

## Does Nutrition Impact Hip Fragility Fracture Risk and Outcomes? The Case of Malnutrition and Bone Health

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### Abstract

Hip fractures and their causative and reparative solutions remain suboptimal despite years of research. One potentially remedial as well as causative factor, namely poor or malnutrition, which has been studied for some time in various health contexts, still remains somewhat in question and is not truly integrated or translated into clinical preventive practices against hip fractures among the elderly. This mini review examines the degree of support for considering more concerted nutritional screening efforts, plus targeted nutritional programs among vulnerable older adults in an effort to offset the immense disability associated with the presence of osteoporosis and possible subsequent hip fragility fractures, whenever, and wherever they occur. Based largely on a five year literature analysis on this topic extending between 2018–2022, articles listed in the PUBMED database show little emphasis on securing nutrition as a hip fracture antecedent, yet imply more consideration of the value of nutrition based prevention approaches that provide for bone and muscle building in at risk individuals is likely to be valuable. Moreover, screening for malnutrition before and after hip fracture surgery may prove more beneficial than not in attempts to reduce the immense public health as well as personal impact and costs of one or more disabling hip fractures among the elderly, regardless of originating country.

## Background

As widely documented in recent years, hip fracture injuries continue to pose one of the most serious threats to optimal wellbeing among most aging populations, and remain a leading cause of excessive morbidity, and reduced life quality, as well as premature mortality, especially among those with chronic health conditions. While this condition has many antecedents, the presence of a hip fragility fracture may well be found in some cases to represent the downstream impact of any extended or limited availability of foods required to promote overall health in the aging adult as well as to provide for adequate energy levels, plus bone and muscle health, including their structural properties, and functional attributes. On the other hand, even if not a strong hip fracture antecedent, poor or suboptimal nutrition practices do appear to have a significant bearing on the degree and pace of recovery experienced post hip fracture injury and surgery among hip fracture survivors [1-4].

Yet, despite multiple efforts to stress the immense importance of averting all forms of malnutrition or under nutrition in the context of optimal health maintenance in later life, as well as with regard to bone health linked to the onset and pathogenesis and pathology of hip fragility fractures [eg., 5], the incorporation of these possible clinically relevant nutritional understandings, that may well impact primary as well as exacerbating secondary and tertiary hip fracture risk and disability, appears limited [6], and possibly understudied, even though this line of inquiry is highly recommended by some [1,2], albeit not all [7] and has ensued for over seven decades. As such, since the degree of suffering and mortality rates incurred post hip fracture have tended to remain unchanged over time [8], and may have increased inadvertently post COVID-19 [9], it was felt this topic might prove both timely as well valuable to explore further. Indeed, given the burgeoning aging populations across the globe, especially the likely rise of frail elders, those with sarcopenia, a health condition involving muscle and bone mass age associated declines, and those who are undernourished who already constitute one fifth of all community dwelling adults above 50 years of age [10] and who may be at high risk for sustaining a fragility fracture, but are unaware of their plight should be urgently targeted. In particular, a failure to detect and remediate any persistent state of protein malnutrition, which appears pervasive in the older adult population, may not only increase the risk for primary hip joint fragility fractures, but also for secondary fractures [12] due to its adverse impact on muscle weakness and osteoporosis—a bone disease characterized by low bone density and an impairment in micro-architecture [11,13,14], but malnutrition, which may predate a hip fracture injury may further impede recovery and rehabilitation processes post-hip fracture surgery, while increasing the length of hospital stays as well as mortality risk [15,16].

Since hip fractures continue to pose major degrees of costly outcomes as far as the individual and society are concerned, but malnourished hip fracture patients are still being undertreated [12], and malnutrition is often poorly examined, or deemed of negligible importance in the case of the hip fracture patient [17], even though pre-surgical malnutrition raises the risk for post-operative delirium in the older hip fracture patient [18], this mini review was designed to examine the status of the literature concerning a possible remediable influence of optimal food-based daily delivery of macro and micronutrients that can potentially offset osteoporosis and its influence on raising the risk of fracturing a hip [19], as well as on its impact on recovery among post surgical hip fracture survivors [20]. It specifically explores whether there is any prevailing

consensus as to whether more emphasis on nutrition supplementation, for example by making foods that impact bone and muscle health available to the 'at risk' older adult, sooner rather than later, is a possible hip fracture mitigation strategy that is underutilized.

