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Review Article

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Hip Fracture Injury Projections and their Prevention: Will Vitamin D Supplementation be Helpful or Not? An Updated and Collected Review of the 1990-2026 Literature

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Abstract

Hip fracture injuries continue to be among the leading causes of excess mortality and morbidity rates among aging adults in all parts of the globe. Among those who survive a falls inducing fracture, recovery is often slow and marred by the advent of subsequent falls and fractures, despite advanced operative reparative approaches. This article examines past as well as present thoughts as to whether hip fractures need to be prevented and why. It focuses on a possible role for vitamin D presence and whether this hormone-like substrate can be recommended to protect against falls and hip fractures as well as bone health attrition post hip fracture, thus against possible future hip osteoarthritis, recurrent falls, degraded bone and overall health. The inquiry is based on an updated and past PUBMED data base overview of reports dating back to the 1990s. As in pre COVID times, post COVID data, although limited show vitamin D may yet have a substantive mediating role to play in primary as well as secondary prevention against future hip fractures and others. This data has been conflicting however, and an update may help providers discern what may be best to advise their at risk clients about any vitamin D option they may not be aware of.

Keywords: Frailty, Hip Fractures, Intervention, Prevention, Secondary Fractures, Vitamin D

1. Introduction

Many authors over the years have confirmed hip fractures, a highly common debilitating injury afflicting one of three bone sites of the hip among large numbers of older adults is one strongly associated with significant morbidity and mortality rates [1-3]. Very challenging to prevent as well as remediate even among healthy survivors research to this effect has not yielded substantive guidelines for offsetting this immense public health concern [2,4]. Although promising, whether a persistent deficit of vitamin D serum levels explains hip fracture vulnerability given that a vitamin D deficiency is a common global health problem, especially among the elderly, regardless of any fracture presence [5,6]. Moreover, even if not the most salient hip fracture determinant, a vitamin D deficiency may yet impact the regulation of vitamin D cell and calcium-sensing receptor gene expression, and thus several vital physiological functions including desirable functions of peripheral blood cells involved in immunity as well as bone health, muscle and physical performance status [7-10].

Over time, however, a lack of consensus on the benefits of vitamin D supplementation in instances of deficiency continues to prevail, thus potentially jeopardizing any chance of mitigating a hip fracture injury or its severity. In particular, even if much of the related research is flawed or non robust, a lack of empirical consensus in this regard may impact those decisions required by first line responders and others as far as the implementation of efforts to avert primary hip fractures in falls injury cases, as well as secondary fracture injuries, post hip fracture surgery. In addition to impacting patient outcomes potentially adversely and significantly, this issue is not solely academic but of immense relevance to public health administrators as well as clinicians who seek to rehabilitate or mitigate geriatric disability optimally and effectively. Moreover, in addition to its possible role in fostering functional recovery as well as averting falls and possible re-fracture risk, osteoporosis may ensue unabated, fracture non union or delayed union may be forthcoming, along with emergent post surgical hip osteoarthritis onset or exacerbation requiring further surgery in the midst of a persistent vitamin D deficiency. Indeed,

in an age of immense fiscal restraints, and efforts to have elders live out their lives in the community, this degree of 'uncertainty' may be costing society more than is budgeted for inadvertently as over time the fiscal demands and degree of human suffering may grow exponentially, rather than decline [12-14].

At the same time, even if arguments that hip fracture rates have tended to decline in some countries in the recent past, and this tends to dampen the urgency of need in this regard, globally, many countries or regions appear to be experiencing high rates of aging cohorts, as well as cohorts of higher ages at risk for falls, hip fractures and a cycle of recurrent falls and falls injuries. Thus, even if an apparent age-standardized incidence decline as regards hip fractures has been noted in some countries, it appears assuming this applies universally may yet prove highly debilitating to many aging populations, especially those in poorer less developed countries, and among populations living to higher ages who are malnourished or lack exposure to sunlight and vitamin D containing foods. As outlined by Veronese and Maggi it appears safe to assume the global number of hip fractures as a whole will increase by the year 2050, despite some improvements, and thus the direct costs associated with this condition will rise exponentially if the status quo is maintained [1]. Furthermore, high rates of morbidity may compound this issue among those cases where the presence of a hip fracture is associated with the development of other negative consequences, such as depression, and cardiovascular diseases, and losses of independence as well as increases in health care residential demands.

In this regard, we believe actions taken at many levels are imperative rather than optional and cannot be delayed even though such efforts have been implemented to some degree for some time. In addition, this enormous rise in aging adult numbers that is tentatively anticipated over time as a whole may yet prove to alter the epidemiological projections made over time quite considerably. In particular, frail elders may be at heightened risk even if surgery is applied to permit some degree of functional recovery. In the interim, and regardless of data source, and geography, the literature appears quite consistent in identifying that hip fractures continue to have a substantial impact on older peoples' physical abilities, quality of life, and adaptability that has not diminished substantively in this regard over time, even though many forms of prevention have been discussed and implemented for decades [4]. In this respect, although the possible use of vitamin D can be predicted to impact favorably when present before or after a serious hip fracture, data remain inconclusive. However, what is apparent is that when bone building medication usage is available and applied, its effect may plateau and eventually be too low to make a meaningful impact on the societal hip fracture burden without parallel attention to nutritional factors including vitamin D [11].

1.1 Specific Aims

In this present narrative overview we aimed to document some formative past and present research that may point towards establishing whether hip fracture injuries, rehabilitation and outcomes can be impacted favorably by efforts to ensure optimal pre and post injury vitamin D daily desirable serum levels. More specifically does the evidence point to a need for advancing the bone health, muscle health, and overall well-being of older adults in the context of averting both primary and secondary hip fractures as well as hip osteoarthritis. Since the pre COVID era data were not clear on these points, we hoped to offer the reader an updated and comprehensive synthesis of what we know about hip fractures today in 2026, and whether vitamin D exposure is one method that may help mitigate its current and projected health burden. Clinicians and those who treat acute hip fractures may benefit if they can identify at risk cases and make cogent recommendations to advance optimal and desirable outcomes.

Questions

The key questions posed in this present report were:
Is there a need to continue to pursue preventive strategies against hip fractures in the older adult population?
If so, is there a role for vitamin D, and if so, in what respect?

Significance

Hip fractures among the elderly pose a significant economic, social, and physical burden wherever they occur [1,12-14]. Moreover, as outlined by Haentjens et al., even after initial hospitalization, hip fractures continue to generate significant costs throughout the ensuing 12 months after discharge [14]. Cost estimates based on data obtained prospectively from hip-fracture patients and matched controls also showed the costs associated with the treatment of hip-fractures to be about three times greater than those resulting from the treatments of age and residence-matched controls without a fracture. Yet, whether vitamin D could reduce costs or be of some import in the context of mitigating future osteoporosis exacerbation, cartilage degradation and arthritis, osteoporosis, and limitations in mobility has been uncertain to date [14-17].

2. Methods

To examine this issue we elected to review whether hip fractures are likely to remain a major health concern in a global context in the future, and whether vitamin D is potentially of clinical relevance specifically in the context of pre and post hip fracture bone prevention efforts. Pertinent articles listed on **PUBMED, Google Scholar, and PubMed Central** that appeared to inform about hip fractures and/or vitamin D from approximately 1990 up to March 31 2026 and those that have emerged as of 2021 were specifically sought.

Excluded were non-clinical or English language reported studies, preprints, abstracts, proposals and conference proceedings. Articles were screened for relevance and data addressing the review questions by the author, a former injury fellow, and key points were duly extracted, regardless of study approach. We accepted the fact many studies included in the data base were

observational or of possible low quality, and did not pertain to the current questions, but some were used if they appeared to have some important clinical utility. What is present is however challenging to aggregate, or are already aggregated hence no definitive statistical analyses were conducted. From those reports that met citeria, we elected to tabulate the key anticipated trends in upcoming decades, where available and relate other findings in narrative form.

In light of present space limitations, and the fact we sought to largely narrate only key data published from 2016-2026, readers who may want to examine those hip fracture trends and others can do so by referring to citation [18]. Those who wish to examine comparable hip fracture data covering the periods from 1980-2009 are referred to the detailed prior review by Marks, citations 6, 11, and 19, and Rapp et al. No AI was employed at any stage [3,19].

