

Relative Mortality in U.S. Medicare Beneficiaries with Parkinson Disease and Hip and Pelvic Fractures

Marcie Harris-Hayes, PT, DPT, MSCI, OCS, Allison W. Willis, MD, Sandra E. Klein, MD, Sylvania Czuppon, PT, DPT, OCS, Beth Crowner, PT, DPT, NCS, MPPA, and Brad A. Racette, MD

Investigation performed at Washington University School of Medicine, St. Louis, Missouri

Background: Parkinson disease is a neurodegenerative disease that affects gait and postural stability, resulting in an increased risk of falling. The purpose of this study was to estimate mortality associated with demographic factors after hip or pelvic (hip/pelvic) fracture in people with Parkinson disease. A secondary goal was to compare the mortality associated with Parkinson disease to that associated with other common medical conditions in patients with hip/pelvic fracture.

Methods: This was a retrospective observational cohort study of 1,980,401 elderly Medicare beneficiaries diagnosed with hip/pelvic fracture from 2000 to 2005 who were identified with use of the Beneficiary Annual Summary File. The race/ethnicity distribution of the sample was white (93.2%), black (3.8%), Hispanic (1.2%), and Asian (0.6%). Individuals with Parkinson disease (131,215) were identified with use of outpatient and carrier claims. Cox proportional hazards models were used to estimate the risk of death associated with demographic and clinical variables and to compare mortality after hip/pelvic fracture between patients with Parkinson disease and those with other medical conditions associated with high mortality after hip/pelvic fracture, after adjustment for race/ethnicity, sex, age, and modified Charlson comorbidity score.

Results: Among those with Parkinson disease, women had lower mortality after hip/pelvic fracture than men (adjusted hazard ratio [HR] = 0.63, 95% confidence interval [CI] = 0.62 to 0.64), after adjustment for covariates. Compared with whites, blacks had a higher (HR = 1.12, 95% CI = 1.09 to 1.16) and Hispanics had a lower (HR = 0.87, 95% CI = 0.81 to 0.95) mortality, after adjustment for covariates. Overall, the adjusted mortality rate after hip/pelvic fracture in individuals with Parkinson disease (HR = 2.41, 95% CI = 2.37 to 2.46) was substantially elevated compared with those without the disease, a finding similar to the increased mortality associated with a diagnosis of dementia (HR = 2.73, 95% CI = 2.68 to 2.79), kidney disease (HR = 2.66, 95% CI = 2.60 to 2.72), and chronic obstructive pulmonary disease (HR = 2.48, 95% CI = 2.43 to 2.53).

Conclusions: Mortality after hip/pelvic fracture in Parkinson disease varies according to demographic factors. Mortality after hip/pelvic fracture is substantially increased among those with Parkinson disease.

Level of Evidence: Prognostic Level III. See Instructions for Authors for a complete description of levels of evidence.

Peer Review: This article was reviewed by the Editor-in-Chief and one Deputy Editor, and it underwent blinded review by two or more outside experts. It was also reviewed by an expert in methodology and statistics. The Deputy Editor reviewed each revision of the article, and it underwent a final review by the Editor-in-Chief prior to publication. Final corrections and clarifications occurred during one or more exchanges between the author(s) and copyeditors.

Parkinson disease is a neurodegenerative disease characterized by bradykinesia, rigidity, resting tremor, and postural instability¹. With disease progression, postural instability increases, often leading to falls^{2,3}. While dopaminergic therapy improves tremor and rigidity, symptoms such as bradykinesia, freezing when walking, and impaired balance may remain, resulting in an increased risk of falls and injury^{4,5}. People

with Parkinson disease are particularly susceptible to hip fractures⁵⁻⁷, with a 3.2-fold greater risk compared with the risk for people without Parkinson disease⁸. In addition to gait disturbances and postural instability, other factors such as postural hypotension, decreased bone mineral density^{9,10}, low vitamin-D levels^{11,12}, dementia⁸, medications⁵, and advanced age⁸ further increase the fracture risk for people with Parkinson disease.

Disclosure: One or more of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of an aspect of this work. In addition, one or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. No author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work. The complete **Disclosures of Potential Conflicts of Interest** submitted by authors are always provided with the online version of the article.

TABLE 1 Demographic Characteristics

Patient Characteristics	Parkinson Disease with Hip Fracture (N = 131,215)	No Parkinson Disease with Hip Fracture (N = 1,849,186)	All with Hip Fracture (N = 1,980,401)
Race/ethnicity* (no. [%])			
White	123,769 (94.3)	1,722,622 (93.2)	1,846,391 (93.2)
Black	3632 (2.8)	71,553 (3.9)	75,185 (3.8)
Hispanic	1829 (1.4)	22,087 (1.2)	23,916 (1.2)
Asian	787 (0.6)	11,270 (0.6)	12,057 (0.6)
Sex (no. [%])			
Male	45,563 (34.7)	423,355 (22.9)	468,918 (23.7)
Female	85,652 (65.3)	1,426,831 (77.2)	1,512,483 (76.4)
Mean age (standard deviation) (yr)	81.0 (7.8)	82.3 (6.6)	82.2 (7.7)
Mean modified Charlson comorbidity score (standard deviation)	6.47 (1.72)	6.30 (1.84)	6.33 (1.84)

*Native American, unknown, and other were not reported due to small numbers of subjects or race ambiguity; therefore percentages do not equal 100.

