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The epidemiology of bone fracture across the age span in blacks and whites

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Abstract

Introduction—Gender and racial disparities in injury mortality has been well established, but less is known regarding differences in fracture-related hospitalizations across the age span.

Methods—Cross-sectional analysis of annual incident fracture hospital admissions used state-wide acute care hospital discharge data (SPARCS) for non-Hispanic white (n=138,763) and non-Hispanic black (n=19,588) residents of New York State between 2000-2002. U.S. Census data with intercensal estimates were used to ascertain the population at risk. Gender and race specific incident fracture were calculated in 5 year age intervals. Chi Square was used to analyze categorical variables.

Results—Mechanisms of injury vary by race and gender in their relative contribution to injury-related fractures across the age span. Black males exhibited higher fracture incidence until approximately age 62 while incidence in women diverged around age 45. Total motor vehicle traffic-related fracture (MV) hospitalization is bimodal in whites, but not in blacks. Over the life span, all groups exhibited bimodal pedestrian fractures with pedestrian fractures accounting for 8.8% and 2.5% of all fractures in blacks and whites respectively. Racial disparities were present from preschool through age 70. Violence-related fractures were 10 times higher in blacks, accounting for 18.2% of hospitalizations. Black males exhibit higher fracture incidence due to violence by age 5 and higher gun violence by age 10; both remain elevated through age 75.

Conclusions—Despite historical studies demonstrating higher bone density in blacks, this study found racial disparities with increased fracture risk in both black children and adults across most non-fall related injury mechanisms examined.

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Keywords

injury; bone fracture; racial disparities; age span

INTRODUCTION

Injury-related bone fractures contribute to an increase in morbidity, death, disability, and health expenditures across the age span. The incidence of bone fracture is impacted by many factors including age, race, gender, biology, physiology, body habitus, environmental exposure to fracture-producing injury mechanisms and access to prevention programs (1-18).

Despite reports that blacks have better bone quality that provides a protective factor against fracture, black children and adolescents have an increased incidence of femoral shaft and hip fracture than similarly-aged young whites (1, 5, 6, 8). Several investigators have suggested that issues of bone mineral density (BMD) observed in later life actually begin in early life and that some important childhood clues, such as childhood fractures, that might provide for early interventions are being overlooked. Conditions reported with potential to compromise child and/or child-to-adult BMD and fracture risk include vitamin D insufficiency, being a late maturing female, childhood growth patterns, including childhood thinness, and certain diseases including inflammatory bowel diseases, cystic fibrosis and others (4,5,7,9,10). In contrast, activity levels involving high impact and/or strength building exercises have demonstrated varied beneficial effects on bone mineral acquisition (11-14).

This descriptive paper uses cross-sectional data to investigate black/white differences in the shifting incidence of fracture risk across the age span and reports age- and gender-specific disparities in several mechanisms that commonly produce fracture.

Materials and Methods

Data sources

The primary source of data for this study was the statewide hospital discharge database for New York State known as the Statewide Program and Research Cooperative System (SPARCS) (19). SPARCS is a mandatory hospital discharge reporting system that includes all discharges from acute care hospitals in the state. Maintained at the New York State Department of Health, SPARCS data are created through two primary forms: the uniform billing and clinical data abstracting forms (20). The SPARCS inpatient data base includes demographic data, patient disposition, length of stay, type and source of admission, primary and secondary payors, and up to 18 diagnosis-related codes per hospital discharge, including separate E-coded variables for injury mechanism and other variables. U.S. Census 2000 provided denominator data for the at-risk population in New York State with intercensal estimates of population change for calendar years 2001-2002 (21).

Study population

Of the more than 9 million hospital discharges from acute care hospitals in New York State between January 1, 2000 and December 31, 2002, 194,251 were either admitted through the emergency department and/or categorized as an urgent or emergent admission for incident fracture (ICD-9-CMs 800-829.9; 733.1-733.19; 733.93-733.95; 767.2-767.4; and E887) (22). The population for this study consisted of 158,351 (81.5%) persons admitted with incident fracture of which 138,763 (71.4%) were non-Hispanic whites and 19,588 (10.1%) were non-Hispanic blacks. We focused on blacks and whites for examination of race

specific fracture by anatomic site and mechanism due to small numbers in other race/ethnic categories.