To achieve the goals of this review, only the most recent research findings documented over the past five years, along with the overall science-based knowledge in this realm were sought. Simultaneously, we hoped to propose salient lines of endeavor for future research as well as for practice in this regard, including preventive practices against hip fragility fractures and primary or secondary osteoporosis that are often unduly costly and irreversible.

## Methods

To achieve the goals of this report, the present search strategy employed the search terms Hip Fracture and Malnutrition as applied to the **PUBMED** data base, the world's largest peer reviewed medical depository. To provide some clarity as to whether there is any current clinical evidence to support the idea that mal or under nutrition can either foster osteoporosis risk, as well as muscle weakness and wasting that are known hip fracture risk determinants, full length articles published between 2018 and 2022 that addressed these issues were specifically sought and examined. As well, those discussing the bone healing process, and value of sound nutrition published in the realm of the clinic rather than the laboratory, were deemed valid. In addition to stand alone full length research reports, systematic reviews were deemed acceptable. No abstracts or foreign non-English articles were accepted, along with those focusing on pharmacologic solutions, those that discussed malnutrition and dementia, diet and its inflammatory effects, plus the specific impact of various micronutrients on fracture status Analyzed, however were all modes of study that focused on the elderly and their vulnerability to hip fractures as a result of poor nutrition. The review does not examine any specific nutrient in isolation, nor malnutrition in diseases such as cardiovascular disease, kidney disease, and dementia—even if linked to hip fracture occurrences indirectly.

However, those articles deemed to refer to poor nutrition, under nutrition or malnutrition as related to hip fracture prevention and intervention were duly reviewed. Since this topic does not lend itself readily to controlled studies that might adequately support the above mentioned premises, this current discourse on nutrition and its possible relationship to preventing osteoporotic hip fractures, including their extent and ability to heal is presented in a descriptive format. However, by including the most up to date findings on this topic, plus an overview of prior work of nutrition in the context of bone health, a broad picture of the state of the art and possible clinical importance of regarding the overall topic as a worthy one to continue to research in the future was anticipated.

To convey the nature of this body of information, the discussion below first outlines some general findings, followed by some specific clinically relevant observations. It is possible some articles are not included, especially earlier salient articles, but it is believed this ensuing review examines almost all, if not all, currently relevant clinical studies and reviews on the topic of malnutrition and hip fractures as demonstrated between 2018-2022.

## Results

### General Observations

Although articles on hip fractures are numerous, and malnutrition as a broad concept, has long been studied in its own right in the context of geriatric care, the number of **PUBMED** articles published on this combined topic in the past five years of January 1, 2018-April 20, 2022 of 170 items was quite low given the 1106 citations listed for malnutrition and bone health reported over the same period. Moreover, even those articles listed as reporting on the combined topics of malnutrition and hip fractures, revealed a high percentage were not directly applicable to the current review, or discussed malnutrition in relation to dementia as a hip fracture precursor, or focused solely on vitamin D. It was also evident that almost none focused on the possible causative implications of malnutrition in mediating at least some degree of hip fracture injuries in older vulnerable adults, other than dementia, where bone attrition is often linked to poor calcium and vitamin D intakes. On the other hand, almost all focused on nutrition as a possible highly important outcome explanatory variable that needs to be uniformly addressed post hip fracture surgery. By contrast, the topic of malnutrition and frailty, while related to hip fragility fractures has received considerable attention, and shows 672 possible related hip fracture preventive articles, but few that discuss nutrition, frailty, and hip fracture risk collectively, even though studies in small hip fracture samples show malnutrition presence to range from 31-88 percent, especially in cases with low protein and vitamin D levels [21] and those with intra capsular hip fractures [22]. Other preventive topics more widely discussed are pharmacologic therapies for averting osteoporosis, the application of exercise to protect bone, the efficacy of hip protectors among the elderly, along with efforts to reduce falls fears, and the need for systematic medication reviews to mitigate falls risk. Most too detail secondary hip fracture prevention approaches, rather than primary approaches.