Among the general population, mortality rates for people with hip fractures are reported to be up to 36% greater compared with the rates in non-hip-fracture reference populations¹³. Although it is clear that hip fracture increases mortality in the general population, less is known about the mortality risk after hip fracture in people with Parkinson disease. Hip fractures are common in Parkinson disease and recovery may be complicated by the disease signs and symptoms. Understanding the comparative mortality associated with hip fracture in patients with and without Parkinson disease may help identify those at higher risk of death and determine specific treatment strategies to reduce that risk.

The goal of this study was to investigate mortality rates associated with demographic and clinical risk factors after hip or pelvic (hip/pelvic) fractures in people with Parkinson disease and compare these rates with postfracture mortality rates among those with other medical conditions. We hypothesized that, similar to what has been found in non-Parkinson disease populations, men with Parkinson disease would have a higher mortality after hip/pelvic fracture than women with Parkinson disease, and that mortality would differ according to race/ethnicity. Finally, we expected patients with Parkinson disease to have greater mortality after hip/pelvic fracture than those without Parkinson disease.

Materials and Methods

This study was approved by the Human Protection Research Office of the Washington University School of Medicine.

Study Population

Beneficiaries with a Medicare part-A or B claim for a hip fracture from 2000 to 2005 were identified from the Medicare Beneficiary Annual Summary File, which contains the date of diagnosis of a hip fracture. In the Medicare Beneficiary Annual Summary File, the diagnosis of hip fracture (hereafter referred to as "hip/pelvic fracture") includes any fracture of the proximal part of the femur, acetabulum, or pelvic ring. The International Classification of Diseases, Ninth Revision (ICD-9) codes representing the hip fracture diagnosis in the Medicare Beneficiary Annual

Summary File are provided in the Appendix of this article. The Medicare Beneficiary Annual Summary File also contains twenty-one other common diseases contained in Medicare's Chronic Condition Data Warehouse, as well as demographic and vital status data¹⁴. Using these data, we identified hip/pelvic fracture cases with the following comorbid diagnoses: chronic obstructive pulmonary disease, stroke/transient ischemic attack, diabetes mellitus, ischemic heart disease, osteoporosis, dementia, heart failure, and chronic kidney disease. Medicare outpatient and carrier claims data were used to identify hip/pelvic fracture cases with comorbid Parkinson disease with use of previously published methods^{15,16}.

Demographic and Clinical Data

Race/ethnicity (according to standard Medicare race codes), sex, and date of birth were extracted for each subject. Using information from Medicare's Chronic Condition Data Warehouse contained in the Medicare Beneficiary Annual Summary File, we calculated an age-weighted modified Charlson comorbidity score for each case on the basis of the presence of malignant disease (breast, prostate, endometrial, lung, or colon/rectum), ischemic heart disease, diabetes, chronic obstructive pulmonary disease, stroke/transient ischemic attack, acute myocardial infarction, chronic kidney disease, or heart failure¹⁴. Using specifications documented by Medicare's Chronic Condition Data Warehouse¹⁷, we calculated the Charlson comorbidity score on the basis of the presence of a diagnostic claim made in any inpatient or outpatient setting. The time frames used by the Chronic Condition Data Warehouse are (1) the previous calendar year for malignant disease, chronic obstructive pulmonary disease, stroke/transient ischemic attack, and acute myocardial infarction and (2) the previous two years for ischemic heart disease, diabetes, chronic kidney disease, or heart failure.

Survival Analyses

Survival status was determined by using the 2000 to 2008 Medicare Beneficiary Annual Summary Files with previously published methods¹⁸. The time-to-event variable was calculated from the date of the hip/pelvic fracture to the recorded date of death (measured in months). Surviving cases were censored at the end of the calendar year in 2008. Covariates included race, sex, age at diagnosis, and modified Charlson comorbidity score. To investigate whether demographic or clinical factors were associated with differential survival after hip/pelvic fracture in people with Parkinson disease, we performed Cox proportional hazard analysis using people with Parkinson disease and hip/pelvic fracture and adjusting for age and modified Charlson comorbidity score. To investigate comparative mortality, we performed Cox proportional hazards analysis comparing mortality of people with Parkinson disease and hip/pelvic fracture with

TABLE II Post-Hip Fracture Mortality Risk Associated with Sex and Race/Ethnicity Among Individuals with Parkinson Disease

	Unadjusted		Adjusted*		P Value
	HR	95% CI	HR	95% CI	
Race/ethnicity					
White		Reference		Reference	
Black	1.00	0.97-1.04	1.12	1.09-1.16	<0.001
Hispanic	0.86	0.81-0.91	0.87	0.81-0.95	0.001
Asian	0.78	0.72-0.85	0.93	0.85-1.02	0.132
Sex					
Male		Reference		Reference	
Female	0.65	0.64-0.66	0.63	0.62-0.64	<0.001

*Adjusted for age and age-weighted modified Charlson comorbidity score, with the race/ethnicity analysis adjusted for sex as well and the sex analysis adjusted for race/ethnicity as well.

mortality of people with hip/pelvic fracture and other common illnesses (dementia, stroke, chronic obstructive pulmonary disease, kidney disease, diabetes, heart failure, ischemic heart disease, and osteoporosis), with hip/pelvic fracture cases without any of these conditions used as the reference group.

