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REVIEW

Hip fracture epidemiological trends, outcomes, and risk factors, 1970–2009

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Ray Marks

City University of New York
and Columbia University,
New York, NY, USA

Abstract: Hip fractures – which commonly lead to premature death, high rates of morbidity, or reduced life quality – have been the target of a voluminous amount of research for many years. But has the lifetime risk of incurring a hip fracture decreased sufficiently over the last decade or are high numbers of incident cases continuing to prevail, despite a large body of knowledge and a variety of contemporary preventive and refined surgical approaches? This review examines the extensive hip fracture literature published in the English language between 1980 and 2009 concerning hip fracture prevalence trends, and injury mechanisms. It also highlights the contemporary data concerning the personal and economic impact of the injury, plus potentially remediable risk factors underpinning the injury and ensuing disability. The goal was to examine if there is a continuing need to elucidate upon intervention points that might minimize the risk of incurring a hip fracture and its attendant consequences. Based on this information, it appears hip fractures remain a serious global health issue, despite some declines in the incidence rate of hip fractures among some women. Research also shows widespread regional, ethnic and diagnostic variations in hip fracture incidence trends. Key determinants of hip fractures include age, osteoporosis, and falls, but some determinants such as socioeconomic status, have not been well explored. It is concluded that while more research is needed, well-designed primary, secondary, and tertiary preventive efforts applied in both affluent as well as developing countries are desirable to reduce the present and future burden associated with hip fracture injuries. In this context, and in recognition of the considerable variation in manifestation and distribution, as well as risk factors underpinning hip fractures, well-crafted comprehensive, rather than single solutions, are strongly indicated in early rather than late adulthood.

Keywords: epidemiology, disability, hip fractures, injury, prevention, risk factors

Background to the problem

For many years hip fracture injuries have been identified as one of the most serious health care problems affecting older people. Much attention has consequently been placed on comprehensive efforts to reduce the incidence and severity of this condition. Indeed, some recent evidence suggests these efforts have met with some degree of success.[1,2] However, the literature is unequivocal in this regard. Moreover, several current reports confirm hip fractures remain a leading cause of excessive morbidity, and premature mortality among older people.[3,4] Thus, despite some positive downward trends in hip fracture incidence rates,[5] these may not be occurring universally or rapidly enough to offset the immense human and social costs projected to persist over the next several decades.[6]

Correspondence: Ray Marks
Columbia University, Teachers College,
Department of Health and Behavior
Studies, Box 114, 525W 120th Street,
New York, NY 10027, USA
Tel +1 212 678 3445
Fax +1 212 678 8259
Email rm226@columbia.edu

That is, given that hip fracture incidence rates rise exponentially with age, and that age specific hip fracture rates are rising for subsequent cohorts,[7] as longevity increases across the globe,[8] along with sedentary lifestyles that correlate with several key hip fracture determinants, it seems reasonable to speculate hip fractures will remain a serious world wide public health problem as proposed by Wehren and Magaziner in 2003.[6] To this end, this paper explores if there is sufficient current support for this premise, and if so, whether concerted efforts towards prevention are desirable. By analogy it also explores whether long-term costs of this health problem of nearly US$9 billion dollars in 1995[6] are also likely to rise, first, because an increasing body of older people survive after hip fracture injuries as a result of better acute care. Second, because these survivors commonly encounter various degrees of progressive disability that require long-term care and extensive ongoing services.[6] Third, as more adults reach the age of 85 years, these adults who are commonly in precarious health or recover more slowly when injured than younger adults, are 10–15 times more likely than those younger than 85 years to fracture a hip.[9]

It is the author's view that hip fractures will continue to be of substantive importance to public health planners, particularly if as predicted, a vast majority of these injuries in the 21st century will occur in developing countries[10] where the resources to deal with this problem are likely to be somewhat undeveloped, underfunded and technologically suboptimal. Another related issue is that a high percentage of hip fractures are linked with osteoporosis, which is an escalating global problem. Additionally, hip fractures, the most catastrophic complication of osteoporosis, continue to result in significant mortality and morbidity rates despite the increasing availability of effective preventative agents.[11] Lastly, the costs of care for this debilitating injury are immense because they are not limited solely to the costs of functional disability and increased death rates,[8] but commonly to several other factors including, a loss of the ability of the injured adult to function independently, the related costs of nursing care, rehabilitation care, and need for one or more surgeries. Thus, rather than becoming complacent given some progress in reducing anticipated rates of hip fracture in some regions, continued vigilance, plus the implementation of widespread cost-effective preventive strategies against hip fractures, as stressed by Wilson and Wallace[8] and Haleem and colleagues[3] remain strongly indicated.

However, to secure support for efforts to prevent hip fractures and their debilitating outcomes within an economic climate that often demands service cutbacks and fiscal restraint, and a science base that does not always stress the economic and social value of prevention, the rationale for this approach must be clearly depicted. That is, a clear case must first be made for why the issue merits specific attention, and thereafter, for what specific strategies might be set in place or emphasized to minimize the related human and economic impact.

To this end, the present review reports pertinent data from the available peer-reviewed literature detailing the distribution and possible casual factors related to hip fractures published in the peer-reviewed literature over the last 30 years. Also reported are some findings regarding second hip fractures, an often overlooked, albeit important, associated outcome of the initial injury. As well, information depicting the economic and human impact of this condition, a topic not often detailed in the related literature is presented. Finally, some recommendations for improving our understanding of this health condition including potential preventive directives against first and second hip fractures, and their debilitating consequences are provided.

