BMC Public Health

RESEARCH

Open Access

Impact of the COVID-19 pandemic on emergency department visits in adults with diabetes: findings from the national health interview survey

Kavita Mosalpuria[1*], Nasser Sharareh[2], Olutobi Adekunle Sanuade[2,3], Olanrewaju Onigbogi[4] and Afua O. Asare[2,5]

Abstract

Background The COVID-19 pandemic affected healthcare utilization, particularly for populations with chronic disease. This study examined impact of the COVID-19 pandemic on Emergency Department (ED) visits among adults with diabetes in the U.S.

Methods We conducted a cross-sectional analysis of adults with diabetes using deidentified, publicly available data from the 2019–2021 National Health Interview Survey (NHIS). The primary independent variable was survey year: 2019 (pre-COVID-19 era) and 2020–2021 (COVID era). The outcome variable was any ED visit in the last 12 months. We conducted multivariable logistic regression to estimate the difference in ED visits before and during the COVID-19 pandemic among adults with diabetes. We estimated adjusted odds ratios and 95% confidence intervals adjusting for healthcare access, self-reported health status, demographic, and socioeconomic characteristics.

Results The sample consisted of 9,845 adults with diabetes (3,066 in 2019, 3,086 in 2020, and 2,899 in 2021). Of these, 19.5% were immigrants, 15.6% Non-Hispanic Black, 17.2% Hispanic, and 58.5% Non-Hispanic White. People with diabetes were 15% in 2020 [AOR 0.85 (95% CI 0.73–0.98)] and 24% in 2021 [AOR 0.76 (95% CI 0.65–0.88)] less likely to visit ED compared to 2019. Delayed care due to cost was significantly associated with increased odds (AOR 1.65; 95% CI 1.32, 2.06) of ED visits compared to those who did not delay their care due to cost. Having fair or poor health status was associated with higher odds of ED visits (AOR 2.01; 95% CI 1.68, 2.41) compared to those reporting excellent health status.

Conclusion Limited access to routine care during the COVID-19 pandemic for diabetes should have led to increased ED visits but the study found significant reduction in ED visits compared to pre-pandemic in people living with diabetes. Future studies are needed to examine whether the reductions in ER were derived from better telemedicine use or avoidance of using necessary care. Also, studies are needed for developing solutions that preserves healthcare delivery in public health care crisis.

*Correspondence:
Kavita Mosalpuria
mosalpuriak23@ecu.edu

Full list of author information is available at the end of the article

Keywords Diabetes, COVID-19 pandemic, Emergency departments, Emergency services utilization, Hospital emergency services utilization

Introduction

In 2021, 38 million adults in the United States had diabetes, representing 15% of the adult population [1]. Of 38 million, 9 million (3% of the adult population) were undiagnosed [2]. Diabetes impacts physical and mental health, social relationships, and leads to a higher risk of medical comorbidities [3, 4]. In 2022, diabetes was the most expensive chronic condition to manage in the U.S. with a total medical cost of $413 billion related to diabetes care [1, 5, 6]. People living with diabetes spend an estimated $19,736 annually on medical care [3]. This high cost of care is especially problematic because diabetes is most prevalent in populations that may already face financial difficulties, specifically, adults with low socioeconomic status, living in rural areas and from racial and ethnic minority groups [2, 3].

The novel coronavirus disease 2019 (COVID-19) is caused by the SARS-CoV-2 virus. The first known case of COVID-19 was identified in Wuhan, China in December 2019 [7]. The disease spread globally and was declared a pandemic by the World Health Organization (WHO) in March 2020 [8]. The COVID-19 pandemic led to a global health crisis [9]. In the U.S., the spread of COVID-19 peaked on January 21, 2022 with 2,363.68 cases per million people [10]. The WHO declared an end to the global Public Health Emergency for COVID-19 on May 5, 2023, followed shortly by a declaration by the U.S. Department of Health and Human Services of the end to the national public health emergency in the U.S. on May 11, 2023 [11–13]. In 2022, COVID-19 illness were less severe and less deadly compared to 2020 and 2021, and no new variant emerged with the capacity to fuel a major wave of cases [14]. The COVID-19 pandemic significantly disrupted global healthcare systems, resulting in profound changes in care delivery and health-seeking behaviors. Individuals with diabetes mellitus represent a particularly vulnerable population, as they are at elevated risk for both severe COVID-19 outcomes and complications associated with suboptimal disease management.

Emergency department (ED) visits have historically played an essential role in the acute management of most common and life-threatening diabetes-related complications, including hypoglycemia, hyperglycemia, and diabetic ketoacidosis [15]. There are many factors that are associated with ED visits among people with diabetes. For example, people living in urban areas and without insurance are known to have higher all-cause diabetes ED visits [16]. Diabetes-specific ED visits were three times higher for Black patients and 1.29 times higher for Hispanic patients compared to non-Hispanic Whites patients [16]. Adults with diabetes who receive inadequate care whether in form of inadequate pharmacological therapies or inadequate laboratory evaluations are known to have more diabetes-related complications and subsequently increased emergency healthcare utilization [17]. However, the onset of the pandemic introduced substantial barriers to accessing health care, driven by public health measures, apprehension regarding viral exposure, and the redirection of healthcare resources. Additionally, ED visits are a critical indicator of performance of any health system [18]. Measures of ED visits are used to assess disparities in access to primary health care, healthcare utilization, quantify costs and quality of care, and to provide insights into public health trends [18]. For these reasons, high rates of ED visits suggest poor management of health care, and the presence of barriers to accessing health care, especially primary health care [19, 20].

For routine diabetes care, a set of tests are conducted for risk assessment and to prevent complications due to diabetes. These are Hemoglobin A1c (HbA1c), examination of retina, and evaluation of kidney functions. A study using electronic health records in North Carolina found relationship between COVID-19 and disruption in diabetes care [21]. Specifically, for the first two months of the pandemic, the frequency of HbA1c, retina screening, and evaluation of kidney function tests reduced to less than 50% [21]. By the end of 2020, the frequency of these tests increased but never reached the same as previous year. These decreases in procedures resulted in 35–98% delay in first assessment during the pandemic [21]. Decrease and delays in diabetes care significantly affect the health outcomes of people with diabetes.

During the early months of the pandemic in 2020, there were substantial decreases in ED visits across the U.S. in the general population [22–24]. But there are limited studies that explored the impact of pandemic on ED visits in people living with diabetes. Thus, the aim of this study was to examine the impact of the COVID-19 pandemic on ED visits in adults living with diabetes in the U.S. Given the widespread accounts of increased avoidance of health care systems during the pandemic [25–29], our hypothesis was that ED visits amongst adults with diabetes would be lower during the COVID-19 pandemic (2020 and 2021) compared to the pre-pandemic era (2019). Over the course of different waves of COVID-19, past literature has shown recover and relapse in the use of various health services [30, 31]. Anticipating similar changes, we stratified the ED visits by survey year among people with diabetes.