Statistical Analyses

Descriptive analyses were performed to compare members of the study population by survival status according to demographic and clinical variables. We used independent t tests to compare means of continuous variables, and we used chi-square tests to compare proportions. Standard methods were used to produce Cox proportional hazard coefficients with 95% confidence intervals (CIs).

Source of Funding

Funding for this study was received from the National Institute of Neurological Disorders and Stroke (5T32NS007205-27); National Center for Research Resources and National Institutes of Health Roadmap for Medical Research (UL1RR024992, KL2RR024994); National Institute of Environmental Health Sciences (K24 ES017765); National Institute of Child Health and Human Development, National Center for Medical Rehabilitation Research (K23HD67343); St. Louis chapter of the American Parkinson Disease Association; Walter and Connie Donius; and the Robert Renschen Fund.

Results

Subject Demographics

The demographic characteristics of the study population are summarized in Table I. Our analysis included 1,980,401 individuals who had sustained a hip/pelvic fracture, 131,215 of whom had Parkinson disease. There were more whites and fewer blacks in the Parkinson disease cohort than in the general hip/pelvic fracture population ($p < 0.001$). While in both groups, the majority of the patients with a fracture were women, 34.7% of the patients with a hip/pelvic fracture and Parkinson disease were men compared with 22.9% of the individuals with a hip/pelvic fracture who did not have Parkinson disease ($p < 0.001$). Those with Parkinson disease were younger and demonstrated a higher modified Charlson comorbidity score than those without Parkinson disease ($p < 0.001$).

Association of Mortality with Sex, Race/Ethnicity

The risk of death after hip/pelvic fracture associated with sex and race/ethnicity among beneficiaries with Parkinson disease

are provided in Table II. After adjustments for age, race, and modified Charlson comorbidity score, women had a lower risk of death than men (adjusted hazard ratio [HR] = 0.63, 95% CI = 0.62 to 0.64). Compared with whites with Parkinson disease, blacks with Parkinson disease had higher mortality (adjusted HR = 1.12, 95% CI = 1.09 to 1.16) and Hispanics with Parkinson disease had lower mortality (adjusted HR = 0.87, 95% CI = 0.81 to 0.95). The mortality rates of whites and Asians were similar (adjusted HR = 0.93, 95% CI = 0.85 to 1.02).

Association of Mortality with Medical Condition

The risks of death after hip/pelvic fracture associated with Parkinson disease and other medical conditions are provided in Table III. Among all individuals with hip/pelvic fracture, those with Parkinson disease had a greater risk of death (adjusted

TABLE III Post-Hip Fracture Mortality Risk Associated with Medical Conditions*

	HR*	95% CI	P Value
No documented disease		Reference	
Dementia	2.73	2.68-2.79	<0.001
Kidney disease	2.66	2.60-2.72	<0.001
Chronic obstructive pulmonary disease	2.48	2.43-2.53	<0.001
Parkinson disease	2.41	2.37-2.46	<0.001
Diabetes mellitus	2.37	2.32-2.41	<0.001
Stroke/transient ischemic attack	2.28	2.23-2.34	<0.001
Heart failure	2.28	2.23-2.33	<0.001
Ischemic heart disease	2.17	2.14-2.21	<0.001
Osteoporosis	1.89	1.86-1.92	<0.001

*Adjusted for age, age-weighted modified Charlson comorbidity score, sex, and race/ethnicity.

HR = 2.41, 95% CI = 2.37 to 2.46) than patients without Parkinson disease. Patients with dementia (adjusted HR = 2.73, 95% CI = 2.68 to 2.79), kidney disease (adjusted HR = 2.66, 95% CI = 2.60 to 2.72), or chronic obstructive pulmonary disease (adjusted HR = 2.48, 95% CI = 2.43 to 2.53) had the highest mortality.

Discussion

Despite hip fractures being common in individuals with Parkinson disease⁵⁻⁷, little is known about the factors associated with the post-hip fracture mortality of these individuals. Similar to what has been found in the general population, men with Parkinson disease demonstrated a higher risk of death than women. We also found that mortality varied across race/ethnic categories, with black patients demonstrating a higher and Hispanic patients demonstrating a lower adjusted risk of death compared with white patients. Finally, we demonstrated that people with Parkinson disease had substantially increased postfracture mortality, suggesting a need for aggressive fracture prevention and coordinated postfracture care for people with Parkinson disease.