Socioeconomic status

Individual level socioeconomic status was based on insurance status obtained from SPARCS. Low socioeconomic status (SES) was defined for ages 0-64 years as uninsured or Medicaid-insured and for ages 65 and older as being uninsured, having Medicare only, or Medicare plus Medicaid.

Incident injury

Acute injury was defined as admission through an emergency department or admissions classified as urgent or emergent. Emergent patients were defined as those who ‘required immediate medical intervention as a result of severe, life threatening or potentially disabling condition(s)’ and urgent patients as those requiring ‘immediate attention for a physical or mental disorder generally resulting in admission to the first available and suitable accommodation’ (19). To avoid double counting patients with fracture, admissions through inter-hospital transfer were excluded at the transferring, but not the receiving hospital.

Classification of fracture

Fractures were classified into the following categories using ICD-9-CM codes as indicated: skull, 800-801.9, 803 (.0-.9); facial, 802 (.0-.9); vertebral, 805-806.9; hip, 820.8-820.9, 821.00, 820.03, 820.13, 733.14; all lower extremity, 820-827.1; 733.14; and all upper extremity, 810-819.1(22). Data was not available for those with fracture who died before hospital admission or who experienced fracture not resulting in hospitalization.

Statistical analyses—Cumulative annual incidence was calculated by race and gender for non-Hispanic whites and non-Hispanic blacks in 5 year age intervals using SPARCS hospital discharge data for the numerators (19). The denominator for incidence calculations for the at-risk population was obtained from the U.S. Census 2000 with intercensal estimates (21). The relative distribution of fracture by age and anatomic site was calculated within the age categories: infants, children, and adolescents (age 0 to 19); adults (age 20-64); and elderly (65 and older). The chi-square test was used in univariate analyses of categorical variables with statistical significance defined as less than or equal to 0.05. We used SAS 9.1 to process and analyze the large data sets (23).

RESULTS

Study population

The age, gender, and insurance status of persons experiencing fracture differed significantly by race. Blacks were younger, more frequently male, less likely to be insured and more likely to be on Medicaid than whites. Among blacks, the majority of fractures occurred in children, adolescents and adults with only 21.9% occurring in the elderly. Conversely, among whites only 7.6% occurred in children while the majority (63.1%) were in elderly ($p<0.0001$) (Table 1).

Cumulative incidence of total fracture by age, race and gender

Blacks exhibit a higher cumulative incidence of fracture through age 50. During the 50-54 age interval, a crossover occurs and white incidence exceeds that of blacks (Figure 1a). However, distinctly different patterns are present when incidence is examined by race and gender. A racial crossover is observed for black and white males around age 62 years (Figure 1b). Among women, there is oscillating relative fracture incidence until age 46 when

incidence begins to diverge (Figure 1b). Among adult women, total fracture incidence is higher and occurs at earlier ages in whites than blacks. In black women, increases were more moderate and lag those observed for white women by 5-10 years (Figure 1b). Both white and black adult men experience a plateau in fracture incidence during their adult years while their similarly-aged female counterparts demonstrate a gradual increase in fracture incidence that accelerates with age.

Gender crossovers were observed within race for both blacks and whites. White men have higher fracture incidence than white women until the mid-fifties when a crossover occurs and white female incidence exceeds that of white males. A similar crossover occurs in blacks about 10 years later than in whites (Figure 1b).

Distribution of anatomic site by race and age group

Despite notable differences in cumulative incidence of fracture in blacks and whites, the anatomic distribution of fracture showed marked similarity across age groups with some racial variation within age groups (Figure 2a-c). The proportion of fracture accounted for by upper extremity fractures as well as skull and facial fractures generally decreased with increasing age for both blacks and whites while the proportion of fractures to neck and trunk and lower extremity increased with age among both blacks and whites (Figures 2a-2c). In particular, the proportion of fractures of the lower extremity was lowest in children, but rose with age accounting for nearly half of hospitalized fractures in black and white adults and approximately two-thirds in black and white elderly (Figures 2b and 2c).

