Chapter 12
Geriatric Hip Fracture Care in Low- and Middle-Income Countries

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Introduction

The scope of this chapter is the epidemiology, management, and outcomes of geriatric hip fractures in low- and middle-income countries (LMICs). We define LMICs as those with World Bank designations of low, lower-middle, and upper-middle income, based on per capita gross national income (GNI) (Table 12.1) [1]. As a result of the aging global population, geriatric hip fractures have become increasingly common throughout the world and are anticipated to reach an estimated annual global incidence of 4.5 million in 2050 [2]. World Health Organization (WHO) estimations project that by 2050, 80% of the global elderly population will reside in LMICs [3]. With this increase in age comes increased incidence and burden of hip fractures. In addition to advanced age, risk factors for geriatric hip fracture include female gender, frailty, fragility, and prior fracture. Orthogeriatric co-management and early surgery can be difficult to accomplish in low-resource settings, but they have been shown to improve geriatric hip fracture outcomes. Barriers to surgery persist in LMICs, and non-operative treatment results in inferior outcomes and increased mortality. The literature on geriatric hip fracture management in LMICs is scarce but highlights efforts to minimize delays to surgery and improve access to affordable implants. International organizations have put forth guidelines and support networks to facilitate efforts to minimize complications,

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N. C. Danford et al. (eds.), *Geriatric Hip Fractures*,
https://doi.org/10.1007/978-3-030-78969-5_12

Table 12.1 World Bank 2021 classification of low-income, lower-middle income, and upper-middle income countries based on per capita GNI and subcategorized by region. (Created by authors with data from: World Bank Country and Lending Groups [Internet] [1])

Low income	Lower middle income	Upper middle income
East Asia and Pacific		
Korea, Dem. People's Rep.	Cambodia, Kiribati, Lao PDR, Micronesia, Mongolia, Myanmar, Papua New Guinea, the Philippines, Solomon Islands, Timor-Leste, Vanuatu, Vietnam	American Samoa, China, Fiji, Indonesia, Malaysia, Marshall Islands, Samoa, Thailand, Tonga, Tuvalu
Europe, and Central Asia		
Tajikistan	Kyrgyz Republic, Moldova, Ukraine, Uzbekistan	Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Georgia, Kazakhstan, Kosovo, Montenegro, North Macedonia, Russian Federation, Serbia, Turkey, Turkmenistan
Latin America and Caribbean		
Haiti	Bolivia, El Salvador, Honduras, Nicaragua	Argentina, Belize, Brazil, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, Grenada, Guatemala, Guyana, Jamaica, Mexico, Paraguay, Peru, St. Lucia, St. Vincent and the Grenadines, Suriname, Venezuela
Middle East and North Africa		
Syrian Arab Republic, Yemen	Algeria, Djibouti, Egypt, Morocco, Tunisia, West Bank and Gaza	Iran, Islamic Rep., Iraq, Jordan, Lebanon, Libya
South Asia		
Afghanistan	Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka	Maldives
Sub-Saharan Africa		
Burkina Faso, Burundi, Central African Republic, Chad, Dem. Rep. Congo, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Rwanda, Sierra Leone, Somalia, South Sudan, Sudan, Togo, Uganda	Angola, Benin, Cabo Verde, Cameroon, Comoros, Congo, Côte d'Ivoire, Eswatini, Ghana, Kenya, Lesotho, Mauritania, Nigeria, São Tomé and Principe, Senegal, Tanzania, Zambia, Zimbabwe	Botswana, Equatorial Guinea, Gabon, Namibia, South Africa

prevent future falls, and achieve early mobilization. Geriatric hip fractures in LMICs present an opportunity to improve patient outcomes by investing in healthcare systems, education, and research.

Epidemiology

The Hip Fracture Epidemic: Aging Populations in LMICs

As the world's population ages, the incidence of geriatric hip fractures is anticipated to increase and shift from primarily impacting high-latitude, high-income countries (HICs) to disproportionately affecting LMICs. Throughout the world, there has been a trend toward increased life expectancy, which has, in turn, increased the incidences of geriatric illness and injuries faced by countries across the globe. Geriatric hip fractures represent a major source of global morbidity and mortality, more so than nearly any other age-related or osteoporotic injury [2]. As the burden of geriatric hip fractures shifts to lower resourced regions, a global effort must be made to better understand these trends and more effectively meet the needs of our global elderly population.

Estimates suggest that, worldwide, the number of people over 80 years of age will increase from 143 million in 2019 to 426 million in 2050 and 881 million by 2100 [2]. LMICs will have a more significant shift in their population pyramid as life expectancy improves more substantially in these regions compared to HICs, which have already made this transition. In 2019, 38% of the population over 80 years of age lived in Europe and North America, regions with a high proportion of HICs. This number is anticipated to decline to 26% in 2050 and 17% in 2100 as the population in LMICs ages due to advances leading to increased life expectancy [4]. On the other hand, the number of hip fractures in Asia will have more than doubled by 2050, accounting for nearly 50% of the world's hip fractures [5].

As these epidemiological transitions occur in Asia, Africa, and Latin America, particularly in the LMICs, the aging population will be accompanied with an increased prevalence of osteoporosis [6–8]. As a result, the largest growth in hip fracture incidence is expected to occur in these three continents, resulting in a high fracture burden that will have significant economic and social impacts. For example, among Asian Federation of Osteoporosis Societies (AFOS) countries, about half of which are classified as low- or middle–income countries, there is expected to be a 2.28-fold increase in hip fractures by 2050 as compared to 2018. China and India are expected to account for 79% of the total increase [5]. In Latin America, there is expected to be a 700% increase in hip fractures in individuals aged 65 or older [8]. Data from Mexico specifically estimated a fivefold increase in the number of hip fractures from 2005 to 2050, but this estimate likely underestimates the growth [9]. The projections in the literature are limited in their ability to provide a comprehensive understanding of the current and future burden of hip fractures in low- and

middle-income countries, largely due to the lack of data from these countries and inconsistent methodology across studies.

Global Burden of Disease: Death and Disability

Globally, musculoskeletal injury led to more loss of productivity and life, as measured by disability adjusted life years (DALYs), than HIV, tuberculosis, and malaria combined, which are the better funded and more publicized global health initiatives [10]. Though the Global Burden of Disease (GBD) studies conducted by the World Health Organization (WHO) do not specify hip fractures within their illness and injury classification system, an analysis of DALYs attributable to falls in the population over age 70 provides an overview of the general trends (Fig. 12.1). Due to their large populations, the loss of productive years of life attributed to geriatric falls in India and China vastly outweighs that of much of the rest of the world. There have been suggestions that even this may be an underestimate of the true impact of fall-associated disability in these regions. The global assessment of DALYs does not adequately capture regional variations in societal burden, not only by the injury in isolation but also in the context of the local environment. For instance, a hip fracture in a region without

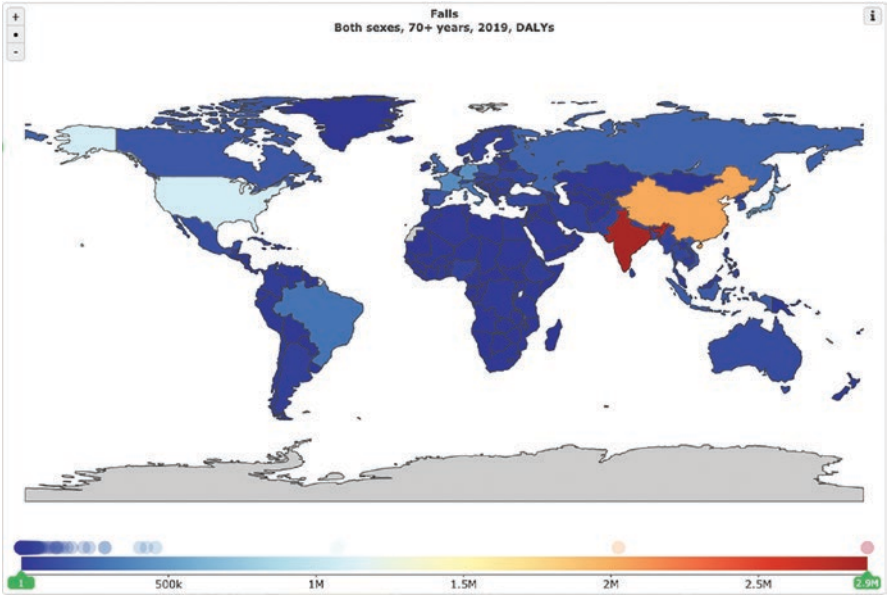

Fig. 12.1 Global number of disability adjusted life years (DALYs) attributed to falls in the elderly (>70 years of age)
China and India account for a disproportionate number of global DALYs attributed to falls in the elderly. (Reprinted with permission from: Institute for Health Metrics and Evaluation (IHME) [70])

wheelchairs, elevators, or paved surfaces may render an elderly patient completely homebound, while the same injury in a region with this infrastructure may be much less debilitating. Regional estimates of disability may provide more accurate assessments of the true impact of geriatric hip fractures, as they can better account for the impact of culture, infrastructure, and social support on the recovery process.

The individual factors affecting disability and quality of life (QOL) after hip fracture likely vary widely both across and within countries. QOL is impacted by injury factors, individual patient factors, and regional or societal factors. Hlaing et al. 2020 demonstrated that in Myanmar, the functional limitations following hip fracture led to a greater loss of QOL in women, who had less social support as a consequence of their gender [11]. Amphansap et al. in 2018 demonstrated that in Thailand, the initial sharp decline in QOL seen after hip fracture was diminished by nutritional supplementation and early surgery [12]. The duration of reduced QOL after hip fracture also varies on both individual and regional levels. While QOL in the patient population in the previously mentioned Thai study did not return to baseline a full year after injury, patients in a study out of Mexico showed similar initial reductions in QOL but that had nearly returned to baseline by 1 year [9].

Increased research is needed to understand the factors impacting hip fracture–related disability and QOL in LMICs in order to better understand and mitigate the long-term detrimental individual and societal impacts of hip fracture.

Economic Impact: Direct and Indirect, Individual and Societal

The direct and indirect economic impact of geriatric hip fractures can be felt on both individual and societal levels. Societal costs consider the economic burden to the country or region as a whole and are significantly impacted by the disability and death caused by geriatric hip fractures. Both direct costs of treatment and indirect costs related to lost productivity vary substantially across healthcare systems, countries, and cultures. Assessing indirect and societal costs is especially important in LMICs, where hip fracture patients are presenting at younger ages and living in cultures and economies that support or require work into the later years of life. The evaluations that go into assessing the economic burden attributed to geriatric hip fractures in HICs do not necessarily translate directly to evaluating those in LMICs.

The direct costs of hospitalization, surgery, and rehabilitation in LMICs may differ significantly from those seen in HICs. These costs are significant; for example, the expected increase in hip fractures in Latin America is projected to have a direct cost of 13 billion USD [8]. Within a single country, direct costs can vary widely across health systems and insurance models. It has been estimated that nearly 80% of the populations of low-income countries have no form of health care insurance [13]. As a consequence, prior to receiving treatment in many LMICs, hip fracture patients' families may be expected to purchase surgical supplies, including expensive implants, sutures, surgical gloves, fluids, and antibiotics [14]. This can lead to delayed surgery, longer hospital stays, and worse outcomes, which consequently

increase the indirect cost felt by the patient and their support system. Even in settings where public or private health insurance systems are in place to reduce the individual financial burden, residual direct costs, and subsequent indirect costs can be devastating to patients and their families.

