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ORIGINAL ARTICLE

Diversity, Equity and Inclusion

What explains differences in average wait time in the emergency department among different racial and ethnic populations: A linear decomposition approach

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Abstract

Objective: Non-Hispanic Black (NHB) and Hispanic/Latino (Hispanic) patients wait longer in the emergency department (ED) to see practitioners when compared with non-Hispanic White (NHW) patients. We investigate factors contributing to longer wait times for NHB and Hispanic patients using a linear decomposition approach.

Methods: This retrospective observational study included patients presenting to one tertiary hospital ED from 2019 to 2021. Median wait times among NHW, NHB, and Hispanic were calculated with multivariable linear regressions. The extent to which demographic, clinical, and hospital factors explained the differences in average wait time among the three groups were analyzed with Blinder–Oaxaca post-linear decomposition model.

Results: There were 310,253 total patients including 34.7% of NHW, 34.7% of NHB, and 30.6% of Hispanic patients. The median wait time in NHW was 9 min (interquartile range [IQR] 4–47 min), in NHB was 13 min (IQR 4–59 min), and in Hispanic was 19 min (IQR 5–78 min, $p < 0.001$). The top two contributors of average wait time difference were mode of arrival and triage acuity level. Post-linear decomposition analysis showed that 72.96% of the NHB–NHW and 87.77% of the Hispanic–NHW average wait time difference were explained by variables analyzed.

Conclusion: Compared to NHW patients, NHB and Hispanic patients typically experience longer ED wait times, primarily influenced by their mode of arrival and triaged acuity levels. Despite these recognized factors, there remains 12%–27% unexplained factors at work, such as social determinants of health (including implicit bias and systemic racism) and many other unmeasured confounders, yet to be discovered.

KEYWORDS
Blinder–Oaxaca decomposition, emergency department, race and ethnicity, wait time

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1 | INTRODUCTION

1.1 | Background

Centers for Disease Control and Prevention in 2018 reported that 56% of patients nationwide waited nearly 1 h in the emergency department (ED) to be seen by a healthcare practitioners and nearly 4% of them left without being seen.[1] Based upon the Academy of Administrators in Academic Emergency Medicine (AAAEM) survey, all patients should be seen within 30 min.[2] Unfortunately, longer wait time occurs commonly in the EDs across the nation, especially when EDs are overly crowded. In addition, wait time also varies among people of different races and ethnicities. Previous studies showed longer wait time occurred among non-Hispanic Black (NHB) and Hispanic/Latino (Hispanic) patients in comparison to the non-Hispanic White (NHW) population.[3–5] For example, using National Hospital Ambulatory Medical Care Survey (NHAMCS) data (2007–2008), it was found that the mean waiting times were 27.3 min in NHW, 37.7 min in NHB, and 32.7 min in Hispanic patients.[3] Similarly, when focused on pediatric patients, another study showed Hispanic children waited over 10% longer than NHW children in hospital EDs (ie, an unadjusted mean wait time of 46.7 min in NHW vs 65.3 min in Hispanic children, and an adjusted 10.4% of difference).[4] However, factors affecting longer wait times among minority patients are still not completely clear.

Research studies indicate factors affecting wait times mainly include ED administrative factors and patient clinic/non-clinic factors. ED administrative factors include type of ED (eg, trauma center vs community, urban vs rural), ED time (patient seen during weekend vs weekday, during clinical hours vs clinic off-hours), ED crowding status at time of patient presentation to the ED, etc. Patient clinical/non-clinic factors include patients' demographic, social determinants of health, and patient level of acuity assigned at triage.[3,6–8] However, differences in wait time among different races and ethnicities were not commonly reported. At present, differences in wait times among different races and ethnicities were mainly focused on patient socioeconomic conditions and specific diseases. For example, Lopez et al reported that NHB and Hispanic patients with chest pain were less likely to be triaged emergently in comparison to the NHW patients with chest pain.[9] McIntyre et al reported patients with low socioeconomic status experienced longer wait times.[10] These studies provide limited interpretation of generally longer wait times among ED minority patients. On the other hand, many studies performed multivariable analysis to determine whether race and ethnicity can independently predict longer wait time. However, the results of these studies are quite controversial.[11,12]

It is almost impossible to include all the factors that could potentially influence wait time. Recognizing those potential factors not previously discovered as contributors to longer wait time is challenging. In order to address this, our study introduces a post-linear decomposition model to analyze average wait time.[13] Post-linear decomposition facilitates determination of leading factors contributing to average wait time as well as identification of the existence of previously undiscovered wait time factors.[14] Such an analysis identifies important factors contributing to a longer average wait time, which can be prioritized

The Bottom Line

Non-Hispanic Black and Hispanic patients experience longer wait times in the emergency department compared to non-Hispanic White patients. A linear decomposition model was utilized to investigate the factors contributing to these extended wait times. The primary influences on longer wait times are patients' mode of arrival and triaged acuity levels. In this study, we identified 73%–88% of the factors contributing to the differences in wait times between non-Hispanic Black/Hispanic and non-Hispanic White patients. However, 12%–27% of the factors remain unexplained and warrant further investigation.

for interventions. Additionally, it highlights the extent to which unobserved and unmeasured factors contribute to differences in average wait time, warranting further investigations.

