6-1-2022

Assessment of the impact of the COVID-19 pandemic on health services use

Kimberly J Johnson
Washington University in St. Louis

Charles W Goss
Washington University School of Medicine in St. Louis

Jeannette Jackson Thompson
University of Missouri

Anne M Trolard
Washington University School of Medicine in St. Louis

Brett B Maricque
Washington University School of Medicine in St. Louis

See next page for additional authors

Recommended Citation

Authors

Kimberly J Johnson, Charles W Goss, Jeannette Jackson Thompson, Anne M Trolard, Brett B Maricque, Victoria Anwuri, Rachel Cohen, Kate Donaldson, and Elvin Geng
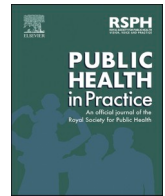
Contents lists available at ScienceDirect

Public Health in Practice

Assessment of the impact of the COVID-19 pandemic on health services use

Kimberly J. Johnson [a,*], Charles W. Goss [b], Jeannette Jackson Thompson [c], Anne M. Trolard [d], Brett B. Maricque [e], Victoria Anwuri [f], Rachel Cohen [g], Kate Donaldson [g], Elvin Geng [h]

[a] *Brown School, Washington University in St. Louis, St. Louis, MO, 63130, USA*
[b] *Division of Biostatistics, Washington University School of Medicine, St. Louis, MO, 63110, USA*
[c] *Health & Behavioral Risk Research Center, University of Missouri School of Medicine Dept. of Health Management & Informatics, Columbia, MO, 65211, USA*
[d] *Institute for Public Health, Washington University in St. Louis, St. Louis, MO, 63130, USA*
[e] *McDonnell Genome Institute, Washington University in St. Louis School of Medicine, St. Louis, MO, 63110, USA*
[f] *Institute for Public Health, Washington University in St. Louis, St. Louis, MO, 63110, USA*
[g] *St. Louis County Department of Public Health, St. Louis, MO, 63134, USA*
[h] *Division of Infectious Diseases, School of Medicine, Washington University in St. Louis, St. Louis, MO, 63110, USA*

ARTICLE INFO

Keywords:
Health services
Covid-19
Emergency

ABSTRACT

Objectives: The coronavirus disease of 2019 (COVID-19) pandemic declared by the World Health Organization on March 11, 2020 impacted healthcare services with provider and patient cancellations, delays, and patient avoidance or delay of emergency department or urgent care. Limited data exist on the population proportion affected by delayed healthcare, which is important for future healthcare planning efforts. Our objective was to evaluate the impact of the COVID-19 pandemic on healthcare service cancellations or delays and delays/avoidance of emergency/urgent care overall and by population characteristics.
Study design: This was a cross-sectional study.
Methods: Our sample (n = 2314) was assembled through a phone survey from 8/12/2020–10/27/2020 among non-institutionalized St. Louis County, Missouri, USA residents ≥18 years. We asked about provider and patient-initiated cancellations or delays of appointments and pandemic-associated delays/avoidance of emergency/urgent care overall and by participant characteristics. We calculated weighted prevalence estimates by select resident characteristics.
Results: Healthcare services cancellations or delays affected ~54% (95% CI 50.6%–57.1%) of residents with dental (31.1%, 95% CI 28.1%–34.0%) and primary care (22.1%, 95% CI 19.5%–24.6%) being most common. The highest prevalences were among those who were White, ≥65 years old, female, in fair/poor health, who had health insurance, and who had ≥1 medical condition. Delayed or avoided emergency/urgent care impacted ~23% (95% CI 19.9%–25.4%) of residents with a higher prevalence in females than males.
Conclusions: Healthcare use disruptions impacted a substantial proportion of residents. Future healthcare planning efforts should consider these data to minimize potential morbidity and mortality from delayed care.

1. Introduction

Existing epidemiological literature has primarily focused on the direct effects of coronavirus disease of 2019 (COVID-19) on human health versus the collateral damage to health systems and healthcare in general. We understand, for example, through numerous epidemiological studies conducted before vaccination that 45%–60% of infected individuals are asymptomatic [1,2]. An estimated 7% of COVID-19 cases became ill enough for hospitalization and 0.11–1.45% have been estimated to die of COVID-19 depending on the world region, age, and comorbidities [3,4], with more recent data suggesting lower rates of hospitalization and deaths among fully vaccinated than unvaccinated individuals [5,6]. In addition to these factors, race and structural inequalities also influence hospitalization and death rates [7,8]. Studies also document long-ranging effects of COVID-19; 13% of cases had symptoms lasting longer than 28 days with "long COVID" emerging as a constellation of symptoms that limit an individual's energy and activities of daily living for an extended period after the acute illness phase [9]. The severity of the pandemic is reflected in the estimates of life expectancy in the United States demonstrating a fall of over a year in life

---

expectancy in 2020 with greater impacts in Black and Latinx populations [10]. It is clear that as a disease, COVID-19 is one of the most severe respiratory pathogens since the 1918 influenza pandemic.

