Gender and racial disparity for hospital emergency service usage in USA: a quantitative analysis for various age groups during 2010–2017

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Background: Annually emergency department (ED) services are utilized by more than 100 million Americans making ED usage trends important determinants of healthcare quality, outcomes and cost. Previous workers have demonstrated the existence of disparity in various healthcare services in USA although a comprehensive analysis has not been undertaken. Dahlgren and Whitehead rainbow model has offered insights for multiple factors of influence on an individual's health and focuses on the relationships among these factors. The Commission on Social Determinants of Health (CSDH; WHO initiatives) suggests that the social and environmental factors are at the root of most of the inequalities responsible for both communicable and non-communicable diseases.

Methods: The objectives of this study were to quantify the existing disparity in ED usage between 2010–2017 by age, race and gender primarily using the Federal and State databases and comparing the quantitative trends with prior works from 2006–2020 that shed lights on health disparity. Single user normalization was developed to achieve randomization to reduce the heterogeneity of the database.

Results: Each age group was represented by the usage pattern of the "single" average individual revealing significantly different ED usage for different age groups. Black and white Americans as well as males and females showed large variation indicative of racial and gender disparity.

Conclusions: This is the first comprehensive meta-analysis demonstrating racial and gender specific variation in the usage of emergency health care services that exist in USA and seem to be multifactorial and age specific. Using a tool of single user normalization developed in this work as a means of randomization these disparities were quantified and may help identify such disparity trends in other regions that suffer from similar disparities.

Keywords: Gender and racial disparity; emergency services; single user normalization; COVID pandemic; Dahlgren and Whitehead rainbow model

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Introduction

Health care disparity is an impious or iniquitous problem and has been a subject of healthcare policies and political debates for several decades. Measures, efforts and regulations have been evolving to try to mitigate disparity and allow fair resource allocation. Despite evidence and examples of disparity in the access to and provision of healthcare in various populations, there aren't enough quantitative tools to measure disparity and to mitigate or eliminate it. There is a need to remove existing disparity due to socioeconomic forces which is not amplified by the users. It is important to determine how much emergency department (ED) overuse stems from individual factors like lack of insurance or primary referral sources and how much is due to systemic factors inherent in US healthcare. To fairly address the issue of unnecessary use of ED, it is prudent to assess if overuse is concentrated to a particular race or to a particular age group or a particular gender!

The goal of this analytical study was to examine and quantify disparity in racial and gender linked usage of ED services between 2010 and 2017 in USA and identify patterns for over or under use. The data for this study was compiled from publicly available sources based on the survey results of National Hospital Ambulatory Medical Care Survey (NHAMCS) (1,2) and works of various researchers identifying problems in healthcare delivery.

Soto et al. reviewed (3) the current literature on racial and gender disparities in critical care and the mechanisms underlying these disparities in the course of acute critical illness that showed such disparities as multifactorial and involve individual, community, and hospital-level factors responsible at several points spanning the duration of the acute critical illness.

Schrager et al. analyzed (4) the NHAMCS ED Subfile (2) between 2005 and 2014 and showed that black patients had 14% less chances of receiving diagnostic imaging in the ED compared to white patients. Natale et al. studied (5) 20 North American EDs between 2007–2010 for a total of 5,847 patients consisting of 54% white, 34% black and 12% Hispanics where black children had 20% lower chance of getting CT imaging for blunt abdominal trauma.

Shah et al. looked at (6) a total of 6,710 ED visits comprising 61% white, 20% black and 14% Hispanics. Compared to white patients, black patients and other races had 22–30% lower chance of getting pain analgesics. Work by Kressin et al. showed (7) that insurance instability and uncontrolled blood pressure went together for 44,000 adult ED visits during 2005–2013 in Massachusetts for age group of 21–64 and higher rates of uncontrolled blood pressure existed for blacks and Hispanics. In particular, uninsured black patients fared worst, while white and Hispanic patients with consistent public insurance fared best.