3. Results

3.1 General Findings

Since the 1990s a considerable body of research has evolved in efforts to better understand the origins and epidemiology of hip fracture injuries, modes of prevention, and surgical as well as non surgical outcomes, and that implies it is a theme of high interest to many. Among those that detail future hip fracture trends up until 2050, most if not all affirm its importance and indicate rising rates and an urgent need not only for continued study in this regard but for action to retard this emerging epidemic that threatens the independence of many community dwelling older adults highly and significantly [eg., 1,14,21-24,26]. Indeed, ample formative research data shows hip fractures are serious health concerns not only when viewed individually, but also collectively, and from multiple angles. Data further support the emergence of an immense target or 'at risk' group of older adults-a rapidly growing population globally, especially in Asia where services may not be well developed or available widely [27].

Projections pointing to a need to act now and not later to avert undue costs of failing to do this are summarized in Table 1 below.

Table 1: Summary of Data Supporting Efforts to Counter Burgeoning Projected 2050 Hip Fracture Injury Rates

RESEARCHERS' FINDINGS	
Ong et al. [27]	**By 2050, it is estimated six million hip fractures will occur annually and the majority will be in Asia**
Cooper et al. [28]	**Hip fracture numbers will increase from 1.66 million observed in 1990 to 6.26 million by 2050**
Downey et al. [29]	**The number of fragility hip fractures in adults >60 years is estimated to triple/quadruple by 2050**
Barrios-Moyana et al. [30]	**According to figures from 2009, 1/12 Mexican women and 1/20 men over age 65 will suffer a hip fracture when cases reach 110,055 patients in the year 2050**
Lesnyak et al. [31]	**An estimated 2752 hip fractures in 2015 will increase by 207% to 8435 in 2050 in the Kyrgyz Republic**
Issayeva et al. [32]	**2015 data estimates of 11,690 in 2015 are predicted to increase by 140% to 28,000 in 2050 in Kazakhstan**
Zakroyeva et al. [33]	**The 2015 Moldova data reflecting 3911 hip fracture cases will increase by 60% to 6492 in 2050**
Naureen et al. [34]	**An estimated 36,524 hip fractures in Pakistan in 2015 will increase by 214% to 114,820 in 2050**
Kim et al. [35]	**Hip fractures increases from 159.1/100,000 in 2008 to 181.5/100,000 in 2012, are estimated to increase by 1.4 times over the next 10 years in South Korea**
Wilk et al. [36]	**There will be an increase of a total crude rate of 467.2 (men 329.6; women 584.7) for the year 2050 in Poland**
Tuzun et al. [37]	**The number of hip fractures is expected to increase to nearly 64,000 in 2035 in Turkey**
Abeygunasekara et al. [38]	**According to Sri Lanka data, 3824 hip fractures would have occurred island-wide during the study period and will likely reach 12,068 in 2051**
Leznyk et al. [39]	**Estimated numbers of hip fractures in persons 50+ years for 2015 of 16,764 are predicted to increase to 60,272 in 2050 in Uzbekistan**

Note: Additional findings are reported in references 40-50.

3.2 Specific Findings

3.2.1 Hip Fracture Epidemiologic Trends

The available research articles covering the time periods 2021-2026 are aligned with those of earlier studies to a high degree, and continue to strongly indicate that hip fractures will likely continue to pose an enormous challenge to many health systems as well vulnerable high age adults over the next few decades, despite some contrary evidence in some regions in recent years [eg., 20,40-50]. In particular, selected population trend estimates conducted largely prior to 2021, can be said to generally show that regardless of geographic location, or declining or low rates of hip fracture rates in the past, hip fractures will continue to increase up to at least 2050 in those regions studied [see Table 1]. This seems especially evident in the case of men who exhibit frailty or multiple coexisting chronic conditions thought to be increasing among the aging population in their own right. Increases in untreated osteoporosis leading to bone fragility and possibly to higher rates of hip fracture displacement requiring surgery may also evolve if not addressed effectively in a timely manner, especially in regions previously deemed 'low risk' regions [21,26,50-52,62,63].

A recent systematic review of hip fracture outcomes and events in Saudi Arabia showed that across predominantly studied hospital-based cohorts, hip and femoral fractures accounted for a substantial proportion of orthopedic admissions with approximately 7,000 femoral fractures annually. Reported one-year mortality rates varied widely across studies, ranging from approximately 11% to nearly 48%, with higher rates consistently observed among those with delayed surgery or a higher American Surgical Association classification. Functional recovery was frequently limited, and postoperative complications were common. What was telling was that despite a high prevalence of osteoporosis or osteopenia among the studied fracture cases, an osteoporosis diagnosis and its secondary prevention were consistently underutilized [51]. A further similar report has affirmed femoral neck fractures, one highly disabling type of hip fracture, are due in part the presence of osteoporosis and frailty. This is accompanied by a high post surgical reoperation risk, the risk of complications such as dislocation, peri-prosthetic fractures and infection, second hip fractures, plus a declining ability to function physically [62,64].

Severity and trend data may also be underestimates or inaccurate if current data sets fail to represent the changing nature of the aging population and its health status in the post COVID realm. It may exclude those who have limited access to care, those excluded from research studies for many reasons, high age adults, along with increasingly prevalent multi morbidities that may impact hip fracture risk. The incidence rates applied to provide base line calculations in predictive models may also fail to depict more recent upward trends of relevance to fracture risk, such as increases in rates of sarcopenia, increases or successes in averting hip fractures in regions not studied, as well as the lack of sub group study. As a result, some older chronically ill adults and even those who are healthy, may be overlooked, as being at risk for any pending hip fracture and are not treated preemptively and accordingly [63].

In addition to the role of delayed surgical care, an under or a missed diagnosis, as well as suboptimal osteoporosis treatments, and system-level practice variability are evident key clinical challenges that may lead to a rise in hip fractures, rather than not [51,56]. Earlier, Ha et al. in calculating projected future hip fracture occurrences in Korea implied its incidence will likely continue to increase, along with its socioeconomic burden, a conclusion echoed by Glinkowski et al. based on circumstances in Poland [41,52]. As per Rapp et al. we agree the bulk of the data although not universal, indicate a need for action in many spheres before as well as after any hip fracture occurrence [3].

Indeed, Zhang et al. recently showed that despite stable hip fracture incidence rates from 2012-2016, actual numbers of hip fracture injuries increased in parallel with the aging of the their studied population [42]. That is, the absolute number of hip fractures in those 55 years and older increased about 4-fold, and accordingly, the total costs for hospitalization showed a steep rise from US$60 million to US$380 million over the study period. As well, costs of hospitalization increased about 1.59-fold, from US$4,300 in 2012 to US$6,840 in 2016. These data may yet be underestimates because they did not necessarily account for the possible recurrence of the fracture at the initial injury site, or the development of a new fracture in the contra-lateral hip, that may occur in almost 10 percent of hip fracture survivors nor the consistent use of FRAXR evaluation model to assess hip fracture risk [53,44]. As well, regardless of case numbers, mortality rates post hip fracture remain high, especially for men, and according to Hagen et al., estimates of health lost to hip fractures will approximately double, from 32,850 DALYs in 2020 to 60,555 in 2040 in Norway, even though hip fracture incidence rates were found to be decreasing in the high incidence area of Oslo, Norway, and the global burden remains high especially in socially deprived regions [1,40,54,55].

In short, in terms of the anticipated increases in coming decades of high hip fracture volumes and their dire consequences among many high age adults in multiple regions, and when considering these injuries solely from a remaining lifetime perspective, it can be anticipated that subsequent fractures as well as post all-cause and excess mortality rates will probably continue to rise if no comprehensive efficacious primary preventive strategies are forthcoming in the immediate future [53]. Indeed, among those who do not die prematurely even before treatment is initiated Veronese and Maggi have noted hip fracture recovery to be commonly associated with highly negative health consequences, such as disability, depression, and cardiovascular diseases, as well as immense social costs [1,66-68]. Moreover, as discussed by Dyer et al. the long-term outlook for hip fracture surgery survivors even those deemed initially independent in self-care pre-fracture, is bleak, and one where 20-60% of survivors will likely require

assistance for accomplishing various daily tasks for up to two years, especially those in the older age groups with primary fragility fractures, as well as subsequent fractures [65,66]. Additionally, even where hip mortality rates appear to have declined, 11% cases undergoing hip fracture surgery who return home are often readmitted within 30 Days [67].