Cumulative incidence of fracture by anatomic site, gender, race, and age

Skull and face: When examined by race, the incidence of skull and facial fractures in whites and blacks are similar at ages less than 10 years with higher incidence in blacks during adolescence and adulthood. During adolescence, white male incidence is nearly triple that of white females and black males six-fold higher than black females (Figure 3a). Incidence in black and white females is similar until after age 50. Incidence in white females begins to increase in the 55 to 59 age range and in black females beginning in the 65 to 69 age group while black males decrease to their lowest levels (Figure 3a).

Neck and trunk: Fracture incidence of the neck and trunk is low in young blacks and whites under age 10, but increases with age thereafter (Figure 3b). In adolescence and young adulthood, this occurs as black female incidence doubles, while white females, as well as white and black males increase between 6 to 10 fold. Both black and white elderly show an increased incidence of fractures of the neck and trunk with increasing age. In white females, this begins subtly around age 30 with increases accelerating beginning with the 40-44 age range. Black females show dramatic increases beginning in the 55 to 59 age range.

Vertebral: White females and white males exhibit two distinct time periods of increased vertebral fracture risk, one in adolescence and one beginning in older adulthood (Figure 3c). After age 55, vertebral fracture patterns are more similar within race than gender with white incidence for males and females increasing exponentially. White women begin to show increases in the 45 to 49 age range with white males and black women showing increases beginning 10 years later in the 55 to 59 age range. Although the increases are relatively more modest, vertebral fracture in black women quadruples after age 55.

Upper extremity: Prior to age 50, the incidence of upper extremity fracture is more similar by gender than by race with male incidence being 2 to 4 fold higher than females in adolescence and young adulthood (Figure 3d). In adulthood, white female upper extremity fracture begins to increase subtly in the late 30's with exponential increases observed

beginning in the 40s. Among females, incidence in blacks lags that of whites by approximately 10 years. Although fracture incidence in black males doubles between age 65 and the end of life unlike white male incidence, it does not reach the high levels observed in early adulthood.

Lower extremity: For both white and black females, exponential fracture incidence increases begin earlier for lower extremity fracture than for other sites examined in this study (Figure 3e). These increases begin from a lower base in females where incidence is less than half that of their male counterparts during adolescence and early adulthood. In males, lower extremity fractures plateau at a high level in the teenage years and remain there until age-related increases begin in white males in the 45 to 49 age group and in black males by age 60 to 64 (Figure 3e).

Hip: There are distinct childhood peaks in hip fracture for both black males and black females while changes in white hip fractures during this age range increase more subtly (Figure 3f). After age 35, hip fracture increases in all race and gender groups examined until the end of life. By age 50, black and white males and white females show exponential acceleration in incidence of hip fracture with similar increases in black females lagging by 5 or more years. This lag between white and black hip fracture in females widens with increasing age (Figure 3f).

Fracture incidence by fracture mechanism—Mechanisms of injury exhibit very distinctive patterns in their contributions to fracture-related hospitalizations across the age span and vary in their respective contribution by race and gender (Figures 4a-f). Notable differences were observed for fracture-related hospitalizations for unintentional injury in whites and blacks (94.2% vs. 77.5%, $p<0.0001$). Falls accounted for a smaller proportion of injury in blacks than in whites (41.1% vs. 69.2%, $p<0.0001$). Motor vehicle traffic-related fracture was higher in blacks than in whites (21.6% vs. 14.5%, $p<0.0001$) with differences accounted for primarily by the higher pedestrian fracture admissions in blacks (8.8% vs. 2.5%, $p<0.0001$). Assault was higher among blacks than whites (18.3 vs. 1.8%, $p<0.0001$). Firearm related fracture hospitalizations were higher in blacks than whites (5.4% vs. 0.1%, $P<0.0001$).

Motor Vehicle –All Traffic, Driver and Pedestrian: Fracture hospitalization for all motor vehicle traffic injury is bimodal in whites, but not blacks (Figure 4a). Young black males have higher fracture-related hospitalizations until age 10 when young white males exceed young black males. For whites, fracture incidence due to motor vehicle traffic is highest in the teen and elderly years. Black and white males show remarkably similar MV traffic fracture hospitalizations between ages 25 and 70 years. Except for similarities in incidence during mid-life, black and white women show markedly different MV traffic fracture patterns across the age span (Figure 4a). Fracture hospitalizations for drivers increase at age 15 for all groups except black females (4b). Despite the marked similarity in total MV traffic injury hospitalization among males, the relative contribution of pedestrian injury is 2 to 3 times higher in black males than white males and is nearly double in middle-aged black females compared to white females (Figure 4c).