Indirect costs are not due to medical management of a disease specifically, but rather due to the lost wages, lost productivity, and additional costs patients would not otherwise experience. Missed days of work, both pre- and postoperative, can add to the financial burden, especially for those who work in agriculture or the informal sector. Families in LMICs struggle to cover non-medical costs, such as transportation and food, which can further the burden of hospitalization [14]. Many estimates of hip fracture costs focus primarily on direct medical costs, despite the magnitude of these indirect costs. A model that considers both direct and indirect costs of hip fractures in Turkey estimated the 2019 burden to be 455 million USD. The projected 5-year burden was estimated to be 2.42 billion USD, with 23% of the costs coming from patient productivity losses [15]. While there is clear evidence that hip fractures are a significant financial burden on individuals and society, the data quantifying the burden of geriatric hip fractures in LMICs is still limited and warrants further investigation.

Risk Factors

Non-modifiable Factors: Age and Sex

The risk factors for hip fractures in high-income countries are well understood and overlap with those seen in LMICs. Two significant non-modifiable patient factors include age and gender. Hip fractures disproportionately affect women, who tend to have longer life expectancies and lower bone mineral density (BMD) after menopause. Though estimates vary significantly throughout the world, it has been estimated that roughly three-quarters of elderly individuals suffering from hip fractures are women. For instance, in the São Paulo, Brazil Ageing and Health (SPAH) study, the age-standardized incidence of hip fractures was 421.2/100,000 person-years in women and 89.9/100,000 in men [16]. While in Sri Lanka, women accounted for 79% of crude hip fracture rates, with an incidence of 132.2/100,000 and 35.3/100,000 person-years in women and men, respectively [6]. The difference in elderly hip fracture incidence by gender is significant throughout most of the world and has been shown to widen with advancing age.

An exception to this otherwise universal trend can be seen in some local studies and may be a consequence of study design or social factors, leading to the underrepresentation of women. For example, some hospital-based studies in India have shown higher rates of hip fracture among men, who also tend to present at younger ages [17]. This divergence from the global trend may be a consequence of increased use of alcohol in men or an increased unmet need in women. Studies that calculate hip fracture incidence from hospital admissions or surgical intervention miss the

portions of the population that never make it to the hospital or operating room. Accurately capturing the unmet surgical need of vulnerable populations in LMICs represents a major area of focus for future research and investment.

Modifiable Risks: Fragility, Frailty, and Falls

Modifiable patient factors are those that may be targeted by interventions in at-risk populations. Addressing these modifiable risk factors can drastically reduce the risk of hip fracture. The major modifiable risk factors for geriatric hip fractures are fragility (low bone mineral density/osteopenia/osteoporosis/prior fractures), frailty (poor nutrition and overall health), and susceptibility to falls.

Bone mineral density (BMD) decreases with age and low BMD has been shown to be associated with increased risk of hip fracture [16]. Osteopenia and osteoporosis are relative measures of BMD, defined by T-scores of −1 to −2.5 and <−2.5, respectively, with the T-score comparing BMD to that of a healthy young adult. In Brazil, decreased total hip BMD in the elderly has been shown to be predictive (RR 1.56, 95% CI 1.21–2.01) of non-vertebral fragility fractures, including hip fractures [16]. Bone mineral density in the geriatric populations of LMICs can be affected by a number of factors, including nutrition, medication use, and comorbid conditions.

Patients at risk of sustaining an osteoprotic hip fracture can be identified using country-specific FRAX models, which are based on clinical risk factors and BMD. In regions without access to densitometry, clinical risk factors alone can be used to predict fracture risk based on epidemiologic data. While this could potentially be a powerful tool in countries with limited resources, it relies on data that may be incomplete or absent. In LMICs that lack epidemiologic hip fracture data, the application of fracture rates from Sweden or other HICs with complete data thought to be representative of the population have been implemented [18]. It is hard to determine whether the method of using a surrogate population is an effective technique for estimating fracture risk in the absence of data. In LMICs that have some epidemiologic data, FRAX models may be constructed from local studies with geographic variability, low sample size, incomplete capture of cases, or short follow-up [16]. Studies on osteoporotic hip fracture epidemiology and risk factors in LMICs are needed to better understand, predict, and prevent geriatric hip fractures.

Both general nutritional and specific vitamin D deficiencies have been shown to be associated with increased risk of hip fractures. Vitamin D is a fat-soluble vitamin obtained through diet and exposure to sunlight. At present, hip fractures are more prevalent in higher latitude countries, further from the equator and direct sunlight. In China, research showed populations at higher latitudes were at increased risk of fracture, an association likely secondary to hypovitaminosis D [19]. While in Brazil, a country located mostly south of the equator, the southern regions, furthest from the equator, had the highest incidence of geriatric hip fracture [16]. However, even in regions with plentiful sunlight, hypovitaminosis D can be significant and is associated with hip fracture. A recent study in Thailand found that vitamin D deficiency

(<20 ng/mL) and insufficiency (20–30 ng/mL) were common, occurring in 46.3% and 32.1% of elderly hip fracture patients, respectively [20]. Similarly, in Myanmar, mean serum vitamin D was found to be significantly decreased in the older population [11]. In LMICs, where there is adequate daily sun, recommendations can be made to patients to get outside daily, especially elderly individuals recovering from hip fracture, who may not otherwise leave their homes. Dietary recommendations and vitamin D supplementation can be pursued in regions or for individuals where this is not an option.

Generalized nutritional deficiency is a significant risk factor for a fragility hip fracture and poor outcome after hip fracture surgery [21]. Inadequate nutrition contributes to anemia and frailty in the elderly, especially in countries with diminished food security [22]. Low body mass index (BMI) and associated malnutrition can be a significant problem in the elderly. This may be especially true in LMICs, where higher rates of poverty limit the ability to address nutritional needs. Targeted nutritional interventions are needed to address this risk factor, as elderly individuals may be unable to obtain adequate nutrition without family, community, or social support. Research in Thailand demonstrates that nutritional supplementation can blunt the initial sharp decline in quality of life after hip fracture [12].

With obesity on the rise throughout the world, the problems of malnutrition and fragility are not only found in patients with low BMI but also in those with obesity and diabetes. Diabetes has also increased the problem of end-stage renal disease (ESRD) and associated low bone mineral density. Research in Palestine has shown that 42.8% of ESRD patients had osteoporosis and 40.2% had osteopenia, with increasing incidence in those >60 years of age [23]. This puts those with ESRD at increased risk for hip fracture unless osteoporosis and osteopenia are addressed. Endocrine workups and long-term primary care follow-up for these patients should include nutritional optimization, treatment of low bone mineral density, and education on hip fracture risk reduction. Improving access to primary care in LMICs can reduce the impact of medical comorbidities, and public health campaigns can improve health literacy to improve nutrition, reduce chronic illness, and decrease the risk of hip fracture.

Elderly patients throughout the world experience physiologic changes that place them at increased risk of falling. Accumulation of medical comorbidities with age often results in increased use of prescription medications in the geriatric populations throughout the world. Seixas et al. demonstrated that in Brazil, nearly 30% of patients over the age of 80 are taking five or more medications, which is similar to rates seen in Europe [24]. Polypharmacy and use of potentially inappropriate medications (PIM) in the elderly can increase the risk of fall and fracture due to adverse effects such as orthostatic hypotension, delirium, and gait instability. Guidelines on PIMs vary throughout the world but perhaps the most well known is Beers Criteria, which was published in 1991 and has since been updated and modified by various national organizations to be inclusive of new medication classes and regional prescribing practices (Table 12.2) [25]. Country-specific modifications of Beers Criteria typically come from high-income nations with well-developed healthcare systems and ample geriatric pharmaceutical literature. The data on polypharmacy in the elderly in LMICs is scarce, but understanding prescribing practices and the impact on falls is a

Table 12.2 2019 American Geriatrics Society Beers Criteria® for potentially inappropriate medication use in older adults with a history of falls or fractures[a]

Drug(s)	Rationale	Recommendation	Quality of evidence	Strength of recommendation
Antiepileptics Antipsychotics[b] Benzodiazepines Non-benzodiazepine, benzodiazepine receptor agonist hypnotics Eszopiclone Zaleplon Zolpidem Antidepressants TCAs - tricyclic antidepressants SSRIs - Selective serotonin reuptake inhibitors SNRIs - Serotonin and norepinephrine reuptake inhibitors Opioids	May cause ataxia, impaired psychomotor function, syncope, additional falls; shorter-acting benzodiazepines are not safer than long-acting ones. If one of the drugs must be used, consider reducing use of other CNS-active medications that increase risk of falls and fractures (i.e., antiepileptics, opioid-receptor agonists, antipsychotics, antidepressants, non-benzodiazepine and benzodiazepine receptor agonist hypnotics, other sedatives/hypnotics) and implement other strategies to reduce fall risk. Data for antidepressants are mixed but no compelling evidence that certain antidepressants confer less fall risk than others.	Avoid unless safer alternatives are not available; avoid antiepileptics except for seizure and mood disorders Opioids: avoid except for pain management in the setting of severe acute pain (e.g., recent fractures or joint replacement)	Opioids: moderate All others: high	Strong

This table includes a shortened list of medications that are potentially inappropriate for use in older adults with a history of falls or fractures

Reprinted with permission from: The 2019 American Geriatrics Society Beers Criteria® Update Expert Panel. [25]

[a]The primary target audience is the practicing clinician. The intentions of the criteria include (1) improving the selection of prescription drugs by clinicians and patients, (2) evaluating patterns of drug use within populations, (3) educating clinicians and patients on proper drug usage, and (4) evaluating health outcome, quality of care, cost, and utilization data

[b]May be required to treat concurrent schizophrenia, bipolar disorder, and other selected mental health conditions but should be prescribed in the lowest effective dose and shortest possible duration

critical component of curbing the hip fracture epidemic. Simple, low-cost education programs in LMICs can help orthopaedic surgeons and primary care physicians reduce their elderly patients' risk of hip fracture by avoiding polypharmacy and PIMs.

In the elderly in LMICs, as in HICs, prior non-vertebral fracture is predictive of hip fracture [16]. Fracture liaison services (FLS) are designed to identify patients at

risk of repeat fracture and provide structured standardized interventions that can be implemented in both high- and low-resource environments alike. FLSs are discussed in more depth in the postoperative management section of this chapter as a recommended component of postoperative care for all hip fracture patients. By identifying individuals at risk of fracture, optimizing bone mineral density, and completing falls risk assessments, physicians and surgeons can prevent the morbidity and mortality caused by a second osteoporotic fracture.