A major strength of our study is the large sample size. The sample was obtained with use of the Medicare data set, the only population-based U.S. health-care database, which provides substantial power to detect effects on mortality. We were able to achieve complete case follow-up and adjust for multiple factors, including comorbidities. Additionally, we were able to determine mortality differences based on race/ethnicity, which is often underreported in studies of hip fracture. Finally, Medicare data provide a “real world” demonstration of the impact of hip/pelvic fracture on patients with Parkinson disease, in contrast to specialty center studies that report outcomes on a select and often non-representative population. Our study demonstrates the importance of demographic factors in mortality after hip/pelvic fracture in people with Parkinson disease.

Our findings related to sex are consistent with those of previous studies on mortality following hip fracture in the general population¹⁹⁻²⁸. A meta-analysis of mortality following hip fracture surgery demonstrated that men with hip fracture have a higher mortality (pooled HR = of 1.7) than women²⁷. The relationship was similar among those with Parkinson disease in our study. It is unclear why men have higher mortality after fracture than women. Previous studies have indicated that men have more comorbidities and more severe comorbidities at the time of fracture^{19,20,22-24}, but male sex remained a significant risk factor after adjustment for comorbidities in our study and in others^{19,20,22-24}. We were unable to adjust for comorbidity severity, postural instability, gait impairments, or postoperative complications due to the limited data available in this administrative data set.

We are the first, to our knowledge, to report on the association between race/ethnicity and mortality after hip/pelvic fracture in people with Parkinson disease. Studies related to race/ethnicity and mortality after hip/pelvic fracture in the general population have shown conflicting results. Jacobsen et al.²⁸ used Medicare data from 1984 to 1987 to assess the

relationship between sex/race pairings and mortality and reported that mortality rates among white and black men were similar, but black women had a higher mortality rate (22.9 of 1000) than white women (17.2 of 1000). Lu-Yao et al.²¹ used Medicare data from 1986 to 1989 and reported that, compared with whites, blacks (adjusted odds ratio [OR] = 1.21, 95% CI = 1.08 to 1.36) and patients with other, unknown, or missing race (adjusted OR = 1.65, 95% CI = 1.41 to 1.94) had higher mortality. Penrod et al.²⁹ also found that whites were more likely to survive (adjusted OR = 1.74, 95% CI = 1.15 to 2.65) after hip fracture compared with nonwhites. Hannan et al.³⁰ reported greater six-month mortality in nonwhite patients (24%) compared with white patients (13%); however, this difference was not significant. In contrast, Orces and Alamgir³¹ reported higher post-hip fracture mortality in whites compared with blacks and Hispanics among people aged fifty years and older. Our study showed disproportionate mortality among blacks with hip/pelvic fractures and emphasizes the importance of identifying contributors such as health-care quality (both Parkinson disease-related and general) and access to and utilization of specialty care.

The reduced mortality found among Hispanics in our data set, however, suggests that socioeconomic factors may not be the only consideration when assessing differences related to race/ethnicity. Our findings are consistent with previous studies that have shown similar differences related to race/ethnicity in all-cause mortality³². Compared with whites, blacks demonstrate higher and Hispanics demonstrate lower all-cause mortality³². Socioeconomic differences have been implicated in the higher all-cause mortality among blacks³²; however, socioeconomic differences may not explain the lower mortality in Hispanics. Hispanics in the U.S. demonstrate lower all-cause mortality compared with non-Hispanics despite lower socioeconomic status and lower rate of health insurance coverage^{33,34}. Three theories to explain this paradox include (1) migration patterns that involve healthier people emigrating to the U.S. and less healthy people returning to their native country; (2) positive cultural differences, such as diet or family structure; and (3) potential data artifacts. Investigators have also found that this may be a feature specific to certain Hispanic subgroups related to national origin or ancestry^{34,35}. We cannot address migration patterns or cultural differences on the basis of the administrative data used in our study.

We found increased mortality associated with Parkinson disease similar to that associated with other conditions, such as dementia, kidney disease, chronic obstructive pulmonary disease, and diabetes. Previous reports specific to Parkinson disease and hip fracture have revealed conflicting findings. Studies published in 1980 and 1990 showed increased mortality following hip fracture in patients with Parkinson disease^{36,37}. These early studies, however, included patients without access to therapies such as deep brain stimulation or aggressive rehabilitation protocols that are in current use. Three recently published studies demonstrated no relationship between Parkinson disease and mortality after hip fracture^{25,29,38}. However, all were based on relatively small samples, the largest being 2692 subjects²⁹. In contrast, our study includes data from 1,980,401

Medicare beneficiaries diagnosed with hip/pelvic fracture, representing the entire elderly hip/pelvic fracture population in the U.S.