Moreover, among those older adults forced to live in a residential care setting post-fracture are likely to exhibit a level of function lower than that of comparable aged elders returning to and able to continue living in the community. As per Papadimitrou et al., hip fracture injuries, which are found to increase in prevalence with age, can undoubtedly be expected to lead to a substantial loss of years of healthy life even in previously healthy older adults, in addition to producing substantive decrements in independence and mobility in the first year post fracture, along with an increased risk of depressive symptoms and a decrease in activity participation [69,70,71]. In addition to the high mortality rates within the first three to six months of their injury in surgical cases, these rates may be even higher in non-operative cases, or in those receiving poorly integrated care [72-76]. As well as a possible heightened risk for a second or third hip fracture, very poor functional outcomes may be forthcoming if the individual is deemed frail, as well as having possible high levels of psychological distress [74-76].

3.2.2 Mitigation Approaches

Among a multitude of potentially remediable factors uncovered since the 1960s, including the prevention of falls, low bone and muscle mass, chronic health conditions, impaired cognitions, low milk consumption, suboptimal exposure to sunlight, and vitamin D deficiency, addressing these hip fracture risk factors has not resulted in desirable outcomes for all to date [77-82]. Additionally, even though research points to a salient linkage between hip fractures, muscle degeneration and inadequate calcium/vitamin D intake this has not been well articulated or applied in the context of hip fracture preventive goals and objectives at any level [62]. Thus, not only is much suffering potentially inadvertent and reversible in part, but the risk of a recurrent fracture burden may remain even if surgery is successful in mediating a hip repair technically speaking [62]. The same applies to the failure to apprehend and allay persistent environmental, psychological, health, intrinsic capacity, and social factors, steroid usage, and medication effects that can underpin both hip fracture risk as well as vitamin D insufficiency [19,57-60].

In addition, in the specific case of vitamin D, it is not agreed by all that vitamin D is possible hip fracture co-factor even though most hip fracture cases are found to be vitamin D deficient and could possibly benefit from some form of daily vitamin D exposure. This state of uncertainly of a possible mediating variable against hip fracture onset and severity prevails moreover despite a strong rationale from basic research studies and others that vitamin D plays a key or important role in bone physiology and maintenance, muscle physiology, overall health status, and possibly in cognitive and falls associated situations. As well, many epidemiological studies suggest that vitamin D insufficiency is related to a number of other disorders frequently observed among elderly fallers who are prone towards hip fracture, such as type 2 diabetes, and cardiovascular disorders including hypertension. Although no preventive vitamin D role against hip fractures may ensue if the predominant determinants of hip fractures are lack of physical activities and low weight, a 2021 study report indicated 407 of 872 (47%) hip fracture patients –who may or may not have been sedentary or frail-were vitamin D deficient and those cases tended to demonstrate more delirium, more new hip fractures, and more medical readmissions than those with adequate baseline levels [81]. The low levels of vitamin D in older hip fracture patients was also more marked than the levels of hip joint arthroplasty cases of a similar age [77].

Unfortunately considerable emphasis is placed on a failure to show universal benefits or linkages in the hip fracture injury cycle and that vitamin D sufficiency alone may not prevent the degree of trauma generating all hip fractures. A recommendation pointing to the lack of vitamin D in healthy older adults in general, may however, prevent its possible future mediating role on hip fracture extent and severity in selected cases such as those at risk for fear of falls or kinesiophobia, osteoporotic fractures and recurrent falls [60,81,82,84-88,98].

In short, even though ample evidence supports the importance of vitamin D in maintaining calcium and bone metabolism, a risk factor for osteoporosis, falls and hip fractures in old age its preventive impact or replacement is not always advocated for or effective in countering hip fractures, hip fracture survival, or optimal recovery. Its value in pre and post surgical states must however warrant consideration in that certain results do lend support to the overarching importance of maintaining serum vitamin D levels above 30 nmol/L in the older population, where vitamin D deficiency is common, especially in women with brittle bones.

Moreover, doing all that is possible to preserve bone health status earlier rather than later appears imperative given one in ten older adults are found to suffer a secondary hip fracture that may yet implicate muscle degeneration and inadequate calcium/vitamin D intake [89]. Indeed, it seems vitamin D can likely impact hip fracture risk, its re-fracture risk, as well as surgical recovery given its essential role for calcium metabolism, bone mineralization and musculoskeletal health, however almost 75% of admitted hip fracture cases can be expected to exhibit a vitamin D deficiency and to remain so if not attended to [90-93]. In this respect, those with proximal femur fractures may experience poorer functional mobility and higher perioperative and 1-year mortality rates than not if found to present with fragility fractures [15]. They may suffer intently and more so if no attention or relevance is placed on fostering their bone health and their vitamin D status [82,83]. Zhao et al., too noted those suffering from inter-trochanteric hip

fractures and a lower than desirable vitamin D level may exhibit more severe fractures than those with higher levels [94]. They may also exhibit more evidence of post-operative delirium, more new hip fractures, and more medical readmissions, at 1 year, unless action to counter this is forthcoming [95,96].

3.2.3 Implications

Although not currently advocated by all in averting or treating hip fracture cases or those at risk, Jarusswan et al. have concluded that in treatment settings where baseline serum vitamin D level can't be evaluated readily, high-dose vitamin D2 of approximately 60,000 IU/week applied for 12 weeks, with a subsequent switch to a maintenance dose is likely to prove beneficial in restoring serum vitamin D to optimal levels in 82.8% of cases without causing symptomatic hypercalcemia, a common obstacle to vitamin D supplementation [97]. Mak et al. who conducted a randomized, double-blind, placebo-controlled trial of 218 adults, aged 65-years or older, requiring hip fracture surgery assigned to receive a single loading-dose of vitamin D (250,000 IU vitamin-D3, did find falls related benefits in the active group after four weeks [98]. As well, a higher percentage of the active group reported 'no pain or consistent discomfort', and trended towards higher life quality scores at week-26.

Sprague et al. who used data from a large hip fracture trial to determine the proportion of patients who used vitamin D after hip fracture surgery and whether supplementation was associated with improved health-related quality of life and reduced reoperation rates found that despite guidelines recommending vitamin D supplementation only a limited proportion of elderly patients may be using vitamin D supplements consistently post hip fracture surgery, even if desirable [99]. On the other hand, compliant cases showed significant improvements in health-related quality of life, including selected cases with fragility fractures who may have a severe vitamin D deficiency both at baseline and at 6-month after hip surgery [100,101]. As a result, the authors proposed there may be a need for additional post operative strategies to help promote the uptake and compliance of vitamin D exposure in this regard, and related benefits of higher one year and four year survival rates if vitamin D supplementation is coupled with exercise [102]. As well more cases may be discharged home rather than to a rehabilitation unit [103]. Ben-Natan et al. show tentative data implicating lower vitamin D levels and longer hospitalization stays and higher fall risks in elderly hip fracture patients in the realm of peri-operative recovery, As per Singh et al. it thus appears safe to conclude a proximal femur fracture in the presence of osteoporosis is a serious situation that can explain the high mortality and morbidity rates associated with hip fractures in the older adult population, especially where vitamin D levels are suboptimal [104,105].

It is also apparent that although hip fracture risk in the elderly is a function of multiple factors, including bone mineral density, muscle strength, and balance, all of these possible deterministic factors have been related to vitamin D status and function in their own right. Their study of cases with proximal femoral fractures showed almost all their hip fracture patients (96%) were suffering from hypovitaminosis D (vitamin D levels <30 ng/ml), and 38% of had vitamin D deficiency (Vitamin D levels <20 ng/ml) regardless of age, and sex [105]. Clearly an indirect impact of a vitamin D deficiency on hip fracture risk also extends to several biological processes other than calcium metabolism including, neuromuscular function, immune system function. inflammation control, glucose metabolism, immune and cell growth modulation processes. The related cell receptor vitamin D receptor, along with the active form of vitamin D, also modulates many genes that encode for proteins responsible for regulating cell proliferation, differentiation, and apoptosis or cell death sequences, thus of enormous promise in explaining and intervening to maximize its diverse roles [106].

4. Discussion

As outlined earlier, this mini umbrella overview was designed to re-examine whether hip fractures remain a noteworthy global cause of excess morbidity and mortality among older adults, and if so, if there is a need to prevent the injury and its consequences jn the future. It also examined the possible role of vitamin D in this regard. Using data published primarily between 2016 and 2026, it seems most nations can clearly anticipate increases, rather than decreases in hip fractures case rates by 2050, regardless of geographic location or prior successes in reducing hip fracture rates and their devastating impacts on the injured older adult, unless widespread intensely focused actions are taken to avert this. At the same time, many aging adults will likely be unable to age 'in place' as a result of a hip fracture especially if they are already in poor health [107]. However, despite the urgency of this issue, a very limited number of research projects from limited geographical locations prevail, some using retrospective data or observational approaches.

