis to describe changes in service use pre-COVID-19 compared to during COVID-19, and interviews to explore reasons for changes in ED attendance.

Setting

In Australia, the largest outbreak of COVID-19 to date was in Melbourne in 2020, accounting for 75% of all Australian cases (n = 20,330 on 24th October), and 90% of all deaths (n=817). In response to rising COVID-19 case numbers, a state of emergency was declared in Victoria on the 16th of March 2020. On the 23rd of March Stage 3 restrictions were implemented

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that limited travel out of the home. These were lifted for a short period of time from the 13th of May to the 8th of July when restrictions were reintroduced. On the 2nd of August the Victorian government imposed a Stage 4 lockdown, adding a night-time curfew, further restriction of daytime activities (including imposing a 5km radius for essential shopping and exercise), and large financial penalties for breaches. Cases in Victoria peaked on the 5th of August, when 725 new cases were reported in the State over a 24-hour period. The state of emergency was extended seven times and remained in place until the 8th of November, 2020.

Northern Health (NH) is the major provider of hospital services in the northern Melbourne metropolitan region. It has the busiest ED in Victoria. This study was approved by the NH Human Research Ethics Committee (LNR 64196).

Patient and public involvement

This project was reviewed by an ethics committee that included consumer representatives who provided feedback on the interview questions and on study methods. All participants were patients of NH and all will be provided a report of findings. There was no other patient or public involvement in this research.

Participants and procedure

Describing the impact of COVID-19 on ED attendance for frequent attenders

Data was sourced from the NH data warehouse. A request was made for all hospital attendances from the period of 1st January 2019 to 30th September 2020. To identify the

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most vulnerable cohort of patients, we used a case-finding algorithm developed by the Victorian Department of Health and Human Services (HealthLinks prediction algorithm) to identify patients who met the criteria and who were predicted to continue their pattern of attendance.(supplementary material A) (12). The algorithm is designed to identify patients most at risk of preventable hospital admissions, with escalating ED attendance being one of a number of predictor variables. To determine the effect of COVID-19 on attendance we conducted an interrupted time series analysis (13) separately for the Healthlinks group (frequent attenders), and the remaining group (non-frequent attenders). Weekly attendance data were separated into two phases: pre- impact (1st January 2019 to 16th March 2020) and post- COVID-19 (16th March to 30th September 2020). 16th of March was chosen as the impact date to reflect the timing of the declaration of the State of Emergency. This included 63 weekly time points pre- and 28 time points post-impact. Based on the distribution of the data, a standard segmented linear regression model was chosen to describe whether COVID-19 impacted the (i) level and (ii) trend of weekly hospital presentations. A change in trend was investigated by introducing an interaction term between the week number and phase (pre vs post COVID-19). We expected an immediate effect of COVID-19, so a time-lag was not introduced between phases. Presentations to ED were observed to be lower in the two weeks surrounding 1 January 2019 and 2020. A sensitivity analysis was therefore used to investigate the seasonal effect of these dates on the overall results of the simpler, unadjusted model. Autocorrelation was investigated using the Durbin-Watson test.

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Further inspection of the HealthLinks cohort was considered by stratifying patients by their most severe Australasian Triage Scale (14, 15) triage category over the study period, with a Wilcoxon signed-rank test used to test for change between the March 19th to September 22nd 2019 period and the March 17th to September 20th 2020 period. We also collected data on the top categories for which a change in presentation rate has been identified.

Exploring potential reasons for changes in attendance

Computer generated random sampling was used to select a representative sub-sample of 200 patients for interview from the HealthLinks cohort across age, gender and chronic and complex health conditions. A sample of 200 was considered above the required number to reach thematic saturation but would provide insight across a range of culturally and linguistically diverse groups (16). We employed stratified sampling to include limited English proficiency patients from our top spoken languages (Arabic, Turkish, Italian, Assyrian/ Chaldean, Macedonian, Greek, Vietnamese, Punjabi, Mandarin, Persian, Nepali, Hindi and Urdu). Exclusion criteria were: inability to provide informed consent, speaking a language other than those in the top 10, hearing impairment impacting ability to participate in a telephone interview.