Methods

The study used three cycles of publicly available data from the 2019–2021 National Health Interview Survey (NHIS) [2, 32–34]. The NHIS is an in-person, cross-sectional household interview survey, but data collection shifted partially to telephone interview in 2020 due to the pandemic. Consequently, the response rate declined slightly; however, they still provided detailed, pandemic-era, nationally representative data. The survey is representative of the noninstitutionalized U.S. population and is conducted by the National Center for Health Statistics. Information about sampling structure and weighting is described elsewhere [2, 32–34]. The study population was limited to adults aged 18 years and older diagnosed with either type I or type II diabetes. All other types of diabetes were excluded from the sample. People with diabetes were determined by participant's response to the survey question, "has a doctor or other health professional ever told you that you had diabetes (not including gestational diabetes, prediabetes)?" The type of diabetes people had was determined by response to survey question, "According to your doctor or other health professional, what type of diabetes do you have? Is it type 1, type 2, or some other type? If you don't remember or weren't told, that's OK."

The outcome was a constructed binary variable based on participant-reported any ED visit in the last 12 months in response to the survey question, "during the past 12 months, how many times have you gone to a hospital emergency room about your health?" ED visits among people with diabetes is not a rare event. ED visits were treated as a categorical variable to accommodate the non-linear and non-Poisson distribution of visit frequencies across the study population. In many cases, healthcare utilization such as the number of ED visits may be heavily skewed, zero-inflated, or influenced by unmeasured confounders, violating assumptions of standard count models. Categorizing ED visits enables more flexible modeling of relationships with key predictors and allows for easier interpretation of thresholds of healthcare use. ED visits were dichotomized, with zero (0) as having no ED visit in last 12 months and one [1] having one or more ED visits in last 12 months. The primary independent variable was the survey year. Therefore, outcomes from the 2019 NHIS dataset was used to represent the pre-COVID-19 era (reference variable), and the 2020 and 2021 NHIS datasets represented the COVID era. The selection of other independent variables were informed by the Andersen's Behavioral Model of Health Services Use [35].

In this study we adjusted for a set of independent variables classified under predisposing, enabling, and need factors in the regression model to estimate the determinants of ED visits among people living with diabetes. According to the Andersen behavioral model of health service utilization, the predisposing factors are the general characteristics of the population and exist before the onset of a problem [36]. The predisposing factors included in this study are age (18–34 years, 35–49 years, 50–64 years, 65 + years), sex (male, female), race/ethnicity (non-Hispanic Black [NHB], Hispanic, non-Hispanic other, non-Hispanic White [NHW]), sexual orientation sexual orientation (heterosexual, gay/lesbian, bisexual, other non-heterosexual), marital status (not married, married), and U.S. nativity (immigrant, U.S.-born). Enabling factors are those that facilitate or impede access to resources [36]. Enabling factors included in this study are highest level of education achieved (no diploma, GED or high school, some college, bachelor, graduate degree or higher), U.S. region (Northeast, Midwest, South, West), metropolitan status (non-metropolitan, metropolitan), type of health insurance (Medicare/Medicaid, other coverage, uninsured, private), working status in last week (not worked, worked), income-poverty ratio (< 100 Federal Poverty Level (FPL), 100–200 FPL, 200–400 FPL, > 400 FPL), last time saw a doctor to receive health care (within last year or two, more than 3 years or never), usual source for receiving healthcare (one or more usual place, no place), delayed care due to cost (yes, no), experiencing food insecurity in the last 30 days (yes, no), supplemental nutrition assistance program (SNAP) utilizer (yes, no), and household size(1, 2, 3, 4 or more members). Factors that motivate people to use health services are need factors [36]. This study included self-reported health status (good, fair or poor, excellent or very good) and disability (yes, no).

Statistical analysis

We conducted a retrospective cross-sectional analysis using the R Statistical Software using the survey package and accounting for the complex survey design (R codes are available in Online Resource). After listwise deletion, we estimated the weighted proportions of independent variables for the full sample and then stratified the sample by survey year. We then fitted a multivariable logistic regression model with independent variables selected a priori to estimate the determinants of ED use among diabetic patients. Additionally, in the years 2020 and 2021, there were different waves of COVID-19. These waves were found to be correlated with recovery and relapse of use of various health services [30, 31]. During the COVID-19, there were exacerbation of preexisting barriers and emergence of new ones to access the health services [31]. To examine such heterogeneity, we further stratified our analysis based on survey year. We calculated the adjusted odds ratios (AOR) and their 95% confidence intervals (CI). A two-sided alpha of less than 0.05 was considered significant. We also evaluated the multicollinearity among independent variables for each model.

We used pairwise correlation between independent variables and found that none of them were highly correlated (i.e., the correlation was below 0.6). Institutional review board was waived because this study was a secondary analysis of a publicly available, deidentified data set. This study adhered to Strengthening the Reporting of Observational studies in Epidemiology (STROBE) reporting guidelines [37].

Results

Table 1 shows the descriptive statistics of the study sample and stratified by year for the ED visits. A total of 93,047 U.S. adults participated in the NHIS from 2019 to 2021. Of these, 9,051 had diabetes [3,066 (32.7%) in 2019, 3,086 (32.7%) in 2020, and 2,899 (34.5%) in 2021]. Overall, 30.3% (2,716) of the total sample reported having an ED visit in the last 12 months with 36.2% (1,012) in 2019, 32% (897) in 2020, and 31.8% (807) in 2021. More than half (58.5%, 5,804) of people with diabetes were NHW. Less than half (46.2%, 4,916) of the total people with diabetes were 65 years and older.

Table 2 shows the results of the multivariable logistic regression model comparing the likelihood of ED visits during the COVID-19 era compared to the pre-COVID-19 era. After adjusting for covariates, adults with diabetes were 15% less likely in 2020 and 24% less likely in 2021 to visit ED compared to 2019: AOR 0.85 (95% CI 0.73–0.98) and AOR 0.76 (95% CI 0.65–0.88), respectively. People who delayed getting care were 1.65 times more likely to have at least one ED visit than those who did not delay their care (95% CI 1.32–2.06). People who self-reported having a disability were more likely to have an ED visit compared to adults who did not have disability [AOR 1.64 (95% CI 1.42–1.89)]. SNAP utilizers were more likely to have an ED visit compared to those without SNAP [AOR 1.30 (95% CI 1.07–1.57)]. NHB were 1.51 times more likely to have an ED visit compared to NHW [AOR 1.51 (95% CI 1.27–1.78)]. Adults with diabetes aged 50–64 years were 42% [AOR 0.58 (95% CI 0.41–0.84)] less likely and those 65 + years were 43% [AOR 0.57 (95% CI 0.39–0.82] less likely to have an ED visit compared to adults aged 18–34 years with diabetes. People who did not work in the last week were more likely to have an ED visit compared to those who worked in the last week [AOR 1.21 (95% CI 1.02–1.43)]. Lastly, immigrants with diabetes were 27% less likely to have an ED visit compared to U.S.-born adults with diabetes [AOR 0.73 (95% CI 0.60–0.89)].