In terms of nutrition, most discussed are calcium and vitamin D although controversial, and despite the fact many nutrients appear essential for bone health and formation across the lifespan including an adequate and constant supply of protein, magnesium, phosphorus, potassium, and fluoride. In addition, there are several other bioactive compounds, macronutrients, micronutrients, vitamins and minerals that appear to foster an array of metabolic processes related to bone, including manganese, copper, boron, iron, zinc, vitamin A, vitamin K, vitamin C, and the B vitamins [23], even though the evidence base varies from firm to scant [24,25].

### Specific Research Observations

As extracted from the **PUBMED** database evaluating nutritional aspects in older adults at risk for a hip fragility fracture as reported over the past five years, it appears most researchers tend to agree that older adults hospitalized for hip fractures do often present with signs of an inadequate nutrient intake for their requirements. In addition, most authors agree the presence of poor nutrition appears to foster or contribute to an undesirable deterioration of their already compromised health status [25]. Frailty indicators possibly resulting from poor nutrition are also commonly observed to be associated with a higher prevalence of surgical complications during periods of hospitalization and with a worse functional prognosis and an increased risk of mortality among numerous older adults. Actively planned and duly implemented nutritional interventions on the other hand appear associated with an improved nutritional status and a greater chance

of preventing or reversing a state of sarcopenia [26], plus the likelihood of fostering more optimal levels of functional recovery following a hip fracture [27]. This is important because research shows malnutrition leading to sarcopenia predicts osteoporotic fractures, as well retarding early post-operative mobilization processes associated with possible increases in short and long-term mortality rates among older adults, as well as a diminished life quality among survivors who have sustained a hip fracture [28-30].

However, according to Merloz *et al.* [31] even though hip fractures in the elderly may be deemed to not only be serious life-threatening events in the medium-to-long term, they appear to be impacted unfavorably in the current period by suboptimal extrinsic efforts to secure adequate intake of protein nutrients and with this a possible trend towards bone demineralization and a risk of incurring sarcopenia, even though this was pointed out as requiring attention in 2004 by Spanish group of researchers [32]. Mortality too may ensue prematurely in the presence of persistent pre existing [22] under-nutrition or signs of this post hip fracture surgery [1]. By contrast, a carefully construed and comprehensive care program that involves desirable nutrition approaches-as indicated-may not only help to reduce post hip fracture suffering and premature mortality rates, but readmissions due to complications or subsequent fractures, as well as excess functional declines that can foster unwanted or excess bone demineralization, and muscle weakness, major causes of hip and other bone fractures [14]. Thus even though Nishioka *et al.* [33] concluded that advanced nutritional care during the hip fracture rehabilitation period has dubious or weak possible effects, more research on nutritional support directed towards clarifying this issue may yet prevent or mitigate some degree of otherwise probable hip fracture risk and ensuing disability [14], as well as helping to minimize wound healing complications and poor postoperative functional recovery outcomes post hip fracture [11], while lowering the risk of premature morbidity as well as mortality [34]. Poor nutrition alone, such as that where a vitamin D deficiency may prevail [35] is also found to increase one year post hip fracture mortality rates, while the close relationship between protein intake and muscle maintenance and possible skeletal muscle weakness, an independent risk factor for falls and fall-related injuries in the elderly, is also an independent marker of post operative hip fracture surgery prognosis and is one showing practitioners should not overlook this [30]. In addition, as per Bell *et al.* [36] hip fracture patients who are both overweight or obese, and malnourished, have significantly and substantially worse clinical outcomes than their well-nourished, albeit overweight or obese, counterparts, thus this subgroup should not be excluded from any routine screening practices. To ensure appropriate clinical nutrition care is appropriately directed, it is possible that comprehensive nutrition assessment measures should be applied to all hip fracture inpatients.