Our findings suggest that treatment strategies to prevent hip/pelvic fracture and reduce mortality after fracture, particularly in men with Parkinson disease, have the potential to have a substantial public health impact. Most studies have investigated the prevention and treatment of hip fractures in women because of their higher risk for sustaining a hip fracture. Even though women are more likely to sustain a fracture, men are more likely to die after the fracture. Therefore preventative screenings and treatment strategies targeting those at risk for falls and subsequent hip fracture should not be limited to women²⁵ as they could be potentially life-saving for men. One example is screening for osteoporosis, a risk factor for hip fracture. A statement recently published by the U.S. Preventive Services Task Force provided specific recommendations for osteoporosis screening for women but did not provide a recommendation for men because of insufficient evidence. Given the lack of evidence to support osteoporosis screening for men, it is likely that osteoporosis is underdiagnosed in men. This may be particularly true for men with Parkinson disease, who are more likely to have low bone mineral density compared with healthy controls^{9,39}. In their study of 177 patients newly diagnosed with Parkinson disease, Eng et al.⁴⁰ reported that only 11% of men had been previously screened for low bone mineral density compared with 71% of women. Evaluation provided by a physical therapist may also assist in preventing hip/pelvic fracture by identifying, through gait and balance analysis, patients with Parkinson disease who are at risk for falls^{41,42} and by providing treatment to improve gait and postural instability, thus reducing the risk of falls⁴³⁻⁴⁵.

Coordinated care during the perioperative phase may also help to reduce postfracture mortality of patients with Parkinson disease. Hip/pelvic fracture and the subsequent hospitalization can interrupt complex Parkinson disease medication regimens, reduce efficacy of Parkinson disease medications, and result in a decline in functional mobility⁴⁶⁻⁴⁹. Recent reports highlight the clinical problems faced by patients with Parkinson disease when hospitalized, such as frequent medication errors, infections, confusion, falls, and decubitus ulcers⁴⁶⁻⁴⁹. An interdisciplinary team that is educated in the complexities of Parkinson disease management likely improves outcomes⁴⁹. A small retrospective study of patients with Parkinson disease who underwent a total knee arthroplasty showed that early involvement of a neurologist in the postoperative phase resulted in significantly shorter hospital stays and improved early outcomes⁵⁰, suggesting the need for early neurologic consultation to reduce associated morbidities.

Our study had limitations. There are a number of factors proposed to be related to mortality after hip/pelvic fracture for which we could not account, including prefracture residence²⁷, previous level of function²⁷, smoking²⁵, fracture type^{30,51}, and type of postfracture management. These variables are not contained in the Medicare database⁵². There was also no way to track Parkinson disease or comorbidity severity, which likely remain

important uncontrolled confounders. We were not able to validate the accuracy of the diagnosis of Parkinson disease, so conditions mimicking Parkinson disease such as multiple system atrophy may have been misdiagnosed as Parkinson disease and could have influenced the results. However, atypical parkinsonism represent only a small percentage of the total cases presenting with parkinsonism^{53,54}. Minority representation in our data set is lower than that of the U.S. population⁵⁵. The difference in minority representation in our data set, however, is likely influenced by selection of only Medicare beneficiaries who had sustained a hip/pelvic fracture. Whites are more likely to sustain a hip/pelvic fracture than minority populations^{56,57}, which may explain the discrepancy. The hip fracture variable provided in the Medicare Beneficiary Annual Summary File includes all hip and pelvic fractures that the Centers for Medicare & Medicaid Services (CMS) determined to be relevant to classify as hip fractures. We were unable to identify fracture subtypes, post-fracture management, operative procedure, or nonoperative approach provided for each patient. The goal of our current study, however, was to assess the mortality associated with any hip/pelvic fracture in patients with Parkinson disease, a population prone to immobility due to the neurodegenerative disease. Moreover, the inclusion of pelvic fractures, which have lower associated mortality^{58,59}, likely resulted in an underestimate of the true mortality associated with femoral and intertrochanteric fractures in patients with Parkinson disease. Postural instability in Parkinson disease is associated with an increased risk of falls, and, although the distribution of anatomical site cannot be determined from these data, high-energy fractures may be more likely in people with Parkinson disease. The increased mortality that we observed may reflect a greater percentage of high-energy fractures or a greater tendency toward high-energy fractures.

Despite these limitations, our study provides valuable information on the relative mortality of people with Parkinson disease and hip/pelvic fracture. The risk of death after hip/pelvic fracture in people with Parkinson disease varies according to demographic factors. Mortality is increased substantially after hip/pelvic fracture among patients with Parkinson disease. Future studies to understand the factors that contribute to increased mortality after hip/pelvic fracture in patients with Parkinson disease and in subpopulations will help guide treatment strategies to reduce morbidity and mortality in these complex cases.

Appendix

eA A table showing ICD-9 codes representing the hip fracture diagnosis in the Medicare Beneficiary Annual Summary File is available with the online version of this article as a data supplement at jbjs.org. ■

Marcie Harris-Hayes, PT, DPT, MSCJ, OCS
Sylvia Czuppon, PT, DPT, OCS
Beth Crowner, PT, DPT, NCS, MPPA
Program in Physical Therapy,

Washington University School of Medicine,
4444 Forest Park, Campus Box 8502,
St. Louis, MO 63108.
E-mail address for M. Harris-Hayes: harrisma@wustl.edu

Allison W. Willis, MD
Sandra E. Klein, MD

Brad A. Racette, MD
Departments of Neurology (A.W.W. and B.A.R.)
and Orthopedic Surgery (S.E.K.),
Washington University School of Medicine,
660 South Euclid Avenue,
Campus Box 8111,
St. Louis, MO 63110

