



The disparity is a more significant challenge for orthopaedic surgeons than the planet's population growth

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The world is facing numerous health challenges, one of which is the rising demand for orthopaedic care. This is exacerbated by an increasing global population and, more significantly, by the unequal distribution of healthcare resources. While population growth poses its own set of challenges, the disparity in healthcare, particularly orthopaedic resources and services, presents a more immediate and direct threat to orthopaedic patients.

Currently, inequities and disparity surrounding access to health are mainly the result of both unequal distribution and global scarcity. However, the size of the population, its composition, and economic and geographic disparity do not automatically impact orthopaedic outcomes.

The global paradox of hip fracture mortality: the same everywhere, despite the disparity.

Except in young patients [1], Hip fractures are a critical public health issue, significantly affecting elderly populations worldwide. Contrary to common assumptions, emerging evidence suggests that the mortality risk associated with hip fractures within one month and one year of the event does not substantially vary with the economic status of a country.

Recent studies [2, 3] on mortality rates related to hip fractures revealed that the average one-year mortality rate (Fig. 1) was 23.3% in Europe, based on 22 studies, and 17.9% in Asia, according to 10 studies. The figure stood at 21% in the United States, while Australia reported a higher rate of 24.9%. South America saw the highest rate at 26.8%, Africa and Middle East around 19%. A comprehensive analysis of 36 studies, encompassing 229,851 patients

showed that the global average one-year mortality rate was 20%, with a standard deviation of 7.2% and a median rate of 22.8%. While the literature reports a decreasing trend in mortality at one year post-hip fracture, the risk of mortality remains globally the same for high-income and low-income countries, and this remains true over six decades.

Even though there have been significant improvements [4, 5] in all aspects of managing hip fractures, including pre-operative prevention, the establishment of specialized hip fracture units, timely surgical intervention, and rehabilitation combined with orthogeriatric care, a comprehensive review of literature [6] published on hip fracture outcomes from 1959 to 2018 reveals shifts in patient demographics, geographical trends, and mortality rates over this period. The average age of individuals suffering from hip fractures has been gradually increasing by just over a year for every five-year interval. Specifically, the average patient age rose from 73 in the 1960s to 81 in the 2000s and 82 in the 2010s. But, throughout these sixty years, the one-year mortality rate (Fig. 2) saw a modest decrease, moving from an average of 27% in the 1960s to 20% in the 2010s, corresponding to a reduction per year of only 0.1%.

Why does a high-level healthcare system have the same results as a low-level for hip fracture?

The phenomenon where high-level healthcare system characteristics yield similar outcomes for hip fracture patients as those seen in lower-level systems can be perplexing at first glance. This observation can be attributed to several factors that play a crucial role in determining patient outcomes after a hip fracture, regardless of the overall wealth or sophistication of the healthcare system.

The treatment of hip fractures, especially in the acute phase, is guided by well-established clinical guidelines that are widely adopted across various healthcare settings. These