1.2 | Importance

Longer wait time can result in decreased patient satisfaction, delayed diagnoses and treatments, and an increased number of patients left without being seen. All these indicators suggest poor quality of care delivery as endorsed by the Agency for Healthcare Research and Quality (AHRQ).[15–17] Furthermore, longer wait time in the ED may affect timely delivery of care and exacerbate already existing racial and ethnic disparities in quality of care and outcomes. Longer wait time also can be considered as one of the healthcare access issues, which if not corrected, can cascade the downstream effects including patient clinical outcomes. At present, there are very few studies that analyze all potential factors simultaneously. Most of them fail to provide a thorough comparison across different minority patient populations. Therefore, more studies are needed to examine risk factors affecting wait time with greater significance among minorities.

1.3 | Goals of this investigation

To better understand factors contributing to longer wait time among patients of different races and ethnicities, this study aims to further explore patient clinic/non-clinic and ED administrative factors associated with longer wait time among NHW, NHB, and Hispanic ED patients by using a post-linear decomposition model.

2 | METHODS

2.1 | Study design and setting

This retrospective single-center observational study was conducted at an urban tertiary referral center. The study ED has an annual

volume of approximately 110,000 to 130,000 visits (127,911 in 2019, 113,563 in 2020, and 115,267 in 2021). This study was approved by the regional institutional review board with waived informed consent (IRB#1967558-1).

2.2 | Exposure—defining race and ethnicity

In this study, race and ethnicity categories were determined based on self-reported information provided by the patients. The race and ethnicity categories were consolidated into three primary groups: (1) NHW—individuals who identified as White or Caucasian, primarily of European descent, and did not identify as Hispanic or Latino; (2) NHB—individuals who identified as Black or African American, primarily of African descent, and did not identify as Hispanic or Latino; and (3) Hispanic or Latino (Hispanic)—individuals who identified as Hispanic or Latino, including those of Latin American descent, regardless of their races.

2.3 | Selection of participants

The study population restricted to only self-identified NHB, NHW, and Hispanic patients who presented to the study ED from January 1, 2019, to December 31, 2021. Patients belonging to racial and ethnic groups outside the primary categories, such as Asian, American Indian, Alaska Native, Native Hawaiian or other Pacific Islanders, as well as those with multi-racial backgrounds, missing, unreported, or unknown ethnicity, were excluded due to relatively small sample sizes.

2.4 | Outcomes

This study's primary outcome measure was "wait time," defined as the time from completion of patient triage to the time of patient placement in an examination room. Wait time did not include the time from patient placement in an examination room to the time the patient was seen by a healthcare practitioners. This is because our data revealed that the duration of "bed-to-practitioners time" was very short and exhibited no correlation with patient wait time, consistent with findings from a previous study.[18]

2.5 | Measurements

Factors affecting wait times were divided into several categories. (1) Sociodemographic: age, gender (male and female), marital status (single, married, others), preferred language (English, Spanish, and others), and insurance coverage (yes and no); (2) clinical information: mode of arrival (ambulance, private car, public transportation, ambulatory, and others), chronic disease (no chronic disease, one chronic disease, and multimorbidity [multimorbidity was defined as patients having two or more chronic diseases], chronic diseases include

coronary artery disease, diabetes, hypertension, back pain, headache, asthma, chronic obstructive pulmonary disease (COPD), hyperlipidemia, HIV/AIDS, obesity, chronic kidney disease, cirrhosis, leukemia, dementia, cerebrovascular accident (CVA), and solid tumor); (3) level of acuity: emergency severity index (ESI) was used as patient level of acuity; (4) ED crowding condition upon arrival of patient: the SONET score was employed and divided ED crowding status into three categories (not crowded, crowded, and overcrowded)[19,20]; and (5) other hospital conditions: weekend (Saturday and Sunday) versus weekday (Monday through Friday) presentation, clinic hours (on and off, clinic was open from 8 am to 5 pm Monday through Friday; therefore, we defined patients who arrived to ED from 8 am to 5 pm as having presented during clinic hours [ie, on], whereas patients arriving to ED from 5 pm to 8 am Monday through Friday or during the weekends as having presented during non-clinic hours [ie, off]).