Telephone interviews were conducted from 6th July to 24th August 2020, over the peak of the pandemic in Melbourne. All interviews were conducted by experienced researchers and an interpreter where required. Verbal consent was gained and an explanatory statement was mailed to participants. Participants could withdraw during and up to two weeks following participation. We used an interview guide that included both open- and closed-

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ended questions adapted from a World Health Organization survey (17). To address the study aims we analysed responses to the following questions:

1. Can you name the four reasons you are allowed to leave home during stage 3/ stage 4 restrictions? (binary)
2. Have you avoided/ postponed any appointments during COVID-19? (binary)
3. How worried are you about the health system being overloaded? (scale)
4. What is your understanding of what you can do to manage your health conditions at the moment? (open)

Responses to binary questions were presented as proportions and for the total sample size of 200 would infer an estimated maximum margin of error of +/- 6.2%. (for a sub-group of 50, the margin of error increased to +/- 14%). Fear and worry were expressed as means ± standard deviation. Chi Square (and Fisher's Exact test when values <5) to assess whether responses differed for age (dichotomised to <65/ ≥ 65), gender (male/ female) or language (English/ non-English).

Open-ended responses were analysed using content analysis. Content analysis condenses text into small parts (described as 'meaning units'), which are labelled using pre-formulated coding rules which concisely describe the condensed text (18). Two independent researchers developed the meaning units and applied the coding. The level of agreement of the coders was measured using Cohen's Kappa, a statistical measure of inter-rater reliability (19). We considered a kappa-co-efficient of 0.7 or above sufficient evidence of demonstrably similar results on extracts from the data (19).

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Results

Describing the impact of COVID-19 on ED attendance for frequent attenders

A total of 4,868 patients met the HealthLinks algorithm criteria for inclusion in the study. Of these, 4679 (96%) people presented to ED at least once between 1st January 2019 through to 21st September 2020. Figure 1A provides a plot for the interrupted time series analysis of weekly ED presentations. At the impact point of COVID-19, there was an immediate reduction in weekly ED presentations by 36% ($p<0.001$). There was also a further 1% reduction in presentations per week from the point of impact ($p<0.001$). The Durbin-Watson test indicated no evidence of autocorrelation. There was evidence of seasonality however this did not change the outcome of the simpler, unadjusted model (see supplementary material B and C for coefficients).

Figure 1B provides an illustrative comparison of weekly ED presentations for those not identified as frequent presenters. There were 105,062 patients in the cohort who presented to ED but who were not healthlinks patients over the same timeframe. At the point of COVID-19, ED presentations for this cohort significantly reduced by 15% ($p=0.007$) from baseline, with a further reduction of 0.6% per week from baseline ($p=0.041$).

Table 1 provides an overview of the change in rates of ED presentations by triage category for the two time periods 19th March to 22nd September 2019 and 17th March to 20th September 2020 for the eligible cohort. There was a statistically significant difference in ED presentations across the two timeframes when stratified by triage category ($p<0.001$ for

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categories 1 to 4 and p=0.013 for category 5), with the largest decrease being seen for triage categories three and four (-62% and -66% respectively).

Table 1: ED presentations for HealthLinks patients by Australasian Triage Scale triage category

Category	*2019 total presentations	*2020 total presentations	% difference	P value
Resuscitation (1)	195	102	-48%	<0.001
Emergency (2)	3488	1929	-45%	<0.001
Urgent (3)	3072	1169	-62%	<0.001
Semi-urgent (4)	339	114	-66%	<0.001
Non-urgent (5)	12	4	-67%	0.013

*Data date ranges: March 19th to September 22nd, 2019 and March 17th to September 20th, 2020

Table 2 provides an overview of the top 10 largest reductions in presentations by diagnostic categories. In terms of overall percentage change, the largest decrease in presentations was for viral infections. In raw numbers, the largest decrease was for chest pain.

Table2 : Top 10 diagnostic categories based on change for HealthLinks patients

Category	*2019 total presentations	*2020 total presentations	% difference
Acute / Lower respiratory tract infection, chest	156	35	-78%
Renal colic	130	32	-75%
(Unknown) - People left before diagnosis	131	35	-73%
Collapse / Faint / Vasovagal attack / Micturition / syncope. Excludes Syncope caused by heat	114	34	-70%
Dizziness / Vertigo	146	47	-68%
Chest pain	815	339	-58%
Backache, unspecified	117	50	-57%
Abdominal / Flank pain / cramps / Intestinal Colic	541	256	-53%
Chronic obstructive pulmonary disease (COPD)	185	104	-44%
Congestive cardiac failure	168	100	-40%