In addition to these direct effects, the COVID-19 pandemic has also exerted indirect effects on health and mortality through the disruption of routine functions of healthcare systems. In previous epidemics, such as the Ebola epidemic in West Africa, these disruptions may have had larger effects on health than the epidemic itself [11]. In the United States, there has been excess mortality from diseases other than COVID-19 [12]. While the direct effects due to the large absolute number of persons infected and a high mortality rate from COVID-19 are well known–in the United States alone, by June of 2021, almost 600,000 deaths were attributed to COVID-19, resulting in the single largest annual fall in U.S. life expectancy since WWII [13]–far less is known about the indirect impacts on health through disruptions of healthcare during the pandemic. Indeed, the fact that 2020 saw an excess of U.S. deaths that could not be explained by COVID-19 alone [14] suggests other factors including delays in healthcare may have played a role. A more in-depth characterization of the types of delays as well as socio-demographic groups (including among individuals with high co-morbidities) most affected is needed to identify vulnerable populations for future pandemic healthcare planning.

We undertook a study to assess the impacts of the COVID-19 pandemic on St. Louis County, Missouri, USA residents. The parent study's primary and secondary objectives were to estimate the prevalence of COVID-19 infection (current and past) and to collect survey information assessing the pandemic impacts on a variety of factors among St. Louis County residents. In this study, we evaluated the impact of the pandemic on health services use and emergency department/urgent care avoidance by participant characteristics. We hypothesized that the pandemic impacted both health services and emergency department/urgent care use. The results of this study will inform future pandemic preparedness planning to mitigate healthcare service disruption and minimize excess morbidity and mortality when healthcare resources are constrained.

2. Methods

Study population. Our study population included non-institutionalized St. Louis County, Missouri residents age $\geq$18 years who could be reached by landline or cellphone from August 12 to October 27, 2020. We used telephone survey sampling methods to reach adults 18 years or older living in 46 zip codes (63005, 63011, 63017, 63021, 63025, 63026, 63031, 63033, 63034, 63038, 63040, 63042, 63043, 63044, 63049, 63069, 63074, 63088, 63105, 63114, 63117, 63119, 63120, 63121, 63122, 63123, 63124, 63125, 63126, 63127, 63128, 63129, 63130, 63131, 63132, 63133, 63134, 63135, 63136, 63137, 63138, 63140, 63141, 63143, 63144, 63146) in St. Louis County. We initially reached residents through random-digit-dialing (RDD) techniques using cellphone and landline phone number lists from Marketing Systems Group (MSG), a commercial vendor [15] that supplies RDD numbers for the Behavioral Risk Factor Surveillance System (BRFSS) survey [16] and sought to recruit them to participate in a survey and/or severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) testing for current and past infection. Due to the rapid timeline needed to complete the study, we switched to calling publicly listed landline and consumer cellphone numbers using additional listed numbers obtained from MSG that had appended zip codes that allowed pre-determination of eligibility. For both RDD and listed numbers, the landline to cellphone number ratio was 30%–~70%. We sought an equal number of Black and White residents in our sample through over-sampling of phone numbers tied to county areas where the majority of the residents are Black. Eligible participants were invited to test for SARS-CoV-2 infection and/or participate in an ~15-minute survey. We included eligible respondents with completed questionnaires (as determined by non-missing responses to 5 variables (see Supplementary

methods). The Washington University Institutional Review Board approved this study.

Measures. The survey included 11 sections covering demographics, testing willingness, health status and access, chronic health conditions, hypertension awareness, tobacco use, and questions specific to the COVID-19 pandemic. Where possible, we used BRFSS survey [16] questions because of the standardized format, they have previously been used in annual BRFSS surveys, and there have been multiple studies examining validity and reliability of the BRFSS [17]. The investigators designed questions to assess health service use and emergency/urgent care delays and avoidance during the pandemic that were included in the COVID-19 section of the survey (Supplementary Table 1). Sex was categorized as male or female. Race was categorized as White or Black/Other with Other and Black race being combined due to the small number of participants reporting Other races. Age group was categorized as 18–44, 45–64, and $\geq$65 years. Several questions were used to determine whether the participant had an underlying medical condition. Briefly, participants were asked if they ever had a myocardial infarction, angina or coronary heart disease, a stroke, current asthma, skin cancer, chronic bronchitis, arthritis, gout, lupus or fibromyalgia, a depressive disorder, kidney disease, diabetes, or hypertension. If the participant responded no to all these conditions, they were classified as not having a medical condition, otherwise they were classified as having 1 condition if they reported 1 condition and >1 condition if they reported more than one condition. For insurance, participants were classified as insured if they reported any health insurance coverage and not insured if they reported no health insurance coverage. Finally, general health was categorized as excellent/very good, good, or fair/poor in response to a question asking participants to rate their general health. A variable list can be found on Github [18].

Statistical analysis. R version 3.6.2 was used for all analyses. Missing values were imputed for weighting prevalence estimates according to St. Louis County resident characteristics and other factors (see Supplementary methods). The complex survey design was accounted for using the R survey package. Unweighted prevalence estimates are also included for comparison. We estimated prevalence ratios (PRs) using Poisson models for characteristics associated with emergency/urgent care delay or avoidance adjusted for other factors. Poisson regression was used instead of logistic regression due to the concern that odds ratios (ORs) overestimate PRs for common events (>10%) [19]. Statistical tests for differences in prevalences were based on the Wald chi-square tests contained within the svychisq function in the R survey package. All statistical tests were two-sided with p-values <0.05 considered significant. Code for the analysis can be found on Github [18].