Table 3 shows the results of the multivariable model comparing the odds of ED visits by the survey years, 2019, 2020 and 2021. People who reported fair or poor health status reported to have higher odds of ED visits across all the three years: [AOR 1.86 (95% CI 1.38–2.50) in 2019, AOR 2.35 (95% CI 1.70–3.25) in 2020, and AOR 2.03 (95% CI 1.45–2.85) in 2021]. People who had disability reported to have higher odds of ED visits across all the three years: [AOR 1.97 (95% CI 1.56–2.50) in 2019, AOR 1.46 (95% CI 1.14–1.88) in 2020, and AOR 1.48 (95% CI 1.15–1.91) in 2021]. Immigrants with diabetes were significantly less likely to have an ED visit compared to U.S.-born with diabetes in 2020 [AOR 0.54 (95% CI 0.38–0.77)]. NHB with diabetes were more likely to have an ED visit compared to NHW across all three years [AOR 1.48 (95% CI 1.10–1.99) in 2019, AOR 1.49 (95% CI 1.11–2.01) in 2020, and AOR 1.59 (95% CI 1.18–2.13) in 2021]. Adults aged 50–64 years with diabetes were less likely to have an ED visit compared to adults aged 18–34 years with diabetes in 2020 [AOR 0.52 (95% CI 0.27–0.99), and 2021 [AOR 0.48 (95% CI 0.25–0.91)]. Similarly, adults aged 65 + years with diabetes were less likely to have an ED visit compared to adults aged 18–34 years with diabetes in 2020 [AOR 0.46 (95% CI 0.24–0.90)]. Lastly, SNAP utilizers were more likely to have an ED visit in 2021 [AOR 1.60 (95% CI 1.16–2.21)] compared to those who were not SNAP utilizers.

Discussion

This study examines the impact of COVID-19 on ED visits among adults with diabetes in the U.S., using the NHIS data from 2019 to 2021. The analyses reveal a significant decrease in ED visits during the pandemic years compared to the pre-pandemic year, even after adjusting for healthcare access, self-reported health status, demographic, and other socioeconomic factors. These findings suggest that COVID-19 may have led to a substantial change in healthcare-seeking behaviors among people with diabetes but delaying care is not the only contributing factor in changes in ED visits. This study highlights the disparities among people living with diabetes whose care was affected not only by the COVID and its related factors but also may have been due to existing factors that were exaggerated due to COVID.

Over 40% of adults in the U.S. avoided the healthcare system due to COVID-19 concerns, with significant declines in overall healthcare utilization [38]. Past literature shows 10% decrease in ED visits from diabetes-related crisis during the early pandemic than pre-pandemic period [39]. Some of the decline in ED visits among patients with diabetes during the pandemic can be explained by widespread fear of contracting COVID-19, stay-at-home orders, public health recommendation to avoid crowded places in healthcare settings likely discouraged the patients from seeking urgent or emergency care, even when it was necessary [25, 26, 31, 39]. Second, increased use of telemedicine services during the pandemic may have provided an alternative to in-person ED visits [27–29], allowing patients to manage their conditions remotely without having to visit the ED [40].

Table 1 Weighted percentages of independent variables for the study sample of the U.S. Adults living with diabetes and their ED utilization and total study sample stratified by year: NHIS 2019–2021

INDEPENDENT VARIABLES	Total Sample Weighted % (unweighted *N*)	Used ED Weighted % (unweighted *N*)	Did Not Use ED Weighted % (unweighted *N*)	*P*-Value	2019 Weighted % (unweighted *N*)	2020 Weighted % (unweighted *N*)	2021 Weighted % (unweighted *N*)
Year				< 0.001			
2019	32.7 (3,066)	36.2 (1,012)	31.3 (2,037)				
2020	32.7 (3,086)	32.0 (897)	33.0 (2,166)				
2021	34.5 (2,899)	31.8 (807)	35.7 (2,071)				
ED Utilization				< 0.001			
Used ED	30.3 (2,716)				33.4 (1,012)	29.6 (897)	27.9 (807)
Did Not Use ED	69.7 (6,274)				66.6 (2,037)	70.4 (2,166)	72.1 (2,071)
NEED FACTORS							
Self-Reported Health Status				< 0.001			
Excellent or Very Good	20.6 (1,962)	12.3 (364)	24.2 (1,589)		20.0 (634)	20.1 (693)	21.5 (635)
Good	38.5 (3,515)	32.9 (912)	40.9 (2,582)		37.2 (1,170)	37.7 (1,195)	40.3 (1,150)
Fair or Poor	41.0 (3,573)	54.7 (1,440)	34.9 (2,102)		42.7 (1,262)	42.2 (1,198)	38.2 (1,113)
Disability Status				< 0.001			
Do not have a disability	76.2 (6,800)	64.7 (1,725)	81.2 (5,033)		75.9 (2,273)	76.2 (2,348)	76.4 (2,179)
Have disability	23.8 (2,251)	35.3 (991)	18.8 (1,241)		24.1 (793)	23.8 (738)	23.6 (720)
ENABLING FACTORS							
Delayed Care				< 0.001			
Did Not Delay Care	91.9 (8,348)	87.5 (2,430)	93.8 (5,908)		90.4 (2,788)	92.9 (2,883)	92.2 (2,677)
Delayed Care	8.1 (652)	12.5 (286)	6.2 (365)		9.6 (264)	7.1 (184)	7.8 (204)
Last Doctor Visit				0.034			
Last Doctor Visit Within Last Year or Two	99.1 (8,935)	99.6 (2,703)	98.9 (6,215)		99.1 (3,028)	99.2 (3,046)	99.1 (2,861)
Last Time Saw Doctor Was More than 3 years or never	0.9 (67)	0.4 (12)	1.1 (55)		0.9 (26)	0.8 (21)	0.9 (20)
Usual Source of Care				0.81			
One or More Than One Usual Place to Go for Care	97.5 (8,822)	97.4 (2,664)	(6,146)		97.2 (2,980)	97.6 (3,015)	97.7 (2,827)
Have No place to Go for Care	2.5 (181)	2.6 (52)	2.4 (127)		2.8 (73)	2.4 (53)	2.3 (55)
Health Insurance				< 0.001			
Private	47.8 (4,252)	39.8 (1,069)	51.4 (3,164)		49.3 (1,483)	46.1 (1,439)	48.1 (1,330)
Uninsured	6.5 (406)	6.6 (123)	6.4 (280)		6.7 (152)	7.1 (130)	5.6 (124)
Medicare/Medicaid	35.9 (3,417)	41.9 (1,181)	33.1 (2,203)		34.1 (1,097)	37.0 (1,188)	36.5 (1,132)
Other Coverage	9.8 (955)	11.6 (337)	9.1 (615)		9.9 (327)	9.7 (323)	9.8 (305)
Food Insecurity				< 0.001			
No Food Insecurity	88.3 (7,771)	82.2 (2,183)	90.8 (5,578)		86.5 (2,609)	87.4 (2,635)	90.6 (2,527)
With Food Insecurity	11.7 (963)	17.8 (439)	9.2 (524)		13.5 (380)	12.6 (326)	9.4 (257)
SNAP Utilization				< 0.001			
Not a SNAP Utilizer	82.7 (7,301)	74.6 (2,008)	86.2 (5,285)		82.9 (2,502)	82.6 (2,484)	82.5 (2,315)
SNAP Utilizer	17.3 (1,414)	25.4 (608)	13.8 (804)		17.1 (479)	17.4 (471)	17.5 (464)
Working Status in Last Week				< 0.001			
Worked last week	37.6 (2,925)	29.7 (684)	41.1 (2,239)		37.8 (1,017)	35.7 (935)	39.3 (973)
Not Worked Last Week	62.4 (5,850)	70.3 (1,953)	58.9 (3,889)		62.2 (1,977)	64.3 (2,041)	60.7 (1,832)
Income-Poverty ratio				< 0.001			
> 400 FPL	29.9 (2,791)	23.2 (671)	32.9 (2,107)		28.4 (894)	29.6 (982)	31.7 (915)
< 100 FPL	13.9 (1,288)	19.6 (545)	11.3 (729)		15.4 (491)	14.1 (420)	12.3 (377)
100–200 FPL	23.5 (2,141)	26.9 (711)	21.9 (1,410)		23.4 (724)	24.2 (723)	23.0 (694)
200–400 FPL	32.6 (2,831)	30.2 (789)	33.8 (2,028)		32.8 (957)	32.1 (961)	32.9 (913)
Education				< 0.001			
Graduate Degree or Higher (Ref)	12.9 (1,195)	10.0 (276)	14.3 (917)		12.3 (384)	12.5 (430)	14.0 (378)