The major risk factors of hip fractures in LMICs are similar to those of HICs. Age and gender consistently are the most significant non-modifiable risk factors. Identifying the demographic most at risk allows LMICs to target interventions and increase impact while minimizing cost. Identifying modifiable risk factors is of increased importance, as they provide targets for intervention. Low BMD can be addressed by providing medications to treat low bone mass, addressing nutritional deficiencies, and treating comorbidities such as diabetes. Different approaches to hip fracture risk reduction are needed in regions with variable access to medications and other healthcare resources. Research and resources in LMICs can be directed toward improving access to primary care, reducing polypharmacy, and minimizing inappropriate medication prescribing in the elderly. Public health initiatives using simple community level education to improve overall nutrition, vitamin D, physical conditioning, and fall prevention are also low-cost steps that can be taken to reduce the risk of geriatric hip fractures in LMICs.

Preoperative Management

Orthogeriatric Co-management

Achieving streamlined multidisciplinary orthogeriatric co-management of hip fracture patients presents a challenge to healthcare systems in LMICs, which are strained by limited resources. A standardized multidisciplinary approach to the management of geriatric hip fractures and associated co-morbidities has been shown to improve outcomes and reduce mortality, though most available evidence of these gains comes from high-income countries with well-developed healthcare systems [26]. Across the globe, incorporation of comprehensive geriatric assessment (CGA) into preoperative hip fracture protocols varies significantly. Models range from completely integrated orthopaedic and geriatric co-management to primary management by one service, with the other following as a consultant [27]. Systems that rely on protocol-based co-management place shared responsibility on all team members and have shown great success; however, implementation is not always practical in low-volume or limited-resource settings [28].

Orthogeriatric hip fracture systems rely on numerous resources that are scarce in LMIC, most notably geriatricians and orthopaedic surgeons, which are absent from many hospitals across the globe. Furthermore, successful hip fracture protocols in high-income countries often include anesthesiologists, nurses, physical and

occupational therapists, nutritionists, endocrinologists, and social workers [29]. Establishing orthogeriatric co-management is a cost-effective redistribution of available resources in well-established, well-resourced hospitals in HICs [30]. However, in LMICs, tertiary care centers are often so strained for resources that time to OR and patient outcomes are more dependent on hospital factors, such as bed, OR, X-ray, implant, and surgeon availability, than the efficient preoperative medical optimization targeted by orthogeriatric co-management programs [14, 31, 32].

International organizations have developed initiatives to bring standardized orthogeriatric care and hip fracture protocol best practices to all regions of the world, including LMICs. In 2018, the Fragility Fracture Network (FFN) published a global call to action urging the world's policy-makers to address the increased incidence and burden of fragility fractures worldwide with evidence-based multidisciplinary management best practices. The global call to action was endorsed and co-sponsored by professional organizations throughout the world and had special focus on LMICs [33]. To date, regional FFN care guidelines are only listed for high-income countries, with no published guidelines in FFN's Africa, Latin America, and Middle East regions [34]. This disparity between intention and implementation highlights the challenge of orthogeriatric care in LMICs.

To complement FFN's focus on policy, the AO Foundation's AO Trauma Orthogeriatrics initiatives focus on clinical education, including a free orthogeriatrics app, educational core competencies, and a series of best practice clinical summary documents [35]. With the aim of establishing improved assessment of orthogeriatric co-management models across the globe, AOTrauma published a set of standardized outcome parameters and timepoints [36]. Although experts from all regions of the world were invited to contribute and there was a focus on easy-to-assess parameters, the authors and regions represented in the literature used to create this tool are from HICs, potentially limiting its applicability in LMICs.

Prophylactic Antibiotics

Surgical site infections (SSI) complicate the postoperative course of geriatric hip fracture patients in both high- and low-income settings. Though there is limited SSI data specific to geriatric hip fracture surgery in LMICs, rates of SSIs after operative fixation of closed fractures have been shown to be nearly three times higher in LMICs than after comparable surgery in HICs [37]. Routine administration of appropriately timed prophylactic preoperative IV antibiotics, in conjunction with sterile operating procedures, has been shown to reduce the rate of SSIs, but patient and healthcare factors specific to LMICs may require alternative or multimodal SSI prophylaxis. In addition to standard administration of cephalosporins, supplemental approaches to minimize the rate of SSIs have been implemented in LMICs [38]. These include use of broad-spectrum IV antibiotics in high-risk patients, addition of

antibiotics to cement for hip arthroplasties, and increased duration of postoperative antibiotics.

Many LMICs have been disproportionately affected by the HIV epidemic; thus, any discussion of minimizing postoperative SSIs in LMICs must involve consideration of HIV management. Variability in preoperative access and adherence to antiretroviral therapy (ART) leads HIV-positive patients to be at variable risk of SSIs. In Malawi, implementation of national and WHO guidelines ensures that preoperatively, in addition to IV cefuroxime, HIV-positive elective total hip arthroplasty patients also receive trimethoprim-sulfamethoxazole [38]. All patients in this study, regardless of HIV status, also had implants secured with antibiotic cement. Incorporating similar standardized antibiotic guidelines into national hip fracture protocols could improve the rates of postoperative surgical site infections in HIV-positive hip-fracture patients.

The resource limitations faced by many healthcare systems in LMICs can increase the risk of SSI. Lower extremity intramedullary nails have been shown to have slightly higher and notably variable rates of infection in LMICs, which has been attributed to operative technique considerations specific to these resource limitations [37]. Lack of fluoroscopy, for instance, necessitates open rather than closed reduction during intramedullary nailing of hip fractures, which can lead to increased operative time and extensile or multiple incisions, both known risk factors of SSIs. Implants such as SIGN Fracture Care International's SIGN Hip Construct (SHC), specifically designed for hip fracture fixation without fluoroscopy in LMICs and accompanied by an international registry, can help potentially reduce the impact of this risk factor for SSIs in LMICs.

It has been suggested that in hospitals in LMICs with delayed hip fracture presentation and operative intervention, longer duration of postoperative antibiotics may be beneficial; however, conclusive evidence is lacking [37]. More research on perioperative antibiotic prophylaxis in geriatric hip fracture surgery in LMICs is needed to better understand and reduce the risk of SSI. Despite rates of SSIs being higher in some LMICs than that reported by HICs, these data may still be an underestimate of the true incidence. While HICs generally have mandatory or standardized voluntary reporting of SSIs, LMICs SSI reporting is often limited to single tertiary care hospitals [39]. In the absence of mandatory or standardized reporting, in many hospitals, these infections likely remain unreported.

Anticoagulation and Anemia

Though guidelines exist for negotiating the risk of operating through anticoagulation in order to prioritize expedient surgery for hip fracture fixation or replacement, clinical decision-making in these circumstances remains a balancing act, which can be more challenging in LMICs. There is general consensus that rapidly correctable comorbidities, such as anemia, should not delay operative treatment of geriatric hip fractures [31]. However, in regions without ample access to safe blood products or

anticoagulation reversal agents, the risk-benefit analysis of early surgery versus delay for medical optimization becomes more challenging. Anticoagulant medications frequently delay surgery in geriatric hip fracture patients [31].

While more aggressive initiatives for early surgery may be safer in regions where excess blood loss can be readily repleted, in many LMICs, blood products are in short supply. Only 27% of hospitals in low-income countries have an onsite blood bank, and many countries report that donated blood is not routinely tested for transfusion transmissible illnesses [14]. Inadequate nutrition contributes to anemia and frailty in the elderly, especially in LMICs with diminished food security [22]. As a consequence, patients in LMICs more frequently suffer from severe preoperative anemia [40]. A study of elective surgery patients in Republic of Congo and Madagascar demonstrated that severe preoperative anemia was associated with >8 times higher odds of postoperative complications, while mild preoperative anemia was associated with no such risk [41].

In LMICs, delays to surgery and intraoperative blood loss place geriatric hip fracture patients at increased risk of venous thromboembolic events (VTE) [42]. The use of VTE chemoprophylaxis has been shown to decrease the risk of VTE only when combined with prompt surgical treatment [43]. This has significant implications in LMICs where hip fracture surgery is frequently delayed [42]. Further research on preoperative management of anticoagulation medications, anemia, and VTE prevention in hip fracture patients in LMICs is needed.

Anesthesia and Pain Management

Lack of access to safe, affordable anesthesia is a major problem facing geriatric hip fracture patients in LMICs (Fig. 12.5) [14]. Studies show that roughly one in four hospitals in low-income countries lack reliable access to electricity, running water, and oxygen, while other anesthesia essentials such as pulse oximeters, laryngoscopes, and anesthesia machines are also largely unavailable [14]. Innovations to overcome these limitations include the development of durable low-cost pulse oximeters (Lifebox), inexpensive anesthesia machines that can operate through power outages (Glostavent and the Universal Anaesthesia Machine), and World Federation of Societies of Anaesthesiologists (WFSA) training fellowships to increase the number of anesthesiologists practicing in LMICs [14]. Increased investment in anesthesia infrastructure and training in LMICs is needed to meet the growing need for operative treatment of geriatric hip fractures in these countries.

Traditional approaches to anesthesia and pain management are challenging in geriatric hip fracture patients due to physiologic changes associated with aging and increased number of comorbidities [44]. Many medications, such as opioids, benzodiazepines, and muscle relaxants, which may be appropriate for younger patients with fractures, place geriatric patients at increased risk of delirium and subsequent falls (Table 12.2) [25]. Cognitive impairment, which is relatively common in elderly hip fracture patients, also poses a significant barrier to assessing pain and providing

effective pain management [36]. Research in HICs has demonstrated that geriatric hip fracture patients benefit from the use of multimodal pain control, including regional blocks, to improve mobility and decrease systemic analgesia requirements [44]. The literature on anesthesia and pain management of geriatric hip fracture patients in LMICs is lacking.

Operative Intervention

Timely, appropriate operative treatment is critical to hip fracture management. Hip fractures can broadly be classified into two categories: intracapuslar (subcapital and transcervical femoral neck fractures) and extracapsular (basicervical fractures, intertrochanteric fractures, and subtrochanteric fractures). Operative management takes the form of either osteosynthesis or arthroplasty. Osteosynthesis involves fracture reduction and fixation. In the case of extracapsular trochanteric femur fractures, implants are typically cephalomedullary nails or sliding hip screws [7], while non-displaced or impacted intracapsular femoral neck fractures are secured using parallel implants. Displaced femoral neck fractures are treated with prosthetic replacement using either a total hip arthroplasty for younger, higher demand patients or hemiarthroplasty for older, lower demand patients. The femoral component of both types of arthroplasty can be either press-fit if the surrounding bone is of adequate quality or cemented into place in the case of osteoporotic, low-quality bone. Operative management of geriatric hip fractures in LMICs is complicated by delays to surgery, lack of affordable implants, and scarcity of resources.

Timing of Surgery

Patients in LMICs face delays to care that lead to an increased proportion of neglected or delayed hip fracture management and contribute to excess morbidity and mortality. Fracture fixation or arthroplasty performed within 48 hours has been shown to significantly reduce the morbidity and mortality associated with geriatric hip fractures [31]. Early operative treatment of hip fractures is widely accepted as the standard of care throughout the world. However, achieving timely surgery is more challenging in LMICs (Fig. 12.2).

To better understand delays in accessing timely surgical care, the Lancet Commission on Global Surgery established the Three Delays framework, which categorizes delays in seeking (First Delay), reaching (Second Delay), and receiving care (Third Delay) in low- and middle-income countries (Fig. 12.3) [32]. This framework can be used in LMICs to identify the source of delays and focus resource allocation to improve time to surgery and meet geriatric hip fracture best practice goals.