*Data date ranges: March 19th to September 22nd, 2019 and March 17th to September 20th, 2020

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Exploring potential reasons for changes in attendance

We approached 272 individuals to participate in the interviews before reaching our target of 200 participants (response rate 73.5%). Twenty-nine countries of origin and 11 languages were represented in the group. Mean age was 66 years (range 23 to 99) (supplementary material D). 14.5% of participants (n = 29) were unable to complete all questions in the interviews. Those who did not complete were slightly older (mean age 71, SD 16) and 25 spoke limited English and were interviewed using interpreters. All who did not complete cited their reason for incompletion as fatigue.

Table 3 provides an overview of participants' understanding about restrictions, their health-seeking behaviours and their fear and worry about the health system becoming overloaded. Only 66% of participants identified that they could leave home to seek medical care, with those speaking English 1.4 times more likely to report this than those with limited English proficiency (p <0.001). Over one third of respondents (35%) reported they had postponed medical care since the pandemic began, and those who spoke proficient English were significantly more likely to have postponed or cancelled an appointment than those with limited English proficiency (p -.001). There was a high level of fear about the health system becoming overloaded, with the mean score on a 0 to 6 scale being 4.2 (±2). There was no significant difference in mean scores in age, gender or language spoken.

Table 4 provides an overview of the content analysis for the question 'What is your understanding of what you are allowed to do to manage your health conditions at the

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moment?' Four key themes emerged from the data on influences on, or changes to, health-seeking behaviour. These were: Fear and/or avoidance of hospital care; Use of telehealth to connect to general practitioner (GP) for remote assessment; No fear or avoidance of hospital care; Not leaving the house for any reason. There was substantial to almost perfect agreement between the two raters on the first application of content analysis by two reviewers, with Kappa co-efficients ranging from 0.83 to 0.93.

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Table 3: Participants' understanding of restrictions, health-seeking behaviours and fear about the health system

		Age			Gender			Language		
	Overall	**<65**	**≥65**	**P value**	**Male**	**Female**	**P value**	**English**	**Non-English**	**P value**
Four reasons to leave home – number correctly identified (%) (n= 200)										
Work	63 (31.5%)	39 (48.1%)	24 (20.2%)	<0.001	33 (32.0%)	30 (30.9%)		25 (29.4%)	38 (33.0%)	0.58
Shopping	158 (79.4%)	72 (90.0%)	86 (72.3%)	0.002	79 (77.5%)	79 (81.4%)		72 (84.7%)	86 (75.4%)	0.11
Exercise	97 (48.7%)	44 (55.0%)	53 (44.5%)	0.15	52 (51.0%)	45 (46.4%)		45 (52.9%)	52 (45.6%)	0.31
Attend medical*	131 (65.8%)	57 (71.3%)	74 (62.2%)	0.19	63 (61.8%)	68 (70.1%)		67 (78.8%)	64 (56.1%)	<0.001
Has postponed or avoided an appointment/s (n=179)	70 (35.0%)	33 (40.7%)	37 (31.1%)	0.014	32 (31.1%)	38 (39.2%)	0.2	34 (40.0%)	36 (31.3%)	0.001**
Fear and worry about the health system being overloaded** (n=171)	Mean 4.2 (SD 2)	4.4 (SD1.8) (n=78)	4.0(SD2.2) (n=93)	0.48	4.1 (SD2.0) (n=85)	4.3 (SD2.1) (n=86)	0.3	4.3 (SD2.0) (n=81)	4.1 (SD2.1) (n=90)	0.54

** Four reasons to leave home were to 1) attend workplace if providing approved essential service 2) shop for groceries or pharmaceuticals 3) exercise for 1 hour 4) attend medical appointment or provide care*

*** There was also a statistically significant difference in the number of missing values for English versus non-English speakers (n=6 [7%] versus 21 [18.3%], p<001)*

**** Scaled response from 0 to 6, with 0 being no fear and 6 being most fearful or worried you've ever been*

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Table 4: What is your understanding of what you are allowed to do to manage your health condition?