Falls: Fractures related to unintentional falls are a major contributor to injury-related hospitalizations across the age span becoming more important in their relative contribution with age (Figure 4d). There are racial differences early in life in which both black and white males have higher fracture rates due to falls than either white or black females (Figure 4d, inset). Fall-related hospitalized fracture incidence increases gradually until age 55 at which

point white males and white females increase exponentially. Hospitalization due to falls increases more gradually in black females and black males.

Violence: The incidence of fractures due to assault is highest for black males. This increased risk begins around age 5 and continues until age 85 years. White males and black females have similar assault related fracture hospitalizations (Figure 4e). Fracture-related hospitalizations due to gun violence increases sharply beginning at age 10 for black males and remains higher through age 75 (Figure 4f).

DISCUSSION

Despite reports that blacks may have a higher bone density early in life that offers a protective effect against fracture later in life, the findings of this study suggests that this may be offset beginning in childhood and continuing through adulthood possibly through increased exposure to fracture-producing injury mechanisms as well as other factors (1, 2, 15, 16). Despite similar total MV traffic injury among black and white males over a nearly 40 year span, the distribution of fracture-producing mechanisms is quite different with pedestrian injury contributing to higher fracture-related hospitalization in black males and MV driver contributing more substantially in white males. A similar pattern is seen during the mid-life years for black and white females. This suggests that, in addition to the historical and important emphasis on occupant injury prevention efforts, greater reductions in MV traffic fracture-related hospitalizations are more likely to be observed in black children, teens and adults with access to injury prevention initiatives where non-occupant injury is also a priority.

This paper adds to the body of scientific investigations and explanations of racial differences in bone fracture-- demonstrating both the multi-factorial contributors to black-white differences in fracture-producing injury mechanisms as well as a shifting incidence of fracture risk mechanisms across the age span. Not surprising, where data are available, the finding of disparity in fracture-related hospitalization is consistent with known age-related injury mechanisms. In addition, the higher violence-related fracture hospitalization in black males mirrors the mortality patterns due to this cause. A large and disproportionate share of violence-related fracture in black males is gun-related. This finding supports increased prevention efforts in neighborhoods where young black males reside.

Child supervision has repeatedly been documented as important to injury prevention across a variety of mechanisms (15, 16). Extended families increasingly provide supervision of children who may be more vulnerable to injury if social stability or supervision is interrupted through a fracture-related hospitalization of an adult or elderly caregiver or when an adult who normally provides supervision is called to extend caregiving to elderly who become incapacitated due to fracture. These findings suggest the need to explore further the possibility of addressing missed opportunities to implement preventive measures in families that might benefit children through less social and supervisory disruption.

Studies of osteoporotic fractures have shown that blacks excrete less calcium than whites thus possibly retaining more in their bones leading to faster bone growth in children and adolescents and higher peak bone mass (6). Despite having higher bone mass than whites, blacks experience exponential age-related increases in fracture incidence across multiple anatomic sites suggesting the need for improved fracture risk screening including injury risks and primary and secondary factors for osteoporosis (6,17). Although it is unclear whether increasing fracture risk observed beginning as early as 35 in white women is related to participation in high risk activities, secondary causes of osteoporosis, early stages of primary osteoporosis, or an interaction among these, both white and black women have a

gradual increased risk of fracture that begins much earlier in the life course than previously recognized (6, 17). While primary osteoporosis associated with aging and menopause may account for much of the acceleration in older black and white women, similar acceleration occurred in older men suggesting the need for further study of the interaction between injury mechanisms, medical conditions and bone health.

An NIH consensus panel on osteoporosis recommends maximizing bone mass at earlier ages to counter age-related losses later in life (6). Several studies of childhood and adolescent bone mineral content have demonstrated the advantages of high impact exercise for site specific strengthening on bones implicated in hip fracture (11-14). This suggests that current initiatives aimed at obesity prevention and reduction that incorporate high impact exercise may have a side effect of improving site specific bone density in children.