2.6 | Analysis

Three groups (NHB, NHW, and Hispanic) were compared using analysis of variance (ANOVA) for mean wait times and Kruskal–Wallis's test for median wait times. We report percentage differences of median wait times of categorical variables and the mean wait time of different variables is shown in Table S1. Categorical variables were compared by chi-square tests. We used multivariable linear regression to estimate the association of log-transformed wait time with all potential independent risk factors. We also reported the relative magnitude impact of categorical variables in percentages using the method proposed by Halvorsen and Palmquist.[21] Furthermore, to determine (1) which factors are leading factors contributing to longer wait time, and (2) the existence of other factors affecting longer wait time not included in the current risk factor list, we used the post-linear decomposition method proposed by Blinder–Oaxaca (see detail in Appendix 1).[13] Stata 14.2 was used (Stata Corp.) for all the analyses.

2.7 | Reporting guideline

Strengthening of the reporting of observational studies in epidemiology reporting guidelines were followed in this study.[22]

3 | RESULTS

3.1 | Characteristics of study subjects

A total of 310,253 patients were included in the final analysis, with 107,757 NHW, 107,604 NHB, and 94,892 Hispanic ED patients, respectively. Table 1 shows the general characteristics of all three groups. A significant number of patients in the Hispanic group (39%) preferred to speak Spanish as compared with NHW (0.2%) and NHB (0.03%) groups ($p < 0.001$). NHB patients tended to have more chronic diseases (45%) than NHW (40%) or Hispanic patients (34%, $p < 0.001$).

TABLE 1 Characteristics of the study population by race and ethnicity emergency department visit database (2019–2021).

	NHW (n = 107,757)	NHB (n = 107,604)	Hispanic (n = 94,892)
Age			
Mean (SD)	46 (16)	44 (17)	42 (17)
Median (IQR)	46 [33, 58]	44 [30, 57]	41 [28, 54]
ED wait time, n (%)			
Within 30 min	74,117 (69)	67,939 (63)	54,404 (57)
30 min or longer	33,640 (31)	39,665 (37)	40,488 (43)
Gender, n (%)			
Male	57,177 (53)	55,614 (52)	45,806 (48)
Female	50,580 (47)	51,990 (48)	49,086 (52)
Marital status, n (%)			
Single	55,525 (52)	70,735 (66)	45,143 (48)
Married	21,750 (20)	18,254 (17)	33,203 (35)
Others	30,482 (28)	18,615 (17)	16,546 (17)
Language, n (%)			
English	106,880 (99)	104,222 (97)	57,606 (61)
Spanish	223 (0.2)	27 (0.03)	37,019 (39)
Others	654 (0.6)	3355 (3)	267 (0.3)
Insurance, n (%)			
Yes	72,843 (68)	73,630 (68)	51,070 (54)
No	34,914 (32)	33,974 (32)	43,822 (46)
Chronic disease(s), n (%)			
No chronic disease	47,985 (45)	39,891 (37)	48,513 (51)
One chronic disease	16,642 (15)	18,940 (18)	14,236 (15)
Multimorbidity	43,130 (40)	48,773 (45)	32,143 (34)
Crowding status, n (%)			
Not crowded	23,616 (22)	26,367 (25)	20,742 (22)
Crowded	40,785 (38)	41,287 (38)	35,663 (38)
Overcrowded	43,356 (40)	39,950 (37)	38,487 (41)
Acuity level, n (%)			
ESI-1	5138 (5)	4460 (4)	3739 (4)
ESI-2	33,296 (31)	26,297 (24)	21,400 (23)
ESI-3	60,980 (57)	65,871 (61)	63,119 (67)
ESI-4	7470 (7)	10,096 (9)	6194 (7)
ESI-5	873 (1)	880 (1)	440 (0.5)
Mode of arrival, n (%)			
Private car	43,528 (40)	49,035 (46)	55,052 (58)
Ambulance	43,360 (40)	36,757 (34)	20,937 (22)
Public transportation	890 (1)	1089 (1)	258 (0.3)
Ambulatory	8745 (8)	9885 (9)	9183 (10)
Others	11,234 (10)	10,838 (10)	9462 (10)
Clinic hour, n (%)			
Clinic hours arrival (8 am–5 pm)	54,471 (51)	54,683 (51)	49,266 (52)
Non-clinic hours arrival	53,286 (49)	52,921 (49)	45,626 (48)

(Continues)

TABLE 1 (Continued)

	NHW (n = 107,757)	NHB (n = 107,604)	Hispanic (n = 94,892)
Weekday versus weekend, n (%)			
Weekday	79,561 (74)	79,529 (74)	69,888 (74)
Weekend	28,196 (26)	28,075 (26)	25,004 (26)

Note: Based on 310,253 ED visits of three groups (NHW, NHB, and Hispanic) from January 1, 2019, to December 31, 2021. Average of age was compared among three groups using either analysis of variance (ANOVA) (mean) or Kruskal–Wallis test (median). Other categorical variables were compared among three groups using chi-square tests. $p < 0.001$ among all variables when the three study groups were compared.
Abbreviations: ESI, emergency severity index; Hispanic, Hispanic/Latino; IQR, interquartile range; n, number; NHB, non-Hispanic Black; NHW, non-Hispanic White; SD, standard deviation.
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However, when triaged in the ED, more NHW patients were assigned a higher level of acuity (eg, 31% at ESI-2) than those of NHB (24% at ESI-2) or Hispanic patients (23% at ESI-2, $p < 0.001$, Table 1). More detailed wait time comparisons across racial and ethnic groups are shown in Table S1.