3. Results

Our analytic dataset contained data from 2314 survey participants who completed the survey (Supplementary Fig. 1). The percentage of respondents with missing values for each variable used in the analysis ranged from 0.04% to 1.21% (Supplementary Table 2). Compared to county residents, participants in the survey were more likely to be female (63.1% vs. 53.5%), older than 64 years (44.7% vs. 23.7%), Black (37.2% vs. 25.8%), and less likely to be Other race (2.7% vs. 5.3%) (Table 1).

Overall, an estimated 53.9% of residents were impacted by healthcare appointment cancellations or delays either initiated by the provider or the patient themselves as a result of the COVID-19 pandemic. Estimated cancellations or delays were higher for those who identified as White vs. Black/Other race (58.0% vs. 44.6%), those who were 65 or older vs. <45 years old (58.1% vs. 33.0%), females vs. males (60.0% vs. 46.7%), those who were in fair/poor vs. excellent/very good health (68.0% vs. 50.2%), those with insurance (55.3% vs. 38.2%), and those with 1 and >1 vs. no medical conditions (54.6% and 60.3% vs. 47.7%) (Table 2). Patterns were similar for provider and resident-initiated cancellations or delays. However, cancellations initiated by providers

Table 1
Characteristics of the study population (N = 2314)[a] vs. target population.

Variable	Survey sample N (%)	St. Louis County residents N (%)[a]
Sex		
Male	853 (36.9)	360,916 (46.5)
Female	1461 (63.1)	415,438 (53.5)
Age category (years)		
18 to 44	489 (21.1)	332,777 (42.9)
45 to 64	790 (34.1)	259,297 (33.4)
≥65 years	1035 (44.7)	184,280 (23.7)
Race category		
White	1385 (59.9)	684,902 (68.9)
Black	861 (37.2)	256,193 (25.8)
Other	68 (2.9)	53,110 (5.3)

[a] Based on the 2019 St. Louis County population ≥ 18 years old [14].

were higher than those initiated by residents (37.8% vs. 29.01%). Unweighted prevalences are provided in Supplementary Table 3 for comparison.

The types of services with the highest prevalence of cancellations or delays were dental (31.1%) followed by primary care (22.1%) and other specialty care (7.1%). The prevalence of provider-initiated cancellations was higher for all services except cancer screening than for resident-initiated cancellations or delays (Supplementary Table 4). Unweighted prevalences are provided in Supplementary Table 5 for comparison.

Overall, an estimated 22.7% of St. Louis County residents avoided or delayed needed urgent medical care due to concerns about contracting COVID-19. There were no significant differences in the estimated prevalence of emergency/urgent care delay or avoidance by race, age category, general health, insurance status, or the number of medical conditions. However, a lower prevalence of males than females (18.1% vs. 26.6%) were estimated to have avoided or delayed emergency/urgent care due to concerns about contracting COVID-19 (Table 3). Unweighted prevalences are provided in Supplementary Table 6. Among those who delayed or avoided emergency/urgent care, the most common reason was fear of COVID-19 infection (74.02%), followed by other/unsure (16.12%) (Supplementary Table 7). Unweighted prevalences are provided in Supplementary Table 8.

In a multivariable logistic regression model, the only significant predictor of emergency/urgent care delay or avoidance was female sex (as compared to male sex) (PR = 1.44, 95% CI 1.11 to 1.87) (Fig. 1).

4. Discussion

In this study, we found that a majority of St. Louis County residents were impacted by healthcare appointment cancellations or delays with a higher prevalence of cancellations/delays being provider versus resident initiated. The estimated impacts were highest among those who were White, ≥65 years old, female, in fair/poor health, who had health insurance, and who had >1 medical condition, which is likely due to a greater number of appointments among individuals in these groups. The most common services impacted were dental followed by primary care. Further, we found that approximately 23% of residents delayed or avoided emergency or urgent care with the strongest predictor of emergency/urgent care avoidance being sex.

There has been limited research surveying U.S. residents estimating healthcare delays and cancellations during the COVID-19 pandemic. A

Table 3
Prevalence of emergency/urgent care delays/avoidance due to the COVID-19 pandemic.

Variable	Prevalence (95% CI)	P-value[a]
Overall	22.69 (19.94–25.43)	
Race		
White	22.49 (19.10–25.88)	0.828
Black/Other	23.13 (18.48–27.78)	
Age group (years)		
18-44	22.99 (10.57–35.41)	0.337
45-64	21.16 (12.59–29.73)	
>65	27.06 (19.38–34.75)	
Sex		
Male	18.13 (14.05–22.20)	0.003
Female	26.58 (22.87–30.29)	
General health		
Excellent/Very good	22.21 (18.68–25.74)	0.670
Good	22.77 (17.95–27.59)	
Fair/Poor	25.99 (16.82–35.17)	
Insurance status		
Insured	23.2 (20.31–26.08)	0.214
Uninsured/unsure	17.26 (8.54–25.99)	
Medical conditions		
None	20.42 (15.71–25.12)	0.376
One Medical condition	25.59 (19.95–31.22)	
>1 Medical condition	23.2 (19.16–27.24)	

[a] Based on Wald chi-square test.