References

- de Lau LM, Breteler MM. Epidemiology of Parkinson's disease. *Lancet Neurol*. 2006 Jun;5(6):525-35.
- Boonstra TA, van der Kooij H, Munneke M, Bloem BR. Gait disorders and balance disturbances in Parkinson's disease: clinical update and pathophysiology. *Curr Opin Neurol*. 2008 Aug;21(4):461-71.
- Frenklach A, Louie S, Koop MM, Bronte-Stewart H. Excessive postural sway and the risk of falls at different stages of Parkinson's disease. *Mov Disord*. 2009 Feb 15;24(3):377-85.
- Rothermel JE, Garcia A. Treatment of hip fractures in patients with Parkinson's syndrome on levodopa therapy. *J Bone Joint Surg Am*. 1972 Sep;54(6):1251-4.
- Vestergaard P, Rejnmark L, Mosekilde L. Fracture risk associated with parkinsonism and anti-Parkinson drugs. *Calcif Tissue Int*. 2007 Sep;81(3):153-61. Epub 2007 Aug 20.
- Gnädinger M, Mellinshoff HU, Kaelin-Lang A. Parkinson's disease and the bones. *Swiss Med Wkly*. 2011;141:w13154. Epub 2011 Feb 16.
- Genever RW, Downes TW, Medcalf P. Fracture rates in Parkinson's disease compared with age- and gender-matched controls: a retrospective cohort study. *Age Ageing*. 2005 Jan;34(1):21-4.
- Melton LJ 3rd, Leibson CL, Achenbach SJ, Bower JH, Maraganore DM, Oberg AL, Rocca WA. Fracture risk after the diagnosis of Parkinson's disease: Influence of concomitant dementia. *Mov Disord*. 2006 Sep;21(9):1361-7.
- Melton LJ 3rd, Leibson CL, Achenbach SJ, Bower JH, Maraganore DM, Oberg AL, Rocca WA. Fracture risk after the diagnosis of Parkinson's disease: Influence of concomitant dementia. *Mov Disord*. 2006 Sep;21(9):1361-7.
- Fink HA, Kuskowski MA, Taylor BC, Schousboe JT, Orwoll ES, Ensrud KE; Osteoporotic Fractures in Men (MrOS) Study Group. Association of Parkinson's disease with accelerated bone loss, fractures and mortality in older men: the Osteoporotic Fractures in Men (MrOS) study. *Osteoporos Int*. 2008 Sep;19(9):1277-82. Epub 2008 Feb 27.
- Schneider JL, Fink HA, Ewing SK, Ensrud KE, Cummings SR; Study of Osteoporotic Fractures (SOF) Research Group. The association of Parkinson's disease with bone mineral density and fracture in older women. *Osteoporos Int*. 2008 Jul;19(7):1093-7. Epub 2008 Feb 27.
- Sato Y, Iwamoto J, Honda Y. Vitamin d deficiency-induced vertebral fractures may cause stooped posture in Parkinson disease. *Am J Phys Med Rehabil*. 2011 Apr;90(4):281-6.
- Sato Y, Kikuyama M, Oizumi K. High prevalence of vitamin D deficiency and reduced bone mass in Parkinson's disease. *Neurology*. 1997 Nov;49(5):1273-8.
- Abrahamsen B, van Staa T, Arieli R, Olson M, Cooper C. Excess mortality following hip fracture: a systematic epidemiological review. *Osteoporos Int*. 2009 Oct;20(10):1633-50. Epub 2009 May 07.
- Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. *J Clin Epidemiol*. 1994 Nov;47(11):1245-51.
- Wright Willis A, Evanoff BA, Lian M, Criswell SR, Racette BA. Geographic and ethnic variation in Parkinson disease: a population-based study of US Medicare beneficiaries. *Neuroepidemiology*. 2010;34(3):143-51. Epub 2010 Jan 15.
- United States Department of Health and Human Services. Centers for Medicare and Medicaid Services. 2007. <http://www.cms.gov/>.
- Chronic Condition Data Warehouse (CCW). Additions and access task order 10. 2012 May 22. https://www.cdwdata.org/cs/groups/public/documents/document/clin_cond_algo_req_proc.pdf. Accessed 2013 Sep 10.
- Willis AW, Schootman M, Evanoff BA, Perlmuter JS, Racette BA. Neurologist care in Parkinson disease: a utilization, outcomes, and survival study. *Neurology*. 2011 Aug 30;77(9):851-7. Epub 2011 Aug 10.
- Wehren LE, Hawkes WG, Orwig DL, Hebel JR, Zimmerman SI, Magaziner J. Gender differences in mortality after hip fracture: the role of infection. *J Bone Miner Res*. 2003 Dec;18(12):2231-7.
- Kannegaard PN, van der Mark S, Eiken P, Abrahamsen B. Excess mortality in men compared with women following a hip fracture. National analysis of comorbidities, comorbidity and survival. *Age Ageing*. 2010 Mar;39(2):203-9. Epub 2010 Jan 14.
- Lu-Yao GL, Baron JA, Barrett JA, Fisher ES. Treatment and survival among elderly Americans with hip fractures: a population-based study. *Am J Public Health*. 1994 Aug;84(8):1287-91.