Interestingly, Crowe et al. looked at (8) the gender and racial composition of emergency medical technicians (EMTs) and paramedics and found that out of half a million that entered into the profession from 2008 to 2017 the proportion of females rose from 28% in 2008 to 35% in 2017 while black EMTs remained at 3–5% without any upward movement. From 1990 through 2017, Filut et al. observed (9) workplace discrimination even for advanced level healthcare providers—the physicians of color. Black physicians and women of color were discriminated through multiple sources; discrimination by patients was in the forms of refusal of care performed by black physicians.

Esper et al. analyzed (10) African American males that develop sepsis at a younger age needing ICU admission. Males developed more pulmonary infections resulting in 40% of sepsis cases while females developed sepsis from genitourinary sources that accounted for 10% of cases. African Americans in age groups <65 years developed more Gram-positive infections that were less responsive to therapy and led to severe illness and higher rates of acute organ failure as well as more invasive pneumococcal disease compared to whites.

Mohareb and co-authors noted (11) that HIV-infected individuals visited ED at 20% higher rates and consumed significantly more resources than the general population. Tabit et al. concluded (12) that without early consultation with a cardiologist in the ED low-socioeconomic urban patients for acute decompensated heart failure had over-utilized the ED (0.56 vs. 0.79, respectively) with increased re-hospitalization rate and health care cost. Pines et al. found (13) that during 2003–2005 staying back in ED longer after being admitted as in patient caused increased morbidity and mortality for black patients compared to whites admitted to ICU (6 vs. 5 hr) and to non-ICU beds (6.5 vs. 5.7 hr).

These national findings represented a baseline prior to full implementation of the 2010 Patient Protection under Affordable Care Act (ACA). It will be important to have sufficient quality control measures in ACA framework mitigating these disparities toward access and usage of ED services.

Work by Goyal et al. (14) revealed (racial and ethnic

differences in antibiotic prescribing for acute respiratory tract infections. In the data from 7 pediatric emergency departments (PEDs) studied, compared to white children, black and Hispanic children received much less antibiotics for these infections. Dotson and co-authors investigated (15) in 38 hospitals the impact of race and insurance status on ED diagnostics and treatment among children with Crohn's disease between 2007 and 2013 for age ≤21 years. White children from a higher median household income and private insurance (57% *vs.* 30% Medicaid) had a 40% higher chance for complete blood count and C-reactive protein/erythrocyte tests and 52% more chance of receiving antiemetics compared to Medicaid insured. Repeat visits due to complication or relapse was 33% for blacks and 22% for whites.

Hudgins *et al.* observed (16) that although only 6% pediatric patients presented to PEDs, the complexity of cases is higher compared to pediatric patients presenting to general EDs, and PEDs had greater rates of hospitalization (10% *vs.* 4%). The background presented on ED usage reveals complexity, and heterogeneity caused by different factors in rural and urban settings as well as in small *vs.* large EDs. Kahan and Morris found (17) that randomization of multiple centers (small and large) statistically performs better than fixed-effects approaches, i.e., drawing conclusions from limited gender or race based data even if such first-hand analyses offer actionable, local insights. Random center effects models lead to increased statistical power and precision when some centers have small number of patients, when there is an imbalance between treatments or the distribution of patients within centers. Note in our quantitative analysis using single patient normalization we have implemented such randomization to flatten the group heterogeneity.

New contribution

"Single user" normalization

This work focuses on understanding the factors that might have resulted in moderate to significant utilization differences in ED service by four groups as we have defined and are normalized to the habits and needs of a single user. Analysis of federal and state reports and peer-reviewed articles on ED usage and overuse from year 2010–2017 was undertaken followed by discussions with emergency department physicians and academic radiologists to gain insight and relevance for this work. Four groups as listed

below were compared across all ages:

(I) All female ED users in US between 2010 and 2017;
(II) All male counterparts;
(III) All black ED users within the same period in US;
(IV) All white counterparts.