Table 2
Estimated weighted prevalences of provider and resident cancellations and/or delays of healthcare appointments.[a]

Variable	Provider or Resident		Provider		Resident	
	% (95% CI)	P-value[a]	% (95% CI)	P-value[a]	% (95% CI)	P-value[a]
Overall	53.85 (50.61–57.09)		37.75 (34.74–40.75)		29.01 (26.1–31.92)	
Race						
White	57.96 (54.05–61.88)	0.0001	39.88 (36.16–43.6)	0.032	32.04 (28.38–35.7)	0.001516
Black/Other	44.62 (39.08–50.16)		32.97 (27.99–37.95)		22.21 (17.68–26.74)	
Age group (years)						
18-44	32.97 (27.33–40.47)	0.0005	32.27 (26.77–37.76)	0.008	28.9 (23.3–34.5)	0.502337
45-64	48.89 (38.58–50.76)		43.82 (39.23–48.41)		30.81 (26.53–35.08)	
≥65	58.11 (41.11–49.63)		38.93 (34.91–42.94)		26.69 (23.02–30.35)	
Sex						
Male	46.69 (41.73–51.64)	0.0001	33.73 (29.22–38.25)	0.016	23.47 (19.31–27.64)	0.00066
Female	59.96 (55.80–64.13)		41.18 (37.18–45.17)		33.74 (29.75–37.73)	
General health						
Excellent/Very good	50.24 (46.08–54.41)	0.0007	34.6 (30.91–38.29)	0.025	27.13 (23.47–30.79)	0.030386
Good	58.19 (52.5–63.89)		43.22 (37.43–49.02)		29.95 (24.58–35.32)	
Fair/Poor	67.96 (59.67–76.25)		45.2 (35.69–54.7)		40.27 (30.67–49.87)	
Insurance status						
Insured	55.32 (41.32–48.04)	0.0094	38.94 (35.81–42.08)	0.016	29.68 (26.66–32.7)	0.215357
Uninsured/unsure	38.21 (49.65–73.93)		25.05 (14.72–35.39)		21.91 (11.07–32.74)	
Medical conditions						
None	47.74 (42.06–53.41)	0.0043	31.12 (26.16–36.08)	0.001	28.49 (23.23–33.76)	0.518254
One Medical condition	54.62 (48.08–61.15)		39.03 (32.83–45.23)		26.91 (21.65–32.17)	
>1 Medical condition	60.32 (55.72–64.92)		44.45 (39.95–48.94)		31.11 (26.81–35.41)	

[a] Based on Wald chi-square test.

PR (95% CI)

Variable

Sex
Female vs. Male   1.44 (1.11 to 1.87)

Race
Black/Other vs. White   1.02 (0.79 to 1.32)

Age group (years)
45−64 vs. 18−44   0.93 (0.69 to 1.24)
65+ vs. 18−44   0.72 (0.52 to 1.00)

General health
Good vs. Excellent/Very good   1.03 (0.78 to 1.38)
Fair/Poor vs. Excellent/Very good   1.12 (0.76 to 1.65)

Insurance status
Insured vs. Uninsured/Unsure   1.37 (0.82 to 2.29)

Medical conditions
1 vs. 0   1.26 (0.91 to 1.73)
>1 vs. 0   1.19 (0.84 to 1.67)
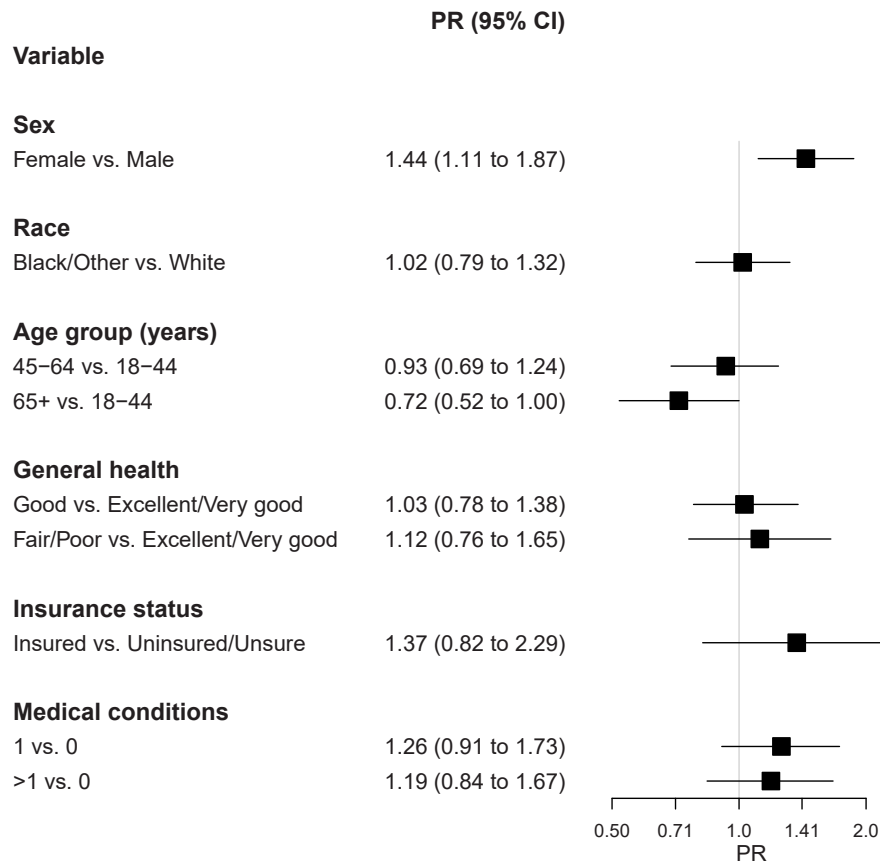
0.50   0.71   1.0   1.41   2.0
PR