3.2 | Main results

The median wait time in the NHW group was 9 min with an interquartile range (IQR) of 43 min (IQR 4–47 min), 13 min (IQR 4–59 min) in the NHB group, and 19 min (IQR 5–78 min) in the Hispanic group ($p < 0.001$). Detailed comparison of median wait times across all three groups revealed that Hispanic patients waited longer than NHW or NHB when referenced to each of the variables measured (Table 2). In comparison to NHW patients, the wait times in log-transformed unit for both NHB ($\beta = 0.050$, $p < 0.001$) and Hispanic patients ($\beta = 0.054$, $p < 0.001$) were prolonged (Table 3). In addition, except marital status, other factors are all independent factors affecting patient wait times (Table 3).

Post-regression Blinder–Oaxaca linear decomposition analysis results are summarized in Table 4 and interpreted in detail in Appendix 1. Briefly, when comparing the difference in wait times between NHW and NHB, only 72.96% of the wait time difference could be explained by the variables utilized in this study, and 27.04% of the observed wait time difference remains unexplained. Similarly, when comparing the wait time difference between NHW and Hispanics, 87.77% of the difference in wait times could be explained by the variables used, leaving another 12.23% unexplained, indicating the presence of additional variables contributing to wait times not included in this analysis. The difference of average log-transformed wait times between the NHW and Hispanic groups was 0.417 units, and between NHW and NHB patients was 0.196 units ($p < 0.001$). Based on the pooled regression weights, differences in mode of arrival (i.e., 62% difference between NHW and NHB, and 72% difference between

TABLE 2 Median wait times in minutes comparisons of all variables by race and ethnicity emergency department visit database (2019–2021).

	NHW, median (IQR)	NHB, median (IQR)	Hispanic, median (IQR)
Overall wait time			
Minutes	9 [4, 47]	13 [4, 59]	19 [5, 78]
Wait time in 2019	11 [4, 50]	15 [4, 59]	23 [6, 77]
Wait time in 2020	8 [4, 37]	12 [4, 48]	16 [5, 60]
Wait time in 2021	8 [3, 57]	13 [4, 76]	21 [5, 100]
Gender			
Male	8 [3, 39]	11 [4, 52]	14 [4, 65]
Female	11 [4, 56]	17 [5, 68]	25 [6, 88]
Marital status			
Single	9 [4, 44]	13 [4,58]	16 [5, 70]
Married	10 [4, 52]	17 [5,66]	25 [6,87]
Others	9 [4, 48]	11 [4, 55]	19 [5, 79]
Language			
English	9 [4, 47]	13 [4, 58]	17 [5, 72]
Spanish	10 [3, 49]	11 [5, 66]	23 [6, 86]
Others	18 [5, 75]	26 [7, 84]	26 [6, 91]
Insurance			
Yes	8 [3, 41]	11 [4, 55]	16 [5, 70]
No	13 [4, 59]	19 [5, 69]	24 [6, 85]
Comorbid			
No	8 [3, 42]	15 [4, 62]	19 [5, 74]
One	11 [4, 52]	15 [5, 63]	23 [6, 86]
Multimorbidity	9 [4,50]	11 [4, 56]	19 [5, 79]
Crowding status			
Not-crowded	7 [3, 16]	8 [4, 20]	9 [4, 22]
Crowded	9 [4, 41]	15 [4, 51]	19 [5, 59]
Overly-crowded	13 [4, 102]	32 [5, 125]	52 [6, 143]
Acuity level			
ESI-1	1 [0, 4]	1 [0, 4]	2 [0, 5]
ESI-2	5 [3, 10]	5 [3, 11]	6 [3, 14]
ESI-3	20 [5, 81]	25 [5, 85]	35 [8, 104]
ESI-4	31 [11, 76]	34 [14, 77]	37 [15, 86]
ESI-5	20 [7, 54]	28 [11, 64]	35 [14, 80]
Mode of arrival			
Private car	29 [10, 84]	33 [11, 87]	35 [11, 98]
Ambulance	3 [2, 6]	3 [2, 6]	3 [2, 5]
Public transportation	30 [11, 79]	37 [14, 94]	35 [14, 96]
Ambulatory	24 [8, 80]	30 [9, 91]	37 [10, 107]
Others	13 [5, 47]	17 [6, 60]	18 [6, 75]
Clinical hours			
Within clinical hour	11 [4, 50]	16 [5, 60]	21 [6, 75]
Out of clinical hour	7 [3, 44]	11 [4, 58]	18 [5, 80]

(Continues)