As per Groenendijk *et al.* [37] who conducted a cross-sectional study that enrolled 40 hip fracture patients (mean  $\pm$  SD age  $82 \pm 8.0$  years) from geriatric rehabilitation wards of two nursing homes in the Netherlands, malnutrition or the risk thereof was present in 73% of the study participants. These deficiencies were diverse and included protein, intakes that were significantly below the recommendations, while saturated fat was significantly above the recommended limit. Micronutrients, including the mean intakes of calcium, vitamin D, potassium, magnesium and selenium were significantly below those recommended. The prevalence of low muscle mass, low handgrip strength and sarcopenia were common in a sizeable number of these older hip fracture patients.

Indeed, even if the elderly hip fracture patient is considered to be adequately nourished, examining the individual's nutritional status routinely and objectively may reveal deficits that are not immediately observable,

but are noteworthy, and require prompt strategies in any effort aiming to overcome the possible adverse impact of any prevailing poor peri-operative nutritional status and intake. At the same time, efforts to provide appropriate nutritional supplementation, as indicated, before surgery among the vulnerable and growing older frail adult population appears to have considerable merit [34,38]. Wilson *et al.* [39] concluded that when a hip fracture patient is frail and malnourished, which appears to be more common than not [40], there is an elevated risk beyond that of frailty or malnutrition in isolation, especially if this affects post operative recovery and induces an unanticipated negative situation for the patient who requires further hospitalization. This high-risk cohort can however, be easily identified at admission with routine clinical observations, medical records, measures of weight status, laboratory values and clinical history, and their identification offers a probable substantive opportunity to improve outcomes among the frail hip fracture patient because malnutrition represents a potentially modifiable risk factor in this regard.

As per Wong *et al* [41] who studied 172 Singaporean hip fracture patients prospectively after surgery this group found malnutrition was present in more than half their postoperative hip fracture patients. This study specifically showed that poor nutritional status is associated with significantly lower rehabilitation efficiency and functional outcome on discharge of the hip fracture patient, and that given the medical, social and economic stakes relating to hip fractures, it is essential to recognize and treat malnutrition both in the hospital as well as in the community.

In their study, Yoo *et al.* [42] who examined 327 elderly patients with hip fractures, showed that of these 327 patients with hip fractures (78 men and 249 women), the prevalence of sarcopenia was 60.3% and 30.1% in men and women, respectively. The rates of three indicators of malnutrition in men and women (low BMI, hypoalbuminemia, and hypoproteinemia) in sarcopenia patients with hip fractures were 23.4%, 31.9%, and 53.2% and 21.3%, 21.3%, and 37.3%, respectively. The prevalence of markers of chronic inflammation (increased CRP and ESR) in men and women with sarcopenia and hip fractures were 74.9% and 52.2%, and 49.3% and 85.1%, respectively. After adjusting for covariates, low body mass index and hypoproteinemia in women were associated with a 2.9- and 2.1-fold greater risk of sarcopenia than non-sarcopenia, cohorts respectively. It was concluded that there appears to be a strong relationship between the presence of sarcopenia and evidence of co-existing malnutrition as well as chronic inflammatory factors among elderly hip fracture cases, especially those who have sustained femoral neck fractures [43].

This should probably not be surprising for as demonstrated by Choi *et al.* [44] an insufficient protein intake is a common occurrence among the older hip fracture patient population. In particular, the presence of a lower than desirable protein intake, found significantly associated with a lowered muscle strength capacity can possibly add to the dangers of falling and sustaining a traumatic hip fracture. Moreover, according to Yocoyama *et al.* [45] a persistently poor nutritional status not only affects walking ability, and hence the probable risk of incurring an injurious fall, but also the systemic wellbeing of many older adults who go onto sustaining a femoral neck fracture. At the same time; when coupled with a vitamin D deficiency [which may reflect lack of sunlight exposure, rather than food intake], a persistent state of malnutrition raises the one year mortality risk post hip fracture surgery quite markedly [47].