Fig. 1. Predictors of emergency/urgent care delays/avoidance. Estimates are adjusted for other variables in the table. PR = prevalence.

cross-sectional study early in the pandemic (April and May of 2020) conducted in Vermont reported that 41%–48% of survey respondents reported deferral of care, primarily for preventative care visits to dentists (27%) and primary care (23%) providers [20], which is similar to our results. In a U.S. cross-sectional survey of adults also conducted early in the pandemic, 46.7% of participants reported delaying dental care, a higher percentage than we observed in our study [21].

In studies relying on administrative data, the Veteran's Administration, which is the largest health system in the United States, reported 7.3 million appointment cancellations including those for mental health, primary care, and specialty care from the period of March 15, 2020 to May 1, 2020. Importantly, approximately a third of these appointments had no indications for follow-up, which has likely resulted in further delays in care for these veterans [22].

It has also been reported that there have been COVID-19-related impacts on screening and diagnostic test appointments for breast [23], colon, lung, and prostate cancers [24] and orthopedic services [25]. In one of the largest analyses using electronic health data from EPIC, weekly cancer screening volumes for colon, breast, and cervical dropped between 86% and 94% in 2020 following the start of the pandemic. The authors found that between mid-March and mid-June 2020, an estimated 285,000, 95,000, and 40,000 breast, colon, and cervical cancer screenings, respectively, were missed [26].

Concerning emergency and urgent care avoidance, a study surveying ~5000 people from June 24–30, 2020 among a Qualtrics supplied "network of participant pools" reported that ~12% of adults avoided emergency or urgent care. This number is lower than our estimate, which could be because it was conducted earlier in the pandemic. Although not significant in our study, similar to our findings, the

prevalence of emergency/urgent care avoidance was higher among people with underlying medical conditions. Our results were also consistent with respect to females being more likely to avoid emergency/urgent care than males [27].

Coherent with our and others' results, emergency department visits declined during the pandemic [28,29], which may be explained by a combination of factors including avoidance due to COVID-19 infection fears and reductions in both motor vehicle accident and other-related trauma [30], which are a major reason for emergency department visits [28,30]. However, it should also be noted that another contributing factor to emergency department visit declines may be the unusually low influenza rates during 2020–2021, likely due to masking, social distancing, and increased uptake of flu vaccines as a result of the COVID-19 pandemic [31–33].

The impact of delayed care could increase risk for morbidity and mortality for several diseases due to diagnosis of more advanced disease. For example, a modeling study estimated the pandemic impact of pauses in cancer screening and deferrals of diagnostic tests during the year following March 16, 2020 on survival up to 5 years under three different scenarios that moved patients from routine to urgent diagnosis pathways. The authors reported increases in death ranging from 7.9% to 9.6% for breast cancer, 15.3%–16.6% for colorectal cancer, 4.8%–5.3% for lung cancer, and 5.8%–6.0% for esophageal cancer [34]. Further, in a modeling study it was estimated that disrupted screening without catch-up strategies would result in an excess of 2.0, 0.3, and 2.5 cancer deaths per 100,000 people within a decade for breast, cervical and colorectal cancer, respectively [35]. For cardiovascular diseases, a study in the United Kingdom reported that hospital admissions for acute coronary syndromes declined by 40% from mid-February 2020 to the end of

March 2020. The authors interpreted these results as being likely to contribute to out-of-hospital deaths and increased morbidity due to myocardial infarctions [36]. This is substantiated by an Italian study that reported an increase in out-of-hospital cardiac arrests during the pandemic [37]. Another study reported early pandemic delays in presentation of strokes [38].

The healthcare system responded to the COVID-19 pandemic by canceling or delaying non-urgent care appointments and procedures. The healthcare system also responded by increasing telehealth and telemedicine services [39], which could offset some of the anticipated long-term consequences of delayed in-person care. However, detection of some conditions may require a physical exam to be identified (for example, conditions detected by abdominal exams). Moreover, there have been anecdotal reports of delays in non-urgent surgeries including for early-stage cancer [40], which may not ultimately impact the patient in terms of morbidity or mortality but may have an adverse psychological impact. Thus, it will be important to develop future pandemic plans that minimize healthcare service disruptions to reduce the impact of the pandemic not only on physical health but also on psychological well-being.

Finally, it should be noted that some delays may have been beneficial, particularly for non-urgent visits and patients at high risk for COVID-19 morbidity and mortality. This is especially true early during the pandemic when hospital-acquired COVID-19 infections occurred as the healthcare system adapted its policies and procedures to minimize hospital-based COVID-19 infections [41]. More research is needed in the coming months and years to tease out the role that various factors beyond healthcare service disruptions played and are continuing to play if, as has been suggested, the decreased life expectancy exhibited in 2020 [14] carries forward. Marked increases in drug overdose deaths [42], for example, likely contributed to the drop in life expectancy and may have been independent of healthcare access. Economic disruption, social isolation, trauma, and other as yet unidentified factors may lead to sequelae more explanatory than healthcare delays themselves.