Essentially this work analyzed usage patterns as if each group was made up of a single user irrespective of the location, demographics, training, resources or capabilities of ED allowing uniform analyses irrespective of the size and share of ED use by each group and normalizing local variation in ED care due to income, insurance or access.

Flattening of heterogeneity by randomization

This normalization to generate one user's behavior during a single year flattened the seasonal heterogeneity like holiday patterns or flu season or back to school trends, for example. There are populations in USA that have a much greater fraction of 1-year-old than 14, while other regions may have many more 14-year-old than 1 making ED usage by the age group <15 across the whole USA quite heterogeneous. Single patient normalization is an example of randomization (17) that is better suited when an age group in certain race has smaller number of patients, as number of blacks age ≥75 years, compared to whites or when there is an imbalance between treatments, like in Crohn's disease for Medicaid insured children mentioned above, Dotson *et al.* (15).

Methods

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Study population

The study population consisted of all adult patients (n=202,480) with documented race, ethnicity and gender in the NHAMCS ED Subfile (1,2) between 2010 and 2017. NHAMCS is an annual nationally representative sample survey of visits to EDs; outpatient departments; and hospital-based and freestanding ambulatory surgical centers. NHAMCS-ED subfile we selected and analyzed was a consecutive 8-year long probability trend sample of ED visits in the US, collected by the Centers for Disease Control from a total of 3,055 hospitals and a statistically adequate responding EDs [65–82 patient records per ED each year out of 100 randomly asked, exception (*) in the year 2011, *Table 1*]. The characteristics of the data analyzed

Table 1 Patient records and ED services meeting study qualifications between 2010 and 2017

Year service utilized	Qualified hospitals total (n=3,055)	Participation rate (%)	Qualified ESA fulfilling criteria	Responding ESAs (%) fulfilling criteria	Patient records submitted (n=202,480)	Patient records/ESA
2017	374	62.6	331 (240)	72.5	16,709	70
2016	361	73.4	385 (271)	70.4	19,467	72
2015	374	70.8	385 (291)	77.8	21,061	72
2014	375	75.5	397 (319)	80.4	23,844	75
2013	369	80.8	416 (339)	81.5	24,777	73
2012	535	76.3	544 (454)	83.5	29,453	65
*2011	279	78.9	1,001 (847)	84.6	32,233	38
2010	388	92.0	449 (427)	95.1	34,936	82

*, A very low number of qualified hospitals and large number of ESAs in 2011 data may require re-assessment of original data collected in 2011. ED, emergency department; ESA, emergency department service area.

in this work are summarized below. In addition, works by other researchers were searched from literature using keywords like racial disparity, gender disparity, emergency services and ED usage and were analyzed for US primary emergency care disparities for the publication period from 2006–2020. Learning points from such prior works and our analysis have been included in the discussion section.

Inclusion criteria

Total number of qualified hospitals [3,055] surveyed with eligible ED's ranged from 279–535 during 2010–2017 provided response rates of 62.6% to 92%. From those respondents 70.4–95.1% had met the criteria (of at least 50% of total patient visits during an arbitrarily chosen 4-week reporting period) by submitting a total of 202,480 records (yearly ranged from 16,709–34,936 records. The coding errors for the eligible records ranged from 0 to 1.5% during the 8-year analysis presented here. The low number of qualified hospitals in 2011 (*) data, almost doubling of emergency department service areas (ESAs) and a small number of patient records collected warrant further research.

Statistical analysis

ED use data was classified in four cohorts: two primary genders and two primary races as:

(I) All female ED users in US between 2010 and 2017;
(II) All male counterparts;

(III) All black ED users within the same period in US;
(IV) All white counterparts.

Single user normalization model

Essentially this work analyzed usage patterns as if each group was made up of a single user irrespective of the population size allowing usage pattern to be compared without considering overall share of ED use by each group or including any variable related to income, health insurance or disease disparity. Each of these four groups were broken down to smaller, coherent age groups with similar usage; for example: all females age <15 *vs.* all males of age <15, all black patients (male and female) of age <15 *vs.* all white patients of age <15, and so on.