Methods

The literature reviewed was primarily accessed from an array of research based articles written in English, and located in the Medline and PubMed databases and published between 1980–2009. Key terms used were: 'hip fracture', 'epidemiology', 'incidence', 'prevalence', 'risk factors'. All related articles that reported on hip fracture rehabilitation or surgery were excluded from the report. The pertinent data was carefully examined and then categorized into the key themes of interest: distribution and prevalence, outcomes and risk factors. In terms of the author's aims, as well as space limitations, only those risk factors deemed both consistently salient and amenable to prevention are highlighted. The magnitude and extent of the disability is included to draw attention to the need for reducing the incidence and severity of this debilitating condition. In keeping with the broad aims of the paper, the review approach adopted was largely a narrative one, and an attempt was made to simplify and tabulate themes of importance. Based on the high numbers of reports from well known research establishments and researchers, and the consistency of many reports from diverse laboratories and regions, regardless of study design, an assumption was made that the reports reviewed provided consistently valid conclusions.

Descriptive epidemiology

Hip fracture trends 1970–2009

While somewhat variable, data published since the early 1990s describing the occurrence of hip fractures across

the globe has generally shown the age-adjusted incidence of this injury is increasing[3,6] or is projected to increase.[12] Accordingly, it was initially predicted that if there was a steady increase in the numbers of United States residents reaching the age of 85 years or older,[13] the numbers of elderly at risk for a hip fracture would double by 2007. That is, the total number of hip fracture cases in later life was not only expected to remain significant, but was projected to rise substantively.[8] At the same time, this age-associated trend in longevity was not only influencing hip fracture risk in the United States, but was also evident in The People's Republic of China where hip fracture rates, once amongst the lowest in the world compared with more affluent countries,[14] increased by 34% for women and 33% for men between 1988 to 1992.[15] Similarly, in Finland, the whole population incidence rate increased approximately three fold between 1970 and 1991 with respect to both genders,[16] and between 1970 and 1997, the age-specific incidence of hip fractures increased in all age groups.[17]

Likewise, linear increases of age-adjusted fracture incidences for men and women were reported in the Netherlands between 1972–1987 and the analysis also showed that this age-specific incidence increase was higher than that of earlier birth cohorts.[18] Similar trends were noted in Japan where hip fracture incidence rates for both genders were shown to increase exponentially with age after the age of 70 years with an annual incidence among women aged 85 years and older of 2,000 cases.[19] Rates in Sweden from 1966–1986 were also found to increase from 3.3 per 1,000 inhabitants to 5.1 for persons aged more than 50 years, and almost doubled in persons aged more than 80 years, with a proportional increase that was greatest for men and city dwellers.[20]

Indeed, despite some evidence of declining hip fracture incidence rates in North America[21] and among some Swiss women,[22] as people live longer, and the average age of the hip fracture patient continues to increase from 73–79 years,[3] it is possible the total number of hip fractures in the world, estimated at 1.7 million in 1990[16] will still rise exponentially to 6.3 million by the year 2050.[23] In support of this argument, it has been noted that even in those regions of the United States where downturns in hip fracture incidence rates have been recorded,[21] there are still increasing numbers of adults living to higher ages. In addition, rates of downturn over a 10-year period from 1991–2000[22] may only reflect declines among standardized hip fracture incidence rates of institution-dwelling women, rather than a general reversal in secular trends.[5] Further, the fact that more older United States adults had low femoral neck bone mass density in 2005–2006 than in 1988–1994, implies the number of United States adults at risk for future hip fractures will remain high.[24] Other estimates are that there will be a sevenfold increase between the present time and 2050 in Belgium[25] that will be greater in men than women if no comprehensive preventive policy is set up, and marked increases in Asia where the highest absolute increment in the elderly population will be observed.[26]

Moreover, high incidence rates continue to prevail in some northern Europe regions[16] and these are expected to rise.[6] In Germany, for example, a call for improving and developing prevention strategies against hip fractures attributable to osteoporosis currently prevails because 2050 projections of this condition are expected to increase costs exponentially between 2020 and 2050 due to changing demographics.[27] In Australia, the number of hip fractures is similarly expected to double over 29 years and quadruple in 56 years.[28] Furthermore, data published in 2008 covering the years 1994–2006 in Austria, showed that in contrast to findings in some countries, there has been no levelling-off or downward trend of hip fracture incidence in the Austrian elderly population. After adjusting for age and gender, the fracture increase, while small was significant and rose numerically from 11,694 in 1994 to 15,987 in 2006.[29]

Summary

While many studies conducted in the 1990s predicted increasing hip fracture prevalence rates in the 21st century, the current literature reveals some levelling off of these rates, especially among individuals at risk for osteoporosis. However, as the number of older adults living to higher ages increases globally, the total numbers of hip fracture cases and their related expenditures are likely to rise substantively.[27] Moreover, even if some of the aforementioned data do not take into account more recent bone sparing pharmacologic interventions[3] and other experimental therapies that may prevent hip bone loss,[30] some published data reporting an age-specific flattening of the incidence of hip fractures,[31,32] may be underestimates because they often exclude hip fracture injury cases or injuries that have occurred have not been accurately coded.[3]