Table 1 (continued)

INDEPENDENT VARIABLES	Total Sample Weighted % (unweighted *N*)	Used ED Weighted % (unweighted *N*)	Did Not Use ED Weighted % (unweighted *N*)	*P*-Value	2019 Weighted % (unweighted *N*)	2020 Weighted % (unweighted *N*)	2021 Weighted % (unweighted *N*)
No Diploma	9.2 (832)	9.9 (293)	8.8 (531)		10.2 (307)	10.3 (266)	7.2 (259)
GED or High School	24.7 (2,211)	27.2 (709)	23.6 (1,485)		25.0 (778)	23.3 (702)	25.9 (731)
Some College	33.9 (3,062)	36.7 (993)	32.7 (2,048)		34.1 (1,022)	35.3 (1,074)	32.2 (966)
Bachelor	19.2 (1,727)	16.2 (439)	20.5 (1,276)		18.4 (564)	18.6 (608)	20.6 (555)
Household Size				0.015			
1 member	21.2 (3,535)	22.8 (1,118)	20.3 (2,389)		21.7 (1,224)	21.5 (1,223)	20.4 (1,088)
2 members	42.4 (3,600)	39.9 (1,019)	43.4 (2,553)		41.8 (1,187)	42.2 (1,223)	43.2 (1,190)
3 members	22.0 (1,151)	21.3 (339)	22.4 (810)		22.0 (398)	21.3 (375)	22.6 (378)
>=4 members	14.4 (752)	15.9 (236)	13.8 (513)		14.4 (252)	15.0 (257)	13.8 (243)
Region				0.49			
West	20.5 (1,879)	20.7 (548)	20.4 (1,319)		19.6 (607)	20.8 (624)	21.0 (648)
Northeast	15.9 (1,399)	14.8 (411)	16.4 (979)		16.2 (471)	16.3 (529)	15.4 (399)
Midwest	20.3 (2,013)	20.8 (618)	20.0 (1,381)		20.3 (675)	19.8 (680)	20.8 (658)
South	43.2 (3,760)	43.6 (1,139)	43.1 (2,595)		43.9 (1,313)	43.1 (1,253)	42.8 (1,197)
Metropolitan Status				0.13			
Metropolitan	82.4 (7,315)	81.3 (2,159)	82.9 (5,110)		80.9 (2,431)	82.0 (2,499)	84.1 (2,385)
Non-Metro Area	17.6 (1,736)	18.7 (557)	17.1 (1,164)		19.1 (635)	18.0 (587)	15.9 (514)
PREDISPOSING FACTORS							
Age (in years)				< 0.001			
18–34	3.9 (217)	4.9 (80)	3.4 (134)		3.6 (75)	4.2 (75)	3.8 (67)
35–49	13.9 (965)	16.4 (325)	12.7 (635)		14.6 (345)	13.8 (307)	13.2 (313)
50–64	36.0 (2,953)	33.7 (864)	37.1 (2,070)		36.8 (1,030)	32.9 (921)	38.2 (1,002)
65+	46.2 (4,916)	45.1 (1,447)	46.7 (3,435)		45.0 (1,616)	49.1 (1,783)	44.8 (1,517)
Sex				< 0.001			
Male	50.5 (4,381)	46.0 (1,257)	52.5 (3,094)		48.9 (1,478)	51.4 (1,500)	51.3 (1,403)
Female	49.5 (4,669)	54.0 (1,459)	47.5 (3,179)		51.1 (1,588)	48.6 (1,585)	48.7 (1,496)
Race/Ethnicity				< 0.001			
Non-Hispanic White (Ref)	58.5 (5,804)	55.5 (1,653)	59.9 (4,118)		59.9 (1,995)	58.3 (2,023)	57.4 (1,786)
Non-Hispanic Black	15.6 (1,401)	20.2 (527)	13.6 (861)		15.3 (475)	15.0 (456)	16.4 (470)
Hispanic	17.1 (1,166)	16.3 (355)	17.5 (801)		16.1 (373)	17.6 (382)	17.7 (411)
Non-Hispanic Others	8.7 (680)	7.9 (181)	9.0 (494)		8.6 (223)	9.1 (225)	8.4 (232)
Sexual Orientation				0.5			
Heterosexuals (Ref)	97.7 (8,476)	97.3 (2,534)	97.9 (5,929)		98.2 (2,893)	97.7 (2,900)	97.2 (2,683)
Gay/Lesbian	1.2 (116)	1.3 (35)	1.2 (81)		0.8 (29)	1.5 (45)	1.3 (42)
Bisexuals	0.8 (57)	0.9 (21)	0.6 (36)		0.6 (20)	0.5 (15)	1.0 (22)
Other non-heterosexuals	0.3 (31)	0.4 (10)	0.3 (20)		0.3 (9)	0.3 (11)	0.5 (11)
Marital Status				< 0.001			
Married	56.1 (4,014)	49.4 (1,063)	58.9 (2,947)		55.5 (1,338)	54.8 (1,349)	57.8 (1,327)
Not Married	43.9 (4,767)	50.6 (1,574)	41.1 (3,187)		44.5 (1,657)	45.2 (1,632)	42.2 (1,478)
Nativity				< 0.001			
U.S. Born	80.5 (7,496)	84.1 (2,320)	78.9 (5,165)		81.7 (2,580)	79.2 (2,563)	80.4 (2,353)
Immigrants	19.5 (1,301)	15.9 (326)	21.1 (973)		18.3 (411)	20.8 (443)	19.6 (447)

NHIS National Health Interview Survey, *Ref* Reference category, *GED* General Educational Development, *SNAP* Supplemental Nutrition Assistance Program, *FPL* Federal Poverty Level

About 68 million people in the U.S. have two or more chronic conditions [41]. Chronic conditions often require urgent care when complications arise, particularly if they are poorly managed due to limited access to primary care. This study shows that older age groups (50–64 and 65 + years) had significantly lower odds of visiting the ED compared to younger adults. This may suggest better disease management and continuity of care among older patients with established healthcare routines. However, this disparity may also indicate that younger patients are underutilizing necessary care, potentially due to barriers in access or a lack of engagement with healthcare services