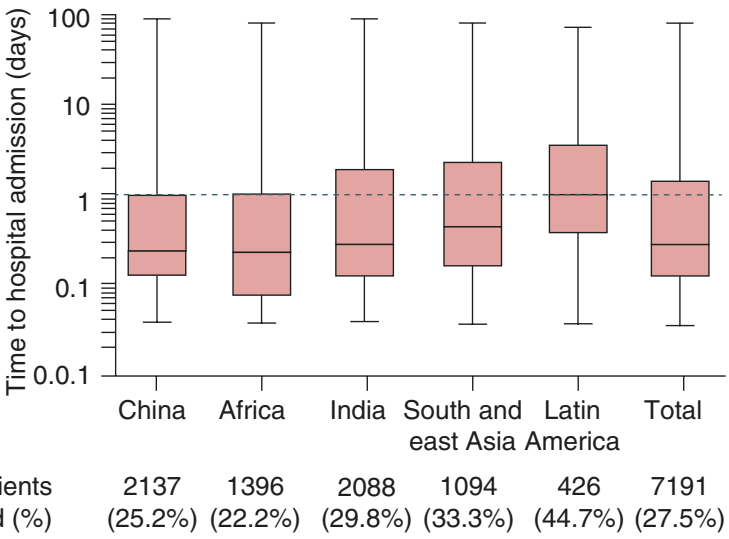

Fig. 12.2 Time from injury to admission to a treating hospital for patients with closed fractures, by region. The dotted line indicates 24 h delay. Box plots show median and IQR, with whiskers showing the full range. The proportion of patients delayed is reported in brackets. (Reprinted with permission from: Pouramin et al. [32])

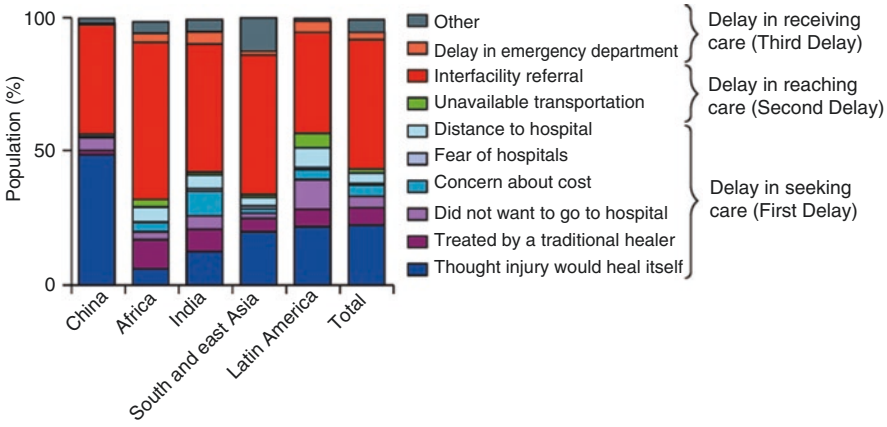

Fig. 12.3 Reasons patients with fractures had for delayed (>24 h) presentation to the hospital categorized according to the Lancet Commission on Global Surgery 2030 Three Delays framework. (Reprinted with permission from: Pouramin et al. [32])

First Delay – Seeking Care

Variations in the understanding or interpretation of injury as well as financial constraints can contribute to First Delays, with patients potentially turning to non-traditional healthcare systems or presuming their fracture will heal without operative intervention [45]. The type and severity of fracture impact a patient's impetus to seek

treatment. Closed fractures incurred from a fall from standing, a mechanism for most geriatric hip fractures, are more likely to see a delay of >24 h than any other type of injury [32]. Community-based hip-fracture education initiatives to improve health literacy and familiarity with the healthcare system may represent a low-cost intervention to target the First Delay and reduce the time from injury to the time a patient seeks care.

Second Delay – Reaching Care

Patient demographic and socioeconomic factors as well as LMICs' regional infrastructure contribute to the ability of geriatric hip fracture patients to reach an adequately equipped hospital, accounting for the Second Delay. Elderly patients often have limited mobility at baseline and are likely to seek care at the closest regional medical center, which in many LMICs may not have the capability to manage hip fractures. Limited patient mobility and large distances between hospitals, in combination with limited access to pre- and inter-hospital transportation, can delay patients' presentation to a tertiary care center [32]. Delayed referral and transportation from other hospitals is common in many LMICs and has been shown to increase the risk of complications such as preoperative DVT [42]. Improving pre-hospital networks and streamlining the inter-hospital referral systems in LMICs can reduce the Second Delay, improving patients' ability to expediently reach care [31].

Third Delay – Receiving Care

Once geriatric hip fracture patients in LMICs reach a hospital capable of providing operative treatment, they may face prolonged wait times to be admitted and receive surgery, the Third Delay. Healthcare providers in LMICs have attributed Third Delays to inadequate resources and overcrowding. One study of three tertiary care hospitals in India showed that only 65% of geriatric hip fracture patients were admitted for treatment and, of those, only 30% received surgery within 48 h of admission. The remaining patients were treated within 39 days, with 3% expiring while awaiting treatment [17]. Unfortunately, these delays are not an uncommon occurrence in the over-burdened, under-resourced tertiary care hospitals of many LMICs, and allocation of surgical resources is not always fairly distributed. Women are shown to be at greater risk than men of receiving care delayed more than 24 h [32]. This potential gender bias in LMICs' health care systems has broad implications for women's health and human development. With hip fractures being more prevalent in women across the globe and expedient operative intervention acknowledged to reduce morbidity and mortality, addressing the Third Delay gender disparity is of paramount importance.

Non-operative Treatment

In addition to facing numerous delays, once geriatric hip fracture patients in LMICs do reach a healthcare facility, their fractures are more likely to be managed with non-operative treatment than patients in HICs due to a lack of resources. Non-operative treatment of geriatric hip fractures has been widely acknowledged as inappropriate apart from exceptional cases in which severe comorbidities and short life expectancy elevate the risk of surgical intervention beyond any palliative benefit the patient could reasonably expect from surgery [44]. Though HICs have improved outcomes by optimizing and standardizing operative management of geriatric hip fractures over the past few decades, they have done so with better infrastructure and more resources than are typically available in LMICs. Despite evidence of favorable outcomes of surgical intervention for hip fractures in LMICs, conservative treatment persists due to resource and system constraints. The number of surgeons providing musculoskeletal trauma care in LMICs is several folds lower than in HICs, with estimates ranging from 2.6 to 58.8 surgeons per one million inhabitants, respectively [13]. Less than 20% of the world's surgeons practice in the African, Eastern Mediterranean, and South-East Asian WHO regions, which have a high density of LMICs and account for nearly half of the world's population (Fig. 12.4) [46]. Studies drawing attention to the unacceptable rates of morbidity and mortality accompanying non-operative management in LMICs show that practices long ago abandoned in HICs remain inadequate in LMICs [47].

A large portion of the population of LMICs lack access to safe, affordable surgery and anesthesia (Fig. 12.5) [14]. Resources in LMICs need to be allocated to enable orthopaedic surgeons to treat the increasing number of elderly hip fracture patients to the globally accepted standard of care. In Sri Lanka, a case series of 180 patients with fragility hip fractures found that only 107 were managed operatively, and those receiving conservative management had greater than six times higher odds of death within 12 months [6]. In LMICs where the volume of operative trauma exceeds the capacity of the healthcare system, decisions about allocation of surgical resources are challenging. A study out of a high-demand, limited-resource public hospital in Uganda demonstrates that when resources are severely constrained, such as less than 60% of patients admitted with lower extremity fractures able to receive surgical care, these decisions are not always made based on clinic criteria. The study identified social capital as the strongest predictor of access to surgery in the >80% male patients admitted to the hospital with operative lower extremity fractures [48]. With the known morbidity and mortality associated with non-operative management or neglect of geriatric hip fractures, equitable access to surgery is a human rights issue. Systems that provide inferior care to women and the poor exacerbate preexisting social, health, and human development inequalities.

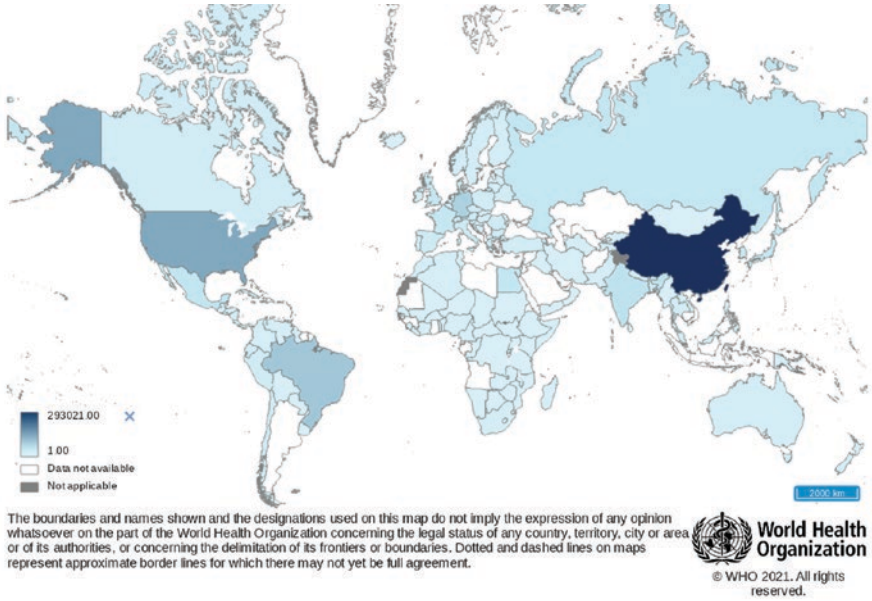

Fig. 12.4 Number of licensed surgeons of all specialties actively working, from the World Health Organization's (WHO) Global Health Observatory (GHO). (Reprinted with permission from: World Health Organization [46])

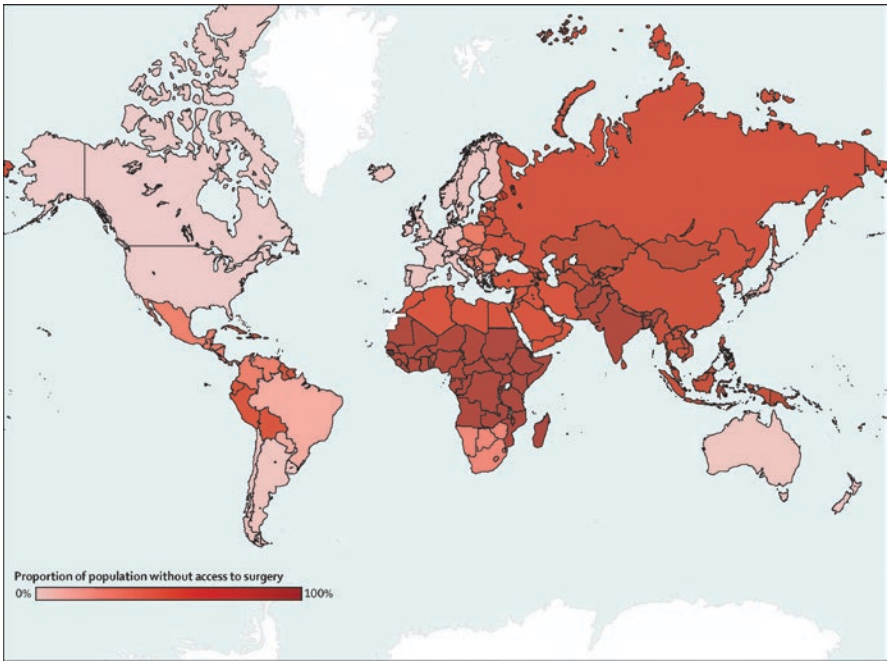

Fig. 12.5 Proportion of the population without access to safe, affordable surgery and anesthesia, from the Lancet report on Global Surgery 2030. (Reprinted with permission from: Meara et al. [14])

Osteosynthesis and Affordable Implants

Osteosynthesis involves fracture reduction and fixation. Non-displaced or valgus-impacted intracapsular femoral neck fractures can be secured using parallel screw fixation placed under fluoroscopic guidance. Extracapsular femur fractures typically require fluoroscopically guided closed reduction or open reduction with direct visualization and internal fixation. The implants most commonly used in HICs are cephalomedullary nails and sliding hip screws; however, their cost and absence of fluoroscopy can be prohibitive in LMICs [7].