The total ED visits of each age group for each year were divided by the total US population of that age group to determine the ED usage fraction of a single person present in USA in each year ("single user normalized usage %"). Finally percentage differences of such usage fractions with relevant comparison groups were computed over the full US utilization by individual age groups.

Normalization steps

For example, the first entry (disparity %) in 2010 (*Table 2*) was computed as follows:

Single patient normalized disparity % in ED usage in 2010 = 100% × (total number of males & females in US of age <15 in 2010) × [(total female visits of age <15/total

Table 2 Single patient normalized disparity % in ED usage, excess (+) or lack of use (–) by females compared to males with age between 2010 and 2017

Age group, yr	ED service year							
	2010	2011	2012	2013	2014	2015	2016	2017
<15	–42.4	–50	–26.8	–39	–28.8	–35.6	–31.6	–35.8
15–24	19.6	37	17.6	25.6	20	21.2	27.1	23.7
25–44	16.6	40	9.5	15	11.7	16.6	10	13.5
45–64	–8.3	–4	–10.8	–11.5	–10.2	–9.3	–5.5	–8.1
65–74	3.2	–14.7	–10.1	–2.8	–4.3	0	–8.6	–0.8
≥75	23.3	16.6	24.4	31	26.2	14.3	17.7	24.8

ED, emergency department.

Table 3 Single patient normalized disparity % in ED usage, excess (+) or lack of use (–) by blacks compared to whites with age between 2010 and 2017

Age group, yr	ED service year							
	2010	2011	2012	2013	2014	2015	2016	2017
<15	12.4	0	15.6	9.2	22.5	11.4	24.4	16.8
15–24	16.7	–4	13	14.7	26.6	13.8	16.3	18.8
25–44	–25.1	8	6.2	15.3	8.5	14.5	11.9	13.7
45–64	4.5	11.5	7.5	4.7	–5	3.6	–11.2	3.1
65–74	–38.6	–7.1	–40	–44.4	–55.2	–51.5	–38.3	–49.6
≥75	–60.3	–53.5	–80	–97.1	–106	–88.4	–76.2	–111

ED, emergency department.

females in US of age <15) – (total male visits of age <15/ total males in US of age <15)]/(total female visits of age <15 + total male visits of age <15 during 2010).

Results

Gender disparity

In *Table 2* excess (+) or reduced (–) ED service usage (%) by female patients for various age groups is reported as compared to their male counterparts from 2010 to 2017 in the US.

The following three gender disparity trends were observed across various age groups:

(I)   Four age groups did not change the usage patterns over 8-year study period: age 15–24 (solid crimson) and those ages ≥75 (dashed black) showed females use ED approximately 25% more than males;

females age 45–64 (solid red) and 65–74 (dotted blue) used ED same as males for these years.

(II)   Girls compared to boys, age <15 have used (35–45% less) ED throughout this period.

(III) Young adult females, age 25–44, have used (15–25% more) ED service than adult male.

Race disparity

In *Table 3* excess (+) or reduced (–) ED service usage (%) by black patients for various age groups is reported as compared to their white counterparts from 2010 to 2017 in US.

The following three racial disparity trends were observed across various age groups:

(I)   Two black patient groups, age <15, solid blue and 15–24, crimson dashed, show modest, increase in the ED use, by 13–19% compared to the whites at the same ages.
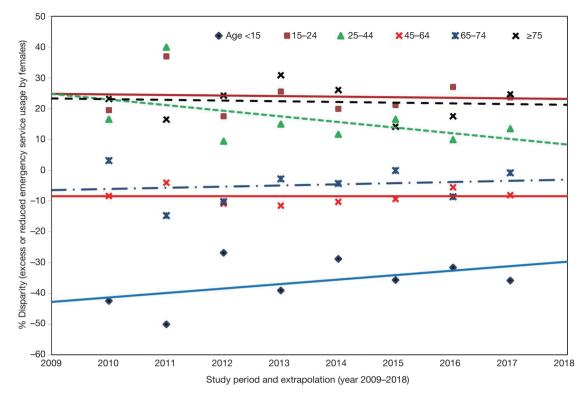
Figure 1 Gender disparity for ED use among various age groups (trends extrapolated to 2009 and 2018). ED, emergency department.