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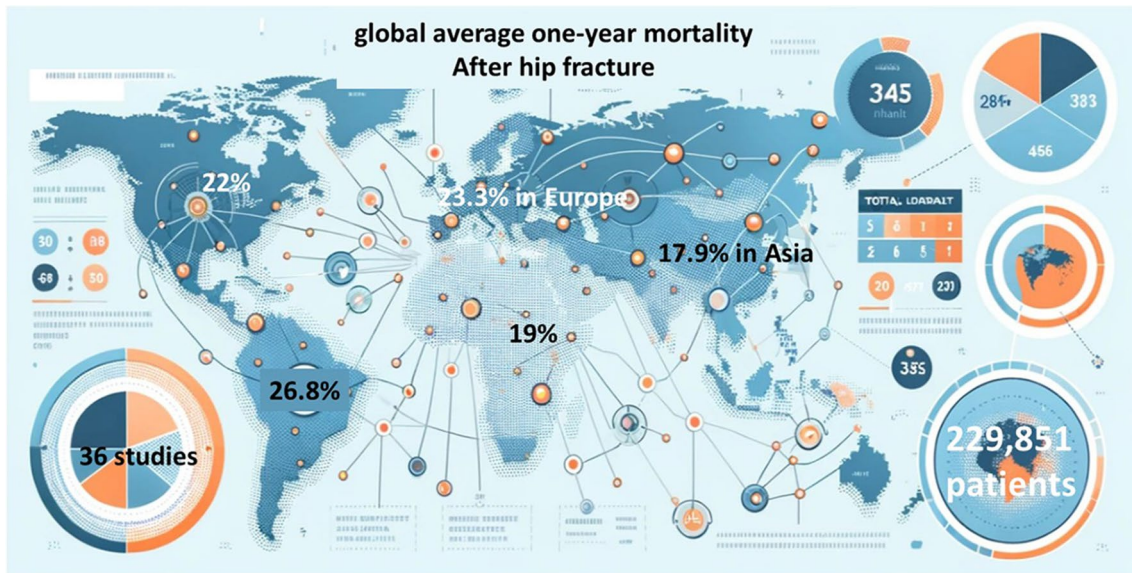


Fig. 1 Percentage of mortality after hip fracture in different regions of the world

guidelines ensure that essential care components, such as timely surgery, are a standard practice everywhere, minimizing the variability in patient outcomes across different healthcare systems.

Hip fractures require a prompt surgical treatment, a priority in both high- and low-resource settings. The critical nature of this intervention means that, regardless of the system's overall level, efforts are made to provide this care promptly, leading to a convergence in outcomes.

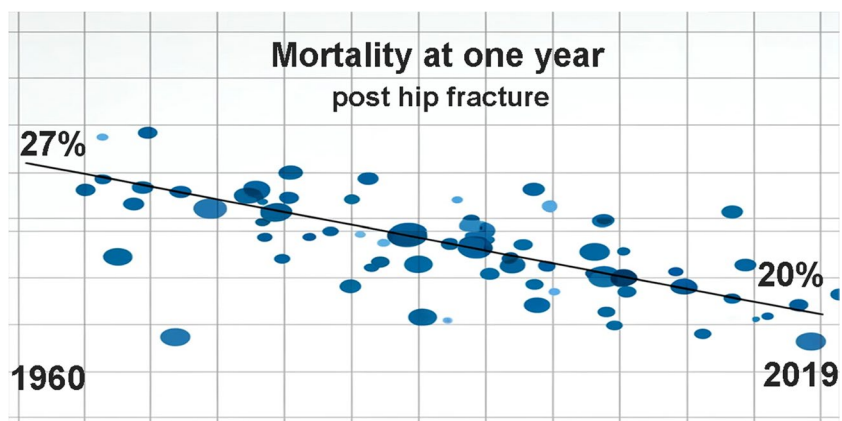
Outcomes after hip fracture surgery are not determined solely by the surgery but also by the patient's factors: The outcomes following a hip fracture are heavily influenced by the patient's overall health, presence of comorbidities, and age. These factors can have a significant impact, sometimes overshadowing the effects of healthcare system characteristics. Older patients with multiple health issues may have similar mortality risks and outcomes despite the level

of the healthcare system due to the critical nature of their condition.

Social networks and the underlying factors of health significantly impact the recovery and rehabilitation process. In some low-income countries, robust social support from the family can compensate for deficiencies in the healthcare system; in large cities of high-level countries, the patient is sometimes alone without family support.

In summary, while high-level healthcare systems offer numerous advantages across a wide range of conditions, the specific case of hip fractures demonstrates that a complex interplay of factors can influence outcomes. These include the implementation of standardized treatment protocols, the nature of the condition requiring immediate intervention, patient-specific factors, and the role of social family support. These elements can converge to produce similar outcomes across different healthcare systems.