Table 2 Multivariable logistic regression of emergency department utilization before (2019) and during (2020 and 2021) the COVID-19 pandemic among U.S. Adults living with diabetes

Exposure Variables	Emergency Department Visit
	Adjusted Odds Ratio
Year	
2019	Reference
2020	**0.85 (0.73–0.98)***
2021	**0.76 (0.65–0.88)*****
NEED FACTORS	
Self-Reported Health Status	
Excellent or Very Good	Reference
Good	**1.39 (1.18–1.64)*****
Fair or Poor	**2.01 (1.68–2.41)*****
Disability Status	
Do not have a disability	Reference
Have Disability	**1.64 (1.42–1.89)*****
ENABLING FACTORS	
Delayed Care	
Did Not Delay Care Due to Cost	Reference
Delayed Care Due to Cost	**1.65 (1.32–2.06)*****
Last Doctor Visit	
Last Time Saw Doctor Within Last Year or Two	Reference
Last Time Saw Doctor Was ≥ 3 Years or Never	0.49 (0.17–1.37)
Usual Source of Care	
Have One Or More Usual Place to Go for Care	Reference
Have No Usual Place to Go for Care	1.02 (0.67–1.55)
Health Insurance	
Private	Reference
Medicare/Medicaid	0.95 (0.69–1.31)
Other Coverage	1.15 (0.98–1.34)
Uninsured	1.18 (0.97–1.44)
Food Insecurity	
No Food Insecurity	Reference
With Food Insecurity	1.21 (1.00-1.47)
SNAP	
Not a SNAP utilizer	Reference
SNAP Utilizer	**1.30 (1.07–1.57)****
Working status in Last Week	
Worked Last Week	Reference
Not Worked Last Week	**1.21 (1.02–1.43)***
Income-Poverty ratio	
> 400 FPL	Reference
< 100 FPL	1.13 (0.88–1.45)
100–200 FPL	1.07 (0.87–1.30)
200–400 FPL	0.97 (0.83–1.14)
Education	
Graduate Degree or Higher	Reference
No Diploma	1.04 (0.78–1.38)
GED or High School	1.18 (0.94–1.49)
Some College	**1.24 (1.01–1.52)***
Bachelor	1.10 (0.88–1.38)
Household Size	
1 member	Reference
2 members	1.04 (0.88–1.22)
3 members	1.05 (0.85–1.31)

Table 2 (continued)

Exposure Variables	Emergency Department Visit
	Adjusted Odds Ratio
>=4 members	1.08 (0.84–1.38)
Region	
West	Reference
Northeast	0.92 (0.75–1.14)
Midwest	0.95 (0.78–1.14)
South	0.86 (0.72–1.02)
Metropolitan Status	
Metropolitan	Reference
Non-Metropolitan	0.98 (0.84–1.14)
PREDISPOSING FACTORS	
Age (in years)	
18–34	Reference
35–49	0.82 (0.56–1.19)
50–64	**0.58 (0.41–0.84)****
65+	**0.57 (0.39–0.82)****
Sex	
Male	Reference
Female	1.12 (0.99–1.26)
Race/Ethnicity	
Non-Hispanic White	Reference
Non-Hispanic Black	**1.51 (1.27–1.78)*****
Hispanic	0.99 (0.80–1.23)
Non-Hispanic Others	1.15 (0.89–1.47)
Sexual Orientation	
Heterosexuals	Reference
Gay/Lesbian	1.16 (0.68–1.96)
Bisexuals	1.01 (0.49–2.05)
Other non-heterosexuals	0.91 (0.38–2.16)
Marital Status	
Married	Reference
Not Married	1.09 (0.93–1.27)
Nativity	
U.S. Born	Reference
Immigrants	**0.73 (0.60–0.89)****

Boldface indicates statistical significance: *, **, *** significant at 5%, 1%, and 0.1% levels, respectively

Ref Reference category, *GED* General Educational Development, *SNAP* Supplemental Nutrition Assistance Program, *FPL* Federal Poverty Level

[42]. Younger people (18–34 years) have higher proportions of type 1 diabetes which has higher likelihood of acute life-threatening complications such as hyperosmolar state (HHS) and diabetes ketoacidosis (DKA) [43]. Both DKA and HHS are known cause of increase health service utilization in people with diabetes [43]. COVID-19 infection may precipitate DKA and HHS [44]. This may also explain lower ED visits in 50–64 years and 65 + years compared to 18–34 years during the pandemic.

Patients relying on SNAP benefits and those not working at the time of the survey had higher ED visits, suggesting that socioeconomically disadvantaged individuals are more likely to rely on emergency services for healthcare needs [45]. These findings highlight the need to address healthcare disparities, which were exacerbated by the pandemic. This study found that adults with diabetes who self-reported a disability were significantly more likely to have an ED visit compared to those without a disability. Individuals with a disability may face compounded challenges in accessing regular primary care, such as mobility issues or communication barriers, leading to poorer disease management and a higher likelihood of ED visits.

The study found significant variation in the ED visits by other socioeconomic and demographic factors. People with diabetes and no health insurance had 1.67 times higher odds of ED visits compared to people with diabetes and having private health insurance in 2021. Aggregated results show that NHB were 1.51 times more likely to use ED compared to NHW between 2019 and 2021.

Table 3 Multivariable logistic regression of emergency department utilization among the U.S. Adults living with diabetes stratified by year