TABLE 2 (Continued)

	NHW, median (IQR)	NHB, median (IQR)	Hispanic, median (IQR)
Weekday versus weekend			
Weekday	10 [4, 55]	15 [4, 68]	23 [5, 93]
Weekend	7 [3, 30]	11 [4, 41]	13 [4, 47]

Note: Based on 310,253 patient ED visits of three groups (NHW, NHB, and Hispanic) from January 1, 2019, to December 31, 2021. Median wait time in minutes was compared among three groups using Kruskal–Wallis test. $p < 0.001$ among all variables when the three study groups were compared. Abbreviations: ESI, emergency severity index; Hispanic, Hispanic/Latino; IQR, interquartile range; NHB, non-Hispanic Black; NHW, non-Hispanic White.

NHW and Hispanic patients) and patient triaged level of acuity (i.e., 50% difference between NHW and NHB, and 26% difference between NHW and Hispanic patients) explained most differences in log-transformed average wait times between NHB/Hispanic and NHW patients (Table 4). Whereas differences in ED crowding conditions (0.55%) did not contribute much for the different log-transformed average wait times between NHW and Hispanic patients (Table 4).

4 | LIMITATIONS

This study has its limitations. First, numerous factors were included that could affect wait times among ED patients. We are unable to include all potential factors in the analyses. For example, some factors such as socioeconomic status (e.g., income, education) were not included. Although such information can be obtained from census data via patients' zip codes, we did not perform those analyses because multilevel analyses were required with the addition of community-level data. Second, although this is a large-scale cross-sectional study, our findings might be limited in application to similar patients presenting in similar ED settings. Third, we included ESI as one of the variables in this study. However, ESI might not be an accurate variable since it is subjective and can be altered by different triage nurses with different patients. It could also be one of the unexplained causative variables. Additionally, inappropriate ESI levels assigned to certain patients could significantly affect their wait times. Unfortunately, we were unable to validate the accuracy of ESI in this study. Fourth, this is a single-center retrospective study, data inaccuracy, missing, and unknown information are unavoidable. Other minority populations such as American Indians, Alaska Natives, Hawaiian Natives, Asian, and Pacific Islanders were not included. Including these individuals in further analyses could enhance the validity and ethical integrity of the study findings. Additionally, race and ethnicity are social constructs that may be closely associated with individuals' socioeconomic status and environmental factors. A comprehensive analysis of the interaction between these variables and race and ethnicity can lead to a better understanding of health disparities.[23] Fifth, the Blinder–Oaxaca decomposition

TABLE 3 Multivariable linear regression on log-transformed wait time emergency department visit database (2019–2021).

	Beta	SE	p-Value	Percentage impact difference[a]
Intercept	−0.311	0.013	<0.001	
Race				
NHW (ref)				
NHB	0.050	0.006	<0.001	5.13
Hispanic/Latino	0.054	0.005	<0.001	5.55
Gender				
Male (ref)				
Female	0.080	0.004	<0.001	8.33
Age[b]	0.009	0.001	<0.001	100.90
Marital status				
Single (ref)				
Married	0.003	0.005	0.495	0.30
Others	0.008	0.005	0.155	0.80
Language				
English (ref)				
Spanish	0.017	0.007	0.020	1.71
Others	0.083	0.017	<0.001	8.65
Insurance				
No (ref)				
Yes	−0.086	0.004	<0.001	−8.24
Chronic disease(s)				
No (ref)				
One	0.096	0.006	<0.001	10.08
Multimorbidity	0.144	0.005	<0.001	15.49
Crowding status				
Not crowded (ref)				
Crowded	0.512	0.005	<0.001	66.86
Overcrowded	1.033	0.005	<0.001	180.95
Acuity level				
ESI-1 (ref)				
ESI-2	0.741	0.010	<0.001	109.80
ESI-3	1.687	0.010	<0.001	440.32
ESI-4	1.768	0.012	<0.001	485.91
ESI-5	1.598	0.025	<0.001	394.31
Mode of arrival				
Ambulance (ref)				
Private car	1.452	0.005	<0.001	327.16
Public transportation	1.475	0.023	<0.001	337.10
Ambulatory	1.416	0.008	<0.001	312.06
Others	1.125	0.007	<0.001	208.02

(Continues)

TABLE 3 (Continued)

	Beta	SE	p-Value	Percentage impact difference[a]
Clinic hour				
Clinic hours arrival (ref)				
Non-clinic hours arrival	0.053	0.004	<0.001	5.44
Weekend/weekday				
Weekend (ref)				
Weekday	0.063	0.005	<0.001	6.50

Note: Based on 310,253 ED visits from January 1, 2019, to December 31, 2021. The association between log-transformed units of wait time and other independent factors was analyzed by the multivariable linear regression. We reported beta co-efficient, standard error, p-value, and percentage impact differences of each categorical variable.