Hip fracture incidence may also be hard to capture with precision because rates may vary depending on seasonality,[33] geography,[34–37] and factors other than aging.[34] These include health status,[38] ethnicity,[38,39] gender,[40–44] neuromuscular status,[45] extent of urbanization,[46] along with year of immigration to the United States,[47] the availability, nature, and potency of current therapeutic and/or preventive measures.[38,48] The method of deducing trends in hip fracture and their

results can also vary substantively with the model used as demonstrated by Fisher and colleagues in the Australian context.[48] In addition, along with the large variation in the age, gender, and geographic distribution of hip fractures within and across countries,[44,49,50] especially challenging in efforts to effectively capture the true global burden of hip fractures is the fact there are three distinctive hip fracture sub-types, each with potentially different risk factor profiles[51–53]and prevalence rates.[54–60]

Although it is not possible to prove or disprove, it seems that the strong correlation between aging and hip fractures favors the prediction that hip fracture incidence rates will rise by 1%–3% per year in most areas of the world for both men and women in the years to come.[61,62] In addition to the aging factor, a widespread lack of awareness of the importance of osteoporosis persists and prevents the widespread use of drugs with anti-fracture efficacy.[63] Moreover, because not all hip fractures are related to osteoporosis,[62,64] but these risk factors may not be addressed or followed-up at all adequately,[64] the health care system and societal costs of hip fractures are projected to increase if concerted preventive efforts with 'new, effective and widely applicable strategies' are not forthcoming.[65–67] These projected costs include, but are not limited to, avoidable deaths, disability, and rising costs due to higher numbers of discharges of post-hip fracture patients to continuing care institutions.[68]

In addition to the above mentioned factors, adults who sustain intertrochanteric fractures, whose numbers increase progressively with age, experience higher mortality, morbidity, and costs than those of cervical fractures.[16] As well, despite declining hip fracture reoccurrence rates greater than anticipated in recent years,[69] adults who have sustained a hip fracture are commonly susceptible to subsequent hip fractures. That is, a second hip fracture, which may be in the same location with a tendency to greater displacement or instability occurs about 6% of the time and within a four-year period post-fracture.[70] Further, if Dolk[71] is correct, the frequency of sustaining two hip fractures over the course of an individual's lifetime could reach 20%. Furthermore, because new hip fractures may occur on the same side as well on the opposite side to an initial fracture, it may be possible to sustain three hip fractures over time, and according to Shroder and colleagues[72] the risk of incurring a third hip fracture per 1,000 men is 8.6 and 9.8 per 1000 women, per year.

Prevention here is key again because there is no well defined pattern to clearly predict who is at risk, because contributory risk factors other than osteoporosis,[73] as well as untreated osteoporosis after the first fracture can be implicated in mediating two episodes of fragility fractures.[74] Other data show the incidence rate for second hip fractures can be higher than that of first hip fractures,[75] and as discussed by Berry and colleagues[76] one year mortality rates can be approximately 10% higher following a second hip fracture than an initial fracture.[76]

However, pursuing the means to prevent first and second hip fractures is very challenging, because as outlined above, and reiterated by Thomas and colleagues,[77] the risk of hip fracture, which rises 100–1000-fold over six decades of age is only explained in a minor way by declining bone mineral density. Several other risk factors for hip fractures that may serve as additional therapeutic targets may be helpful for reducing the rate and severity of the hip fracture injury and its costs (see Table 1) have been the focus of a large volume of research. The predominant determinants that have been studied are discussed below and were selected as representative of those deemed consistently important as well as amenable to intervention.

Risk factors for hip fracture

Biomechanical factors

Falls

In the early 1990s, research by Hayes and colleagues[65] demonstrated that over 90% of hip fractures are associated with falls. Since that time, an additional body of evidence has revealed a strong association between several diverse falls-related mediators and hip fracture injuries that may be useful intervention points in efforts to reduce hip fracture incidence rates. These include: balance impairments,[45,78] neuromuscular and musculoskeletal impairments,[79] fall type,[80] fall severity, and fall speed.[65] In addition, the presence of ineffective or suboptimal protective responses, along with age-associated strength decreases,[81] cognitive impairment,[82] and fear of falling, a serious disorder in older people, may increase the risk of falling and fracturing the hip.[83] Declines in visual perception, proprioception and/or transient circulatory insufficiencies,[68,84] as well as impaired sensory-motor integration functioning,[85] and unexpected perturbations are additional determinants.

Physical inactivity

A sizeable body of research over the last 30 years has also shown physically inactive elderly adults are more than twice as likely as active adults to be at risk for hip fractures (see Table 2).[35,86–89] Indeed, due to its highly negative impact on bone health, muscle physiology, muscle mass, overall health status, and on vitamin D exposure,[90,91] physical inactivity is

Table 1 Summary of studies depicting high monetary costs of treating hip fracture cases in different countries

Author	Sample and site	Outcome
Konnopka et al[27]	108,341 osteoporosis attributable hip fractures Germany, 2002	Cost of care was 2,998,000,000 Euros and there were 3,485 deaths
Koeck et al[62]	11,379 patients with osteoporotic hip fractures Austrian hospitals, 1995	6.8% died during hospitalization 250,268 bed days were required overall Total cost was US$103,509, 800 Average cost per patient was US$9097
Azhar et al[67]	143 cases with hip fracture Major Irish University Hospital, 2005	Average costs per patient was $9326 Euros Average length of stay was 11 days
Luppuner et al[63]	62,535 hospitalization for fracture Switzerland, 2000	Hospitalization for hip fractures accounted for half of the total 357 million CHF costs The hospital costs were lower than in 1992 but did not include costs of ambulatory care
Tanriover et al[196]	50 cases of hip fracture, in Turkey, mean age 74.2 years were followed between 2003 and 2006	The mean hospital expenditure was $5,983 Factors affecting the total cost were age, functional status, duration of hospital stay
Bass et al[197]	Retrospective analysis of national veteran hospital eligible Medicare patients with hip fracture 1999–2002 in Medicare and Veterans Health Administration Facilities	Medicare reimbursed providers for nearly $3 billion in first year of injury. Mean annual payment per patient was $69,389
Lawrence et al[198]	Costs of acute care for 100 patients with hip fracture was conducted in the United Kingdom in 2003	The mean length of stay was 23 days at a cost of 12,163 pounds sterling per person of which ward costs contributed 84%

currently proffered as the most salient explanatory factor for the increasingly high hip fracture rates reported by developing countries, as well as many first-world countries.[85]