By contrast, timely screening and nutritional interventions delivered as indicated may help to shorten the rehabilitation period, reduce post hip fracture injurious falls risk, secondary fractures, and excess mortality

rates [46]. As discussed by Yocoyama *et al.* [45] the application of a Geriatric Nutritional Risk Index, a measure of nutritional status may be quite helpful in this regard as it appears to effectively predict postoperative complications, including mortality, and the quality of gait function of a surviving hip fracture patient. Moreover, parallel research shows the presence of an increasing state of hypoalbuminemia will likely yield poorer outcomes for up to 30 days post hip fracture surgery [48,49] as well as being a powerful independent risk factor for mortality following geriatric hip fracture surgery [50], along with an increased risk of post-operative complications, such as pressure sores, and others that may lead to having a low body weight, muscle fatigue, cognitive dysfunction, or being discharged to a residence other than a community based independent dwelling site, and a lower than desired overall life quality among survivors in the long-term [3,51,52].

These facts are not merely academic, because additional work has further shown that a combination of a low protein intake along with a vitamin D deficiency is the rule rather than the exception among the older acute hip fracture patient population [21]. At the same time, protein-energy malnutrition as well as the presence of sarcopenia are common in those elderly who sustain fragility hip fractures. In addition, those acute hip fracture cases exhibiting a low serum albumin level are predicted to have an increased risk of dying in the hospital, as well as a higher risk of postoperative complications if they survive. As classified by the instrument known as the Mini Nutritional Assessment Survey malnutrition does appear to independently predict increased mortality at one year [53,54], while an inadequate dietary intake, plus a reduced serum albumin level, and having a lower than desirable body and soft tissue mass raises the risk for subsequent hip fractures [55], as well as pressure ulcers [56]. By contrast, following up the vulnerable older adult in a timely way and securing for them any appropriate nutritional requirements may not only help to minimize or avert a state of malnutrition, a frequent finding in the older hip fracture population, but can be expected to improve their ability to recover optimally following a hip fracture [2].

## Discussion

Hip fractures especially those attributable to frailty remain highly common debilitating occurrences among older individuals in all parts of the world. They are hence the targets of multiple research endeavors plus efforts to develop efficacious preventive and intervention approaches to counter this enormous age-associated health challenge. However, as with multiple lines of research being conducted in various aging contexts, neither preventive nor clinically oriented -research endeavors have put forth confirmatory conclusions over time as to what works consistently to avert hip fragility fractures and their consequences. At the same time, many attempts at multiple intervention approaches have yielded possible conflicting conclusions or no effects [56]. This is possibly surprising given an almost uniform body of literature that reveals many foods are likely to prove influential in multiple health respects, especially if deficient and in the realm of malnutrition, which is commonly cited to be a highly prevalent state among many in the geriatric population, including those who have sustained one or more hip fracture injuries [22]. Nevertheless, the importance of good nourishment versus poor nourishment is difficult to assess, as is the concept of nutrition and its implications for bone health in aging adults, which is not widely researched nor discussed in all instances. On the other hand, a substantive evidence base indicates suboptimal nutrition in the form of calcium alone is one possible highly salient hip fracture predictor, among many, as well as an significant outcome variable and mortality