Further, very few robust clinical controlled studies prevail, and many suffer from low quality or questionable efforts to aggregate dissimilar data sets drawn from limited samples and varied inclusion and exclusion criteria. As such, and in light of the very modest successes of past preventive approaches other than in some European and UK settings, and a trend to a more favourable role for vitamin D in hip fracture and osteoporosis prevention efforts, more should clearly be done in the future, especially in the less developed world to examine how vitamin D might be harnessed to play an important preventive role in the context of bone nased hip fracture risk, and recovery, as outlined by Chevalley et al. [108]. At the same time and according to Bischoff-Ferrari given that about two-thirds of hip fracture cases may show signs of a vitamin D insufficiency, its presence at desirable levels may indirectly avert inevitable hip fractures due to falls-the major cause of many post-surgery hip fracture readmissions, and injury severity [102,109,110].

Accordingly, and notwithstanding the lack of any robust evidence to validate universal supplementation of vitamin D among older at

risk populations, in addition to encouraging the use of sound safety measures against falls, appropriate routine screenings to determine the prevailing level of serum vitamin D in vulnerable older adults, along with timely follow up procedures by practitioners to help older adults secure the best food sources of vitamin D if possible is indicated for alleviating much distress and pain, and may possibly delay or mitigate hip fracture mortality and debility outcomes [29,111]. This approach as well as timely surgery and osteoporosis care may also help in mitigating some degree of hip fracture severity and post surgical secondary fracture risk associated with a frail osteoporotic hip fracture [112-114].

Most current authors concur it is vital however, to resolve related literature inconsistencies, as well as research gaps and limitations of those already published. Key issues that might be valuable to address include attention to- the nature of the methods of measuring and classifying both frailty risk as well as vitamin D serum levels– plus attention to food insecurity issues and seasonal variations in vitamin D levels and outdoor versus indoor activities ratios [115].

Nyugen and Lui further imply that to enable more effective implementation and outcomes of hip fracture prevention strategies, it is imperative to develop an optimal model of care for older adults who have sustained a hip fracture, especially in rapidly aging nations [106]. All personnel likely to encounter and counsel an older adult faller or fracture survivor as well as the injured adult may benefit immensely in this respect from a well organized array of educational materials, home safety assessment recommendations, and nutritional strategies they can safely recommend to their older clients, especially the frail [83]. Unfortunately, although many authors identify a higher magnitudes of hip fractures than desired and that it is one health condition that will likely prevail more markedly in 2050 among high age frail sedentary older adults located in low income regions, very few spell out or mention any comprehensive strategy or need to intervene to avert this future possible costly epidemic.

However, based on a considerable volume of supportive literature and a sound biological rationale for its efficacy or lack thereof, vitamin D may be one factor worthy of consideration in the prevention treatment cycle due to its possible bone mineral content/bone metabolic benefits plus ability to influence:

a. Balance/walking speed
b. Effectiveness of protective reflexes
c. Chronic pain
d. Muscle strength/mobility
e. The risk of falls and falling
f. Extra skeletal health status
g. Cognitive health status
h. Immunity status

Other potentially worthy efforts that might reduce the anticipated hip fracture 2050 rates of occurrence and their consequences include the need for:

- Prompt action to counteract predicted global hip fracture increases [21,27,112].
- More effective falls and other practical prevention and safety approaches [111,116,117].
- More intense efforts to offset vitamin D deficiencies, bone fragility, and frailty [113,118].
- Optimisming vitamin D levels, especially in vitamin D deficient aging adults.
- Routine assessment of vitamin D status/ targeted supplementation in risk groups [70,119-122].
- Securing an adequate dietary or supplemental vitamin D and calcium intake source [103].
- More equitable vitamin D deficiency and falls prevention strategies [4,62].
- Improving diagnostic resources, osteoporosis management and bone health [44,51,112,125].

In this respect, first line responders and emergency team personnel can play a considerable role in helping combat the magnitude and severity of late life hip fracture disability in our view by:

- Providing salient educational material to non hospitalized high age falls injury cases.
- Ensuring rapid triaging and transfer to surgery in the face of a hip fracture.
- Screening and prompting surgeons about possible vitamin D deficiency risk.
- Providing the patient with nutritional information plus home safety inspection sources.

In addition, a standardized care path that empowers allied health professionals may help reduce peri-operative complications, while a combined orthogeriatric care service may facilitate more prompt surgical treatment [73]. We further perceive hospital clinics, social media, and public spaces, including the emergency room can convey the overall importance of optimal nutrition, exercise, weight management, and sunlight exposure efforts for maximizing the bone health all older adults, plus listings that offer routine bone density screenings in addition to providing insightful intake and preoperative patient evaluations [17,120-122].

In the interim a desirable vitamin D-calcium regimen applied daily or weekly can be expected to effectively correct a vitamin D deficiency in those older adult with a hip fracture injury, as well as enhancing post fracture healing [123,124]. In the hip fracture preventive realm, the application of well designed and informed education alongside adequate resource allocations and interactive expert collaboration that embraces and is open to following the trail of many favorable reports of a protective role for vitamin D replacement in vulnerable high age adults or other 'at risk' sub groups may prove far reaching as well [4,125-130].

However, to advance the evidence base the role of a sound theoretical framework and action plan, careful follow up, and robust evaluations/measurement procedures need to be addressed

sooner rather than later in carefully-designed and controlled longitudinal adequately powered studies.

5. Conclusions

In spite of the limitations of this mini overview, and those in the cited literature, we conclude: a) there is an obvious pressing need for timely efforts to avert a future epidemic of hip fractures and their debilitating costly outcomes among high numbers of older adults, especially in Asia and low income countries; b) too few current efforts are either employed or not adequately designed to offset this projected hip fracture health burden in general, as well as in the context of intervention personalization; c) a possible omission in this regard is the failure to embrace the plausible role for vitamin D insufficiency in hip fracture disability; d) a strong likelihood of vitamin D deficiencies, and their well established adverse health ramifications underpin many falls occurrences as well as hip fracture risk among older frail adults.

Although some evidence showing a positive impact of vitamin D supplementation for purposes of both a more rapid and optimal post fracture recovery, as well for reducing the high falls rates pre and post hip fractures, we further conclude there may be a mismatch between the mode of vitamin D administration or intervention, its mode of measurement-often only measured once, and its underlying premises in the absence of carefully structured systematically organized related research and evaluation processes that result in confounding results.

To this end we would like to advocate for:

• Honoring more anecdotal as well as evidence based findings.

• Drawing lessons from shortcomings and successes reported in the vitamin D-hip fracture realm.

• Identifying what works and why and what age and sex specific processes are needed to attain valid results.

• Applying an adapted systematic framework and set of biologic as well as behavioral and communication theories to guide program development in diverse settings.