Muscle weakness

Several researchers have concluded that muscle weakness, commonly associated with slower reflex responses[83] can significantly increase the chances of falling due to unexpected perturbations, thus heightening the risk of fracturing a hip.[65,92,93] Related research shows low levels of muscular strength can also heighten the risk of sustaining a hip fracture[88] because of its long term negative impact on bone density[94] and muscle shock absorbing capacity.[95] Not surprisingly, an increased risk of falling and sustaining a hip fracture has been specifically noted in association with muscular impairments at the ankle,[78] hip and knee,[59,85,96,97] low body strength in general,[89,96] and lower limb dysfunction.[98]

Body anthropometrics

While body height, a nonmodifiable factor, may predispose towards a hip fracture,[80,94,99–106] as outlined in Table 3, there is a consistent association between the presence of a low body

Table 2 Research evidence showing a strong relationship between physical activity participation and hip fracture risk in prospective studies

Authors	Study design	Finding
Wickham et al[87]	15 year follow-up study of 1688 community dwelling subjects	Physical activity participation protected against hip fracture
Hoidrup et al[99]	Prospective study of leisure-time physical activity levels and changes in relation to risk of hip fracture among 1,211 men and women with first hip fractures	Moderate levels of physical activity appear to protect against later hip fracture Declining physical activity over time is an important risk factor for hip fracture
Cawthon et al[101]	Prospective study of performance on 5 physical function exams among 5902 men 65 years of age or older	Poor physical performance was associated with an increased risk of hip fracture
Trimpou et al[192]	Prospective study of male risk factors for hip fracture-over 30-years in 7,495 men	A high degree of leisure time and physical activity was protective

Table 3 Summary of prospective studies examining the association between body mass and hip fractures and showing equivocal results

Authors	Study design	Conclusion
Bean et al[92]	Prospective study of 50 consecutive women with fractured hips and 50 age-matched healthy women with no hip fractures	After exclusion of heavily dependent patients, hip fracture was not associated with reduced body mass or fat
Ensrud et al[111]	Prospective study of 8,011 women followed for incident hip fracture	During an average of 5.2 years, 235 (2.9%) experienced hip fracture. Women with smaller body size had a higher risk of subsequent hip fracture compared with those of larger body size. This effect remained after adjusting for height, smoking status, physical activity, health status, estrogen and diuretic use. After further adjustment for femoral neck bone mineral density, the effect of weight was negligible among thin women
Mussolino et al[107]	Prospective population-based follow-up study for maximum of 22 years of 2,879 white men	Weight loss is a risk factor for hip fracture in men
Langlois et al[108]	Prospective study of 2,413 community-dwelling white men aged 67 years or older	Weight loss is a marker of frailty that may increase the risk of hip fracture in older men
Tromp et al[199]	Prospective study of 348 health women, aged 70 years and above	Body mass index was found to be a predictor of hip fracture
Margolis et al[200]	Prospective cohort study of 8,059 non black women 65 years and older over 6.4 years	Women in the lowest quartile of weight had relative risks of 2.0 for hip fracture
Langlois et al[110]	Prospective study of 2180 community-dwelling white women aged 50–74	Weight loss of 10% or more from maximum weight among both middle-aged and older women is an important indicator of hip fracture risk
De Laet et al[109]	Group studied 60,000 diverse men and women from 12 prospective population-based cohorts, with a total follow-up of over 250,0000 person years	Independent of age and gender, the contribution of body mass index to a fracture risk was more marked at low levels of body mass index than higher levels, although the relationship was not linear
Parker et al[113]	Prospective study of hip circumference and hip fractures among 30,652 postmenopausal women	Overall body size may be more important than body composition of the femoral-gluteal area in the prediction of hip fracture risk

mass and an increased fracture risk,[106] especially among Caucasian men,[107] after the age of 50 years,[108] which may be amenable to intervention. This association is especially strong in individuals with low bone mineral density,[109] and where a weight loss relative to maximal weight exceeds 10% of body weight.[106,110] Moreover, older women with smaller body size are likely to be at high risk of fracturing their hips because of their potentially lower bone mineral density,[111] as well as less soft tissue coverage of their hips than women of normal body weight.[46,112]

However, Parker and colleagues[113] found overall body size, rather than body composition of the femoral gluteal area predicted the occurrence of a hip fracture in a cohort of postmenopausal women, and although most people who fracture their hips could be classified as being thin, Cumming and Klineberg[114] and Maffulli and colleagues[115] reported their patients with hip fractures tended to be overweight. Dretakis and Christadoulou[116] too, noted similar rates of overweight and underweight hip fracture cases among their 373 patients. Similarly, when patients with severe dementia were excluded, Bean and colleagues[92] found thinness was not necessarily associated with hip fracture. Heavier individuals may also be expected to have low levels of sex hormone-binding globulin, a prevalent finding among women with recent hip fractures,[117] and several comorbid conditions that are known risk factors for falling, plus medical conditions associated with osteoporosis.[118]