	2019 (*N* = 2,908)			**2020 (*N* = 2,880)**			**2021 (*N* = 2,707)**		
Exposure Variables	Adjusted Odds Ratio	Lower CI	Upper CI	Adjusted Odds Ratio	Lower CI	Upper CI	Adjusted Odds Ratio	Lower CI	Upper CI
NEED FACTORS									
Self-Reported Health Status									
Excellent or Very Good	Reference								
Good	1.10	0.83	1.47	**2.00*** **	**1.48**	**2.69**	1.33	0.98	1.79
Fair or Poor	**1.86*** **	**1.38**	**2.50**	**2.35*** **	**1.70**	**3.25**	**2.03*** **	**1.45**	**2.85**
Disability Status									
Do not have a disability	Reference								
Have Disability	**1.97*** **	**1.56**	**2.50**	**1.46** **	**1.14**	**1.88**	**1.48** **	**1.15**	**1.91**
ENABLING FACTORS									
Delayed Care									
Did Not Delay Care Due to Cost	Reference								
Delayed Care due to cost	**1.83** **	**1.26**	**2.66**	**2.10** **	**1.33**	**3.30**	1.32	0.91	1.92
Last Doctor Visit									
Doctor Visit in Last Year or Two	Reference								
Last Time Saw Dr Was More than 3 years or never	**0.17** **	**0.05**	**0.62**	**0.10***	**0.02**	**0.58**	2.07	0.4	10.59
Usual Source of Care									
One or More Than One Usual Place to Go for Care	Reference								
Have No place to Go for Care	0.95	0.45	1.99	0.87	0.42	1.81	1.18	0.57	2.45
Health Insurance									
Private	Reference								
Medicare/Medicaid	0.79	0.47	1.33	0.88	0.46	1.68	1.25	0.73	2.14
Other Coverage	1.15	0.89	1.48	1.02	0.77	1.36	1.21	0.91	1.6
Uninsured	0.97	0.69	1.37	0.98	0.69	1.39	**1.67** **	**1.20**	**2.32**
Food Insecurity									
No Food Insecurity	Reference								
With Food Insecurity	1.24	0.89	1.73	1.08	0.77	1.53	1.34	0.94	1.91
SNAP									
Not a SNAP utilizer	Reference								
SNAP Utilizer	1.16	0.83	1.64	1.20	0.84	1.71	**1.60** **	**1.16**	**2.21**
Working status in last week									
Worked last week	Reference								
Not worked last week	1.20	0.91	1.58	**1.47***	**1.07**	**2.02**	1.02	0.76	1.38
Income-Poverty ratio									
> 400 FPL	Reference								
< 100 FPL	1.41	0.93	2.12	1.26	0.8	2.01	0.81	0.52	1.26
100–200 FPL	1.32	0.95	1.85	1.13	0.8	1.61	0.81	0.56	1.16
200–400 FPL	0.92	0.70	1.22	1.14	0.86	1.50	0.90	0.68	1.20
Education									
Graduate Degree or Higher	Reference								
No Diploma	1.04	0.66	1.62	0.99	0.59	1.66	1.07	0.64	1.80
GED or High School	1.08	0.73	1.60	1.24	0.82	1.88	1.19	0.79	1.80
Some College	1.12	0.78	1.60	1.15	0.80	1.64	1.42	0.99	2.04
Bachelor	1.31	0.90	1.93	1.03	0.69	1.54	0.92	0.62	1.36
Household Size									
1 member	Reference								
2 members	0.97	0.73	1.27	1.25	0.92	1.71	0.96	0.72	1.29
3 members	0.99	0.70	1.39	1.48	0.99	2.22	0.87	0.58	1.29
>=4 members	1.17	0.79	1.74	1.22	0.76	1.94	0.93	0.60	1.45
Region									
West	Reference								

Table 3 (continued)

	2019 (*N* = 2,908)			2020 (*N* = 2,880)			2021 (*N* = 2,707)		
Northeast	0.88	0.61	1.27	0.82	0.57	1.17	1.21	0.83	1.77
Midwest	0.86	0.61	1.20	0.84	0.61	1.17	1.15	0.83	1.58
South	0.83	0.61	1.11	0.78	0.56	1.09	1.02	0.75	1.39
Metropolitan Status									
Metropolitan Area	Reference								
Non-Metropolitan Area	0.81	0.63	1.05	0.98	0.75	1.29	1.21	0.9	1.61
PREDISPOSING FACTORS									
Age (in years)									
18–34	Reference								
35–49	0.90	0.48	1.70	0.80	0.42	1.54	0.79	0.40	1.54
50–64	0.79	0.43	1.46	**0.52***	**0.27**	**0.99**	**0.48***	**0.25**	**0.91**
65+	0.71	0.39	1.29	**0.46***	**0.24**	**0.90**	0.57	0.30	1.09
Sex									
Male	Reference								
Female	1.11	0.91	1.36	1.03	0.83	1.29	1.12	0.91	1.39
Race/Ethnicity									
Non-Hispanic White	Reference								
Non-Hispanic Black	**1.48****	**1.10**	**1.99**	**1.49****	**1.11**	**2.01**	**1.59****	**1.18**	**2.13**
Hispanic	1.20	0.83	1.73	0.84	0.58	1.22	0.98	0.66	1.47
Non-Hispanic Others	1.11	0.74	1.67	1.22	0.77	1.96	1.17	0.74	1.87
Sexual Orientation									
Heterosexuals	Reference								
Gay/Lesbian	0.73	0.28	1.94	0.82	0.36	1.84	1.87	0.77	4.56
Bisexuals	0.69	0.19	2.46	0.62	0.15	2.51	1.59	0.61	4.13
Other non-heterosexuals	3.81	0.95	15.28	0.46	0.12	1.81	0.53	0.10	3.01
Marital Status									
Married	Reference								
Not Married	1.04	0.80	1.36	**1.41***	**1.06**	**1.87**	0.95	0.72	1.26
Nativity									
U.S. Born	Reference								
Immigrants	0.84	0.60	1.17	**0.54*****	**0.38**	**0.77**	0.77	0.53	1.12

Boldface indicates statistical significance: *, **, *** significant at 5%, 1%, and 0.1% levels, respectively

CI Confidence Interval, *GED* General Educational Development, *SNAP* Supplemental Nutrition Assistance Program, *FPL* Federal Poverty Level

On stratification by year, the odds of ED visits continue to be higher in each year in NHB compared to NHW. Such findings suggest that these disparities were present prior to the pandemic and widened during the pandemic, highlighting broader inequities in healthcare access [31]. On the other hand, these finding were opposite to the decreasing trends of health service utilization and expenditure by adults with diabetes and commercially insured during the pandemic observed in previous studies [46]. The largest reduction was observed between March 2020 and May 2020, but the reduction persisted throughout 2021 [46]. In contrast, this study found that the odds of ED visits were reduced by 24% in 2021 and 15% in 2020. Although literature showed persisted reduction in ED visits in 2021, the findings were limited to commercially insured people with diabetes. Whereas our study includes nationally representative population with all types of health insurance or lack of it. Additionally, we also see from previous literature that the overall ED visits decrease in 2021 compared to 2019, but the decrease is not constant through different quarters of 2021 [47]. And this may be another reason why our study did not find significant decrease in ED visits in 2021.

This study found that immigrants with diabetes were less likely to have an ED visit compared to U.S.-born with diabetes. This could be attributed to several factors. The lower ED visit rate among immigrants may not necessarily indicate a positive outcome. This finding could reflect a limited understanding of diabetes complications or health system or generally restricted access to healthcare services among immigrants [48–50]. Immigrants are more likely to delay medical care due to cost, less likely to visit an ED, and less likely to use telehealth during the pandemic as per the past literature [51].

The result supports the need for expanded healthcare access and tailored interventions for Blacks who may face structural barriers to care. The result of this research informs clinicians to anticipate high-acuity cases among

diabetes and ensue faster triage and optimized care pathways. The study informs public health department in planning for future public health crises, insurance companies and managed care organizations to develop preventive care incentives and develop case management strategies for people with diabetes at risk of complication due to delayed care and challenges related to the social determinants of health. The results help hospital and health administrators to anticipate patient surges and encourage partnerships with SNAP programs, disability services, and minority health organizations to improve diabetic care before utilization of high-cost ED visits.

While this study provides valuable insights on the impact of COVID-19 on ED visits among adults with diabetes, some limitations should be acknowledged. First, the findings were based on self-reported survey data, which may introduce recall bias, particularly regarding healthcare utilization. Additionally, the NHIS data do not have information on the severity of diabetic conditions or complications, which could affect ED use. Lastly, despite adjustment for multiple covariates, unmeasured confounders, such as access to primary care or local pandemic restrictions, may have influenced the study findings.