(II)   Blacks, age 25–44 (dashed green) showed a consistent, slightly more usage by about 10–14%. However, the usage for the two races for age 45–64 seems to be almost same.

(III) Importantly, after age 65 we see a dramatic and full reversal in usage: significantly reduced usage by blacks as early as 2010/2011: the disparity becomes increasingly prominent as blacks grow older. Elderly, age 65–74 (blue dashed line) and geriatric, age ≥75 years (black solid line), show 50–100% less ED use compared to whites by 2017.

Discussions

This work revealed large racial and gender differences in the use of ED services for most of the age groups in the nationally representative NHAMCS survey, between 2010 and 2017. We controlled for the contribution of population difference and singled out individual contributions from "herd behavior" in our analysis of ED utilization. The main advantage of the single user normalization ("methods" section) is its comparability without special accommodation to ED usage skewed by racial practices, age-related

priorities, peer communication, geographic locations or ED size and specialty. For example, the differences in population, social communication and ED complexity for all the 1-year-old through all the 14-year-old were averaged out together by single user normalization for the age group of <15. We feel our single user representation model has a randomization advantage following the arguments of Kahan and Morris (17) in statistical strength.

On gender disparity across age groups

The results shown in *Figure 1* emphasized that the need, usage and ED visit patterns were different for the two genders: for every 10 boys age <15 that visited the ED, only about 5–7 girls went to ED; for every 7 young males (age 15–44), 8–9 young females visited the ED while at middle to young old ages (45–75 yrs) both males and females used ED at a lower and almost at the same rate. At old geriatric age (≥75 yr), for every 4 male ED patients, the ED served 5 female patients. Carret *et al.* (18) observed that excessive ED use globally varied from 20% to 40% based on age and income variability. Female patients, patients without co-morbidities, without adequate insurance and those not
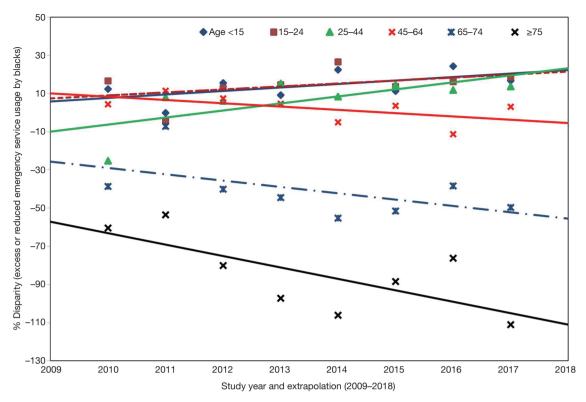
Figure 2 Racial disparity for ED use among various age groups (trends extrapolated to 2009 and 2018). ED, emergency department.

referred to ED by a physician also showed excessive ED use.

On racial disparity across age groups

Racial disparity patterns also seem to be widespread: as shown in *Figure 2*, ED services were used very differently by blacks and whites although the disparity reversed at older age compared to the younger groups. In 2014, 4 black youths (age 15–24, orange line, +26.6%) made as many ED trips as 5 white youths while 4 geriatric black patients (age ≥75, green line, –106%) made only half as many trips to the ED as 4 white patients.

We may be able to draw one plausible cause for this: Rinaldi *et al.* observed (19) that non-physician healthcare providers as well as physicians practice of defensive medicine is mainly caused by fear of litigation; this includes both active and passive defensive medicine, such as over-investigation, over-treatment, and avoidance of high-risk patients. White elderly may have a greater litigation potential and less disease complexity than black patients of same age.