Bone structure

Although hip fracture is the most serious consequence of osteoporosis,[119] the literature is inconsistent in demonstrating diminished bone density is universally predictive of a future hip fracture. For example, while bone density measures at the femoral neck were found to be strongly predictive of hip fractures in both men and women in one study,[120] several others have reported a considerable overlap in bone densities between hip fracture patients and age- and gender-matched controls after the age of 70 years, or no

significant risk.[87–89,93] In addition, Wei and colleagues[119] found the effect of significant risk factors for hip fracture of direct hip impact, previous stroke, sideways fall, decreased functional mobility, or low body mass remained the same regardless of femoral neck bone density. However, bone mineral density was significantly correlated with functional mobility and low body mass, which together are predictive of falls that can result in hip fractures. It has also been observed that bone mineral density is a weaker predictor of intertrochanteric hip fractures than femoral neck fractures.[121] Other data reveal comparable osteoporotic indices between cases and controls,[122] and that hip fracture cases were not more osteopenic than age- and gender-matched controls.[123] Moreover, Asians, who have similar, or lower bone mineral densities than Caucasians, and partake in diets low in calcium, have a low incidence rate of hip fracture, especially in women.[14] Mathematical models too, cannot account for the exponential rise in hip fractures with age solely on the basis of bone density levels.[124] Further, individuals with osteoarthritis and higher bone density levels than the norm are not protected against hip fractures.[125]

Such findings strongly suggest factors other than low bone mineral density and bone mass contribute to the risk of hip fractures. These factors include but are not limited to those that increase the risk for falling, the property of the fall surface, the geometry of the hip, body size, the degree of soft tissue coverage around the hip, and the presence of poor muscle responsiveness and muscle weakness[46,85,93,97,113,114,122] (see Table 4).

Table 4 Selected studies covering a 20 year period describing hip fracture injury risk factors other than bone mineral density and bone mass that could serve as risk assessment and risk reduction intervention points

Author	Factors influencing hip fracture
Cummings and Nevitt[124]	Neuromuscular dysfunction
Cummings and Nevitt[201]	Fall mechanics
Wolinsky and Fitzgerald[202]	Prior falls; Low body weight
Jones et al[203]	Postural instability
Parker et al[204]	Environmental factors
Slemenda[85]	Neuromuscular impairment; Fall mechanics
Dargent-Molina et al[97]	Walking speed; Impaired mobility
Fitzpatrick et al[122]	Factors related to falls; Sleeping tablets; Lower mental health score
Holmberg et al[60]	Diabetes; Poor self-rated health status
Wilson et al[59]	Health insurance status; Education; Residence
Abrahamsen et al[118]	Prostate cancer and Androgen derivation therapy
Kulmala et al[77]	Balance confidence; Functional balance
Chen et al[205]	Breast/other cancers in postmenopausal women
Formigo et al[182]	Recurrent falls in past year; Poor functional status; Use multiple drugs, neuroleptics
Tafuri et al[206]	Work related factors for males; home accidents for females
Piirtola et al[171]	Proximal humeral fractures
Collins et al[207]	Peripheral arterial disease in men
Stolee et al[188]	Older age; Female gender; Falls; Unsteady gait; Use of ambulatory aide; Tobacco use; Severe malnutrition; Cognitive impairment
Wolinsky et al[208]	Recent hospitalization for non-hip fracture
Sahni et al[209]	Inadequate supplemental levels of Vitamin C
Kristensen et al[210]	Knee extension strength

Clinical

Chronic health conditions

Many chronic illnesses associated with aging, in particular, arthritis and Parkinson's disease, substantially increase the risk of falling, and hence the likelihood of incurring a hip fracture.[126–128] In addition, arrhythmias, postural hypertension, and peripheral neuropathies may increase the risk of falls and hip fractures,[67] as may the presence of Alzheimer's disease[129] and other neurological conditions, such as stroke.[130] Diabetes mellitus,[131] hyperthyroidism,[132] and medical conditions associated with osteoporosis,[133] other forms of disability associated with the risk of falling,[133] use of walking aids,[134] as well as prolonged immobilization,[46] may also increase the risk of sustaining a hip fracture. Rehospitalization after hip fracture may also be influenced negatively by the presence of comorbid clinical problems,[135] as may outcomes of acute hip fracture if multiple problems exist, especially respiratory disease or malignancy.[136]

Impaired cognition

In addition to the aforementioned factors, depression, and/or the presence of one or more cognitive impairments may heighten the risk of falling and fracturing a hip.[94,126,128,135,137–139,144–146] Similarly, a prevailing cognitive impairment may impact the effectiveness of postoperative rehabilitation strategies after hip fracture surgery,[140] and increases the risk of falling after a hip fracture.[141] The individual with mental deterioration who trips and fails to break their fall may be especially vulnerable to fracturing the hip if already weak and osteoporotic due to poor nutritional status.[142]

Impaired vision

Impaired vision may be an independent risk factor for hip fracture.[83,126,143] Evidence for this has been provided by

Ivers and colleagues in a prospective study of 3,654 adults aged 49 years or older for five years[143] and by Ivers and colleagues[144] in a case-control study of 911 cases and 910 controls aged 60 years or older. In the latter study, the population attributable risk of hip fracture due to poor visual acuity or stereopsis, vision wherein two separate images from two eyes are successfully combined into one image in the brain, was 40%. In their more recent prospective study, Ivers and colleagues found visual impairment to be strongly associated with risk of hip fracture in the next two years. Pfister and colleagues[145] also noted impaired vision was prevalent among women aged 50 years and older with proximal hip fractures. Impaired vision has also been associated with hip fractures occurring in the hospital[146] and among the Framingham Study Cohort,[147] where those with poor vision in one or both eyes had an elevated fracture risk and those with moderately impaired vision in one eye and good vision in the other had a higher risk of fracture than those with a similar degree of binocular impairment.