Conclusion

This study shows that the COVID-19 pandemic led to a significant reduction in ED visits among adults with diabetes in the U.S. This reduction was likely influenced by concerns about infection risk and the increased use of telemedicine. However, the continued high utilization of ED services by socioeconomically disadvantaged groups and racial minorities highlights persistent disparities in access to routine care. These findings highlight the need for improved healthcare infrastructure and targeted interventions to ensure that vulnerable populations have equitable access to routine care, both during public health emergencies and beyond, to prevent negative health outcomes in patients with diabetes.

Abbreviations

COVID-19	Coronavirus disease 2019
WHO	World Health Organization
ED	Emergency Department
HbA1c	Hemoglobin A1c
NHIS	National Health Interview Survey
SNAP	Supplemental Nutrition Assistance Program
FPL	Federal Poverty Level
GED	General Educational Development
NHB	Non-Hispanic Black
NHW	Non-Hispanic White
AOR	Adjusted Odds Ratios
CI	Confidence Interval
STROBE	Strengthening the Reporting of Observational studies in Epidemiology

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-24776-9.

Supplementary Material 1.

Acknowledgements

Not applicable.

Authors' contributions

All authors have contributed significantly and in keeping with the latest guidelines of the International Committee of Medical Journal Editors. KM: conceptualization, methodology, methodology, validation, visualization, and writing - review & editing. NS: data curation, methodology, software, formal analysis, data curation, writing- reviewing & editing. OAS: conceptualization, resources, writing- reviewing & editing. OO: conceptualization, writing-reviewing & editing. AOA: conceptualization, project administration, writing – original draft, and writing – review & editing.

Funding

Dr. Afua O. Asare contribution to this study was supported by National Institutes of Health Core Grant (EY014800), and an Unrestricted Grant from Research to Prevent Blindness, New York, NY, to the Department of Ophthalmology & Visual Sciences, University of Utah. No other funding to disclose. The views presented in this article are solely the responsibility of the authors and do not necessarily represent the views of the funding agencies.

Data availability

The National Health Interview Survey data analyzed during the current study are available in the National Center for Health Statistics. repository, https://www.cdc.gov/nchs/nhis/documentation/index.html.

Declarations

Competing interests

The authors declare no competing interests.

Author details

[1]Department of Public Health, East Carolina University, Greenville, NC 27834, USA
[2]Department of Population Health Sciences, Spencer Fox Eccles School of Medicine, University of Utah, Salt Lake City, UT 84108, USA
[3]Division of Health System Innovation and Research, Spencer Fox Eccles School of Medicine, University of Utah Intermountain Healthcare, Salt Lake City, UT 84108, USA
[4]Department of Family Medicine, Indiana University School of Medicine, 980 Indiana Avenue, Indianapolis, IN 46202, USA
[5]Department of Ophthalmology & Visual Sciences, Spencer Fox Eccles School of Medicine, University of Utah, Salt Lake City, UT 84108, USA

Received: 5 May 2025 / Accepted: 4 September 2025
Published online: 08 October 2025

References

1. Parker ED, Lin J, Mahoney T, Ume N, Yang G, Gabbay RA, et al. Economic costs of diabetes in the U.S. in 2022. Diabetes Care. 2024;47(1):26–43.
2. National Center for Health Statistics. National Health Interview Survey 2019–2022 [Public-use data file and documentation]: Centers for Disease Control and Prevention; 2024 [cited 2024 October 5]. Available from: https://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm
3. Kaptoge S, Seshasai SRK, Sun L, Walker M, Bolton T, Spackman S, et al. Life expectancy associated with different ages at diagnosis of type 2 diabetes in high-income countries: 23 million person-years of observation. Lancet Diabetes Endocrinol. 2023;11(10):731–42.
4. Trikkalinou A, Papazafiropoulou AK, Melidonis A. Type 2 diabetes and quality of life. World J Diabetes. 2017;8(4):120–9.