Disparities in differential access to care, racial disparities in insurance status and patterns of seeking/delivery of treatment likely impacted our fracture incidence calculations for fractures where hospitalization has a discretionary component. In particular, vertebral fractures are frequently under-diagnosed and may be treated by means other than hospitalization. Studies of vertebral fracture estimate 12% to 25% of persons aged 50 to 60 have evidence of vertebral fracture, but that only 30% come to medical attention (24). In our study, blacks show smaller age-related increases in vertebral fracture than for hip fracture. Since hip fracture has little discretion in hospital admission, it is likely that hip fracture is a better gauge of true racial differences in incident fracture than vertebral fracture.

This study has limitations. We were unable to include in our incidence calculations fractures in persons dying before hospital admission, not seeking treatment, failing to receive diagnostic tests, or those treated and released from an emergency department. In addition, the unit of analysis is admission for fractures and not patients making it possible for a patient to be admitted twice during the same year for separate fractures. Despite the advantages of using a large administrative data set, the variables reported did not include bone mineral density measurements. It is possible for data misclassification to occur due to quality of diagnoses and completeness or accuracy of condition and e-codes. Race and ethnicity data used in incidence calculations may be derived by two separate means. Census data is self-identified and hospitalization data may be self-identified or assigned. Although quality audits are performed at least annually on the SPARCS data base, bias in the recording of race and ethnicity in either the U.S. Census or the SPARCS data base have potential to impact incidence calculations.

In summary, this study highlights the value of developing age-race-gender specific fracture risk reduction strategies that address mechanisms of injury producing fractures. Child, teen and adult blacks could benefit from effective fracture reduction strategies that addressed MV traffic pedestrian injury and violence, particularly among young black males. Depending on the age span examined and the study question of interest, these findings suggest that statistical models of fracture should be aware of issues raised in this study and verify proportionality across age, gender and race strata or use non-proportional hazards models (25).

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Figure 1a.

Cumulative incidence of fracture-related hospitalizations for white and black non-Hispanics by age. Fracture incidence is shown per 100,000 population for white non-Hispanics and black non-Hispanics.

Figure 1b.

Cumulative incidence of fracture-related hospitalizations by age, race and gender. Fracture incidence is shown per 100,000 population for white non-Hispanic males (WM), black non-Hispanic males (BM), white non-Hispanic females (WF), and black non-Hispanic females (BF).

Figure 2a.

Percent distribution of fractures for persons aged 0-19 by race and anatomic location of fracture in New York State. Percentages of fractures are shown for white non-Hispanics and black non-Hispanics.

Figure 2b.

Percent distribution of fractures for persons aged 20-64 by race and anatomic location of fracture in New York State. Percentages of fractures are shown for white non-Hispanics and black non-Hispanics.

Figure 2c.

Percent distribution of fractures for persons aged 65 and older across racial groups by anatomic location of fracture in New York State. Percentages of fractures are shown for white non-Hispanics and black non-Hispanics.

Figure 3a.

Cumulative incidence of skull and facial fractures by race and age. Fracture incidence is shown per 100,000 population for white non-Hispanic males (WM), black non-Hispanic males (BM), white non-Hispanic females (WF), and black non-Hispanic females (BF).

Figure 3b.

Cumulative incidence of neck and trunk fractures by race and age. Fracture incidence is shown per 100,000 population for white non-Hispanic males (WM), black non-Hispanic males (BM), white non-Hispanic females (WF), and black non-Hispanic females (BF).

Figure 3c.

Cumulative incidence of vertebral fractures by race and age. Fracture incidence is shown per 100,000 population for white non-Hispanic males (WM), black non-Hispanic males (BM), white non-Hispanic females (WF), and black non-Hispanic females (BF).

Figure 3d.

Cumulative incidence of upper extremity fractures by race and age. Fracture incidence is shown per 100,000 population for white non-Hispanic males (WM), black non-Hispanic males (BM), white non-Hispanic females (WF), and black non-Hispanic females (BF).

Figure 3e.

Cumulative incidence of lower extremity fractures by race and age. Fracture incidence is shown per 100,000 population for white non-Hispanic males (WM), black non-Hispanic males (BM), white non-Hispanic females (WF), and black non-Hispanic females (BF).