Medications, alcohol, and chemical substances

Although Rashiq and Logan,[148] who examined the role of drugs in hip fractures found that with the exception of antibiotics, fracture risk was lower in those taking drugs, drugs reported to be related to falls that may lead to a hip fracture include: cimetidine, psychotropic anxiolytic/hypnotic drugs, barbiturates (which may also decrease bone quality), opioid analgesics, and antihypertensives,[126,137] long-acting benzodiazepines, anticonvulsants, and caffeine.[89] Tranquillizers, sedatives, and exposure to any of the three classes of antidepressants is associated with a significant increase in the risk of falling and sustaining a hip fracture.[66,67,149] In particular, long-acting sedatives and alcohol that can slow reaction time may partly explain the increased risk of hip fractures associated with use of sedatives and regular alcohol intake.[124,136,134] Alternately, alcohol abuse may result in a negative bone balance,[150] decreased balance, impaired gait, and heightened risk-taking behaviors.[151] Additionally, tricyclic antidepressants may increase the risk for hip fracture due to their detrimental cardiovascular side-effects, and/or their side-effects of sedation and confusion.[152] Use of corticosteroids is also a documented risk factor for hip fracture,[46] and may reflect the detrimental effect of corticosteroids on bone mineral density, as may levothyroxine when used by males.[153] Smoking cigarettes or a pipe,[98] and the consumption of tea, and fluorine concentrations over 0.11 mg per liter[154] also increases the risk of hip fracture,[17,98] as do benzodiazepines.[155]

Environmental factors

Although many preventive programs against hip fracture focus on environmental factors, of the many factors that can influence hip fracture risk, Norton and colleagues[156] found only 25% of falls that could lead to a hip fracture were associated with an environmental hazard. Further, while environmental factors may undoubtedly be a precursor to injurious falls[157] a study by Allander and colleagues[158] found a very low correlation between the number of risk factors of the faller and the environment.

In summary, age, a variety of age-associated physiological changes, low levels of physical activity participation, poor nutrition practices, and some forms of medication may impact two crucial determinants of hip fracture, namely femoral bone strength, and the propensity to falls. In addition, declining muscle, cognitive, visual and neural reflex responses, are likely to impact the propensity of older adults towards hip fracture injuries.[45] The overlapping relationship between these factors as portrayed in Figure 1 are also likely to impact recurrent falls, and second or new hip fractures following a hip fracture[159] and may also explain partly why hip fracture incidence rates vary, and remain substantive in many regions (see Table 5).

Conversely, a better understanding of these factors may help in reducing the persistent and debilitating outcomes of hip fracture injuries portrayed in Table 6.

Discussion

As outlined in the body of the paper, despite some successes in reversing predicted hip fracture trends in some regions, many current reports continue to describe increasing or rising hip fracture trends in other regions (see Table 4). Although it is consequently impossible to determine if the projected global incidence of hip fracture cases is likely to reach 4.5 million by 2050 as predicted,[4] it seems fair to anticipate increases in some regions.

For example, hip fracture incidence rate increases, rather than decreases are expected in Asia, Latin America, the Middle East, and Africa as a result of increases in their elderly populations.[16] Similarly, hip fractures in people aged 60 years and older living in central Australia are predicted to almost double by 2011 and increase 2.5-fold and 5.4-fold by 2021 and 2051, respectively.[160] A current Norwegian study has further revealed regions of the country where high lifetime absolute fracture risk rates among adults aged 25 years and older are predicted based on 1995–2004 data.[161] Another related report showed annual decreases in New York State between 1985 and 1996 were not uniform in all age, gender,

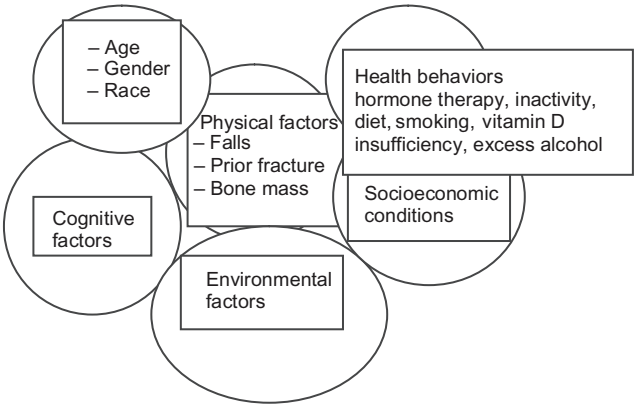

Figure 1 Model of key factors implicated in hip fracture injury with intervention points highlighted.
Source: Kanis, Johansson, Oden, et al.[189]

and race groups.[162] In addition, in 2008, Auron-Gomez and[163] from the Cleveland Clinic stated the incidence of hip fractures in the United States of approximately 250,000 per year is expected to double in 30 years.