Theme	Cohen's Kappa (p-value)*	Agreed final total responses n=175**	Example of responses
Fear/ Avoidance of hospital care	0.93 P<0.001	48 (27%)	Last night I had heart pain but I didn't go anywhere because I am scared. Would I go to the Northern [Hospital]? - no, because they have COVID-19. I am worried about going to the hospital because there are sick people and COVID people at the place and health professionals are among those that test positive for COVID.
Would be comfortable to call general practitioner for advice/ remote assessment	0.86 P<0.001	70 (40%)	Communicate on the phone instead. I think you're allowed to call local GP if you are unwell. They get your symptoms over phone. if very unwell, come in otherwise they provide advice over phone. Can get script easily by calling ahead and doing a contactless pick up.
Would be comfortable to attend or call the hospital	0.83 P<0.001	53 (30%)	If I need to go to the hospital, I would just go. I'm not worried about going to the doctor or the hospital - they would tell me not to come in if they were worried. No of the restrictions apply if you are seeking medical help, you can use common sense to seek help. Even if the hospital is more than 5km, I'm not worried about going to the hospital. We have a great medical system and I have full faith in them.
Don't go out at all	0.93 P<0.001	8 (4%)	Don't leave house. Not allowed to go interstate, not allowed to leave home. Stay at home, not going to seek help.

** Kappa result is interpreted as follows: values ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement (Cohen ref). Kappa results following first round of coding are presented. P-values reflect a test against a minimum Kappa of 0.7.*

*** n=25 participants did not respond to these question*

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Almost 1/3 of participants reported they would not attend the hospital for care for fear of contracting COVID-19. A further 1/3 reported no fear about coming to the hospital. 40% of participants reported use of telehealth as a first response to health issues. A small number of participants (4%) reported not leaving the house for any reason.

Discussion

This study provides both evidence of, and explanation for, a significant change in ED presentations in a group of patients with a history of frequent attendance prior to the COVID-19 pandemic. We found for this group, presentations fell by 36% and continued to fall by 1% per week, which was more than double the 15% drop and weekly reduction of 0.6% seen for non-frequent attenders. Participants with low English proficiency were less likely than those with proficient English to identify health care as one of the reasons they could leave home during the pandemic, suggesting they may have had greater trouble understanding and interpreting government-imposed restrictions, and may not have realised they were allowed to leave home to seek medical care. However, those with lower English proficiency were also less likely to report postponing a medical appointment than those with proficient English. While this finding might be unexpected, the content analysis indicated that the majority of participants were either using telehealth care (40%), or were not afraid to attend the hospital for appointments (30%).

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The recent changes in funding arrangements in Australia that allow GPs to provide telehealth care appears to have been embraced by many of the interview participants, including those with limited English proficiency. This has possibly led to improved access to primary care, thus reducing perceived need to attend ED. This is reflected in the greater reductions seen for lower acuity conditions across triage categories 3 to 5 in this study. For many conditions, telehealth allows individuals to be efficiently screened and treated, and is patient-centred, reducing patient costs associated with travel and waiting times (20). Studies have shown that there has been greater uptake of telehealth from older people during the pandemic than pre-pandemic, perhaps reflecting that this medium provides a safe alternative to face-to-face care for those at higher risk from the virus (21-23). However, these studies also demonstrated that racial disparities that existed in the access and use of telehealth prior to the pandemic were still evident during the pandemic. Policy changes that enhance the use of telehealth for chronic disease management should continue to work toward improving engagement for disadvantaged communities to reduce disparities and improve outcomes.

Similar to our findings, many countries worldwide have seen a reduction in ED presentations, and many have seen the greatest changes in the same diagnostic categories as seen in this study, including for genitourinary, respiratory and circulatory conditions as seen in the top 10 in this study (24-27). Some of the reductions in presentations for these higher acuity conditions have the potential be underdiagnosis due to avoidance of care and may result in excess morbidity and mortality indirectly related to COVID-19. Of particular concern is the reduction in

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presentations in triage categories 1 and 2, including acute cardiovascular events, a finding consistent with studies internationally (6, 24, 28). These studies agree that this partly stems from avoidance of care derived from fear, but may also be attributable to a genuine reduction in events during the pandemic due to a reduction in triggers such as air pollution, physical activity and acute emotional stress. A reduction in circulating viruses has led to fewer exacerbations of existing airways disease and reduced presentations for respiratory infections and COPD, and may have resulted in reductions in the elevation of pro-inflammatory biomarkers that leads to cardiovascular events (29). This is supported by research that demonstrates that influenza vaccination is associated with reduced risk of stroke (30) and that rates of AMI increase during influenza season (31). There were no deaths from influenza recorded in Australia in 2020 – this compares to 310,000 hospitalisations and over 900 deaths in 2019 (32). It is therefore plausible that the reduced pro-inflammatory burden on homeostasis in vulnerable patients has led to reduced rates of stroke and AMI during the pandemic.