Lack of funding for surgical implants in LMICs' hospitals and health systems can result in the cost of surgical implants falling on patients and their families [49]. The absence of disposable income in LMICs thus makes operative fracture care unattainable for many hip fracture patients. The alternative, non-operative care or delayed surgery results in prolonged hospitalization, inferior outcomes, and increased mortality. Investing in early hip fracture fixation and low-cost implants may ultimately provide both individual and societal cost savings when accounting for the direct and indirect costs associated with non-operative treatment of geriatric hip fracture.

Initiatives to bring low-cost implants to LMICs have shown success in improving outcomes. SIGN Fracture Care International's Hip Construct (SHC) is one such implant that was designed specifically for low-resource environments, without the use of fluoroscopy. The SHC is donated to hospitals that participate in the SIGN online database and thus can be provided at no cost to either the hospital or the patient's family. The structure of this program serves to overcome two common problems in LMICs – high implant costs and the absence of standardized hip fracture registry databases. Initial outcomes are promising, with implementation in Africa, Eastern Mediterranean, Western Pacific, Americas, and Southeast Asia (Fig. 12.6) [50].

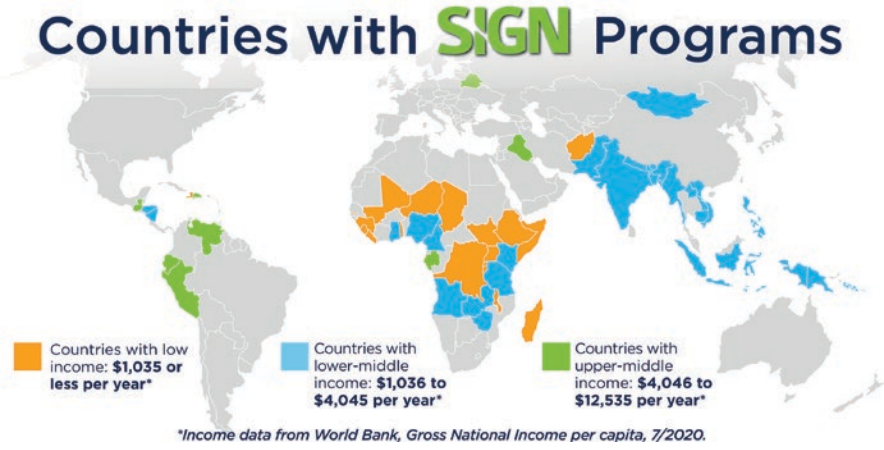

Fig. 12.6 Countries with SIGN Fracture Care International Programs. SIGN Fracture Care International has partnered with surgeons and hospitals in more than 50 LMICs, providing them with free orthopaedic education, implant systems, and surgical database access. (Reprinted with permission from: SIGN Fracture Care International [50])

The SHC has been used primarily in intertrochanteric and subtrochanteric fractures, but there have also been a few cases in which the construct has been used successfully in managing femoral neck fractures [51]. A case series of 68 hip fracture patients treated with the SHC in Tanzania showed promising outcomes [7]. The majority of patients were ambulatory by postoperative day three, and all who returned for follow-up at 6 weeks showed clinical signs of fracture healing. The few cases of major complications, one (1.5%) infection and eight (11.8%) cases of varus collapse, were favorable to the known unacceptable outcomes associated with non-operative management. The SHC has enabled operative fixation and early mobilization of hip fracture patients in LMICs in which resource scarcity or financial constraints would have otherwise prevented timely operative intervention.

Other steps that have been taken to overcome resource limitations in LMICs are consensus guidelines and recommendations on essential equipment required for appropriate operative treatment of hip fractures. Operative equipment guidelines can facilitate appropriate points of investment and intervention by governments and NGOs seeking to improve the capacity and quality of hip fracture care in LMICs. The publication of standardized equipment recommendations for various levels of care within the healthcare system can enable individual hospitals to assess their supplies and advocate for targeted funding. Essential equipment lists for fracture care in LMICs, specifically in sub-Saharan Africa, have been developed by a panel of experts as a means to guide resource allocation [52]. Importantly, the panels developing these recommendations are all from Africa with extensive experience working in LMICs. They specify that although their list may be helpful in other LMICs, it has not been widely tested and may not be completely translatable. Additionally, the panel highlights the frequent occurrence of inappropriately allocated resources burdening the healthcare systems of LMICs, with advanced equipment in basic care facilities being improperly used, maintained, or repaired. These issues not only represent waste of resources but also safety hazards. They illustrate the risk of applying potentially inappropriate HICs' guidelines in the absence of LMIC-specific data and needs-assessments. Further investment in research in LMICs is needed to generate appropriate regional guidelines and improve access to essential instruments and implants.

Arthroplasty

The standard treatment for displaced femoral neck fractures in the elderly is arthroplasty. Debate exists as to whether total hip arthroplasty (THA) or hemiarthroplasty (HA) is a more appropriate procedure for geriatric displaced femoral neck fracture management. HA is a less technically demanding procedure with lower cost implants and rates of dislocation, although it is typically used in older, lower demand patients with longevity and long-term function thought to be better in total hip arthroplasty. Recent research suggests that THA is not a cost-effective treatment

as compared to HA with the exception of younger patients for whom greater gains in quality of life, shorter hospital stay, and fewer complications can be seen with THA [53]. Though this cost analysis comes from a HIC, the implications may be applicable to LMICs. Other studies have suggested that HA and THA result in similar complication profiles for up to 5 years, with no difference in outcomes or clinically significant difference in quality of life within 2 years [54, 55]. The limited clinical advantage of THA over HA may be a particularly important consideration in LMICs where THA may be unavailable or cost-prohibitive. There is a subset of literature from LMICs that reports the use of arthroplasty for unstable intertrochanteric femur fractures [56]. This use of arthroplasty for extracapsular hip fractures has not been supported by high-quality clinical, biomechanical, or cost-effectiveness studies.

The literature remains inconclusive regarding preferability of THA or HA for displaced femoral neck fractures in the elderly. Additional research on this topic from LMICs is needed, particularly with respect to cost-effectiveness and patient outcomes. Throughout the world, we need to prioritize improved access to low-cost, effective implants that can be safely used in low-resource settings. Regardless of whether surgeons in LMICs are using the SIGN hip construct for an intertrochanteric fracture or hemiarthroplasty for a displaced femoral neck fracture, early appropriate operative intervention and multidisciplinary perioperative management are cost-effective and improve patient outcomes.

Postoperative Management

Following operative treatment of geriatric hip fractures, there are three primary goals of postoperative management in both high- and low-income countries across the world: avoid postoperative complications, prevent future fractures, and restore mobility and function. Optimal postoperative care requires engagement of a multidisciplinary team that includes nurses, geriatricians, physical therapists, primary care physicians, social workers, family, and the patients' community.

Complications

Complications after hip fracture contribute significantly to morbidity and mortality. The adverse events seen in LMICs largely overlap with those seen in HICs, although the rates at which they occur may vary as a result of patient characteristics and local management practices. Some of the most commonly encountered and significant adverse events following geriatric hip fracture include mortality, infection, delirium, and thromboembolic events [36, 43]. More research on hip fracture morbidity and mortality in LMICs is needed to better understand and prevent these complications.

Mortality

Mortality rates after hip fracture are influenced by both healthcare factors and patient characteristics, which can vary significantly between and within countries. While 1-year mortality rates in HICs range from 12 to 20%, mortality rates in LMICs can be substantially higher [9]. A major risk factor for mortality is delayed surgery or non-operative treatment, which occur more frequently in LMICs. For instance, with only 13% of hip fracture patients in the Russian Federation receiving operative treatment, 1-year mortality can approach 50% [30]. In contrast, a hospital in Sri Lanka treating 60% of patients operatively reports a lower 1-year mortality rate of 18% [6]. Early surgery within 48 hours has been associated with a 20% lower 1-year mortality risk and fewer perioperative complications [31]. Patient factors such as preoperative comorbidities, baseline physical impairment, anemia, and older age have been associated with increased mortality in LMICs [6, 57]. Orthogeriatric collaboration has been shown to reduce in-hospital and long-term mortality for these patients [27]. Hospitals in LMICs with standardized multidisciplinary protocols may be better equipped to optimize care and prioritize resources to reduce mortality following geriatric hip fracture.

Thromboembolic Events

Patients with hip fractures are at high risk of venous thromboembolic events (VTE) such as deep venous thrombosis (DVT) and pulmonary emboli (PE). The use of chemoprophylaxis has shown to decrease this risk from a 50% rate of DVT and 1.4–7.5% rate of fatal PE to an overall rate of symptomatic VTE of just 1–2%. This low rate of VTE is dependent upon prompt operative fixation, with preoperative delays of more than 48 h increasing the VTE prevalence to 62% in spite of chemoprophylaxis [43]. This has significant implications in LMICs where hip fracture surgery is frequently delayed [42]. Although the type, dose, and duration of chemoprophylaxis are controversial, the use of aspirin – a low-cost, readily available oral medication – has been recommended for VTE prophylaxis after hip fracture surgery, with the caveat that it may be less effective than low molecular weight heparin (LMWH), a universally recommended but more expensive injectable medication [58]. Implementation of protocols that include affordable postoperative chemoprophylaxis, pneumatic compression devices, and most importantly early surgery may decrease VTE in LMICs.