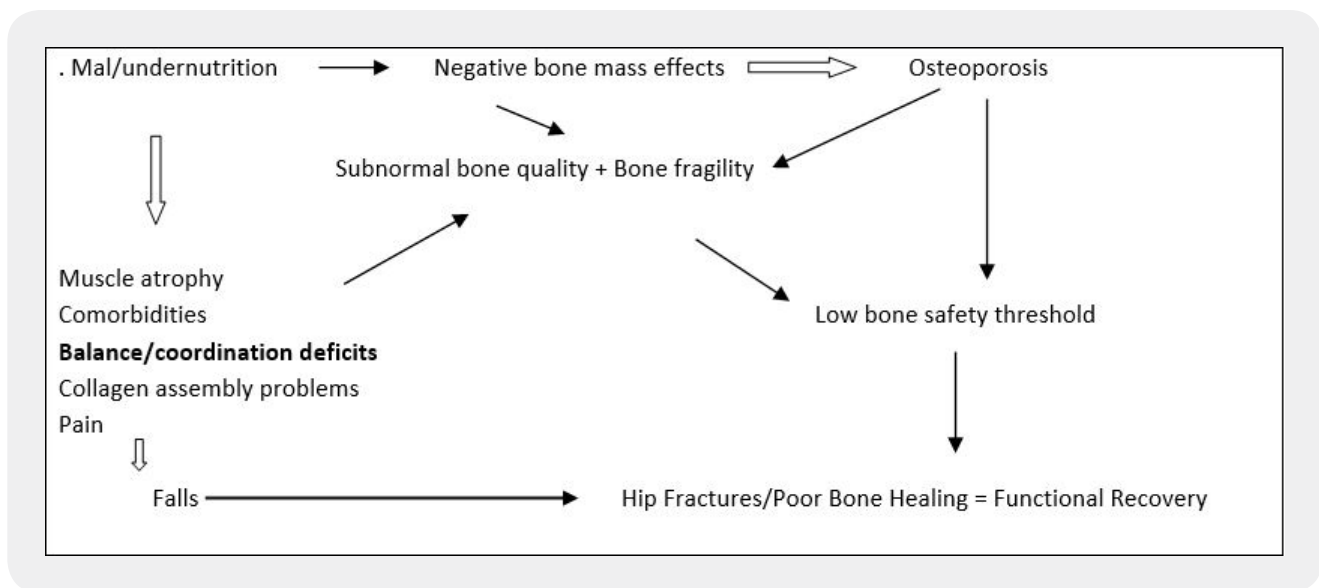
indicator or determinant in older persons with a hip fracture diagnosis who may already have an osteoporosis diagnosis.

Indeed, since multiple foods and nutrients that may foster bone and muscle health including, but not limited to foods containing calcium, vitamin D and vitamin K [5] are likely to be noteworthy in this respect, incorporating nutritional recommendations into basic preventive programs against hip fractures on a routine basis especially for the 'at risk' older adult, even if not likely to be completely successful [6], or to explicitly serve as a functional predictor [57], may yet help to ensure vulnerable older adults do not suffer unduly from a strictly modifiable health determinant that may conceivably do more good than harm, especially when compared to certain risky pharmacologic bone building approaches that may not impact muscle directly [13].

However, even though one can safely say most current researchers do not refute this idea, since there is little robust practical evidence to validate this approach [56], almost all call for more rigorous study and the application of randomized controlled trials to examine malnutrition hip fracture associations observed largely in observational contexts. In the interim, efforts to examine if food intake, especially a lack of adequate nutrients can impact bone and muscle health do tend to show those in the geriatric population who are undernourished may be at higher risk than those who have adequate nutrition. Moreover, older adults undergoing hip fracture surgery tend to recover more slowly if malnourished when compared to those who are optimally nourished, all factors considered [2].

In the interim, while more research to examine nutrition fracture risk effects in the older adult population appears warranted and is likely to prove insightful and clinically valuable, and could have far reaching public health implications, one has to consider whether it is currently best to deny vulnerable older adults or those who have sustained a fragility hip fracture the possible benefits of adequate nutrition and in light of all the plausible roles foods do play in the maintenance of optimal health. In addition, can one design a randomized trial—ethically speaking—where the elderly are denied a possible basic life affirming supplement or comprehensive nutritional intervention in the event this is needed, while controlling for all possible covariates and test instruments that have not yet been agreed upon as proposed by Luo *et al.* [58] and Malmir *et al.* [59]. On the other hand, will this delayed approach be scientifically sound given multiple observations that tend to affirm malnourished hip fracture patients will likely need to spend more time in hospital if they do not receive required nutritional intervention [58], as well as experiencing possible preventable surgical complications [17,60]. In addition, ample data do appear to implicate a role for adequate nutrition in the development and maintenance of bone across the lifespan as noted in preclinical as well as clinical studies, and by analogy, the prevention of hip fragility fractures [61] that might need to be specifically addressed in the realm of food security in early as well as in later life. Moreover, more thoughtful attention especially as regards the assessment and treatment of under nutrition appears recommended [62]. As conceptualized in Figure 1 and in light of the foregoing arguments, it is probable that careful study of one or more of these envisioned linkages in different subgroups and across more diverse communities and durations may yet prove clinically relevant.