4.1. Strengths and limitations

A strength of this study is that it is one of the few studies that has attempted to provide representative estimates of the number of residents impacted by COVID-19 pandemic-related deferrals of healthcare services. Moreover, we oversampled Black residents to enable more precise estimates of the impact of the pandemic in this minority group. Several limitations must be considered when interpreting these results. First, non-probability sampling error could have affected our estimates. Although we attempted to conduct probability sampling using a random-digit-dialing approach, we switched to listed landline and a consumer-based sample of cell phone numbers that have a higher response rate resulting in residents being selected for participation through both probability and non-probability sample designs. These two separate designs were accounted for in our weighting methodology (see Supplementary Methods). In addition, low response rates could also bias the sample further. However, although we attempted to produce representative estimates through weighting, the estimated proportion of St. Louis County residents impacted by healthcare services cancellations and delays could still be biased in either direction due to sampling error and/or participation bias. Concerning healthcare appointment cancellations and delays, we could not estimate cancellations and/or delays among those who had appointments because we only asked whether the participant had any appointments canceled and/or delayed. Therefore, observed differential impacts in the prevalence of cancellations or delays by participant characteristics should not be interpreted as strictly COVID-19 pandemic-related. Third, our data were collected during a 2.5-month window during the COVID-19 pandemic and we asked about provider and participant-initiated cancellations and delays of healthcare services and emergency/urgent care avoidance since the beginning of the pandemic. Therefore, the estimated prevalence of the number of

residents impacted by delayed care may be higher as additional time has passed. Given the nature of the pandemic, we anticipate that residents of counties similar to St. Louis County may have had comparable impacts on health services; however, these results may not be generalizable to all populations in the United States or in other countries with different healthcare systems and levels of infection.

5. Conclusions

Our results indicate that healthcare services cancellations and delays impacted a substantial proportion of residents in St. Louis County Missouri. Future pandemic planning efforts should provide guidance on how to minimize the impact on healthcare service delivery to avoid potential increased morbidity and mortality due to delayed healthcare, particularly for population groups that have a higher risk for disease or higher disease burden.

Conflicts of interest/Competing interests

The authors have no conflicts of interest or competing interests to report.

Ethical approval

This study was approved by the Washington University in St. Louis Institutional Review Board.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhip.2022.100254.

References

[1] S.H. Woolf, D.A. Chapman, R.T. Sabo, E.B. Zimmerman, Excess deaths from COVID-19 and other causes in the US, March 1, 2020, to january 2, 2021, JAMA (2021) 2–5.

[2] M.R. Kasper, J.R. Geibe, C.L. Sears, A.J. Riegodedios, T. Luse, A.M. Von Thun, et al., An outbreak of covid-19 on an aircraft carrier [cited 2021 May 21], N Engl J Med [Internet] 383 (25) (2020 Dec 17) 2417, 26. Available from, https://pubmed.ncbi.nlm.nih.gov/33176077/.

[3] R. Verity, L.C. Okell, I. Dorigatti, P. Winskill, C. Whittaker, N. Imai, et al., Estimates of the severity of coronavirus disease 2019: a model-based analysis [cited 2021 May 21], Lancet Infect Dis [Internet] 20 (6) (2020 Jun 1) 669, 77. Available from, https://pubmed.ncbi.nlm.nih.gov/32240634/.

[4] S. Ghisolfi, I. Almås, J.C. Sandefur, T von Carnap, J. Heitner, T. Bold, Predicted COVID-19 fatality rates based on age, sex, comorbidities and health system capacity [cited 2021 Aug 2], BMJ Glob Heal [Internet] 5 (9) (2020 Sep 1), e003094. Available from, https://gh.bmj.com/content/5/9/e003094.

[5] A.G. Johnson, A.B. Amin, A.R. Ali, B. Hoots, B.L. Cadwell, S. Arora, et al., COVID-19 incidence and death rates among unvaccinated and fully vaccinated adults with

and without booster doses during periods of delta and omicron variant emergence — 25 U.S. Jurisdictions, april 4–december 25, 2021 [cited 2022 Mar 24], MMWR Morb Mortal Wkly Rep [Internet] 71 (4) (2022 Jan 28) 132, 8. Available from, https://www.cdc.gov/mmwr/volumes/71/wr/mm7104e2.htm.

[6] H.M. Scobie, A.G. Johnson, A.B. Suthar, R. Severson, N.B. Alden, S. Balter, et al., Monitoring incidence of COVID-19 cases, hospitalizations, and deaths, by vaccination status — 13 U.S. Jurisdictions, april 4–july 17, 2021 [cited 2022 Mar 24], MMWR Morb Mortal Wkly Rep [Internet] 70 (37) (2022 Sep 17) 1284, 90. Available from, https://www.cdc.gov/mmwr/volumes/70/wr/mm7037e1.htm.

[7] R. Khazanchi, C.T. Evans, J.R. Marcelin, Racism, not race, drives inequity across the COVID-19 continuum [cited 2021 Aug 16], JAMA Netw Open [Internet] 3 (9) (2020 Sep 1), e2019933. e2019933. Available from, https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2770954.