Figure 3f.

Cumulative incidence of hip fractures by race and age with U.S. Preventive Services Task Force Screening Recommendations. Fracture incidence is shown per 100,000 population for white non-Hispanic males (WM), black non-Hispanic males (BM), white non-Hispanic females (WF), and black non-Hispanic females (BF).

Figure 4a.

Incidence of motor vehicle related fractures (all mechanisms) for non-Hispanic white males (WM), non-Hispanic white females (WF), non-Hispanic black males (BM) and non-Hispanic black females (BF) by age.

Figure 4b.

Incidence of fractures due to crash as a motor vehicle driver for non-Hispanic white males (WM), non-Hispanic white females (WF), non-Hispanic black males (BM) and non-Hispanic black females (BF) by age.

Figure 4c.

Incidence of pedestrian-related motor vehicle fractures for non-Hispanic white males (WM), non-Hispanic white females (WF), non-Hispanic black males (BM) and non-Hispanic black females (BF) by age.

Figure 4d.

Incidence of fractures due to unintentional falls for non-Hispanic white males (WM), non-Hispanic white females (WF), non-Hispanic black males (BM) and non-Hispanic black females (BF) by age. Inset is a zoom-in on incidence data for ages 0-49.

Figure 4e.

Incidence of fractures due to assault for non-Hispanic white males (WM), non-Hispanic white females (WF), non-Hispanic black males (BM) and non-Hispanic black females (BF) by age.

Figure 4f.

Incidence of fractures due to gun violence for non-Hispanic white males (WM), non-Hispanic white females (WF), non-Hispanic black males (BM) and non-Hispanic black females (BF) by age.

Table 1

Population characteristics of fracture-related hospitalizations by race

Population characteristics	Whites (n,%)	Blacks (n,%)	Total (n,%)
Population (n,%)	138,763 (87.6)	19,588 (12.4)	158,351 (100)
Age (years) *			
Children and adolescents (0-19)	10,503 (7.6)	4,069 (20.8)	14,572 (9.2)
Adults (20-64)	40,650 (29.3)	11,226 (57.3)	51,876 (32.8)
Elderly (65 and over)	87,610 (63.1)	4,293 (21.9)	91,903 (58.0)
Gender (n, % male) *	53,843 (38.8)	11,931 (60.9)	65,774 (41.5)
Admission type *			
Emergent	128,446 (92.6)	18,948 (96.7)	147,394 (93.1)
Urgent	10,174 (7.3)	619 (3.2)	10,793 (6.8)
Admission source *			
Emergency department	123,562 (89.0)	17,951 (91.6)	141,513 (89.4)
Physician	12,445 (9.0)	1,349 (6.9)	13,794 (8.7)
Skilled nursing facility	1,913 (1.4)	118 (0.6)	2,031 (1.3)
Other	843 (0.6)	170 (0.9)	1,013 (0.6)
Insurance Status *			
Uninsured/selfpay	5,225 (3.8)	3,044 (15.9)	8,269 (5.2)
Medicaid	6,438 (4.7)	5,477 (28.7)	11,915 (7.5)
Medicare only	29,108 (21.1)	1,821 (9.5)	30,929 (19.5)
Medicare + Medicaid	8,798 (6.4)	1,423 (7.5)	10,221 (6.5)
Medicare + supplemental	42,055 (30.5)	760 (4.0)	42,815 (27.0)
Private insurance	46,355 (33.6)	6,583 (34.5)	52,938 (33.4)
Patient Discharge Status *			
Died in hospital	4,848 (3.5)	414 (2.1)	5,262 (3.3)
Self care	53,379 (38.5)	13,012 (66.4)	66,391 (41.9)
Home health care	12,750 (9.2)	1,247 (6.4)	13,997 (8.8)
Skilled nursing, intermediate care facility or hospice	37,596 (27.1)	2,010 (10.3)	39,606 (25.0)
Hospital transfer	4,416 (3.2)	455 (2.3)	4,871 (3.1)
Outpatient facility/rehabilitation	2,111 (1.5)	110 (0.6)	2,221 (1.4)
Other	23,663 (17.1)	2,340 (12.0)	26,003 (16.4)

* P=<0.0001