**Figure 1:** Schematic Highlighting Impact of Poor Nutrition on Hip fracture Occurrences in Later Life [12,63–66]

Moreover, we would like to advocate for more study of the specific role of optimal nutrition in childhood and adolescence as this may impact later life bone health, a topic rarely alluded to in any current study context. In particular, more work on defining the parameters of malnutrition across the lifespan, alongside the development of sensitive tools that can be used routinely to capture relevant aspects of this state may enable more accurate identification of the undernourished vulnerable individual, sooner rather than later or overlooking them entirely, especially those ‘at risk’ adults who may readily succumb otherwise to overwhelming personal and economic hip fracture injuries and their disabling outcome costs [68]. The role of compliance in the context of nutrition therapy or supplementation should also receive more careful attention in comparative as well as longitudinal studies [69].

In the meantime, even after examining 1431 studies that discussed nutrition and hip fractures [70], and despite the fact nutritional therapy appeared to produce a significant reduction in mortality and post-operative hip fracture surgery complications, while improving grip strength, the effects of nutritional therapy on activities of daily living, life quality, and knee extension strength among this patient population remains in question. In addition to that, the majority of the reviewed studies were deemed to be of low quality.

Those older adults who are most vulnerable to this aforementioned envisioned adverse cycle of events in Figure 1 and who might be targeted preferentially in any preventive approach are: 1) older women, 2) those with food security challenges, 3) those who are depressed, 4) those with cognitive challenges, 5) those with osteoporosis, 6) those with a history of fragility hip fractures, 7) those with comorbid health challenges, and 8) those with a falls and osteopenic history [67].

## Conclusion

From a detailed review of current literature we conclude that:

1. Nutrition, an important factor in securing optimal bone health across the lifespan, is a possible overlooked factor in the realm of many hip fracture preventive approaches, as well as post hip fracture rehabilitation outcomes and approaches.
2. Efforts to secure and ensure the delivery of bone building essential daily nutrients among the aging adult population, as well among those older adults who sustain hip fractures, which are rarely stressed in the hip fracture literature, will yield multiple health and cost benefits, while alleviating suffering and the high chances of a low life quality or premature death.
3. Until more concerted dedicated research efforts emerge to consolidate this literature, it appears hip fragility fractures will remain costly public health challenges, as well as impacting the social and economic lives of many older adults immensely and irrevocably, if they survive hip fracture surgery or injuries, and their nutrient requirements are overlooked.
4. Routine screening efforts, validated assessment tools, and individualized follow up interventions as needed appear promising, regardless of the need to build a stronger evidence base-if the aim of geriatric care is to do 'no harm'.
5. To clearly arrive at clinical practice guidelines in this regard, more attention to examining the multiple independent and interactive linkages that appear to prevail between malnutrition and hip fracture risk not only in controlled designs, but through single case studies, and careful retrospective analyses are advocated, so that a reversible hip fracture disability antecedent is not discarded un insightfully and irrevocably.

In sum, in the interim, and in parallel with future research efforts, clinicians are urged to approach the issue of under nutrition judiciously so that vulnerable older adults do not suffer unduly, especially those who do sustain one or more hip fractures and who are quite likely to exhibit nutritional deficits pre and post surgery if they survive.

To specifically advance this line of inquiry, clinicians as well as hospitals may also advance this cause quite significantly by keeping track of their older adults nutritional status over time, especially among those deemed vulnerable to hip fractures as well as those with prevailing acute fracture injuries undergoing surgery.

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