Fig. 2 during 60 years (from 1960 to 2020), mortality from hip fractures has fallen from 27 to 20%, a yearly reduction of only 0.1%



The global epidemiology of hip fractures: How quickly is the frequency of hip fractures increasing?

Most countries showed declining trends in hip fracture incidence [2–6], regardless of sex, while the characteristics of the mean age of hip fracture have been relatively stable over time. Since the causes of hip fractures are multifactorial, the secular trends observed in different countries resulted from varying factors in each population. These factors include improved lifestyle, such as reduced prevalence of smoking and alcohol consumption, increased body mass index, and increased use of calcium and vitamin D, as well as medication for the treatment of osteoporosis. As most hip fractures occur after a fall, implementing fall prevention programs could be another key underlying the declining trend.

Despite declining trends in hip fracture incidence, the projected number of hip fractures will markedly increase by 2050, mainly due to the aging of the population. As reported by the WHO [7], the global population aged ≥ 85 will grow 4.5-fold from 2010 to 2050. Thus, the current declines in hip fracture incidence identified in most countries may be insufficient to offset the impact of the aging population and the attendant high risk of hip fractures in the older population.

Research indicates that although the occurrence rates of hip fractures are declining in many areas, the global count of such fractures is expected to almost double by 2050, attributed to the worldwide aging population. This increase in the number of fractures is occurring despite the decline in incidence rates in many countries, underscoring the growing burden of hip fractures as a global public health concern.

Are there sufficient orthopaedic surgeons to meet global demand?"

To follow the global epidemiology of hip fractures.

While the world's population continues to expand, the growth rate has slowed compared to previous rates. This slowdown in population growth is due to a declining fertility rate, or the number of children born per woman. Key factors influencing this trend include increased educational attainment among women, greater career opportunities, and wider access to contraceptive methods. Projections [2] suggest that the global population will rise to 9.8 billion by 2050. It is only an increase of 50% from seven to ten billion in 25 years, while the absolute number of hip fractures worldwide is projected to nearly double (200%) by 2050 due to the aging global population. Whether orthopaedic surgeons will be enough everywhere to follow the global epidemiology of hip fractures is a challenge.

Surgeons dealing with fractures have slowly increased for 4,000 years [8, 9]. Today, in Greece, Germany, Cyprus, and Italy, there are over 15 orthopaedic surgeons [9] for every 100,000 residents. Conversely, in the Netherlands, Serbia, Ireland, Slovenia, France, and Turkey, there are fewer than six orthopaedic surgeons for every 100,000 residents. Other countries fall in the range of six to 15 orthopaedic surgeons per 100,000 inhabitants, translating to approximately 500 for every five million people. With an increase of hip fractures of 200%, it would be necessary to augment to around 1,000 for every five million in 25 years, which is quite impossible in many countries.

Even in the United States [2], there are approximately 22,965 orthopaedic surgeons, with projections suggesting this number could grow to only 24,350 by 2025. This figure reflects a growth trend in the orthopaedic field, although demand for their services is expected to be 31,400 orthopaedic surgeons by 2025, indicating a potential shortfall of 7,050 orthopaedic surgeons.

To treat other diseases with high risks of complications and mortality

The occurrence of periprosthetic infections is uncommon, yet they present a mortality risk surpassing that of the top five most prevalent cancers when they do manifest [10]. Trauma, particularly from road traffic accidents, also represents a significant financial strain, especially among the younger demographic. It stands as the primary cause of disability in individuals younger than 40 and is the foremost reason for disability and mortality among adolescents and children. Every year, approximately 21,000 European children between the ages of five and 14 years lose their lives to trauma, with road traffic incidents accounting for 36% of these fatalities.

Osteomyelitis, characterized by a bacterial infection-induced inflammatory response in the bone, has seen a marked increase in incidence in the United States, from 11.4 per 100,000 individuals during 1969–1979 to 24.4 per 100,000 in 2000–2009. The surge in osteomyelitis cases predominantly affects those with underlying health conditions [11], elderly adults, and individuals with compromised health statuses. Notably, the incidence of osteomyelitis among older adults has nearly tripled over the past four decades, with the mortality risk escalating by at least 2.5 times. Diabetes-related osteomyelitis patients experience a higher amputation rate (60%) compared to those with blood-borne (6%) or contiguous osteomyelitis (24%).