[8] K. Mackey, C. Ayers, K. Kondo, S. Saha, S. Advani, S. Young, et al., Racial and ethnic disparities in COVID-19-related infections, hospitalizations, and deaths : a systematic review [cited 2021 Sep 30], Ann Intern Med [Internet] 174 (3) (2021 Mar 1) 362, 73. Available from, https://pubmed.ncbi.nlm.nih.gov/33253040/.

[9] C.H. Sudre, B. Murray, T. Varsavsky, M.S. Graham, R.S. Penfold, R.C. Bowyer, et al., Attributes and predictors of long COVID [cited 2021 May 21], Nat Med [Internet] 27 (4) (2021 Apr 1). Available from, https://pubmed.ncbi.nlm.nih.gov/33692530/.

[10] T. Andrasfay, N. Goldman, Reductions in 2020 US life expectancy due to COVID-19 and the disproportionate impact on the Black and Latino populations [cited 2021 Aug 2], Proc. Natl. Acad. Sci. India 118 (5) (2021 Feb 2). Available from: https://www.pnas.org/content/118/5/e2014746118.

[11] J.W.T. Elston, C. Cartwright, P. Ndumbi, J. Wright [cited 2021 Feb 25], The Health Impact of the 2014–15 Ebola Outbreak [Internet], vol. 143, Public Health. Elsevier B.V., 2017, pp. 60–70. Available from: https://pubmed.ncbi.nlm.nih.gov/28159028/.

[12] L.M. Rossen, A.M. Branum, F.B. Ahmad, P.D. Sutton, R.N. Anderson, Notes from the field : update on excess deaths associated with the COVID-19 pandemic — United States, january 26, 2020–february 27, 2021 [cited 2021 May 21], MMWR Morb Mortal Wkly Rep [Internet] 70 (15) (2021 Apr 16) 570, 1. Available from, http://www.cdc.gov/mmwr/volumes/70/wr/mm7015a4.htm?s_cid=mm7015a4_w.

[13] Amid COVID-19, US life expectancy sees biggest drop since WWII | CIDRAP [Internet] [cited 2021 Feb 25]. Available from: https://www.cidrap.umn.edu/news-perspective/2021/02/amid-covid-19-us-life-expectancy-sees-biggest-drop-wwii.

[14] S.H. Jacobson, J.A. Jokela, Non–COVID-19 excess deaths by age and gender in the United States during the first three months of the COVID-19 pandemic [cited 2021 Apr 15], Public Health [Internet] 189 (2020 Dec 1) 101, 3. Available from, https://pubmed.ncbi.nlm.nih.gov/33197730/.

[15] Online survey tools for research | marketing systems group | m-s-g.com [internet] [cited 2022 Mar 22]. Available from: https://www.m-s-g.com/Pages/.

[16] CDC - BRFSS [internet] [cited 2021 Aug 10]. Available from, https://www.cdc.gov/brfss/index.html.

[17] CDC - BRFSS BRFSS Data Quality, Validity, and reliability [internet] [cited 2022 Mar 22]. Available from: https://www.cdc.gov/brfss/publications/data_qvr.htm.

[18] GitHub - kijohnson/Health-services-paper: paper associated code and supplementary materials [Internet] [cited 2022 Mar 22]. Available from, https://github.com/kijohnson/Health-services-paper.

[19] A.J. Barros, V.N. Hirakata, Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio, BMC Med Re [Internet] 3 (1) (2003) 21 [cited 2021 Apr 29];3. Available from: http://www.biomedcentral.com/1471-2288/3/21.

[20] A. Atherly, E. van Den Broek-Altenburg, V. Hart, K. Gleason, J. Carney, Consumer reported care deferrals due to the COVID-19 pandemic, and the role and potential of telemedicine: cross-sectional analysis, JMIR Public Heal Surveill [Internet] 6 (3) (2020 Jul 1) [cited 2021 Feb 25];6(3):e21607. Available from, https://publichealth.jmir.org/2020/3/e21607.

[21] A.M. Kranz, G. Gahlon, A.W. Dick, B.D. Stein, Characteristics of US adults delaying dental care due to the COVID-19 pandemic, JDR Clin Transl Res 6 (1) (2021) 8–14.

[22] VA Office of Inspector General, Appointment management during the COVID-19 pandemic [internet] [cited 2021 May 4]. Available from: https://www.va.gov/oig/pubs/VAOIG-20-02794-218.pdf, 2020.

[23] H. Song, A. Bergman, A.T. Chen, D. Ellis, G. David, A.B. Friedman, et al., Disruptions in preventive care: mammograms during the COVID-19 pandemic, Health Serv. Res. 56 (1) (2021) 95–101.

[24] D. Patt, L. Gordan, M. Diaz, T. Okon, L. Grady, M. Harmison, et al., Impact of COVID-19 on cancer care: how the pandemic is delaying cancer diagnosis and treatment for American seniors, JCO Clin Cancer Informatics (4) (2020) 1059–1071.

[25] M.C. Liebensteiner, I. Khosravi, M.T. Hirschmann, P.R. Heuberer, P. Heuberer, P. Niemeyer, et al., Massive cutback in orthopaedic healthcare services due to the COVID-19 pandemic. Knee Surgery, Sport Traumatol Arthrosc 28 (6) (2020) 1705–1711.