Moreover, as outlined by Abrahamsen and colleagues[164] and summarized in Table 5, even in regions where hip fracture rates are declining, the very stark human impact of sustaining one or more hip fractures supports a continued global effort to minimize this burden. As well, the economic consequences of hip fracture continue to rise, despite declining lengths of hospital stay.[66]

However, because many variations in hip fracture prevalence rates exist, and multiple, rather than single risk factors preside interventions to reduce their prevalence are difficult to develop without further research.[44] In addition, the correlation between hip fractures and low bone density is not a perfectly positive one,[165] and thus more insightful studies to better elucidate the etiology of hip fracture variants is indicated as outlined almost 20 years ago by Cummings and Nevitt.[124] In this regard, as Leibson and colleagues[64] have pointed out, hip fracture prophylaxis and its potential savings may be overestimated by studies that fail to consider differential risk, mortality and long-term follow-up data. Moreover, even though Chang and colleagues[166] emphasized the need for early osteoporosis prevention in both men and women because over 48% of hip fractures in men and 66% of those in a white population in Australia were found to incur hip fractures before the ages of 80 and 85 years, respectively, Lippuner and colleagues[63,64] note there is a significant lack of awareness of this disease and its consequences and this warrants attention. In addition, there are few carefully designed prospective studies that examine the nature of the age-specific increase in incidence, and whether this is due to changes in the etiology of the fracture, and not just the consequence of demographic change as postulated by Boyce and Vessey in 1985.[167]

What is known, is that to prevent unwarranted increases in hip fracture incidence rates and their secondary complications and costs, careful consideration of their multifactorial causation is imperative.[3,36,162,168] Other promising strategies include the development of routine risk-factor assessments

Table 5 Contemporary studies that show evidence of rising hip fracture incidence rates in a number of venues worldwide, despite declining rates in others

Study	Location	Finding
Sanders et al[28]	Australia	Hip fractures rates were projected to increase 36% over next few decades
Hagino et al[211]	Tottori Prefecture, Japan	Hip fracture rates increased from 1986–2001 for both genders
Hernadez et al[212]	Northern Spain	Crude incidence increased 50% from 1988–2002, mainly in women, and for cervical sites
Giversen[213]	Denmark	Age-adjusted hip fracture rates increased between 1987–97 and was 425 per 1000,000 in 1997
Lonnroos et al[124]	Finland	The total number of hip fractures increased by 70% from 1992–93 to 2002–03
Lim et al[43]	Korea	Population based data from 2001–2004 showed rates increased for women, not men
Mann et al[29]	Austria	There was no leveling-off or downward trend in hip fracture rates from 1994–2006
Tafuri et al[206]	Puglia, Italy	Yearly admission rates from 1998–2005 for femoral neck fractures increased
Icks et al[215]	Germany	Between 1995–2004 hip fracture incidence increased only slightly, especially among older ages, and men
Shao et al[194]	Tainan, Taiwan	Overall incidence of hip fractures increased by 30% between 1996–2002, with greater increases in males
Holt et al[216]	Scotland	The number of hip fractures is predicted to rise by 45%–75% between 2004–2031, especially in those >85
Dodds et al[217]	Ireland	Annual hip fracture numbers are expected to increase by 100% by 2026, assuming stable incidence rates

Table 6 Chronology of studies over a 20 year period consistently describing poor outcomes after hip fracture, regardless of contemporary management and rehabilitation strategies

Authors	Hip fracture population	Key findings concerning mortality and morbidity
Jette et al[218]	50 cases with intertrochanteric fractures, and 25 cases with subcapital hip fractures, mean age 78 years	29 percent died in first year, only 21 percent regained pre-fracture function in 6 instrumental activities of daily living; 26 percent regained their pre-fracture level of social/role functioning
Bonar et al[219]	151 community-dwelling elders	64 percent were discharged home within 6 months, 33 percent became permanent nursing home residents
Jalovaara and Virkkunen[220]	185 cases mean age 80 years treated by cementless hemiarthroplasty for acute femoral fractures	There were 22 early complications, and 6 late complications; mortality after at 3 months was 12 percent above controls, 19 percent at 12 months and 21 percent at 18 months; the average loss of life in the fracture group compared to the control group was 425 days
Marottoli et al[221]	120 cases	18 percent died within 6 months, 35 percent were institutionalized within 6 months
Parker and Palmer[180]	643 cases	Mortality at one year was 22 percent; 14 percent were in long-term residential care; and the remaining 65 percent were living at home
Aharonoff et al[222]	612 elderly who had sustained non-pathologic hip fractures	4 percent died during hospitalization, 12.7 percent died within one year of fracture
Stavrou et al[176]	202 cases with femoral neck or trochanteric fractures, ages 52–95	18 percent died during first year; mortality was greater in patients with cardiorespiratory diseases, and if operation was delayed 3 days, or if hemiarthroplasty was performed
Wolinsky et al[223]	368 cases and controls	Hip fracture increased the likelihood of mortality in the first 6 months postfracture significantly; it also increased the likelihood of subsequent hospitalization, and number of days in hospital
Koike et al[224]	114 cases	The mortality rate after one year was 18 percent, which was 2.5 times larger than the general population
Giaquinto et al[225]	58 cases, mean age 86.7 years	12 patients died after complications of previous risk factors, on average survivors showed functional gains from admission to discharge, but most required supervision at discharge
Maggio et al[226]	42 cases	The percentage of residents ambulating autonomously fell from 95–32 percent among those with fractures even though their pre-fracture mobility status was better than those who never fractured their hips
Davidson et al[174]	331 cases	12-month mortality was 26 percent. Follow-up of 231 surviving patients 12–24 months later showed 27 percent still had pain and 60 percent had worsened mobility
Van Balen et al[227]	Prospective study of 102 elderly hip fracture patients mean age 83 years	Mortality at 4 months was 20 percent, only 57 percent survivors returned to original accommodations, 43 percent achieved prior walking ability, 17 percent achieved prior daily living abilities, quality of life at 4 months was worse than reference population
Kirke et al[228]	Prospective 2 year follow up of 106 older Irish women with hip fracture histories and 89 without hip fracture	Mortality at 1 year was 16 percent, and 23.6 percent at 2 years. This occurred even though males or subjects with moderate or severe mental impairment were not included in the study. Hip fracture had a marked negative effect on functional independence
Roche et al[136]	2448 consecutive cases	Mortality was 9.6 percent at 30 days, and 33 percent at one year
De Luise C[178]	1.4 million inhabitants of Western Denmark was the population. All persons over 40 with first hip fractures were identified between 1998–2003	After approximately 22 months, persons with hip fracture had 2–3 times higher odds of death at 1year compared to controls. Comorbid health conditions increased chance of dying by 50% at 1-year, including congestive heart failure, dementia, tumor, and pulmonary disease
Haleem et al[3]	Reviewed all articles on outcome of hip fracture between 1959 and 1998	The mortality rates and 6 and 12 months remained essentially unchanged over the 4 decades, being 11–23 percent at 6 months, 22–29 percent at 1 year