- Holt G, Smith R, Duncan K, Hutchison JD, Gregori A. Gender differences in epidemiology and outcome after hip fracture: evidence from the Scottish Hip Fracture Audit. *J Bone Joint Surg Br*. 2008 Apr;90(4):480-3.
- Hawkes WG, Wehren L, Orwig D, Hebel JR, Magaziner J. Gender differences in functioning after hip fracture. *J Gerontol A Biol Sci Med Sci*. 2006 May;61(5):495-9.
- Endo Y, Aharonoff GB, Zuckerman JD, Egol KA, Koval KJ. Gender differences in patients with hip fracture: a greater risk of morbidity and mortality in men. *J Orthop Trauma*. 2005 Jan;19(1):29-35.
- Roche JJ, Wenn RT, Sahota O, Moran CG. Effect of comorbidities and postoperative complications on mortality after hip fracture in elderly people: prospective observational cohort study. *BMJ*. 2005 Dec 10;331(7529):1374. Epub 2005 Nov 18.
- Sterling RS. Gender and race/ethnicity differences in hip fracture incidence, morbidity, mortality, and function. *Clin Orthop Relat Res*. 2011 Jul;469(7):1913-8.
- Hu F, Jiang C, Shen J, Tang P, Wang Y. Preoperative predictors for mortality following hip fracture surgery: a systematic review and meta-analysis. *Injury*. 2012 Jun;43(6):676-85. Epub 2011 Jun 17.
- Jacobsen SJ, Goldberg J, Miles TP, Brody JA, Stiers W, Rimm AA. Race and sex differences in mortality following fracture of the hip. *Am J Public Health*. 1992 Aug;82(8):1147-50.
- Penrod JD, Litke A, Hawkes WG, Magaziner J, Doucette JT, Koval KJ, Silberzweig SB, Egol KA, Siu AL. The association of race, gender, and comorbidity with mortality and function after hip fracture. *J Gerontol A Biol Sci Med Sci*. 2008 Aug;63(8):867-72.
- Hannan EL, Magaziner J, Wang JJ, Eastwood EA, Silberzweig SB, Gilbert M, Morrison RS, McLaughlin MA, Orosz GM, Siu AL. Mortality and locomotion 6 months after hospitalization for hip fracture: risk factors and risk-adjusted hospital outcomes. *JAMA*. 2001 Jun 6;285(21):2736-42.
- Orces CH, Alamgir AH. Trends in hip fracture-related mortality in Texas, 1990-2007. *South Med J*. 2011 Jul;104(7):482-7.
- Hummer RA, Chinn JJ. Race/ethnicity and u.s. adult mortality: progress, prospects, and new analyses. *Du Bois Rev*. 2011 Spring;8(1):5-24.
- Markides KS, Coreil J. The health of Hispanics in the southwestern United States: an epidemiologic paradox. *Public Health Rep*. 1986 May-Jun;101(3):253-65.
- Palloni A, Arias E. Paradox lost: explaining the Hispanic adult mortality advantage. *Demography*. 2004 Aug;41(3):385-415.
- Borrell LN, Lancet EA. Race/ethnicity and all-cause mortality in US adults: revisiting the Hispanic paradox. *Am J Public Health*. 2012 May;102(5):836-43. Epub 2011 Dec 15.
- Turcotte R, Godin C, Duchesne R, Jodoin A. Hip fractures and Parkinson's disease. A clinical review of 94 fractures treated surgically. *Clin Orthop Relat Res*. 1990 Jul;(256):132-6.
- Coughlin L, Templeton J. Hip fractures in patients with Parkinson's disease. *Clin Orthop Relat Res*. 1980 May;(148):192-5.
- Idjadi JA, Aharonoff GB, Su H, Richmond J, Egol KA, Zuckerman JD, Koval KJ. Hip fracture outcomes in patients with Parkinson's disease. *Am J Orthop (Belle Mead NJ)*. 2005 Jul;34(7):341-6.
- Lorefält B, Toss G, Granérus AK. Bone mass in elderly patients with Parkinson's disease. *Acta Neurol Scand*. 2007 Oct;116(4):248-54.
- Eng ML, Lyons KE, Pahwa R. Prevalence of bone mineral density screening in Parkinson's disease clinic outpatients. *Mov Disord*. 2006 Dec;21(12):2265-6.
- Leddy AL, Crowner BE, Earhart GM. Functional gait assessment and balance evaluation system test: reliability, validity, sensitivity, and specificity for identifying individuals with parkinson disease who fall. *Phys Ther*. 2011 Jan;91(1):102-113.
- Cole MH, Silburn PA, Wood JM, Worringham CJ, Kerr GK. Falls in Parkinson's disease: kinematic evidence for impaired head and trunk control. *Mov Disord*. 2010 Oct 30;25(14):2369-78.
- Ashburn A, Fazakarley L, Ballinger C, Pickering R, McLellan LD, Fitton C. A randomised controlled trial of a home based exercise programme to reduce the risk of falling among people with Parkinson's disease. *J Neurol Neurosurg Psychiatry*. 2007 Jul;78(7):678-84. Epub 2006 Nov 21.
- Protas EJ, Mitchell K, Williams A, Qureshy H, Caroline K, Lai EC. Gait and step training to reduce falls in Parkinson's disease. *NeuroRehabilitation*. 2005;20(3):183-90.