References

1. Veronese, N., & Maggi, S. (2018). Epidemiology and social costs of hip fracture. *Injury, 49*(8), 1458-1460.
2. Ramponi, D. R., Kaufmann, J., & Drahnak, G. Hip fractures. *Adv Emerg Nurs J. 2018; 40* (1): 8–15.
3. Rapp, K., Büchele, G., Dreinhöfer, K., Bücking, B., Becker, C., & Benzinger, P. (2019). Epidemiology of hip fractures: systematic literature review of German data and an overview of the international literature. *Zeitschrift für Gerontologie und Geriatrie, 52*(1), 10-16.
4. Alalwani, Y. J., Aldossari, M. A., Alzahrani, L. A., Alhatlani, N. I., Albarrak, S. M., Moosa, W. K., ... & Al Yousif, G. F. (2026). Fall Prevention Interventions and Fracture Risk in Community-Dwelling Older Adults: A Systematic Review and Meta-Analysis. *Clinics and Practice, 16*(3), 52.
5. He, Q., Zhang, C., Xie, W., Deng, Z., Yang, S., Li, X., & Sun, W. (2025). Association between vitamin levels and geriatric hip fractures: A cross-sectional study. *Frontiers in nutrition, 12*, 1421257.
6. Zhou, Z., Chen, S., & Yang, F. (2026). Prevalence and correlates of vitamin D deficiency in a mixed-age hospital-based cohort. *Frontiers in Public Health, 14*, 1757957.
7. Caballero-Villarraso, J., Navarrete-Pérez, A., Camargo, A., Valentín-Aragón, L., Gómez-Chaparro, J. L., Quesada-Gómez, J. M., & Casado-Díaz, A. (2026). Calcitriol Modulates Both the Vitamin D Receptor and the Calcium-Sensing Receptor in Blood Mononuclear Cells in Elderly Female Patients with Hip Osteoporotic Fractures. *Biomolecules, 16*(2), 266.
8. Silvagno, F., & Bergandi, L. (2026). Special Issue "The Role of Vitamin D in Human Health and Diseases 4.0". *International Journal of Molecular Sciences, 27*(3), 1381.
9. Latham, C. M., Brightwell, C. R., Keeble, A. R., Munson, B. D., Thomas, N. T., Zagzoog, A. M., ... & Fry, J. L. (2021). Vitamin D promotes skeletal muscle regeneration and mitochondrial health. *Frontiers in Physiology, 12*, 660498.
10. Nieczyporuk, M., Omidi, A., Łupicka, A., Kielan, A., Orzechowska, P., Dziurdź, A., ... & Majewska, K. (2026). Vitamin D as a Key Modulator of Physical Performance and Injury Prevention: A Narrative Review. *Quality in Sport, 49*, 67801-67801.
11. Box, M. W., Marchese, C., Puga, T. B., & Riehl, J. T. (2026). Dietary Supplements (Nutraceuticals) for Improving Adult Fracture Healing Outcomes: A Narrative Review of Current Evidence and Gaps. *Journal of Dietary Supplements, 23*(2), 306-330.
12. Kanters, T. A., Van de Ree, C. L. P., De Jongh, M. A. C., Gosens, T., & Hakkaart-van Roijen, L. (2020). Burden of illness of hip fractures in elderly Dutch patients. *Archives of osteoporosis, 15*(1), 11.
13. Williamson, S., Landeiro, F., McConnell, T., Fulford-Smith, L., Javaid, M. K., Judge, A., & Leal, J. (2017). Costs of fragility hip fractures globally: a systematic review and meta-regression analysis. *Osteoporosis international, 28*(10), 2791-2800.
14. Liu, E., & Liu, R. Y. (2026). Negating the burden of hip fracture in high-risk populations: a narrative review of epidemiology, costs, and multifaceted mitigation strategies. *Expert Review of Pharmacoeconomics & Outcomes Research, 26*(2), 143-159.
15. Rajeev, A., Hunter, C., Krishnan, S., Ullah, A., Koshy, G., & Gateshead Health Foundation NHS Trust. (2024). The prevalence and outcomes of pre-admission vitamin D levels in the management of proximal femur fractures. *Aging Medicine, 7*(6), 699-704.
16. Kahwati, L. C., LeBlanc, E., Weber, R. P., Giger, K., Clark, R., Suvada, K., ... & Viswanathan, M. (2021). Screening for vitamin D deficiency in adults: updated evidence report and systematic review for the US Preventive Services Task Force. *Jama, 325*(14), 1443-1463.
17. Altaf, Y., Mobeen, N., Saleem, S., Tauseef, M., Nadeem, J., Rasheed, R., & Shahid, M. (2026). Relationship Between

Vitamin D Deficiency, BMI, Gender, Lifestyle And Its Effects On Health. *Pakistan Journal of Medical & Cardiological Review, 5*(1), 1493-1512.
18. da Silva, R., Quintino, C., Guimarães, L. S., & Lopes, D. C. Clinical Efficacy of Vitamin D3 Supplementation in the Elderly: A Systematic Review.
19. Marks, R. (2010). Hip fracture epidemiological trends, outcomes, and risk factors, 1970–2009. *International journal of general medicine*, 1-17.
20. Meagher, E., Varghese, S., Harty, J. A., & O'Loughlin, P. F. (2021). The decline of hip fracture incidence rates over a 10-year period: a single centre experience. *Injury, 52*(7), 1807-1812.
21. Concin, H., Brozek, W., Benedetto, K. P., Häfele, H., Kopf, J., Bärenzung, T., ... & Nagel, G. (2016). Hip fracture incidence 2003–2013 and projected cases until 2050 in Austria: a population-based study. *International journal of public health, 61*(9), 1021-1030.
22. Ramanau, H., Chernyanin, I., Rudenka, E., Lesnyak, O., Zakroyeva, A., Bilezikian, J. P., ... & Kanis, J. A. (2018). Epidemiology of hip fracture in Belarus: development of a country-specific FRAX model and its comparison to neighboring country models. *Archives of osteoporosis, 13*(1), 42.
23. Kirilova, E., Johansson, H., Kirilov, N., Vladeva, S., Petranova, T., Kolarov, Z., ... & Kanis, J. A. (2020). Epidemiology of hip fractures in Bulgaria: development of a country-specific FRAX model. *Archives of Osteoporosis, 15*(1), 28.
24. Kebaetse, M., Nkhwa, S., Mogodi, M., Masunge, J., Gureja, Y. P., Ramabu, M., ... & Kanis, J. A. (2021). Epidemiology of hip fracture in Botswana. *Archives of Osteoporosis, 16*(1), 24.
25. Diaz-Ledezma, C., Bengoa, F., Dabed, D., Rojas, N., & López, A. (2020). Hip fractures in the elderly Chilean population: a projection for 2030. *Archives of Osteoporosis, 15*(1), 116.
26. Gong, X. F., Li, X. P., Zhang, L. X., Center, J. R., Bliuc, D., Shi, Y., ... & Wu, X. B. (2021). Current status and distribution of hip fractures among older adults in China. *Osteoporosis International, 32*(9), 1785-1793.
27. Ong, T., Khor, H. M., Kumar, C. S., Singh, S., Chong, E. G. M., Ganthel, K., & Lee, J. K. (2020). The current and future challenges of hip fracture management in Malaysia. *Malaysian orthopaedic journal, 14*(3), 16.
28. Cooper, C., Campion, G., & Melton III, L. (1992). Hip fractures in the elderly: a world-wide projection. *Osteoporosis international, 2*(6), 285-289.
29. Downey, C., Flannery, S., Abd Wahab, E. H., Askin, D., O'Kelly, P., Shortt, C. P., ... & Quinlan, J. F. (2022). The patient's second hip fracture–one in ten.
30. Barrios-Moyano, A., & Contreras-Mendoza, E. G. (2018). Frequency of complications in patients older than 60 years with hip fracture. *Acta ortopédica mexicana, 32*(2), 65-69.
31. Lesnyak, O., Zakroyeva, A., Lobanchenko, O., Johansson, H., Liu, E., Lorentzon, M., ... & Kanis, J. A. (2020). A surrogate FRAX model for the Kyrgyz Republic. *Archives of Osteoporosis, 15*(1), 68.
32. Issayeva, S., Lesnyak, O., Zakroyeva, A., Issayeva, B., Dilmanova, D., Johansson, H., ... & Kanis, J. A. (2020). Epidemiology of osteoporotic fracture in Kazakhstan and development of a country specific FRAX model. *Archives of osteoporosis, 15*(1), 30.
33. Zakroyeva, A., Lesnyak, O., Cazac, V., Groppa, L., Russu, E., Chislari, L., ... & Kanis, J. A. (2020). Epidemiology of osteoporotic fracture in Moldova and development of a country-specific FRAX model. *Archives of Osteoporosis, 15*(1), 13.
34. Naureen, G., Johansson, H., Iqbal, R., Jafri, L., Khan, A. H., Umer, M., ... & Kanis, J. A. (2021). A surrogate FRAX model for Pakistan. *Archives of Osteoporosis, 16*(1), 34.
35. Kim, B. S., Lim, J. Y., & Ha, Y. C. (2020). Recent epidemiology of hip fractures in South Korea. *Hip & Pelvis, 32*(3), 119.
36. Wilk, R., Skrzypek, M., Kowalska, M., Kusz, D., Koczy, B., Zagórski, P., & Pluskiewicz, W. (2018). The 13-year observation of hip fracture in Poland—worrying trend and prognosis for the future. *Aging Clinical and Experimental Research, 30*(1), 61-69.
37. Tuzun, S., Eskiyurt, N., Akarirmak, U., Saridogan, M., Senocak, M., Johansson, H., ... & Turkish Osteoporosis Society. (2012). Incidence of hip fracture and prevalence of osteoporosis in Turkey: the FRACTURK study. *Osteoporosis international, 23*(3), 949-955.
38. Abeygunasekara, T., Lekamwasam, S., Lenora, J., & Alwis, G. (2020). Current incidence and future projections of fragility hip fractures in Sri Lanka. *Archives of osteoporosis, 15*(1), 178.
39. Lesnyak, O., Ismailov, S., Shakirova, M., Alikhanova, N., Zakroyeva, A., Abboskhujaeva, L., ... & Kanis, J. A. (2020). Epidemiology of hip fracture and the development of a FRAX model for Uzbekistan. *Archives of Osteoporosis, 15*(1), 119.
40. Hagen, G., Magnussen, J., Tell, G., & Omsland, T. (2020). Estimating the future burden of hip fractures in Norway. A NOREPOS study. *Bone, 131,* 115156.
41. Zhang, C., Feng, J., Wang, S., Gao, P., Xu, L., Zhu, J., ... & Song, C. (2020). Incidence of and trends in hip fracture among adults in urban China: a nationwide retrospective cohort study. *PLoS medicine, 17*(8), e1003180.
42. Coveney, E. I., McKeown, D., Quinlan, J. F., & Cleary, M. (2020). A healthy decline in age-and sex-specific incidence of hip fractures in the elderly in the Republic of Ireland. *The Surgeon, 18*(5), e13-e19.
43. Perez, S. C., Cruz-Priego, G. A., Clark, P., Ortiz-Barboza, A., Johansson, H., & Kanis, J. A. (2026). Epidemiology of hip fractures in Costa Rica and development of country-specific thresholds to estimate fracture risk. *Archives of Osteoporosis, 21*(1), 30.
44. Hagino, H., Osaki, M., Okuda, R., Enokida, S., & Nagashima, H. (2020). Recent trends in the incidence of hip fracture in