Frequent attenders to the ED account for disproportionately high health care costs. Much research has focused on methods for 'diverting' patients away from EDs to primary care services with mixed success (33). COVID-19 has provided a catalyst where large scale adoption and mainstreaming of telehealth has been tested (34). Our research suggests that frequent attenders are adopting telehealth, and that they are capable of changes to their health-seeking behaviour if health systems are designed and provided in a way that adequately supports them. Further research is required to determine whether these observed changes are sustainable post-COVID-

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19. In addition, longer term studies examining excess morbidity and mortality for patients who have forgone ED care during the pandemic is required.

A limitation of the study is that participants who had limited English proficiency were over-represented in the group that did not complete all questions, and this may have impacted on the significance found for some of the outcomes. In addition, the interview cohort focused on only the top 10 most spoken languages at NH and some important groups with low representation may not have been captured. A further limitation of this study is that findings are from a single hospital network in Melbourne and results may not be generalisable. Importantly, reductions in ED presentation both in terms of rates and diagnostic categories at NH appear in line with what has been seen at other hospitals in Victoria (25) and internationally . Data on this cohort's use of GP services are not available and we can only hypothesise, based on their interview responses, that they have more readily interacted with their GP's during this time.

Conclusion

The second wave of COVID-19 in Victoria resulted in a significant reduction in ED attendances across the state. This study found that for patients with a history of frequent attendance prior to the COVID-19 pandemic the reduction in presentations fell by 36% and continued to fall by 1% per week, compared to a 15% drop in non-frequent attenders and a weekly reduction of 0.6% per week. More than one third of participants reported actively avoiding the hospital, however the content analysis suggests that these changes in health seeking behaviour appear to be influenced

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both by fear and better access to remote care as an alternative. COVID-19 has necessitated a rapid pivot towards readily accessible, remotely provided health care outside of the hospital and in this way it has been a driver towards achieving what multiple complex interventions could not. This finding has important implications for the planning and provision of healthcare services beyond the pandemic.

Figure legend

The vertical dashed line is at the 16th of March coinciding with commencement of the Victorian State of Emergency. The x axis values represent year and week within that year. E.g. 2019-40 represents the 40th week in 2019. The horizontal dashed blue line represents the expected trajectory of ED presentations if COVID-19 pandemic had not occurred. The horizontal dotted blue line describes the change in level of weekly ED presentations at the point of impact (16th March 2020).

Contributorship statement

The overall design was conceived and planned by RLJ, AB and AS with contributions from DC, BO, MK and KS. The work was operationalised (protocol development, ethics application) by RLJ and CB. RLJ, CB, NC, DA, HM, YC, AG and TH conducted the data collection and were supported with translators by EZ. AS, AG, MT, RLJ and PC conducted the quantitative analysis and RLJ, BL, CH, AT and AB conducted the qualitative analysis. RLJ wrote the first draft of the manuscript and all authors contributed to the analysis strategy and all drafts. All authors contributed to the interpretation of the results. All authors critically reviewed the manuscript and approved the final version.

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Competing interest statement

All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three year, no other relationships or activities that could appear to have influenced the submitted work.

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Data Sharing Statement

De-identified participant data from this research will be shared upon reasonable request with the corresponding author.

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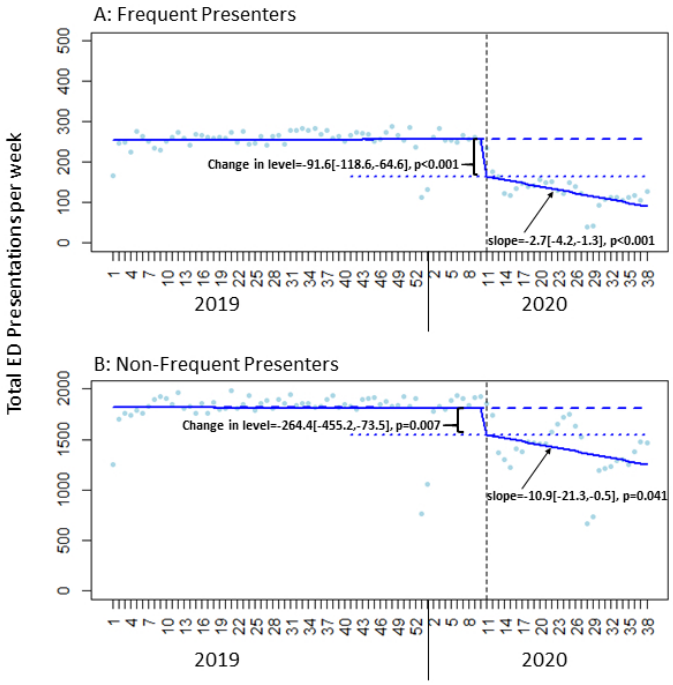