Abbreviations: ED, emergency department; ESI, emergency severity index; Hispanic, Hispanic/Latino; NHB, non-Hispanic Black; NHW, non-Hispanic White; ref, reference; SE, standard error.

[a]Percentage impact differences were calculated using Halvorsen and Palmquist equation, i.e., $100 \times [\exp(\text{co-efficient} - 1)]$.

[b]Age: we divided age by 10 and reported the percentage impact of differences with the increment of 10 years in age, i.e., $100 \times \exp(\text{co-efficient})$.

method does not provide insights on the root causes of the differences between the NHW and minority patient groups. Sixth, we lacked clear explanation on ED crowding with opposite findings contributing to prolonged wait times from NHB and Hispanic patients. Lastly, log-transformed average wait times cannot be easily converted to familiar units of time making it difficult to quantify the changes in wait times as expressed by minutes. Therefore, future studies focused on further investigating risks affecting wait time and implementing effective interventions to reduce wait times among ED minority patients are recommended.

5 | DISCUSSION

It is well known that healthcare disparities occur among minority patients.[24–28] In this study, NHB and Hispanic patients were found to have a longer average wait times when compared to NHW patients presenting to a busy urban ED. This study also validated identify factors (eg, mode of arrival and triage level of acuity) affecting wait time.[7,29] A traditional multivariable linear regression analysis confirmed that race and ethnicity acts as an independent risk factor for longer wait time when adjusting for all risk factors previously reported in the literature (such as ED crowding and triage level of acuity).

Our findings are consistent to the previous national database analyses (NHAMCS) that revealed longer wait time among Black and Hispanic patients than NHW patients with different complaints (eg, acute gastrointestinal illness, substance use disorders).[11,30] However, in another study using the same database to investigate wait times of patients with headache found longer wait times among NHB and Hispanic patients when compared with NHW, which did not show statis-

TABLE 4 Decomposition of log-transformed average wait times by patients of races and ethnicities.

	Unit	95% CI
Hispanic patient log-transformed average wait time	3.086	[3.076, 3.095]
NHB patient log-transformed average wait time	2.865	[2.856, 2.874]
NHW patient log-transformed average wait time	2.669	[2.660, 2.678]
Differences in log-transformed average wait time (Hispanic vs. NHW)	0.417	[0.404, 0.430]
Differences in log-transformed average wait time (NHB vs. NHW)	0.196	[0.184, 0.208]

	NHW versus NHB		NHW versus Hispanic	
	Unit (%)[a]	95% CI	Unit (%)[a]	95% CI
Mode of arrival	0.088 (61.54%)	[0.082, 0.093]	0.265 (72.40%)	[0.259, 0.271]
Triage level (level of acuity)	0.071 (49.65%)	[0.067, 0.076]	0.094 (25.68%)	[0.089, 0.098]
Insurance	−0.0007 (−0.49%)	[−0.0103, −0.0004]	0.013 (35.52%)	[0.011, 0.014]
Patients with chronic diseases	0.010 (6.99%)	[0.009, 0.011]	−0.010 (−2.73%)	[−0.011, −0.009]
Preferred language	0.003 (2.10%)	[0.002, 0.004]	0.005 (1.37%)	[−0.0006, 0.011]*
Sex	0.0009 (0.63%)	[0.0006,0.0012]	0.004 (1.09%)	[0.004,0.005]
Age	−0.001 (−0.07%)	[−0.0015, −0.0004]	−0.005 (−1.37%)	[−0.006, −0.004]
ED crowding condition	−0.028 (−19.58%)	[−0.031, −0.025]	0.002 (0.55%)	[−0.001, 0.005]*
Total explained difference of average wait time	0.143 (72.96%)	[0.134, 0.152]	0.366 (87.77%)	[0.355, 0.376]
Total unexplained difference of average wait time	0.053 (27.04%)	[0.044, 0.063]	0.051 (12.23%)	[0.040, 0.063]

Note: Based on a total number of 310,253 patients presented at ED from January 1, 2019, to December 31, 2021. The association between the log-transformed units of average wait time and other risk factors was analyzed by the post-linear decomposition model. Variables including marital status, weekend versus weekday presentation, and patient presentation during clinic versus non-clinic hours are three variables not shown in this table due to their minimal contributions to the differences among both NHW versus NHB and NHW versus Hispanic (i.e., the log-transformed average wait times were all <0.0001 comprising less than 1% of contributions to the log-transformed average wait time differences). Unless otherwise indicated, *p*-values of all other variables were less than 0.001 (i.e., statistically significant effects).

Abbreviations: CI, confidence interval; ED, emergency department; Hispanic, Hispanic/Latino; NHB, non-Hispanic Black; NHW, non-Hispanic White.

[a]The percentage of a certain variable contributing to the total difference of log-transformed average wait time between two populations.