Infections

Infections in geriatric hip fracture patients can occur at three timepoints: (1) prior to presentation to the hospital, (2) as a consequence of prolonged immobilization, and (3) as a complication of surgery. Preventing and treating these infections in LMICs can be challenging, as patients typically have less access to primary care preinjury

and are more likely to experience delayed surgery and prolonged immobilization postinjury. Urinary tract and respiratory infections often coexist with frequent falls in the elderly [21]. Orthogeriatric co-management can facilitate the diagnosis and treatment of these infections [30]. Standardized hip fracture protocols that prioritize early surgery can reduce the risk of immobilization-associated pressure ulcer, urinary tract, and respiratory infections by facilitating hygiene, voiding, and pulmonary function. Postoperative surgical site infections are thought to occur at higher rates in LMICs than in HICs and frequently go unreported [37, 39]. Postoperative infections have been shown to lead to increased rates of mortality, longer hospital stays, and greater financial burden [39]. In LMICs where prompt operative intervention may not be feasible, it has been suggested that patients may benefit from a longer duration of postoperative antibiotics [37]. Additionally, in LMICs with higher rates of HIV, medical co-management of opportunistic infections and standardized hip surgery protocols including supplemental prophylactic IV antibiotics and antibiotic cement can minimize the rate of infections [38]. Standardized reporting and further research on infections associated with geriatric hip fractures in LMICs is needed.

Delirium

Delirium is a significant but often unreported complication in geriatric hip fracture patients [30]. It can occur as the sequelae of injury, hospitalization, and surgery in the elderly. Orthogeriatric co-management of hip fracture patients has been demonstrated to decrease delirium, improve function, and significantly reduce complications [27]. Avoiding potentially inappropriate medications such as opiates, benzodiazepines, and muscle relaxants can also help to reduce the incidence of delirium (Table 12.2) [25]. A review of fragility hip fractures in Mexico demonstrated that delirium was one of the most common complications, with rates comparable to those seen in the United States [59]. Standardized hip fracture protocols that include early continuous regional anesthesia can reduce opiate use, pain, and delirium in this vulnerable population [44]. Successful implementation of such protocols is resource dependent and not always feasible in LMICs. Research on delirium after hip fracture in LMICs is lacking. Future collaborative efforts should be directed at better understanding the burden of delirium after hip fracture in LMICs to identify areas for intervention.

Subsequent Fractures

Individuals who have sustained a fragility hip fracture are at significant risk of experiencing a subsequent fracture, especially in the first several months following their initial injury [33]. Worldwide, nearly half of patients presenting with hip fractures have suffered a prior fracture [60]. While population-wide osteoporosis screening, treatment, and fall prevention may not be cost-effective in the

developing world, there is an obvious role for secondary prevention of fractures in hip fracture patients [33]. As the most expensive osteoporotic fracture to treat, hip fracture prevention represents great potential cost savings, yet many governments and health care systems in LMICs do not prioritize osteoporosis treatment and post-fracture care [18]. The majority of elderly fracture patients receive neither assessment nor treatment to reduce their risk of future fractures [60]. In Turkey, 75–90% of geriatric hip fracture patients did not receive post-fracture pharmacologic osteoporosis treatment [15]. Similarly, in Argentina, Brazil, Colombia, and Mexico, more than half of patients at risk of osteoporotic fracture do not receive treatment, and fewer than 10% of hospitals have Fracture Liaison Services [18]. Post-fracture care programs, or Fracture Liaison Services, provide multidisciplinary osteoporosis treatment and follow-up to hip fracture patient to reduce the risk of secondary fractures [33].

Fracture Liaison Services

In 2012, the International Osteoporosis Foundation (IOF) launched the Capture the Fracture Campaign to facilitate the global implementation of secondary fracture prevention programs to improve care and reduce cost worldwide (Fig. 12.7) [60]. They established the best practice framework (BPF), which has established international benchmarks through which Fracture Liaison Services (FLS) can be evaluated and improved throughout the world. Although FLS have the greatest representation in HICs, one of the five mentors listed on IOF's Capture the Fracture FLS mentoring page is from Russia, while China is one of the 19 countries represented in national audits and surveys. It has been estimated that universal implementation of FLS in Brazil, Mexico, Colombia, and Argentina, four of the largest LMICs in Latin America, would prevent over 31,000 fractures annually, avoiding hundreds of thousands of days bedbound, and saving over 58 million dollars [18]. These are incremental steps toward adequate representation of LMICs in the movement toward universal FLS implementation to close the secondary fracture gap.

Rehabilitation

Over the next 40 years, the global number of people living with disability due to hip fracture is expected to exceed 21 million, with the full extent of this burden likely underappreciated in LMICs [33]. Rather than being viewed as an essential component of healthcare, rehabilitation is often seen as an optional extra service and is therefore under-prioritized by resource-strained governments and health care systems.

The lack of human resources and infrastructure available for comprehensive inpatient and community-based rehabilitation can make recovery from hip fractures challenging in LMICs [8]. The World Health Organization's Rehabilitation 2030:

Fig. 12.7 The International Osteoporosis Foundation's (IOF) Capture the Fracture Best Practice Framework (BPF) map of 574 Fracture Liaison Service (FLS) programs in 48 countries. Each FLS is recognized with a rating of gold, silver, or bronze. New, not yet rated, FLS are denoted by blue stars. The UK's Royal Osteoporosis Society is denoted by maroon pins. (Reprinted with permission from: Capture the Fracture [60])

Call-to-Action draws attention to this profound unmet need in LMICs, which often have fewer than 10 rehabilitation practitioners per one million population [8]. Inadequate access to rehabilitation services for geriatric hip fracture patients in LMICs can lead to increased death, disability, and poor outcomes [8]. Research on rehabilitation following geriatric hip fractures in LMICs is scarce, but studies have shown that in Colombia, 64% of hip fracture patients are not evaluated by physiotherapists during their hospitalization and fewer than 10% of patients in China and India receive a fall-risk assessment [8]. The absence of rehabilitation following hip fracture in LMICs contributes not only to disability but also to death. In Sri Lanka, physical impairment was associated with a higher risk of mortality in patients with hip fractures [6]. In Brazil, in the first month after hip fracture surgery, falls are the leading cause of mortality, accounting for 43.5% of deaths [8].

Evidence from HICs supports the importance of geriatric hip fracture rehabilitation protocols with early postoperative mobilization and full weight bearing to minimize immobility-associated complications [13]. Implementation of evidence-based rehabilitation recommendations in LMICs is challenging due to clinical, structural, and social barriers, but necessary due to rapidly growing demand. Improving access to postoperative rehabilitation for geriatric hip fracture patients in LMICs will require investment in workforce, infrastructure, and governance through increased awareness, advocacy, and partnerships with HICs [8].

Interventions

There is both need and opportunity for education, research, capacity building, and multidisciplinary protocol-based interventions to improve hip fracture treatment and outcomes in LMICs. Things that you can do to contribute to the implementation of geriatric hip fracture best practices in LMICs include using international best practices in hip fracture care in your own institution, sharing your experience through open-access peer-reviewed publications, volunteering your time and expertise to the international organizations noted below, and establishing longitudinal bidirectional partnerships with stakeholders in LMICs to facilitate the exchange of knowledge and generate high-quality data, research, and publications so that we can all advocate for evidence-based change [61].

Education

In recent years, orthopaedic trainees have shown increased interest in experiencing orthopaedic surgery and fracture care in LMICs. In response to this demand, US orthopaedic residency programs have increased their global health opportunities by 92% over the past 5 years (Fig. 12.8) [63]. Orthopaedic trauma fellows, the trainees for whom hip fracture management is most relevant, likely share a similar degree of interest at this more focused stage of their training; yet, only a handful of US orthopaedic trauma fellowships offer structured global health programs [64].

In order for orthopaedic training partnerships to be mutually beneficial, the exchange of knowledge and experience must be reciprocal or bidirectional and the

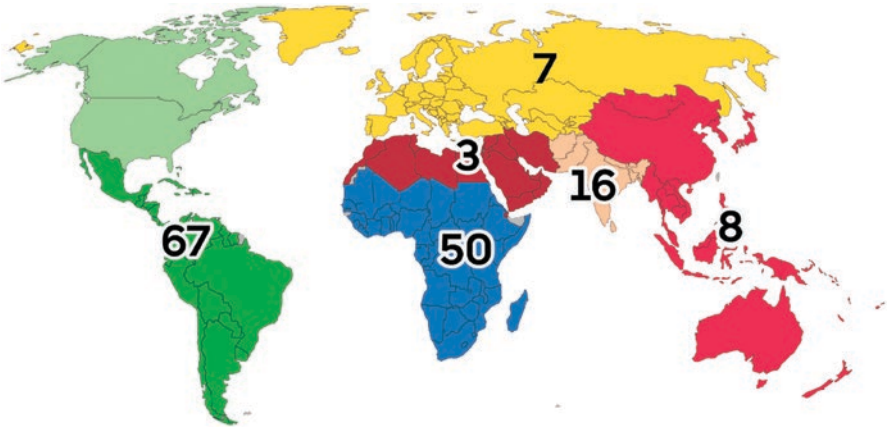

Fig. 12.8 Geographic distribution of international experiences for North American orthopaedic surgery residents. (Reprinted with permission from: Roberts et al. [62])

needs of LMICs' hosts must be prioritized [62, 65]. Unmet surgical need in LMICs poses a significant challenge to accomplishing hip fracture management best practices. US trainees participating in international rotations view addressing unmet surgical need as a major motivating factor, but it is important to note that host attending surgeons see more value in the educational exchange than the temporary provision of additional surgical personnel [62]. Though fully bidirectional partnerships have not yet been universally implemented, there are a number of opportunities for surgeons from LMICs to participate in orthopaedic observerships throughout North America (Fig. 12.9) [66]. Improving partnership, education, and training for young surgeons throughout the world can facilitate collaborations and opportunities to provide better care to geriatric hip fracture patients in LMICs.

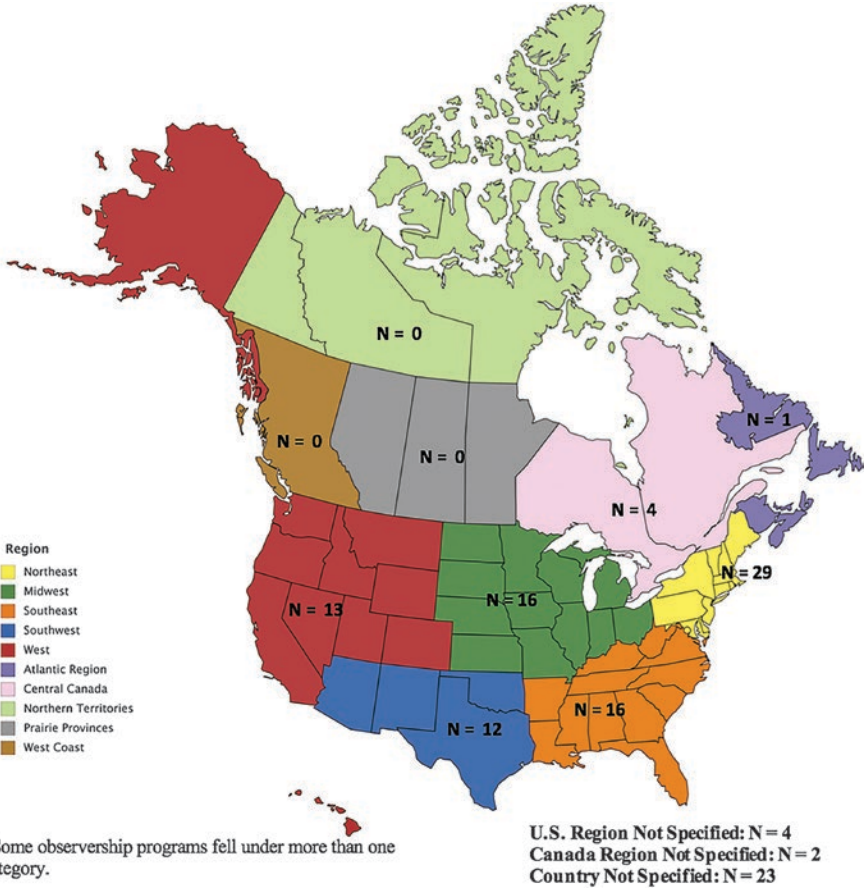

Fig. 12.9 Available North American orthopaedic observership programs for international surgeons, geared toward applicants from LMICs (16), non-LMICs (11), or unspecified (94). (Reprinted with permission from: Carrillo et al. [66])

Research

A defining theme of the literature on geriatric hip fracture management in LMICs has been the paucity of high-quality research. Although LMICs account for much of the global burden of geriatric hip fractures, the vast majority of the research on this topic has been performed in HICs. Scaling up research capacity in LMICs can be achieved by forming collaborations with health systems and academic institutions in HICs with robust research capacity. By providing access to research, education, and infrastructure, these collaborations can lead to a better understanding, improved allocation of scarce resources, and better overall care and outcomes for geriatric hip fractures in LMICs.