[26] Delayed cancer screenings—a second look [internet] [cited 2021 Apr 29]. Available from, https://ehrn.org/articles/delayed-cancer-screenings-a-second-look/.

[27] M.É. Czeisler, K. Marynak, K.E.N. Clarke, Z. Salah, I. Shakya, J.M. Thierry, et al., Delay or avoidance of medical care because of COVID–19–related concerns — United States, June 2020, MMWR Morb. Mortal. Wkly. Rep. 69 (36) (2020) 1250–1257.

[28] B. Boserup, M. Mckenney, A. Elkbuli, The impact of the COVID-19 pandemic on emergency department visits and patient safety in the United States, Am. J. Emerg. Med. 39 (January) (2020) 1732–1736.

[29] M.M. Jeffery, Gail D'onofrio, H. Paek, T.F. Platts-Mills, W.E. Soares Iii, J.A. Hoppe, et al., Trends in emergency department visits and hospital admissions in health care systems in 5 States in the first months of the COVID-19 pandemic in the US, Available from: https://jamanetwork.com/.

[30] T.H. Kamine, A. Rembisz, R.J. Barron, C. Baldwin, M. Kromer, Decrease in trauma admissions with COVID-19 pandemic [cited 2021 Apr 29], West J Emerg Med [Internet] 21 (4) (2020). Available from, http://escholarship.org/uc/uciem_westjem.

[31] Flu season summary | CDC [internet] [cited 2021 Aug 2]. Available from, https://www.cdc.gov/flu/season/faq-flu-season-2020-2021.htm#anchor_1627000307956, 2020-2021.

[32] L. Rodgers, M. Sheppard, A. Smith, S. Dietz, P. Jayanthi, Y. Yuan, et al., Changes in seasonal respiratory illnesses in the United States during the coronavirus disease 2019 (COVID-19) pandemic [cited 2022 Mar 22], Clin Infect Dis [Internet] 73 (Suppl 1) (2021 Jul 15) S110, 7. Available from, https://pubmed.ncbi.nlm.nih.gov/33912902/.

[33] Z.D.W. Dezman, B. Stryckman, K.S. Zachrison, R.M. Conrad, D. Marcozzi, L. Pimentel, et al., Masking for COVID-19 is associated with decreased emergency department utilization for non-COVID viral illnesses and respiratory conditions in Maryland [cited 2022 Mar 22], Am J Med [Internet] 134 (10) (2021 Oct 1) 1247, 51. Available from, https://pubmed.ncbi.nlm.nih.gov/34242620/.

[34] C. Maringe, J. Spicer, M. Morris, A. Purushotham, E. Nolte, R. Sullivan, et al., The impact of the COVID-19 pandemic on cancer deaths due to delays in diagnosis in England, UK: a national, population-based, modelling study, Lancet Oncol. 21 (2020) 1023–1034.

[35] L. Kregting, S. Kaljouw, L. de Jonge, E. Jansen, E. Peterse, E. Heijnsdijk, et al., Effects of cancer screening restart strategies after COVID-19 disruption [cited 2021 Aug 2], Br J Cancer [Internet] 124 (9) (2021 Apr 27) 1516, 23. Available from, https://pubmed.ncbi.nlm.nih.gov/33723386/.

[36] M.M. Mafham, E. Spata, R. Goldacre, D. Gair, P. Curnow, M. Bray, et al., COVID-19 pandemic and admission rates for and management of acute coronary syndromes in England [cited 2021 Apr 15], Lancet [Internet] 396 (10248) (2020 Aug 8) 381, 9. Available from, https://pubmed.ncbi.nlm.nih.gov/32679111/.

[37] T. Squizzato, G. Landoni, A. Paoli, R. Lembo, E. Fominskly, A. Kuzovlev, et al., Effects of COVID-19 pandemic on out-of-hospital cardiac arrests: a systematic review, Resuscitation [Internet] 157 (2020) 241–247. Available from: https://pubmed.ncbi.nlm.nih.gov/33130157/.

[38] C.M. Schirmer, A.J. Ringer, A.S. Arthur, M.J. Binning, W.C. Fox, R.F. James, et al., Delayed presentation of acute ischemic strokes during the COVID-19 crisis, J. Neurointerventional Surg. 12 (7) (2020) 639–642.

[39] A. Kichloo, M. Albosta, K. Dettloff, F. Wani, Z. El-Amir, J. Singh, et al., Telemedicine, the current COVID-19 pandemic and the future: a narrative review and perspectives moving forward in the USA, Fam Med community Heal 8 (3) (2020) 1–9.

[40] The coronavirus is forcing hospitals to cancel surgeries - the New York times [internet] [cited 2021 Apr 29]. Available from, https://www.nytimes.com/2020/03/14/us/coronavirus-covid-surgeries-canceled.html.

[41] R. Barranco, LVB Du Tremoul, F. Ventura, Hospital-acquired SARS-cov-2 infections in patients: inevitable conditions or medical malpractice? [cited 2021 Aug 9], Int J Environ Res Public Health [Internet] 18 (2) (2021 Jan 2) 1–9. Available from, http://pmc/articles/PMC7827479/.

[42] CDC: drug overdose deaths up 29.4% in 2020 | AHA news [internet] [cited 2021 Aug 10]. Available from: https://www.aha.org/news/headline/2021-07-14-cdc-drug-overdose-deaths-294-2020.