Tottori Prefecture, Japan: changes over 32 years. *Archives of osteoporosis, 15*(1), 152.
45. Michaëlsson, K., Baron, J. A., Byberg, L., Larsson, S. C., Melhus, H., & Gedeborg, R. (2024). Declining hip fracture burden in Sweden 1998–2019 and consequences for projections through 2050. *Scientific Reports, 14*(1), 706.
46. Meyer, A. C., Ek, S., Drefahl, S., Ahlbom, A., Hedström, M., & Modig, K. (2021). Trends in hip fracture incidence, recurrence, and survival by education and comorbidity: a Swedish register-based study. *Epidemiology, 32*(3), 425-433.
47. Yao, Y., Yang, G., Liu, G., Ji, B., Li, H., Sun, J., ... & Xiao, W. (2026). Global, regional, and national burden of fractures in the elderly, 1990–2021: a systematic analysis based on GBD 2021. *International Journal of Surgery, 112*(2), 3252-3265.
48. Nakatoh, S., Fujimori, K., Ishii, S., Tamaki, J., Okimoto, N., Ogawa, S., & Iki, M. (2026). Trends in the incidence of hip fractures and osteoporosis treatment in Japan (FY2012–FY2023). *Archives of Osteoporosis, 21*(1), 16.
49. Webster, J., Oguzman, E., Morris, E. J., Shepperd, S., Griffin, X. L., Johansen, A., & Goldacre, R. (2025). Trends and variation in the incidence of hip fracture in England before, during, and after the COVID-19 pandemic (2014–2024): a population-based observational study. *The Lancet Regional Health–Europe, 57.*
50. Argan, M. S., Alwalidi, H. S. A., Alassiry, L. T., Alturki, M. A., Aldaraani, L. G., Asiri, A. A., ... & ALQAHTANI, L. N. (2025). Fragility Femoral and Hip Fractures in Saudi Arabia: A Systematic Review of Epidemiology, Risk Factors, Clinical Outcomes, and Health-System Gaps. *Cureus, 17*(12).
51. Glinkowski, W., Narloch, J., Krasuski, K., & Śliwczyński, A. (2019). The increase of osteoporotic hip fractures and associated one-year mortality in Poland: 2008–2015. *Journal of clinical medicine, 8*(9), 1487.
52. Nolan, P., Tiedt, L., Ellanti, P., McCarthy, T., & Hogan, N. (2020). Incidence of non-simultaneous contralateral second hip fractures: a single-center Irish study. *Cureus, 12*(10).
53. Meyer, A. C., Ek, S., Drefahl, S., Ahlbom, A., Hedström, M., & Modig, K. (2021). Trends in hip fracture incidence, recurrence, and survival by education and comorbidity: a Swedish register-based study. *Epidemiology, 32*(3), 425-433.
54. Wang, Z., Chen, Z., Zhang, C., Liu, W., Liu, J., Lin, W., & Wang, G. (2025). Global trends in fall-induced hip fractures among perimenopausal women 1990 to 2021: results from the global burden of disease study 2021. *Frontiers in Public Health, 13*, 1674535.
55. Paes, V. M., Ting, A., Paes, M. V. I., Masters, J., Graham, S. M., & Costa, M. L. (2026). What is the association between time to surgery and patient outcome after hip fracture?: a systematic review. *The Bone & Joint Journal, 108*(1), 30-38.
56. Zhang, X., Xu, D., Yang, Y., Zeng, Y., Yu, H., Fang, T., ... & Zhang, W. (2026). Intrinsic capacity and risk of hip fracture in older adults: evidence from five multinational aging cohorts. *The Journal of nutrition, health and aging, 30*(2), 100773.
57. Liu, Y. D., Ma, J. Y., Wang, J. H., Sun, T., & Han, Z. Y. (2025). Effect of perioperative psychological intervention on recovery in elderly hip fracture patients with comorbid post-traumatic stress disorder. *World Journal of Psychiatry, 15*(10), 106705.
58. Deng, F., Guo, H., Song, L., & Chen, B. (2026). Relationship between social determinants of health and hip fracture in the American population: a cross-sectional NHANES study. *Journal of Orthopaedics.*
59. Cao, Y., Lan, X., Li, C., Xiang, Y., Xu, Q., Zhang, R., & Li, M. (2026). Identifying kinesiophobia subtypes and their determinants in patients with hip fractures: a latent profile analysis. *Frontiers in Psychiatry, 16*, 1697341.
60. Sun, W., Dai, Z., Lin, X., & Fang, K. (2026). Disease Burden Attributable to Hip Fractures in Asian Women. *International Journal of Women's Health,* 586201.
61. Ren, J., Liu, M., Wang, B., Bai, C., Yang, K., Ma, X., ... & Li, X. (2026). Secondary fracture risk after hip fracture in older patients: an updated sex-specific systematic review and meta analysis with GRADE and PAF assessment. *Osteoporosis International*, 1-12.
62. Trulson, A., Huber, S., Bolierakis, E., Berk, T., Stuby, F., Höch, A., ... & Pieroh, P. (2026). Impact of osteoporosis pharmacotherapy and vitamin d supplementation on fracture morphology and treatment of pelvic fragility fractures: a retrospective cohort study of 1493 patients from the German Pelvic Trauma Registry. *Archives of Osteoporosis, 21*(1), 52.
63. Pietrzak, J. R. T., Geldenhuys, D. B., Nicolaou, C., Elebo, N., & Sikhauli, N. (2026). Fractured Truths: A Collected Review of Modern Insights on Femoral Neck Fracture Management. *Orthopedic Reviews, 18.*
64. Dyer, S. M., Crotty, M., Fairhall, N., Magaziner, J., Beaupre, L. A., Cameron, I. D., & Sherrington, C. (2016). Fragility fracture network (FFN) rehabilitation research special interest group. A critical review of the long-term disability outcomes following hip fracture. BMC Geriatr, 16(1), 158.
65. Yuan, Y., Zhang, M., Li, P. Y., Wang, W., Lu, Y. N., Yang, M. H., ... & Zhang, J. (2026). Subsequent fracture risk after hip fracture surgery in China: a three-year retrospective cohort study. *BMC geriatrics, 26*(1), 210.
66. Sutton, E., Rahman, U., Reilly, H., Miller, C., Vedutla, T., Melody, T., ... & Topping, A. E. (2025). Understanding readmission after hip fracture: a mixed methods study protocol. *BMJ open, 15*(7), e094163.
67. Giummarra, M. J., Ekegren, C. L., Gong, J., Simpson, P., Cameron, P. A., Edwards, E., & Gabbe, B. J. (2020). Twelve month mortality rates and independent living in people aged 65 years or older after isolated hip fracture: a prospective registry-based study. *Injury, 51*(2), 420-428.
68. Papadimitriou, N., Tsilidis, K. K., Orfanos, P., Benetou, V., Ntzani, E. E., Soerjomataram, I., ... & Trichopoulou, A. (2017). Burden of hip fracture using disability-adjusted life-years: a pooled analysis of prospective cohorts in the CHANCES consortium. *The Lancet Public Health, 2*(5), e239-e246.
69. Ren, Y., Hu, J., Lu, B., Zhou, W., & Tan, B. (2019). Prevalence and risk factors of hip fracture in a middle-aged and older