Kanzaria *et al.* surveyed (20) emergency medicine (EM) physicians about shared decision-making (SDM), a law under ACA, when physicians and patients collaboratively choose emergency management strategy from various reasonable options for patient-centered, high quality and effective emergency services. They found male and academic EM physicians tend to use less SDM for several perceived biases against SDM. Lack of black participation demonstrated by our analysis at middle and particularly at geriatric age raises the question if such patients were subjected to inadequate SDM at ED and had less choice compared to whites of same age.

There are several possible explanations for the differences observed in ED service utilization by race and gender, and the ultimate cause is likely a combination of factors. Given the nationally representative data source and the lack of clinical decision-making data, we cannot confirm whether the racial difference in ED use between black and white patients was the result of underuse by elderly black patients by choice or from economic and related constraints or overuse of ED services by elderly whites. The complexity or severity of disease burden or the awareness of it among whites could have been different and was not explored. It is unknown whether these racial differences observed had influenced health outcomes or whether the ED usage was clinically appropriate or followed any guideline recommendations.

Radiology department and inappropriate use of ED services

Of note, radiology service turnaround times and diagnostic accuracy intimately influence ED effectiveness and patient experience as well as quality of hospital care and readmissions. Jalal et al. (21,22) reviewed records during 2013–2017 from a tertiary ED environment to conclude that 24/7/365 radiology physician coverage significantly reduces turnaround time for diagnosis and thus disposition time in ED as corroborated by Hanna et al. (23). Additionally, Hanna et al. (24) also observed that in their patient population 60% of time a second imaging modality was applied without considering the results from the first as a demonstration of inefficient ED resource utilization. Quite frequently low-yield diagnostic imaging modalities for identifying the main issue have been used in ED causing prolonged turnaround time, unnecessary radiation exposure and added medical costs. Examples of such low-yield procedures are: shunt series radiography by Shuaib et al. (25), dedicated rib series from Shuaib et al. (26), sacrum and coccyx radiographs from works of Hanna et al. (27), routine use of facial CT from Shuaib et al. (28) as well as contrast enhanced head CT for non-traumatic neurological presentations in ED shown again by Shuaib et al. (29). Such inappropriate ED use causing prolonged turnaround time and treatment delays with added morbidity and costs when EDs are resource-starved might also cause disproportionate ED usage by specific populations.

Patient choice, role of urgent care and ACA

The growth and development of urgent care centers (UCC) in the context of overcrowded EDs could be partly responsible for somewhat preferred use of UCC by commercially insured. Declining competitiveness of ED services due to growing number of UCC for minor emergencies in major US cities may play a role in ED usage variation in recent years. Krause et al. reviewed (30) Truven Health MarketScan Research Databases of approximately 10M commercially insured UCC users in USA compared to approximately 93M primary care users during 2011–2015. They concluded that urgent care is meeting a need of convenience in spite of being costlier and is potentially replacing outpatient and emergency care for certain acute complaints. We feel since UCC requires upfront co-pay, several young black Americans may be preferably utilizing ED services while many young white Americans are choosing convenience over cost and hence UCC over

ED. Coster et al. summarized (31) the reasons why some patients chose ED over UCC. They point to 24/7 access and confidence in acute ED primary care, higher urgency, greater anxiety, reassurance from emergency-based services, views of family, friends and healthcare professionals, convenient locations as well as having the full-service reputations as the primary reasons for choosing ED.

Gindi et al. found (32) the factors responsible for ED visits in 18% of their cohorts, aged 18–64 from 2013–2014. The visits were 77% due to seriousness of their presenting problems, 12% for emergencies occurring beyond outpatient office hours and 7% due to lack of insurance. Seriousness of the medical problems and lack of insurance were the primary reasons for the Medicaid and uninsured. Weinick et al. commented (33) on the implementation of health care reform under the ACA of 2010 and stressed that it is important to recognize that overall improvements in the US health care system might not automatically benefit all segments of the population equally. Based on our results we find the quality improvement efforts have not adequately removed various disparities nor created enough incentives for providers to serve minority patients in largely minority caring hospitals.