for older adults,[169] improved study designs that examine the predictive role of novel factors in mediating hip fractures,[40] the reduction of remediable visual, hearing, and combined impairments among aging cohorts,[170] and encouraging the avoidance of excessive alcohol, and psychotic drugs among people at risk for first or second hip fractures. Factors that may be especially useful to examine regularly during annual check ups are listed in Box 1 and others warranting attention include those potential predictors outlined by Wilson and colleagues[59] such as health insurance status, and educational level.

In the context of preventing secondary disability and poor outcomes, careful analyses of the type of fracture involved, the etiology of the fracture, and the appropriate timing of tailored interventions may be crucial.[160,171] Identifying risk factors that explain gender differences in risk and outcome,[171] as well regional variations could potentially impact hip fracture incidence rates as well.[162] Examining the role of the health care system in the context of explaining hip fracture variants and the prevailing degree of health or disability may also be helpful.

Box 1 Possible screening interventions that could be applied routinely in primary care or community settings during regular examinations and among those receiving surgical interventions for a first hip fracture to offset primary and secondary hip fractures and poor outcomes

I. Examine:
- Balance capacity
- *Bone density*
- Cognitive status
- Drug usage, medications such as steroids
- Presence of comorbid conditions
- *Falls history*
- Overall health and nutritional status
- Lifestyle, nutritional practices, and activity levels
- Muscle strength and reflex responsiveness
- Proprioception
- Tobacco usage
- Walking ability
- Vision
- Homocysteine levels[229]

II. Do careful follow-up of proximal humeral fracture cases[230]

III. Identify older adults at risk for falls due to:
- Fear of falling
- Poor housing
- Lack of activity opportunities
- Poor nutrition
- Unstable or poor mental status
- Emotional distress[164]
- Adverse neurological status
- Medication mix
- Alcohol problem
- Age
- Prior falls history
- Recent hospitalization
- Unsafe housing or environment

In summary, because hip fracture risk rises exponentially with age,[44,172] hip fractures are likely to remain an important public health problem despite declining incidence trends in some regions.[159] Indeed, high numbers of aging adults will continue to be impacted globally by this injury,[160,173] because by 2031 approximately 45% of all hip fracture cases will be aged 85 years or older.[164]

As well, regardless of progress in reducing hip fracture incidence in some regions, high levels of disability among survivors persists, and a high proportion of hip fracture cases, particularly men[174,175] and those older than 75 years, continue to die at increased rates within the first three to six months of their injury.[171] Those with comorbidities,[140,175,176,178] and poor mental status – which are likely to continue to be consistent features among aging populations – are especially vulnerable.[133,178] Other factors that predict poor post-hip fracture outcomes are less than optimal follow-up of survivors,[179] limited prefracture mobility,[180–182] a variety of psychosocial factors,[183] the patient's general medical condition,[184,178] balance status,[185] their propensity towards falling,[186] and eye and neurological diseases.[187]

To offset the predicted hip fracture burden,[35] careful study of hip fracture variants,[164] collecting and carefully analyzing routinely collected data[188] for evidence of clinical risk factors other than bone mineral density,[165,189] establishing a standard method for determining hip fracture incidence,[50] and more vigilance in secondary prevention contexts is recommended.[3] As well, more epidemiological studies to elucidate trends in hip fracture occurrences due to demographics, age, gender, ethnicity,[6] health care setting,[168,190] and health care system diversity[166] are desirable. Public health organizations in developing countries are especially encouraged to develop innovative preventive strategies,[191] and high risk adults, especially those with comorbid diseases,[178] low body mass and low income,[192] and elders in institutions at high risk for first and second hip fractures, excess mortality and poor outcomes,[168,171,190,193] should be targeted.[50] In addition, men who appear increasingly vulnerable to hip fracture[43] should be targeted.[194] Aging adults should have access to timely preventive strategies,[159] including osteoporosis prevention,[166]

and be encouraged to maintain physically active lifestyles, and appropriate body weights.[119,195]

Disclosure

The author reports no conflicts of interest in this work.

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