A recent research consortium composed of Latin-American leaders in orthopaedics highlighted the need for collaboration between LMICs and HICs in order to obtain the training and infrastructure needed to adequately address research questions impacting their communities. Several of the topics raised by this consortium are relevant to geriatric hip fractures: fragility fractures and osteometabolic disease, cost-effective implants, outcomes studies, and trauma burden [67]. The collaborations resulting from this and other similar working groups can serve as a model of global partnership for research capacity development in LMICs. One such model, which emerged from this aforementioned consortium, was the Asociación de Cirujanos Traumatólogos en las Américas (ACTUAR). ACTUAR, composed of more than 100 members from 20 countries, is dedicated to the development of research infrastructure in Latin America.

ACTUAR has collaborated on projects such as the International Orthopaedic Multicenter Study (INORMUS), coordinated by McMaster University Method Center in Canada, the George Institute of Global Health in Australia, and the Institute for Global Orthopaedics and Traumatology (IGOT) at University of California, San Francisco (UCSF), in the United States – has collaborated on projects such as the International Orthopaedic Multicenter Study (INORMUS). INORMUS is a cohort study of musculoskeletal trauma in Africa, Asia, and Latin America, which established a global research infrastructure to address the critical gap in our knowledge of the epidemiology, management, and outcomes of trauma in LMICs (Fig. 12.10) [68]. Additionally, the Consortium of Orthopaedic Academic Traumatologists (COACT), consisting of orthopaedic surgeon leaders from over 15 orthopaedic academic departments in the United States and Canada, was developed to promote the alignment of academic global health efforts in LMICs. The consortium works toward this goal through the sharing of best practices, mentorship opportunities, and resources for clinical exchange experiences, research projects, and surgical education initiatives. Similar research initiatives are needed to address the paucity of data on geriatric hip fractures in LMICs.

Research education has also demonstrated tremendous impact on the quality and quantity of research in LMICs. UCSF's IGOT International Research Symposium is an annual 1-day research course created to promote research initiatives by surgeons in LMICs. A 2-year follow-up study showed that the participants (from 10 LMICs) had increased research confidence, productivity, and recognition by international organizations like the Orthopaedic Trauma Association (OTA) [69]. By improving

Fig. 12.10 International Orthopaedic Multicenter Study in Fracture Care (INORMUS): participating sites: 50 hospitals in 17 countries. (Reprinted with permission from: Sprague et al. [68])

the quantity, quality, and visibility of research in LMICs, surgeons practicing in these environments can highlight successful implementation of geriatric hip fracture best practices and draw national and international attention to areas in need of resources or additional research.

The following is a selection of organizations that provide information, education, and opportunities to improve the care of geriatric hip fractures throughout the world.

Fragility Fracture Network
www.fragilityfracturenetwork.org
International Osteoporosis Foundation's Capture the Fracture
www.capturethefracture.org
American Orthopaedic Association's Own the Bone partnership with Project ECHO
www.ownthebone.org
hsc.unm.edu/echo/
AOTrauma's Orthogeriatrics
https://aotrauma.aofoundation.org/education/curricula/orthogeriatrics
Institute for Global Orthopaedics and Traumatology
www.igotglobal.org
SIGN
www.signfracturecare.org
Health Volunteers Overseas
www.hvousa.org
The George Institute for Global Health Scholarship: Managing hip fractures in resource poor settings
www.georgeinstitute.org/careers/scholarship-opportunity-managing-hip-fractures-in-resource-poor-settings

Conclusion

With the global population aging most rapidly in LMICs, geriatric hip fractures are anticipated to add significant burden to already strained systems. The economic and social effects of the geriatric hip fracture epidemic in LMICs are significant, but efforts to identify populations at risk and target modifiable risk factors can reduce the negative impact. Current geriatric hip fracture research and publications in LMICs are lacking. International collaborations that are focused on research and implementation of standardized orthogeriatric preoperative care, appropriate timely surgery, and postoperative monitoring and rehabilitation in LMICs can improve outcomes for geriatric hip fracture patients in LMICs.

References

1. World bank country and lending groups [Internet]. [cited 2020 Dec 27]. Available from: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups
2. Gullberg B, Johnell O, Kanis JA. World-wide Projections for Hip Fracture. Osteoporos Int. 1997;7(5):407–13.
3. World Health Organization. World report on ageing and health. World Health Organization; Geneva, Switzerland; 2015. https://apo.org.au/node/58203
4. UN DESA. World Population Prospects 2019. United Nations. Department of Economic and Social Affairs.
5. Cheung CL, Ang SB, Chadha M, Chow ES, Chung YS, Hew FL, Jaisamrarn U, Ng H, Takeuchi Y, Wu CH, Xia W. An updated hip fracture projection in Asia: the Asian Federation of Osteoporosis Societies study. Osteoporos sarcopenia. 2018;4(1):16–21.
6. Abeygunasekara T, Lekamwasam S, Lenora J, Alwis G. Current incidence and future projections of fragility hip fractures in Sri Lanka. Arch Osteoporos. 2020;15(1):1–6.
7. Haonga BT, Eliezer EN, Makupa JE, Shearer D, Liu MB, Wu H. SIGN hip construct: Achieving hip fracture fixation without using an image intensifier. EAOJ. 2016;10(1):7–10.
8. Dyer SM, Perracini MR, Smith T, Fairhall NJ, Cameron ID, Sherrington C, Crotty M. Rehabilitation following hip fracture. In: Falaschi P, Marsh D, editors. Orthogeriatrics. Practical issues in geriatrics. Cham: Springer; 2021. p. 183–222.
9. Guirant L, Carlos F, Curiel D, Kanis JA, Borgström F, Svedbom A, Clark P. Health-related quality of life during the first year after a hip fracture: results of the Mexican arm of the International Cost and Utility Related to Osteoporotic Fractures Study (MexICUROS). Osteoporos Int. 2018;29(5):1147–54.
10. World Health Organization. The world health report 2003: shaping the future. In: World Health Organization; 2003.
11. Hlaing WY, Thosingha O, Chanruangvanich W. Health-related quality of life and its determinants among patients with hip fracture after surgery in Myanmar. Int J Orthop Trauma Nurs. 2020;37:100752.
12. Amphansap T, Sujarekul P. Quality of life and factors that affect osteoporotic hip fracture patients in Thailand. Osteoporos Sarcopenia. 2018;4(4):140–4.
13. Miclau T, Hoogervorst P, Shearer DW, El Naga AN, Working ZM, Martin C, Pesántez R, Hüttl T, Kojima KE, Schütz M. International orthopaedic trauma study consortium. Current status of musculoskeletal trauma care systems worldwide. J Orthop Trauma. 2018;32:S64–70.

14. Meara JG, Leather AJ, Hagander L, Alkire BC, Alonso N, Ameh EA, Bickler SW, Conteh L, Dare AJ, Davies J, Mérisier ED. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. Lancet. 2015;386(9993):569–624.
15. Aziziyeh R, Perlaza JG, Saleem N, Kirazlı Y, Akalın E, McTavish RK, Duperrouzel C, Cameron C. The burden of osteoporosis in Turkey: a scorecard and economic model. Arch Osteoporos. 2020;15(1):1–9.
16. Domiciano DS, Machado LG, Figueiredo CP, Caparbo VF, Oliveira RM, Menezes PR, Pereira RM. Incidence and risk factors for osteoporotic non-vertebral fracture in low-income community-dwelling elderly: a population-based prospective cohort study in Brazil. The São Paulo Ageing and Health (SPAH) study. Osteoporos Int. 2020:1–1.
17. Rath S, Yadav L, Tewari A, Chantler T, Woodward M, Kotwal P, Jain A, Dey A, Garg B, Malhotra R, Goel A. Management of older adults with hip fractures in India: a mixed methods study of current practice, barriers and facilitators, with recommendations to improve care pathways. Arch Osteoporos. 2017;12(1):1–3.
18. Aziziyeh R, Perlaza JG, Saleem N, Guiang H, Szafranski K, McTavish RK. Benefits of fracture liaison services (FLS) in four Latin American countries: Brazil, Mexico, Colombia, and Argentina. Journal of Medical Economics. 2021;24(1):96–102.
19. Zhu Y, Xing X, Liu S, Chen W, Zhang X, Zhang Y. Epidemiology of low-energy wrist, hip, and spine fractures in Chinese populations 50 years or older: A national population-based survey. Medicine. 2020;99(5):e18531.
20. Phusunti S, Suthutvoravut W, Unnanuntana A, Chotiyarnwong P. The prevalence of hypovitaminosis D in patient with fragility hip fracture at a single institution in Thailand. J Med Assoc Thail. 2016;99(11):1233–8. PMID: 29901944
21. Han, T.S., Yeong, K., Lisk, R. et al. Prevalence and consequences of malnutrition and malnourishment in older individuals admitted to hospital with a hip fracture. Eur J Clin Nutr. 2021;75:645–52. https://doi.org/10.1038/s41430-020-00774-5.
22. Chaparro CM, Suchdev PS. Anemia epidemiology, pathophysiology, and etiology in low-and middle-income countries. Ann N Y Acad Sci. 2019;1450(1):15.
23. Nazzal Z, Khader S, Zawyani H, Abdallah M, Sawalmeh O, Hamdan Z. Bone mineral density in Palestinian patients with end-stage renal disease and the related clinical and biochemical factors: Cross-sectional study. PLoS One. 2020;15(11):e0241201.
24. Seixas BV, Freitas GR. Polypharmacy among older Brazilians: prevalence, factors associated, and sociodemographic disparities (ELSI-Brazil). Pharm Pract. 2021 Jan;19:2168–1.
25. The 2019 American Geriatrics Society Beers Criteria® Update Expert Panel. The 2019 American Geriatrics Society Beers Criteria® for potentially inappropriate medication use in older adults. J Am Geriatr Soc. 2019. Published online January 31, 2019; https://doi.org/10.1111/jgs.15767.
26. Prestmo A, Hagen G, Sletvold O, Helbostad JL, Thingstad P, Taraldsen K, Lydersen S, Halsteinli V, Saltnes T, Lamb SE, Johnsen LG. Comprehensive geriatric care for patients with hip fractures: a prospective, randomised, controlled trial. Lancet. 2015;385(9978):1623–33.
27. Grigoryan KV, Javedan H, Rudolph JL. Ortho-geriatric care models and outcomes in hip fracture patients: a systematic review and meta-analysis. J Orthop Trauma. 2014;28(3):e49.
28. Meinberg E, Ward D, Herring M, Miclau T. Hospital-based Hip fracture programs: Clinical need and effectiveness. Injury. 2020;51:S2–4.
29. Patel JN, Klein DS, Sreekumar S, Liporace FA, Yoon RS. Outcomes in multidisciplinary team-based approach in geriatric hip fracture care: a systematic review. J Am Acad Orthop Surg. 2020;28(3):128–33.
30. Mitchell P, Åkesson K, Chandran M, Cooper C, Ganda K, Schneider M. Implementation of models of care for secondary osteoporotic fracture prevention and orthogeriatric models of care for osteoporotic hip fracture. Best Pract Res Clin Rheumatol. 2016;30(3):536–58.
31. Klestil T, Röder C, Stotter C, Winkler B, Nehrer S, Lutz M, Klerings I, Wagner G, Gartlehner G, Nussbaumer-Streit B. Impact of timing of surgery in elderly hip fracture patients: a systematic review and meta-analysis. Sci Rep. 2018;8(1):1–5.