Study limitations

There are several limitations to the interpretation of the results we present in this investigation. As with other studies using the NHAMCS-ED survey, we recognize the inherent bias with using this data source, namely, heterogeneity in documentation from multi-center data pointed out by Vierron et al. (34) and missing responses. Most NHAMCS-ED data items have a nonresponse rate of approximately 5% to 10%. Patients missing race and ethnicity represented 6% of the study sample that is deemed acceptable for the current analysis.

However, despite this, the disparities in ED use by race and gender as demonstrated in this multiyear, nationally representative data analysis warrant further investigation due to potential bias from ignoring socioeconomic factors. Larger EDs tend to have longer wait times and a larger proportion of the black population, which may also contribute to the disparity of usage. This study did not adjust for the variables like insurance, family support and transportation available nor income or educational levels that could be confounding factors of preference, financial status and thus ED usage.

Therefore, we cannot specifically call these findings a

true health care disparity. These are suggestive of but not conclusive enough to separate the differences that are due to structural, inherent weaknesses of healthcare from the ones that originate from individual choice and socioeconomic/educational make up of particular groups built over decades. The low number of qualified hospitals in 2011 (*) data (*Table 1*, "methods" section) while almost doubling of ESAs and a small number of patient records collected warrants scrutiny and was not addressed here.

Disparity models from past: Dahlgren and Whitehead rainbow model of determinants of health

The quality of health across all age groups depends on factors that are within as well as outside a patient's control. Dahlgren and Whitehead model (1991/2007) 'policy rainbow' (35,36) describes multiple factors of influence on an individual's health and focuses on the relationships between these factors, some of which are fixed (non-modifiable core factors: such as age, sex and genetics derived) and a set of individually modifiable factors: personal lifestyle, the physical and social, and broad socio-economic, cultural/environmental conditions. This "rainbow" model raises the awareness about the extent of influence of each of the factors on health, the feasibility of altering specific factors with specific actions that could influence additional linked factors. This widely recognized model allows one to construct hypotheses about the determinants of health as well as their interactions and influences on various health outcomes. In early 2000s in the US the relative impacts on early death from these determinants were approximately: 30% from genetic predispositions, 15% from social circumstances, 5% from environmental exposures, 40% from behavioral patterns and 10% from shortfalls in medical care (37).

However, the Dahlgren and Whitehead rainbow model is only applicable to US or other western countries with similar socioeconomic and environmental conditions and similar populations. Places with different population structure, different social conditions, may show a different result. For example, in a country where a pandemic or a civil war breaks out of control, health of the poor and middle class can deteriorate quite rapidly due to the general socio-economic and environmental disparity. In such a situation racial and gender inequality could result in suboptimal short- and long-term health among these classes. We believe such pandemics can skew the already heterogeneous database used in this work requiring further normalization than proposed here.

The 2003 WHO document 'The Solid Facts' points to such enormous differences in the social determinants of health and reviewed the causal relationships between social and environmental factors and poor health. Wilkinson and Marmot (37) have elicited the role of adequate policies in the presence of these basic differences. Both the works point out that poor social and economic circumstances affect health of those further down the social ladder at least twofold as well as early death compared to those near the top. The effects also run across the employment ladder similarly: lower ranking staff suffers much more disease and earlier death than higher ranking staff aggregated more with advancing age. These works seem to explain the significant disparity computed in the race disparity results of ours (*Figure 2*) for geriatric blacks i.e., a single black patient is twice less likely to take or get emergency service compared to a single white user of same age.