- 45.** Li F, Harmer P, Fitzgerald K, Eckstrom E, Stock R, Galver J, Maddalozzo G, Batya SS. Tai chi and postural stability in patients with Parkinson's disease. *N Engl J Med*. 2012 Feb 9;366(6):511-9.
- 46.** Gerlach OH, Broen MP, van Domburg PH, Vermeij AJ, Weber WE. Deterioration of Parkinson's disease during hospitalization: survey of 684 patients. *BMC Neurol*. 2012;12:13. Epub 2012 Mar 08.
- 47.** Gerlach OH, Winogrodzka A, Weber WE. Clinical problems in the hospitalized Parkinson's disease patient: systematic review. *Mov Disord*. 2011 Feb 1;26(2):197-208. Epub 2011 Jan 31.
- 48.** Chou KL, Zamudio J, Schmidt P, Price CC, Parashos SA, Bloem BR, Lyons KE, Christine CW, Pahwa R, Bodis-Wollner I, Oertel WH, Suchowersky O, Aminoff MJ, Malaty IA, Friedman JH, Okun MS. Hospitalization in Parkinson disease: a survey of National Parkinson Foundation Centers. *Parkinsonism Relat Disord*. 2011 Jul;17(6):440-5. Epub 2011 Apr 01.
- 49.** Aminoff MJ, Christine CW, Friedman JH, Chou KL, Lyons KE, Pahwa R, Bloem BR, Parashos SA, Price CC, Malaty IA, Iansek R, Bodis-Wollner I, Suchowersky O, Oertel WH, Zamudio J, Oberdorf J, Schmidt P, Okun MS; National Parkinson Foundation Working Group on Hospitalization in Parkinson's Disease. Management of the hospitalized patient with Parkinson's disease: current state of the field and need for guidelines. *Parkinsonism Relat Disord*. 2011 Mar;17(3):139-45. Epub 2010 Dec 14.
- 50.** Mehta S, Vankleunen JP, Booth RE, Lotke PA, Lonner JH. Total knee arthroplasty in patients with Parkinson's disease: impact of early postoperative neurologic intervention. *Am J Orthop (Belle Mead NJ)*. 2008 Oct;37(10):513-6.
- 51.** Lin WP, Wen CJ, Jiang CC, Hou SM, Chen CY, Lin J. Risk factors for hip fracture sites and mortality in older adults. *J Trauma*. 2011 Jul;71(1):191-7.
- 52.** U.S. Department of Health & Human Services. Electronic health records and meaningful use. <http://healthit.hhs.gov/portal/server.pt?open=512&objID=2996&mode=2>. Accessed 2013 Sep 10.
- 53.** Schrag A, Ben-Shlomo Y, Quinn NP. Prevalence of progressive supranuclear palsy and multiple system atrophy: a cross-sectional study. *Lancet*. 1999 Nov 20;354(9192):1771-5.
- 54.** Bower JH, Maraganore DM, McDonnell SK, Rocca WA. Incidence of progressive supranuclear palsy and multiple system atrophy in Olmsted County, Minnesota, 1976 to 1990. *Neurology*. 1997 Nov;49(5):1284-8.
- 55.** U.S. Census Bureau. U.S. interim projections by age, sex, race, and hispanic origin. 2004. <http://www.census.gov/population/projections/data/national/usinterimproj.html>. Accessed 2013 Sep 10.
- 56.** Wright NC, Saag KG, Curtis JR, Smith WK, Kilgore ML, Morrisey MA, Yun H, Zhang J, Delzell ES. Recent trends in hip fracture rates by race/ethnicity among older US adults. *J Bone Miner Res*. 2012 Nov;27(11):2325-32.
- 57.** Brauer CA, Coca-Perraillon M, Cutler DM, Rosen AB. Incidence and mortality of hip fractures in the United States. *JAMA*. 2009 Oct 14;302(14):1573-9.
- 58.** Prieto-Alhambra D, Avilés FF, Judge A, Van Staa T, Nogués X, Arden NK, Díez-Pérez A, Cooper C, Javaid MK. Burden of pelvis fracture: a population-based study of incidence, hospitalisation and mortality. *Osteoporos Int*. 2012 Dec;23(12):2797-803. Epub 2012 Feb 04.
- 59.** Bliuc D, Nguyen ND, Milch VE, Nguyen TV, Eisman JA, Center JR. Mortality risk associated with low-trauma osteoporotic fracture and subsequent fracture in men and women. *JAMA*. 2009 Feb 4;301(5):513-21.