Legend: The vertical dashed line is at the 16th of March coinciding with commencement of the Victorian State of Emergency. The x axis values represent year and week within that year. E.g. 2019-40 represents the 40th week in 2019. The horizontal dashed blue line represents the expected trajectory of ED presentations if COVID-19 pandemic had not occurred. The horizontal dotted blue line describes the change in level of weekly ED presentations at the point of impact (16th March 2020).

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Supplementary material A: Criteria used for HealthLinks prediction algorithm

- Age
- Number of unplanned admissions in the past six months
- Number of emergency department visits in the past three months
- Hospital stay being caused by selected chronic progressive condition(s) and multiple co-morbidities such as asthma, kidney disease, chronic obstructive pulmonary disease, rheumatoid arthritis, hepatitis
- Smoking status
- Place of residence (residential aged care or private residence).

Each criterion provides a weighted value and inclusion into Health Links is triggered once a points threshold is reached. A strong correlation has been demonstrated between the observed and expected proportions of frequent users, and the model has been found to accurately identify patients who will be admitted three or more times in the following 12 months 32% of the time .

Supplementary material B: Coefficients of segmented interrupted time series analysis (note, data is centred around COVID impact)

term	Coefficiant	std.error	p.value	Lower CI	Upper CI
(Intercept)	256.390	7.738	<0.001	241.009	271.770
Week	0.025	0.210	0.907	-0.393	0.442
Covid Phase	-91.567	13.587	<0.001	-118.574	-64.560
Week : COVID Phase (Interaction)	-2.742	0.740	<0.001	-4.213	-1.270

Supplementary material C: Coefficients of segmented interrupted time series analysis adjusted for season (note, data is centred around COVID impact)

term	Coefficient	std.error	p.value	Lower CI	Upper CI
(Intercept)	264.549	5.323	<0.001	253.967	275.132
Week	0.096	0.143	0.505	-0.189	0.380
Covid Phase	-99.727	9.274	<0.001	-118.163	-81.290
Season	-123.535	12.222	<0.001	-147.831	-99.240
Week : COVID Phase (Interaction)	-2.813	0.503	<0.001	-3.814	-1.812

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Supplementary material D: COM-VID study demographic characteristics for Health Links eligible cohort and subsample of interview participants

	Interview participants (n = 200)	Health Links eligible cohort 2019 (n = 4,868)
Age (SD)	66.4 (15.6)	66.9 (17.5)
Gender Male Female	103 (52%) 97 (49%)	2,282 (47%) 2,586 (53%)
Spoken Language English Speaking Non-English Speaking	85 (43%) 115 (58%)	3,454 (71%) 1,414 (29%)
Primary Language Southern European (Italian, Greek, Turkish, Maltese, Macedonian) West Asian/ Middle Eastern (Arabic, Assyrian/ Chaldean Neo-Aramaic, Persian) East, South and South-East Asia (Hindi, Urdu, Punjabi, Mandarin, Vietnamese, Nepalese)	 54 (27%) 43 (22%) 19 (9%)	 901 (19%) 295 (6%) 59 (1%)

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5 - 6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4 - 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4 - 6
Bias	9	Describe any efforts to address potential sources of bias	5 - 6
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, explain how loss to follow-up was addressed	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-7 and tables
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5-7
		(b) Indicate number of participants with missing data for each variable of interest	

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		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	4-8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(*b*) Report category boundaries when continuous variables were categorized	6-8
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6-8
Discussion			
Key results	18	Summarise key results with reference to study objectives	7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	8
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	7-8
Generalisability	21	Discuss the generalisability (external validity) of the study results	8
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	MJA portal

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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