On behalf of the 2005 and 2010 WHO initiative, the Commission on Social Determinants of Health (CSDH), Solar and Irwin (38) drew the attention of governments, society, international organizations and donors to the health impacts of social determinants and highlighted various international and national causes of inequalities. It suggested practical ways of tackling these through creating better social conditions for vulnerable communities. According to CSDH, the social and environmental factors are at the root of most of the inequalities that result in both communicable and non-communicable diseases. However, the roles and failures of modern technological advances are not addressed in these documents. We may point out that genetic susceptibilities to disease for certain races or for a particular gender is ill understood and may produce devastating consequences for certain individuals as we are seeing with healthy life losses in COVID outbreak.

Also notice that the applicability of such models is limited to the identification and quantifiable analysis of disparity. Single user normalization approach in the current work normalizes the disparity trends with respect to group heterogeneity, geographic diversity and population size offering disparity quantification at the front end of policy and resource planning in regions that suffer from similar disparities. However, our work does not directly include or address the root causes of determinants of health while offer normalized quantification of trends that may help assess and apply Dahlgren and Whitehead rainbow model (35,36) where health determinants have heterogeneous groups of users.

Future implications

In this national multiyear study of patients in the NHAMCS-ED survey, we observed large racial and gender differences in ED services usage after separating the population by age, race and gender and by normalizing the population differences for various groups. In this work we were able to pinpoint how likely a single female or a single black patient utilized ED services as compared to a male or a white user during 2010–2017 irrespective of geographic location or affordability. Black patients were less likely to utilize or receive ED imaging than white patients past the middle age but not so at earlier ages. These observed differences warrant further investigation to determine whether this represents true racial or gender disparity in patient care. Future research will likely benefit from local examination of socioeconomic factors as well as from the positive effects of technology, manpower and medical advances available in radiology and ED services in recent years.

Our work offers empirical research with a normalization model that, we believe, stratifies the disparity comparison issues from a highly useful, although heterogeneous dataset. Given that complex data may continue to be collected from diverse sources this analysis could offer objective tools to analyze and influence policy and resource planning in countries that suffer from similar disparities. Given that the complexity of data sources will continue to prevail, simple and effective tools are needed to quantify and effectively reduce disparities in spite of the heterogeneity of service data that are used to make policies and resource planning. By normalizing the differential emergency services arising from individual centers in such a multi-center database (39) requires a normalizing tool as we have proposed here. Our analysis with a single user conversion is a part of the randomization (17) that allowed quantification of the disparities and flattened the local and seasonal effects of disease, crowding of inner cities, geographic disadvantages, friends and family habits, cultural bias, specialized ED quality and ED reputation etc. across USA including the age variation of users of this large database.

The ED services disparity seems to have been highlighted in the current COVID pandemic crisis. Recently, according to the *Huffington Post News* entry by Ignaczak and Hobbes (40) CDC has not released coronavirus data by race or gender. But city and state data indicate that COVID cases are heavily afflicting the black population. In Chicago, 23% of residents are black but accounted for 58% of COVID deaths. In Milwaukee, roughly 25% population is black

suffering with approximately one-half of COVID cases. In Louisiana, 7 out of 10 COVID victims were black. Anthony Fauci, MD, director of the National Institute of Allergy and Infectious Diseases, said at a recent White House coronavirus task force briefing. "*The things that get people into [intensive care]*" and require them to be put on a ventilator—something that often leads to death—are the very factors, Fauci said, "*that are, unfortunately, disproportionately prevalent in the African American population*".

Conclusions

This is the first comprehensive meta-analysis demonstrating racial and gender specific variation in the usage of emergency health care services that exist in USA and seem to be multifactorial and age specific. This study also found that the usage patterns from year to year were variable making prediction and resource planning a moving target. However, there were quantifiable trends of gender and racial disparities demonstrated by single user based randomization. This analysis may offer objective tools to analyze and influence policy and resource planning in regions that suffer from similar disparities. A current and stark example at the national level of such disparity is the disproportionate number of infections and deaths among blacks in current COVID Pandemic fallout in USA and deserves urgent attention. However, such pandemics can skew the already heterogeneous databases used in this work requiring further normalization than proposed here.

Footnote

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki

(as revised in 2013). Institutional ethical approval and individual informed consent were waived.

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