5. American Diabetes Association. Economic costs of diabetes in the U.S. in 2017. Diabetes Care. 2018;41(5):917–28.
6. Dieleman JL, Baral R, Birger M, Bui AL, Bulchis A, Chapin A, et al. Us spending on personal health care and public health, 1996–2013. JAMA. 2016;316(24):2627–46.
7. Li QH, Ma YH, Wang N, Hu Y, Liu ZZ. New coronavirus infected pneumonia engulfs Wuhan. Asian Toxicol Res. 2020;1:1–7. https://www.tmrjournals.com/public/articlePDF/20201127/397f4e20d150740756b89bd740ca1d5f.pdf.
8. Cucinotta D, Vanelli M. Who declares COVID-19 a pandemic. Acta Biomed. 2020;91(1):157–60.
9. Pollard CA, Morran MP, Nestor-Kalinoski AL. The COVID-19 pandemic: a global health crisis. Physiol Genomics. 2020;52(11):549–57.
10. Mathieu ER, Rodés-Guirao H, Appel L, Gavrilov C, Giattino D, Hasell C, Macdonald J, Dattani B, Beltekian S, Ortiz-Ospina D, Roser E. M. Coronavirus (COVID-19) Cases Online: Our World in Data; 2020 [cited 2024 October 14]. Available from: https://ourworldindata.org/covid-cases
11. Rigby JSB. WHO declares end to COVID global health emergency 2023 [updated May 8, 2023. Available from: https://www.reuters.com/business/healthcare-pharmaceuticals/covid-is-no-longer-global-health-emergency-who-2023-05-05/
12. Pfizer. Global and U.S. Agencies Declare End of COVID-19 Emergency. 2023.
13. Centers for Disease Control and Prevention. End of the Federal COVID-19 Public Health Emergency (PHE) Declaration 2023 [updated September 12, 2023. Available from: https://archive.cdc.gov/www_cdc_gov/coronavirus/2019-ncov/your-health/end-of-phe.html
14. Powder J. Covid-19 in 2022: A year-end wrap-up. Covid-year-in-review at Johns Hopkins Bloomberg School of Public Health, available at: https://www
15. Ginde AA, Pelletier AJ, Camargo CA Jr. National study of US emergency department visits with diabetic ketoacidosis, 1993–2003. Diabetes Care. 2006;29(9):2117–9.
16. Uppal TS, Chehal PK, Fernandes G, Haw JS, Shah M, Turbow S, et al. Trends and variations in emergency department use associated with diabetes in the US by sociodemographic factors, 2008–2017. JAMA Netw Open. 2022;5(5):e2213867–e.
17. Lewing B, Sansgiry S, Abughosh SM, Lal LS, Essien EJ, Sansgiry SS. Effect of inadequate care on diabetes complications and healthcare resource utilization during management of type 2 diabetes in the United States. Postgrad Med. 2022;134(5):494–506.
18. Honigman LS, Wiler JL, Rooks S, Ginde AA. National study of non-urgent emergency department visits and associated resource utilization. West J Emerg Med. 2013;14(6):609–16.
19. Dowd B, Karmarker M, Swenson T, Parashuram S, Kane R, Coulam R, et al. Emergency department utilization as a measure of physician performance. Am J Med Qual. 2014;29(2):135–43.
20. Agency for Healthcare Research and Quality. Preventable Emergency Department Visits.: Rockville, MD. 2018 [updated June 2018; cited 2024 October 14]. Available from: https://www.ahrq.gov/research/findings/nhqrdr/chartbooks/carecoordination/measure2.html
21. Bancks MP, Lin M-Y, Bertoni A, Futrell WM, Liu Z, Ostasiewski B, et al. Impact of the COVID-19 pandemic on diabetes care among a North Carolina patient population. Clin Diabetes. 2022;40(4):467–76.
22. Baugh JJ, White BA, McEvoy D, Yun BJ, Brown DFM, Raja AS, et al. The cases not seen: patterns of emergency department visits and procedures in the era of COVID-19. Am J Emerg Med. 2021;46:476–81.
23. Westgard BC, Morgan MW, Vazquez-Benitez G, Erickson LO, Zwank MD. An analysis of changes in emergency department visits after a state declaration during the time of COVID-19. Ann Emerg Med. 2020;76(5):595–601.
24. Jeffery MM, D'Onofrio G, Paek H, Platts-Mills TF, Soares WE 3rd, Hoppe JA, 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. JAMA Intern Med. 2020;180(10):1328–33.
25. Khunti K, Aroda VR, Aschner P, Chan JCN, Del Prato S, Hambling CE, et al. The impact of the COVID-19 pandemic on diabetes services: planning for a global recovery. Lancet Diabetes Endocrinol. 2022;10(12):890–900.
26. Czeisler M, Marynak K, Clarke KEN, Salah Z, Shakya I, Thierry JM, et al. Delay or avoidance of medical care because of COVID-19-related concerns - United states, June 2020. MMWR Morb Mortal Wkly Rep. 2020;69(36):1250–7.
27. Monaghesh E, Hajizadeh A. The role of telehealth during COVID-19 outbreak: a systematic review based on current evidence. BMC Public Health. 2020;20(1):1193.
28. Shaver J. The state of telehealth before and after the COVID-19 pandemic. Prim Care. 2022;49(4):517–30.
29. Koonin LM, Hoots B, Tsang CA, Leroy Z, Farris K, Jolly T, et al. Trends in the use of telehealth during the emergence of the COVID-19 Pandemic - United states, January-March 2020. MMWR Morb Mortal Wkly Rep. 2020;69(43):1595–9.
30. Mafi JN, Craff M, Vangala S, Pu T, Skinner D, Tabatabai-Yazdi C, et al. Trends in US ambulatory care patterns during the COVID-19 pandemic, 2019–2021. JAMA. 2022;327(3):237–47.
31. Pujolar G, Oliver-Anglès A, Vargas I, Vázquez M-L. Changes in access to health services during the COVID-19 pandemic: a scoping review. Int J Environ Res Public Health. 2022;19(3):1749.
32. National Center for Health Statistics. National Health Interview Survey. 2019. Public-use data file and documentation: Centers for Disease Control and Prevention; 2020 [cited 2024 October 5]. Available from: https://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm
33. National Center for Health Statistics. National Health Interview Survey. 2020. Public-use data file and documentation.: Centers for Disease Control and Prevention; 2021 [cited 2024 October 5]. Available from: https://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm
34. National Center for Health Statistics. *National Health Interview Survey* [Public-use data file and documentation]. Centers for Disease Control and Prevention; 2022 [cited 2024 October 5]. Available from: https://www.cdc.gov/nchs/nhis/documentation/?CDC_AAref_Val=https://www.cdc.gov/nchs/nhis/data-questionnaires-documentation.htm
35. Andersen R. A behavioral model of families' use of health services. Chicago: Center for Health Administration Studies, University of Chicago; 1968.
36. Alkhawaldeh A, ALBashtawy M, Rayan A, Abdalrahim A, Musa A, Eshah N, et al. Application and use of andersen's behavioral model as theoretical framework: a systematic literature review from 2012–2021. Iran J Public Health. 2023;52(7):1346.
37. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. BMJ (Clinical Res ed). 2007;335(7624):806–8.
38. Vander Woude CA, King EJ, Hirschtick JL, Titus AR, Power LE, Elliott MR, et al. Differential care-seeking behaviors during the beginning of the COVID-19 pandemic in Michigan: a population-based cross-sectional study. BMC Public Health. 2023;23(1):2101.
39. Lange SJ. Potential indirect effects of the COVID-19 pandemic on use of emergency departments for acute life-threatening conditions—United States, January–May 2020. MMWR Morb Mortal Wkly Rep. 2020. https://doi.org/10.15585/mmwr.mm6925e2.
40. Huang WL, Liao SL, Huang HL, Tsai PJ, Huang HH, Lu CY, et al. Impact of post-COVID-19 changes in outpatient chronic patients' healthcare-seeking behaviors on medical utilization and health outcomes. Health Econ Rev. 2024;14(1):71.
41. Boersma P, et al. Prevalence of multiple chronic conditions among US adults, 2018. Prevent Chronic Dis. 2020;17:E106. https://doi.org/10.5888/pcd17.200130.
42. Anderson MD, Gross C. The effect of health insurance on emergency department visits: evidence from an age-based eligibility threshold. Rev Econ Stat. 2014;96(1):189–95.
43. Fayfman M, Pasquel FJ, Umpierrez GE. Management of hyperglycemic crises: diabetic ketoacidosis and hyperglycemic hyperosmolar state. Med Clin North Am. 2017;101(3):587–606.
44. De Sa-Ferreira CO, da Costa CHM, Guimarães JCW, Sampaio NS, de Silva LdML LP, et al. Diabetic ketoacidosis and COVID-19: what have we learned so far? Am J Physiology-Endocrinology Metabolism. 2022;322(1):E44–53.
45. Drennen CR, Coleman SM, Ettinger de Cuba S, Frank DA, Chilton M, Cook JT, et al. Food insecurity, health, and development in children under age four years. Pediatrics. 2019;144(4). https://doi.org/10.1542/peds.2019-0824.
46. Zhou X, Lundeen EA, Rolka DB. Changes in utilization and expenditures among commercially insured US adults with diabetes during the COVID-19 pandemic: preliminary findings. AJPM Focus. 2024. https://doi.org/10.1016/j.focus.2024.100254.
47. Smith AR, DeVies J, Carey K, Sheppard M, Radhakrishnan L, Njai R, et al. COVID-19 pandemic-associated changes in overall emergency department visits by age group, race, and ethnicity - United States, january 2019-april 2022. Am J Emerg Med. 2023;69:121–6.
48. Siddiq H, Choi KR, Jackson N, Saadi A, Gelberg L, Ponce NA, et al. Determinants to tele-mental health services utilization among California adults: do immigration-related variables matter? J Immigr Minor Health. 2024;26(6):966–76.

49. Lee JJ, Chepkorir J, Alharthi A, Adeleye KK, Warren NE. Health service utilization of black immigrant women residing in the united states: A systematic review. J Racial Ethnic Health Disparities. 2024:1–31. https://doi.org/10.1007/s40615-024-01945-x.
50. Cheng TC, Lo CC. Factors in immigrant children's use of physician and dentist visits, hospital care, and prescribed medication in the united States. Eur J Investig Health Psychol Educ. 2023;13(10):2251–61.
51. Spencer MRT, Yoon S, Lee Y, Bustamante AV, Chen J. Healthcare and telehealth use among US immigrants during the COVID-19 pandemic. Front Public Health. 2024;12:1422343.

Publisher's Note