Chinese population. *Bone, 122*, 143-149.
70. Swayambunathan, J., Dasgupta, A., & Bhattacharyya, T. (2021). The pronounced impact of hip fractures on psychosocial well-being. *JAAOS-Journal of the American Academy of Orthopaedic Surgeons, 29*(1), e22-e30.
71. Amrayev, S., AbuJazar, U., Stucinskas, J., Smailys, A., & Tarasevicius, S. (2018). Outcomes and mortality after hip fractures treated in Kazakhstan. *Hip International, 28*(2), 205-209.
72. Tan, L. T. J., Wong, S. J., & Kwek, E. B. K. (2017). Inpatient cost for hip fracture patients managed with an orthogeriatric care model in Singapore. *Singapore medical journal, 58*(3), 139.
73. Guy, P., Sobolev, B., Sheehan, K. J., Kuramoto, L., & Lefaivre, K. A. (2017). The burden of second hip fractures: provincial surgical hospitalizations over 15 years. *Canadian journal of surgery, 60*(2), 101.
74. van de Ree, C. L. P., de Munter, L., Biesbroeck, B. H. H., Kruithof, N., Gosens, T., & de Jongh, M. A. C. (2020). The prevalence and prognostic factors of psychological distress in older patients with a hip fracture: a longitudinal cohort study. *Injury, 51*(11), 2668-2675.
75. Alexiou, K. I., Roushias, A., Varitimidis, S. E., & Malizos, K. N. (2018). Quality of life and psychological consequences in elderly patients after a hip fracture: a review. *Clinical interventions in aging,* 143-150.
76. Johnson, A. L., Smith, J. J., Smith, J. M., & Sanzone, A. G. (2013). Vitamin D insufficiency in patients with acute hip fractures of all ages and both sexes in a sunny climate. *Journal of orthopaedic trauma, 27*(12), e275-e280.
77. Liu, E., & Liu, R. Y. (2026). Negating the burden of hip fracture in high-risk populations: a narrative review of epidemiology, costs, and multifaceted mitigation strategies. *Expert Review of Pharmacoeconomics & Outcomes Research, 26*(2), 143-159.
78. Al-Algawy, A. A. H., Baiee, H. A., Hasan, S., Jassim, I., Razaq, M., Kamel, F., ... & Khudhair, E. (2019). Risk factors associated with hip fractures among adult people in Babylon City, Iraq. *Open access Macedonian journal of medical sciences, 7*(21), 3608.
79. Cauley, J. A., Cawthon, P. M., Peters, K. E., Cummings, S. R., Ensrud, K. E., Bauer, D. C., ... & Osteoporotic Fractures in Men (MrOS) Study Research Group. (2016). Risk factors for hip fracture in older men: the osteoporotic fractures in men study (MrOS). *Journal of Bone and Mineral Research, 31*(10), 1810-1819.
80. Landgraff, I. K., Myrstad, M., Ranhoff, A. H., Talsnes, O., Holvik, K., & Meyer, H. E. (2026). Midlife physical activity, BMI, and hip fracture risk five decades later in men: a NOREPOS study. *Archives of Osteoporosis, 21*(1), 28.
81. Rajesh Khadgawat, R. K., Brar, K. S., Monita Gahlot, M. G., Yadav, C. S., Rajesh Malhotra, R. M., Nandita Gupta, N. G., & Nikhil Tandon, N. T. (2010). High prevalence of vitamin D deficiency in Asian-Indian patients with fragility hip fracture: a pilot study.
82. Sjölander, M., Alvunger, L., Eggertsen, R., Lindgren, A., Mölstad, U., Petrazzuoli, F., ... & Albertsson, D. (2026). Reduced Risk of Recurrent Fragility Fractures After a Primary Care–Based Fracture Prevention Intervention: A 20-Year Non-Randomized Controlled Follow-Up Study in Women Aged 70–100. *Scandinavian Journal of Primary Health Care, 44*(1), 1-16.
83. Avenell, A., Mak, J. C., & O'Connell, D. L. (2014). Vitamin D and vitamin D analogues for preventing fractures in post-menopausal women and older men. *Cochrane Database of Systematic Reviews*, (4).
84. Dadra, A., Aggarwal, S., Kumar, P., Kumar, V., Dibar, D. P., & Bhadada, S. K. (2019). High prevalence of vitamin D deficiency and osteoporosis in patients with fragility fractures of hip: A pilot study. *Journal of clinical orthopaedics and trauma, 10*(6), 1097-1100.
85. Han, J., Cho, Y., Jee, S., & Jo, S. (2020). Vitamin D levels in patients with low-energy hip fractures. *Hip & Pelvis, 32*(4), 192.
86. Jamal, A. B., Khan, M. N. H., & Sadiq, M. (2021). Intertrochanteric hip fractures and vitamin D deficiency; a significant association. *Journal of Ayub Medical College Abbottabad, 33*(2), 257-261.
87. Niikura, T., Oe, K., Sakai, Y., Iwakura, T., Fukui, T., Nishimoto, H., ... & Kuroda, R. (2019). Insufficiency and deficiency of vitamin D in elderly patients with fragility fractures of the hip in the Japanese population. *Journal of Orthopaedic Surgery, 27*(3), 2309499019877517.
88. Yao, P., Bennett, D., Mafham, M., Lin, X., Chen, Z., Armitage, J., & Clarke, R. (2019). Vitamin D and calcium for the prevention of fracture: a systematic review and meta-analysis. *JAMA network open, 2*(12), e1917789.
89. Manoj, P., Derwin, R., & George, S. (2023). What is the impact of daily oral supplementation of vitamin D3 (cholecalciferol) plus calcium on the incidence of hip fracture in older people? A systematic review and meta-analysis. *International journal of older people nursing, 18*(1), e12492.
90. Li, X., Zhao, Y., Cheng, L., Yan, C., Guo, D., Liang, Y., ... & Zhang, J. (2025). Postoperative osteoporosis therapy and risk of re-fracture in elderly patients with hip fractures: a multicenter retrospective cohort study. *Osteoporosis International,* 1-13.
91. Rudy, M. D., & Grant, P. J. (2024). The patient with hip fracture. *Medical Clinics, 108*(6), 1155-1169.
92. Shirsath, D. B. (2025). Evaluation of Vitamin D Status and Its Correlation with Functional Recovery after Fracture Fixation in Elderly Patients. *CME Journal Geriatric Medicine, 17,* 6-17.
93. Ren, J., Liu, M., Wang, B., Bai, C., Yang, K., Ma, X., ... & Li, X. (2026). Secondary fracture risk after hip fracture in older patients: an updated sex-specific systematic review and meta analysis with GRADE and PAF assessment. *Osteoporosis International,* 1-12.
94. Zhao, J., Cai, Q., Jiang, D., Wang, L., Chen, S., & Jia, W.