*p > 0.05.

tically significant differences among different races and ethnicities.[12] All three studies utilized the same national database, employing a consistent definition of wait time. All studies reported mean wait time in minutes and conducted analyses using multivariate linear regressions. However, there were differences in their data timeframes (Wu et al used NHAMCS data from 1997 to 2006, Goldfarb et al used data from 2016 to 2018, and Piere Louis et al. used data from 2015 to 2018). Furthermore, their patient cohorts varied (Wu et al. included patients exclusively with acute gastrointestinal illness, Goldfarb et al. focused on patients with substance use disorders, and Piere Louis et al. included patients only with headaches), Additionally, there were differences in the racial and ethnic groups investigated (Wu et al. compared NHW, NHB, and Hispanic White patients, whereas the other two studies compared NHW, NHB, and Hispanic patients). Taken together, apart from racial and ethnic differences, the composition of study patients in terms of gender, insurance coverage, and mode of arrival could explain the differences in findings between different studies. Therefore, in our study, a more comprehensive analysis was performed including common wait time risk factors and targeting all ED patients regardless of their chief complaints for a better understanding of wait time among different racial and ethnic patient populations. Furthermore, this wait time information could be applied to modified training of those working in triage

with the anticipated result of mitigating recognized biases to reduce these disparities.

Additionally, using post-linear decomposition analysis, this study identified patient mode of arrival, insurance, chronic disease conditions, and triage level of acuity as the most significant contributors to differences in wait time when comparing NHW patients to NHB and Hispanic groups. Apart from this, application of post-linear decomposition analysis also identifies the existence of unexplained factors linked to longer wait time among minority patients in addition to previously recognized factors, thus leading to the future investigations. Understanding the mechanism(s) of racial disparities in wait times can potentially help prevent disparities, recognize factors to avoid disparities, and develop targeted interventions to minimize ED-related health disparities. With busy and fast-paced living style in the modern society, time toxicity (ie, time spent on activities not directly related to medical care such as travel and wait times) negatively affecting patient medical care has become common.[31] Minimizing wait time to reduce time toxicity could thus become an important step to minimize healthcare disparities among minorities.

Understanding risk factors affecting wait time in the ED plays an important role in patient care outcomes and ED administrative management.[15,32] In our study, we observed that Hispanic patients

experienced longer wait times compared to NHW patients. Such findings are consistent with the previous reports. Minority patients tended to be triaged more often to lower acuity status than NHW patients resulting in longer wait time when compared to the NHW group.[9,29] Even with the same triage levels, White patients tended to be seen quicker than Black patients, indicating the occurrence of racial disparities.[33] Black and Hispanic patients had higher non-Emergent ED visits and higher ED use rates than White patients due to lack of usual source of care.[34–36] Consequently, these patients might not qualify for ambulance transport nor receive a high acuity classification (ESI-1/2) since their condition may not appear urgent. As shown in Tables 1 and 4, other observed factors such as language barriers (more NHB/Hispanic patients had language barriers than NHWs), insurance status (more NHB/Hispanic had no insurance coverage than NHWs), chronic disease conditions (more NHB patients had chronic diseases than NHWs), and extreme age (more elderly in NHWs than NHB/Hispanic patients, Table 1) could all affect wait time, thus causing wait time differences among different races and ethnicities.

Moreover, implicit biases among healthcare providers stemming from lack of cultural competency or disparities in health literacy with minority patients could also contribute to this discrepancy. Previous findings from Medicare fee for service claims data showed that the proportion transported to the ED was higher among White than Black and Hispanic patients, indicating racial disparities occurred among prehospital transportations.[37,38] Unfortunately, our study could not include all potential factors influencing these longer wait times among patients of different races and ethnicities. Further investigations are thus warranted to comprehensively explore these unexplained variables and address racial and ethnic disparities in ED wait times.

Common independent factors such as ED crowding conditions are often reported in the literature.[6,19] Longer wait time occurs when the ED is overcrowded.[6] However, ED overcrowding status should affect all low acuity leveled patients (ie, ESI 3–5) regardless of their races and ethnicities. In terms of the ED crowding status, the unique finding in this post-linear decomposition analysis was the difference of wait time increased (0.002 unit, Table 4) in Hispanic patients when compared to NHW patients if ED were crowded. However, the difference of wait time decreased (−0.028 unit, Table 4) in NHB patients when compared to NHW patients under the same ED crowding condition. These findings are also consistent to the fewer NHB patients seen during ED overly crowded conditions in comparison to NHW patients (37% of NHB vs. 40% of NHW, Table 1). Such contrary findings indicate that ED crowding status may be "racial-dependent," interventions to reduce the effect of ED crowding may benefit one race but harm the other. However, we are still not able to explain such findings clearly. Future study needs to focus on the investigation of ED patient flow during different timeframes from patients of different races and ethnicities. Similarly, average wait times are prolonged for all ED patients in terms of other hospital conditions such as patients presenting during clinic hours or during weekends indicating such factors affect patient wait time universally regardless of race and ethnicity.