32. Pouramin P, Li CS, Busse JW, Sprague S, Devereaux PJ, Jagnoor J, Ivers R, Bhandari M, Guyatt G, Petrisor B, Thabane L. Delays in hospital admissions in patients with fractures across 18 low-income and middle-income countries (INORMUS): a prospective observational study. Lancet Glob Health. 2020;8(5):e711–20.
33. Trafton PG. Fragility fractures in the developing world: A rising challenge. Curr Geriat Rep. 2018;7(4):278–87.
34. Fragility Fracture Network. Fragility Fracture Network [Internet]. FFN Central Office; [cited 2020 Jan 13]. Available from: https://www.fragilityfracturenetwork.org/global-regions/
35. AO Trauma. Orthogeriatrics [Internet]. AO Foundation; 2021 [cited 2021 Jan 14]. Available from: https://aotrauma.aofoundation.org/education/curricula/orthogeriatrics
36. Liem IS, Kammerlander C, Suhm N, Blauth M, Roth T, Gosch M, Hoang-Kim A, Mendelson D, Zuckerman J, Leung F, Burton J. Identifying a standard set of outcome parameters for the evaluation of orthogeriatric co-management for hip fractures. Injury. 2013;44(11):1403–12.
37. McQuillan TJ, Cai LZ, Corcoran-Schwartz I, Weiser TG, Forrester JD. Surgical site infections after open reduction internal fixation for trauma in low and middle human development index countries: a systematic review. Surg Infect. 2018;19(3):254–63.
38. Graham SM, Howard N, Moffat C, Lubega N, Mkandawire N, Harrison WJ. Total hip arthroplasty in a low-income country: Ten-year outcomes from the national joint registry of the Malawi Orthopaedic Association. JBJS Open Access. 2019 Oct;4(4).
39. Patel H, Khoury H, Girgenti D, Welner S, Yu H. Burden of surgical site infections associated with arthroplasty and the contribution of Staphylococcus aureus. Surg Infect. 2016;17(1):78–88.
40. Fowler AJ, Ahmad T, Abbott TE, Torrance HD, Wouters PF, De Hert S, Lobo SM, Rasmussen LS, Della Rocca G, Beattie WS, Wijeysundera DN. Association of preoperative anaemia with postoperative morbidity and mortality: an observational cohort study in low-, middle-, and high-income countries. Br J Anaesth. 2018;121(6):1227–35.
41. White MC, Longstaff L, Lai PS. Effect of pre-operative anaemia on post-operative complications in low-resource settings. World J Surg. 2017;41(3):644–9.
42. Zhang BF, Wei X, Huang H, Wang PF, Liu P, Qu SW, Li JH, Wang H, Cong YX, Zhuang Y, Zhang K. Deep vein thrombosis in bilateral lower extremities after hip fracture: a retrospective study of 463 patients. Clin Interv Aging. 2018;13:681.
43. Ricci WM, Broekhuyse H, Keating JF, Teague DC, White TO. Thromboprophylaxis an update of current practice: Can we reach a consensus? Ota Int. 2019;2(4):e027.
44. Elsevier H, Cannada LK. Management of pain associated with fractures. Curr Osteoporos Rep. 2020;18(3):130–7.
45. Tewari A, Pati S, Webster P, Rath S, Yadav L, Sahu KS, Sundari DS, Norton R. Care seeking behaviour of older adults with hip fracture in India: a qualitative study. J Pat Care. 2017;28:3(1).
46. World Health Organization. Surgical workforce: surgeons [Internet]. World Health Organization; 2021 [cited 2021 Jan 26]. Available from: https://www.who.int/data/gho/data/indicators/indicator-details/GHO/number-of-licensed-qualified-surgeons-actively-working.
47. Chagomerana MB, Tomlinson J, Young S, Hosseinipour MC, Banza L, Lee CN. High morbidity and mortality after lower extremity injuries in Malawi: A prospective cohort study of 905 patients. Int J Surg. 2017;39:23–9.
48. Stephens T, Mezei A, O'Hara NN, Potter J, Mugarura R, Blachut PA, O'Brien PJ, Beyeza T, Slobogean GP. When surgical resources are severely constrained, who receives care? Determinants of access to orthopaedic trauma surgery in Uganda. World J Surg. 2017;41(6):1415–9.
49. Kramer EJ, Shearer D, Morshed S. The use of traction for treating femoral shaft fractures in low-and middle-income countries: a systematic review. Int Orthop. 2016;40(5):875–83.
50. SIGN Fracture Care International. SIGN Programs: building orthopaedic capacity around the world [Internet]. [cited 2021 Jan 26]. Available from: https://www.signfracturecare.org/programs
51. Roth J, Goldman B, Zirkle L Jr, Schlechter J, Ibrahim J, Shearer D. Early clinical cxperience with the SIGN hip construct: a retrospective case series. SICOT-J. 2018;4:5.
52. Chan Y, Banza L, Martin C Jr, Harrison WJ. Essential fracture and orthopaedic equipment lists in low resource settings: consensus derived by survey of experts in Africa. BMJ Open. 2018;8(9):e023473.

53. Axelrod D, Tarride JÉ, Ekhtiari S, Blackhouse G, Johal H, Bzovsky S, Schemitsch EH, Heels-Ansdell D, Bhandari M, Sprague SI. Total Hip Arthroplasty a Cost-Effective Option for Management of Displaced Femoral Neck Fractures? A Trial-Based Analysis of the HEALTH Study. J Orthop Trauma. 2020;34:S37–41.
54. Ekhtiari S, Gormley J, Axelrod DE, Devji T, Bhandari M, Guyatt GH. Total hip arthroplasty versus hemiarthroplasty for displaced femoral neck fracture: a systematic review and meta-analysis of randomized controlled trials. JBJS. 2020;102(18):1638–45.
55. Health Investigators. Total hip arthroplasty or hemiarthroplasty for hip fracture. N Engl J Med. 2019;381(23):2199–208.
56. Elhadi AS, Gashi YN. Unstable intertrochanteric fracture in elderly patients: outcome of primary cemented bipolar hemiarthroplasty versus internal fixation. SA Orthopaedic J. 2018;17(4):22–6.
57. Atthakomol P, Manosroi W, Pipanmekaporn PP, Vaseenon T, Rojanasthien S. Prognostic Factors for All-Cause Mortality in Thai Patients with Fragility Fracture of Hip: Comorbidities and Laboratory Evaluations. Medicina. 2020;56(6):311.
58. Jenny JY, Pabinger I, Samama CM. European guidelines on perioperative venous thromboembolism prophylaxis: aspirin. Eur J Anaesth. 2018;35(2):123–9.
59. Viveros-García JC, Torres-Gutiérrez JL, Alarcón-Alarcón T, Condorhuamán-Alvarado PY, Sánchez-Rábago CJ, Gil-Garay E, González-Montalvo JI. Fractura de cadera por fragilidad en México:¿ En dónde estamos hoy?¿ Hacia dónde queremos ir? Acta Ortop Mex. 2019;32(6):334–41.
60. Capture the Fracture. What is Capture the Fracture? [Internet]. International Osteoporosis Foundation; 2021 [cited 2021 Jan 16]. Available from: https://www.capturethefracture.org
61. Wu HH, Liu M, Patel KR, Turner W, Baltus L, Caldwell AM, Hahn JC, Coughlin RR, Morshed S, Miclau T, Shearer DW. Impact of academic collaboration and quality of clinical orthopaedic research conducted in low- and middle-income countries. SICOT-J. 2017;3:6.
62. Roberts HJ, Albright PD, Shearer DW, Won N, MacKechnie MC, Coughlin RR, Miclau IIIT, Morshed S, Sabharwal S, Dawson J, Davis B. Motivations and impact of international rotations in low-and middle-income countries for orthopaedic surgery residents: Are we on the same page? Am J Surg. 2020;221(2):245–53.
63. Pfeifer J, Svec N, Are C, Nelson KL. Rising global opportunities among orthopaedic surgery residency programs. JAAOS Glob Res Rev. 2020;4(12):e20.00102.
64. Shaw J, Siy A, Dahm J, Lins L, Simske N, Whiting P. Limited availability of global health opportunities in US orthopaedic trauma fellowship programs. Ota Int. 2019;2(4):e031.
65. Pean CA, Premkumar A, Pean MA, Ihejirika-Lomedico R, Woolley PM, McLaurin T, Israelski R, Schwarzkopf R, Caplan A, Egol K. Global orthopaedic surgery: an ethical framework to prioritize surgical capacity building in low and middle-income countries. JBJS. 2019;101(13):e64.
66. Carrillo LA, Segarra B, Sabharwal S. Clinical observership opportunities in North America for international orthopaedic surgeons. JBJS. 2020;102(12):e60.
67. Chomsky-Higgins K, Miclau TA, Mackechnie MC, Aguilar D, Avila JR, Dos Reis FB, Balmaseda R, Barquet A, Ceballos A, Contreras F, Escalante I. Barriers to clinical research in Latin America. Front Public Health. 2017;5:57.
68. Sprague S, McKay P, Li CS, Ivers R, Moroz PJ, Jagnoor J, Bhandari M, Miclau T. International orthopaedic multicenter study in fracture care: coordinating a large-scale multicenter global prospective cohort study. J Orthop Trauma. 2018;32:S58–63.
69. Wu HH, Ibrahim J, Conway D, Liu M, Morshed S, Miclau T, Coughlin RR, Shearer DW. Clinical research course for international orthopaedic surgeons: 2-year outcomes. J Orthop Trauma. 2018;32:S35–7.
70. Institute for Health Metrics and Evaluation (IHME). GBD Compare [Internet]. Seattle: IHME, University of Washington; 2015. [updated 2019; cited 2021 Feb 01]. Available from: http://vizhub.healthdata.org/gbd-compare