(2020). The associations of serum vitamin D and bone turnover markers with the type and severity of hip fractures in older women. *Clinical Interventions in Aging,* 1971-1978.
95. Ingstad, F., Solberg, L. B., Nordsletten, L., Thorsby, P. M., Hestnes, I., & Frihagen, F. (2021). Vitamin D status and complications, readmissions, and mortality after hip fracture. *Osteoporosis International, 32*(5), 873-881.
96. Hao, L., Carson, J. L., Schlussel, Y., Noveck, H., & Shapses, S. A. (2020). Vitamin D deficiency is associated with reduced mobility after hip fracture surgery: a prospective study. *The American journal of clinical nutrition, 112*(3), 613-618.
97. Jarusriwanna, A., Phusunti, S., Chotiyarnwong, P., & Unnanuntana, A. (2021). High-dose versus low-dose ergocalciferol for correcting hypovitaminosis D after fragility hip fracture: a randomized controlled trial. *BMC geriatrics, 21*(1), 72.
98. Mak, J. C., Mason, R. S., Klein, L., & Cameron, I. D. (2016). An initial loading-dose vitamin D versus placebo after hip fracture surgery: randomized trial. *BMC Musculoskeletal Disorders, 17*(1), 336.
99. Sprague, S., Slobogean, G. P., Bogoch, E., Petrisor, B., Garibaldi, A., O'Hara, N., ... & FAITH Investigators. (2017). Vitamin D use and health outcomes after surgery for hip fracture. *Orthopedics, 40*(5), e868-e875.
100. Sim, D. S., Tay, K., Howe, T. S., & Koh, S. B. J. (2021). Preoperative severe vitamin D deficiency is a significant independent risk factor for poorer functional outcome and quality of life 6 months after surgery for fragility hip fractures. *Osteoporosis International, 32*(11), 2217-2224.
101. Hao, L., Carson, J. L., Schlussel, Y., Noveck, H., & Shapses, S. A. (2020). Vitamin D deficiency is associated with reduced mobility after hip fracture surgery: a prospective study. *The American journal of clinical nutrition, 112*(3), 613-618.
102. Schultz, K., Maus, U., Brabant, T., Wergen, N., & Beyersdorf, C. (2022). Ernährungsaspekte bei Osteoporose. *Osteologie, 31*(03), 176-183.
103. Lynch, D. J., Romero, A., McFadden, J. P., Zeblisky, P., Liu, H., & Ang, D. (2025). Factors influencing postoperative inpatient rehabilitation requirement after surgical intervention for isolated hip fracture: a multicenter study. *Orthopaedic Surgery, 17*(1), 252-259.
104. Ben Natan, M., Finkel, B., Tal, Y., & Berkovich, Y. (2025). The association between levels of vitamin D and clinical outcomes following hip fracture surgery. *Irish Journal of Medical Science* (1971-), 1-6.
105. Singh, U., Tiwari, P., Singh, N., Kalia, G., & Brar, B. S. (2022). Vitamin D deficiency in proximal femur fractures: an observational, cross-sectional study. *Journal of Orthopaedic Diseases and Traumatology, 5*(3), 173-179.
106. Owczarek, B., Ziomkiewicz, A., & Łukowska-Chojnacka, E. (2024). Has a High Dose of Vitamin D3 Impacted Health Conditions in Older Adults?—A Systematic Review and Meta-Analysis Focusing on Dose 100,000 IU. *Nutrients, 16*(2), 252.
107. Li, L., Bennett-Brown, K., Morgan, C., & Dattani, R. (2020). Hip fractures. *British Journal of Hospital Medicine, 81*(8), 1-10.
108. Chevalley, T., Brandi, M. L., Cavalier, E., Harvey, N. C., Iolascon, G., Cooper, C., ... & Rizzoli, R. (2021). How can the orthopedic surgeon ensure optimal vitamin D status in patients operated for an osteoporotic fracture?. *Osteoporosis International, 32*(10), 1921-1935.
109. Wu, H., & Pang, Q. (2017). The effect of vitamin D and calcium supplementation on falls in older adults: A systematic review and meta-analysis. *Der Orthopäde, 46*(9), 729-736.
110. Gil, Á., Plaza-Diaz, J., & Mesa, M. D. (2018). Vitamin D: classic and novel actions. *Annals of Nutrition and Metabolism, 72*(2), 87-95.
111. Mattisson, L., Bojan, A., & Enocson, A. (2018). Epidemiology, treatment and mortality of trochanteric and subtrochanteric hip fractures: data from the Swedish fracture register. *BMC musculoskeletal disorders, 19*(1), 369.
112. Jinlawal, B., Chotiyarnwong, P., Vanitcharoenkul, E., Adulkasem, N., & Unnanuntana, A. (2026). Current practice and barriers in fragility hip fracture management: insights from a national survey of Thai orthopaedic surgeons. *BMC Health Services Research*.
113. Conley, R. B., Adib, G., Adler, R. A., Åkesson, K. E., Alexander, I. M., Amenta, K. C., ... & Kiel, D. P. (2020). Secondary fracture prevention: consensus clinical recommendations from a multistakeholder coalition. *Journal of bone and mineral research, 35*(1), 36-52.
114. Orces, C. H., & Gavilanez, E. L. (2017). Increasing hip fracture rates among older adults in Ecuador: analysis of the National Hospital Discharge System, 1999–2016. *Archives of Osteoporosis, 12*(1), 109.
115. Di Monaco, M., Castiglioni, C., Di Carlo, S., La Marmora, E., Filipovic, I., Milano, E., ... & Massazza, G. (2018). Classes of vitamin D status and functional outcome after hip fracture: a prospective, short-term study of 1350 inpatients. *European Journal of Physical and Rehabilitation Medicine, 55*(1), 56-62.
116. Nguyen, M. H., & Lui, S. K. (2020). Holistic management of older patients with hip fractures. *Orthopaedic Nursing, 39*(3), 183-191.
117. Mizuno, T., Tsukamoto, M., Teramoto, H., Hamasaki, T., Shirakawa, T., Nakagawa, T., ... & Okimoto, N. (2026). Trends of clinical vertebral and hip fractures following local government involvement in fracture prevention from 2015 to 2021 in Kure, Japan. *Osteoporosis International,* 1-11.
118. Ramírez-Martín, R., Castell Alcalá, M. V., Alarcón, T., Queipo, R., Ríos Germán, P. P., Otero Puime, Á., & González-Montalvo, J. I. (2017). Comprehensive geriatric assessment for identifying older people at risk of hip fracture: cross-sectional study with comparative group. *Family Practice, 34*(6), 679-684.
119. Jętasiewicz, I., Górski, S., Okupniarek, J., Bartosik, M., Oborski, M., Oborski, K., ... & Barczyńska, K. (2026).

Vitamin D in Injury Risk and Healing-A Comprehensive Review. *Journal of Education, Health and Sport, 87*, 67737-67737.

120. Yakabe, M., Hosoi, T., Matsumoto, S., Fujimori, K., Tamaki, J., Nakatoh, S., ... & Ogawa, S. (2023). Prescription of vitamin D was associated with a lower incidence of hip fractures. *Scientific Reports, 13*(1), 12889.
121. Kemah, B., Söylemez, M. S., Erinç, S., Özkan, K., & Poyanlı, O. Ş. (2026). Comparison of vitamin D, parathyroid hormone (PTH), and bone metabolism markers in hip fracture patients by fracture type and control group. *Ulus Travma Acil Cerrahi Derg, 32*(3), 367-373.
122. Reddy, B. A., Sreenath, M., Macherla, V. G., Vakati, S., & Gorla, V. K. R. (2025). Epidemiological Trends and Risk Factors of Hip Fractures in Elderly Patients: A Retrospective Study. *European Journal of Cardiovascular Medicine, 15*, 200-205.
123. Cuadra-Llopart, L., Salvà Casanovas, A., Cerdà Mas, G., & Jovell-Fernández, E. (2025). Efficacy of two calcifediol supplementation regimens in older adults post-hip fracture surgery. A clinical trial. *European Geriatric Medicine*, 1-11.
124. Zaman, M. S., & Ullah, M. I. (2025). Vitamin D and Fracture Healing. In *Vitamin D Function: From Mineral Ion Regulation to Infection* (pp. 103-113). Cham: Springer Nature Switzerland.
125. Balakrishnan, S., Vick, O., Mitchell, J., & McCluskey, H. (2025). 2868 Improving bone health: a quality improvement journey implementing Scottish hip fracture audit recommendations. *Age and Ageing, 54*(Supplement_1), afae277-023.
126. Tian, C., Shi, L., Wang, J., Zhou, J., Rui, C., Yin, Y., ... & Rui, Y. (2025). Global, regional, and national burdens of hip fractures in elderly individuals from 1990 to 2021 and predictions up to 2050: A systematic analysis of the Global Burden of Disease Study 2021. *Archives of gerontology and geriatrics, 133,* 105832.
127. Dawson-Hughes, B. (2024). Effect of vitamin D on risk of falls and fractures–the contribution of recent mega-trials. *Metabolism open, 23*, 100300.
128. Waterhouse, M., Ebeling, P. R., McLeod, D. S., English, D., Romero, B. D., Baxter, C., ... & Neale, R. E. (2023). The effect of monthly vitamin D supplementation on fractures: a tertiary outcome from the population-based, double-blind, randomised, placebo-controlled D-Health trial. *The lancet Diabetes & endocrinology, 11*(5), 324-332.
129. Ochiai, S., Nishida, Y., Higuchi, Y., Morita, D., Makida, K., Seki, T., ... & Imagama, S. (2021). Short-range UV-LED irradiation in postmenopausal osteoporosis using ovariectomized mice. *Scientific Reports, 11*(1), 7875.
130. Leland NE, Lekovitch C, Martínez J, ET AL. Optimizing post-acute care patient safety: a scoping review of multifactorial fall prevention interventions for older adults. J Appl Gerontol. 2022;41(10):2187-2196. 7.