Our study results revealed that 12%–27% of the differences in wait times could not be explained by factors included in the model. While there are many unmeasured and unobservable factors, we want to highlight the negative impact of racism on health services use and speculate that different levels of racism may have contributed to racial and ethnic disparities in wait times.[39,40] For example, institutional racism that can create inequities in access to a range of social and economic benefits—such as quality education, economic security, high quality healthcare, healthy environment, and neighborhood facilities may directly contribute to prolonged wait times of racial and ethnic minorities.[40,41] For example, NHBs and Hispanic individuals may visit ED because of lack of access to primary care. Consequently, these patients may not receive a high acuity classification (ESI-1/2) since their condition may not appear urgent and may not qualify for ambulance transport. It has been documented that NHB and Hispanic patients have higher non-emergent ED visits than White patients due to lack of usual source of care.[34–36] It is also possible that "internalized racism" may lead to inappropriate acuity level assignments and consequent prolonged wait times experienced by NHB and Hispanic individuals. Racial and ethnic diversities may internalize negative messages about their abilities and self-worth,[41] which may lead to inaccurate representation of their healthcare needs at triage, leading to assignment of lower acuity levels. It has been reported that internalized racism is negatively associated with self-evaluation of health.[42] We also speculate that implicit or explicit prejudice or discrimination by healthcare providers could also contribute to longer wait times in ED by NHB and Hispanic individuals.[40] Studies have documented that experiences of discrimination in the US healthcare system is highly prevalent and perceived provider discrimination can lead to racial and ethnic disparities in health.[43,44] Furthermore, a systematic review reported that implicit biases of healthcare professionals often influence diagnosis and treatment decisions.[45] Clinicians' racial biases can exacerbate inequities in quality healthcare and explained lower rates of pain treatment and higher rates of limb amputations among NHBs compared to NHWs.[46–48] Our study used electronic health record data mainly focused on clinical practice and lacked variables that can measure the impact of racism on wait times. However, this paper can serve as a foundation in highlighting the need for the explicit measurement and inclusion of "racism" variables in racial disparities research.

Our study utilized both multivariable linear regression and Blinder–Oaxaca post-linear decomposition regression analyses to identify factors associated with prolonged wait times. Multivariable linear regression is a common method in clinical research to assess the relationship between several independent variables and a continuous outcome. However, due to limitations on the number of variables it can accommodate, this method may face challenges in incorporating all relevant variables into a single study. Moreover, it does not specifically indicate which variables have a more substantial impact on the overall model prediction. In contrast, the Blinder–Oaxaca post-linear decomposition regression addresses some of these limitations. This method not only evaluates the adequacy of selected variables (ie, the percentage of differences explained by included variables vs. unexplained differences) but also delineates the contribution percentage of each variable. This helps pinpoint major factors influencing outcome measures.

This study has notable strengths. First, this is a large-scale observational study including pre-COVID-19 and COVID-19 pandemic periods, aiming to capture the comprehensive COVID-19 impact on ED wait times. It has been reported that, prior to COVID-19, the average wait time was 24.1 min in EDs with less than 20,000 annual visits, 34.5 min in EDs with annual visits ranging from 20,000 to 49,999, and 48.7 min in EDs with 50,000 or more annual visits.[49] Temporary drops in wait time metrics during the initial COVID-19 pandemic phase were observed.[50,51] Our study data covering 2019, 2020, and 2021 shows the similar influence of pandemic effects. While this study is conducted at a single center, it includes a substantial number of patients (ie, 3 years of ED data) with various chief complaints. Therefore, our findings may represent patient wait times in similar ED settings. Second, our study focused on three ED patient groups: NHW, NHB, and Hispanic patients. The study ED serves a relatively well-balanced number of patients (ie, 34.7% NHW, 34.7% NHB, and 30.6% Hispanic) lending our study population ideal for statistical analyses. Third, we use both traditional multivariable linear regression and post-linear Blinder–Oaxaca decomposition analyses to validate risk factors affecting wait time among ED minority patients. Decomposition analysis further allows us to determine both leading and new factors contributing to differences of average wait times between NHW and minority patients thereby providing additional evidence for future risk factors investigations and development of interventions designed to minimize wait time among ED minority patients.

Compared to NHW patients, NHB and Hispanic patients typically experience longer ED wait times, primarily influenced by their mode of arrival and triaged acuity levels. Despite these recognized factors, there remains 12%–27% unexplained factors at work, such as social determinants of health (including implicit bias and systemic racism) and many other unmeasured confounders, yet to be discovered. Implementing interventions to address both identified and yet-to-be-discovered contributors could potentially alleviate healthcare access disparities among ED minority patients, enhancing overall ED management and healthcare outcomes.

AUTHOR CONTRIBUTIONS

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DATA AVAILABILITY STATEMENT

The study data include patient information; therefore, data are available upon requesting to the corresponding author.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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