In children [12], osteomyelitis and septic arthritis are the most frequent musculoskeletal infections, mainly occurring in the first ten years of life in otherwise healthy individuals. Lyme disease, resulting from deer tick bites, is less prevalent than osteomyelitis and septic arthritis but shares

similar clinical and laboratory features with septic arthritis. Epidemiologically, Lyme disease is more common in the Northeastern and Midwestern U.S. and Northern European regions. While most data originate from the U.S., indicating Lyme disease and arthritis as relatively rare in Europe, the highest transmission rates are found in Central and North-eastern Europe, suggesting a focused geographic prevalence.

Global orthopaedists disparity poses greater patient risk than population growth.

Healthcare disparities continue to be present in orthopaedics. These disparities manifest in access to healthcare as well as in the quality and outcomes of care. These disparities are linked to insurance status, race/ethnicity, and gender. However, recognition of disparities is low among orthopaedic surgeons, and populations with disparities are at an increased risk of complications after orthopaedic surgical operations [13, 14].

Orthopaedic care, essential for treating musculoskeletal conditions, is significantly impacted by the geographic and economic disparities [15] across different regions. High-income countries enjoy better access to orthopaedic services, including advanced surgical procedures and rehabilitation, while low- and middle-income countries face a scarcity of facilities, equipment, and trained professionals. Since higher-income countries use disproportionate amounts of orthopaedic resources (as

compared with low-income countries), this may leave developing countries with some scarcities.

Comparatively, there are few data regarding the number of orthopaedic surgeons in low-income and high-income countries. However, The World Bank [16] provides data on the specialist surgical workforce per 1 million population, indicating significant disparities in healthcare resources between high-income and low-income countries (Fig. 3).

Low-Income Countries: 1 orthopaedic surgeon per 1 million residents.

Low & Middle-Income Countries: 20 orthopaedic surgeons per 1 million residents.

High-Income Countries: 100 orthopaedic surgeons per 1 million residents.

While only an increase of 50% of orthopaedic surgeons in the United States of America is needed for 2025, the increase from 1 to 100 is necessary for adapting the number of orthopaedic surgeons from a low-income country to a high-income country represents an increase of 9,900%.

This data highlights the disparity in healthcare resources, specifically in the availability of specialists like orthopaedic surgeons, across countries with varying economic statuses. The significant difference in the ratio of orthopaedic surgeons

Fig. 3 Visualization of the global disparity of orthopedic surgeons. The stylized Earth and the distribution of surgeon figures with different orthopedic tools highlight the varying access to healthcare across different regions



to the population in high-income countries compared to low and low & middle-income countries underscores the challenges faced in accessing specialized healthcare services in less affluent parts of the world. It points to the need for efforts to improve medical training, infrastructure, and healthcare accessibility globally, especially in orthopaedics, which deals with conditions involving the musculoskeletal system.

Delays in access to elective surgery, complex scheduling appointments, care setting (outpatient, inpatient, hospital-based), significant variations in reimbursement based on insurance status, proximity to urban areas/academic centres, and limited primary and subspecialty health resources are major concerns that drive the access to healthcare [17]. Many reasons may be responsible for healthcare disparities related to race and ethnicity including variability in providers offering surgical care to minority populations, differences in patient attitudes and expectations regarding surgical care and outcomes, and socioeconomic barriers to access healthcare. Gender related disparities are less examined; these may be related to differences in perceptions/expectations of total joint replacements and clinicians who more likely offer conservative treatments to female patients based on their own profession, function, activity level, postoperative expectations, and degree of pain.

Disparities in received care and outcomes has been related to insurance/socioeconomic status, race/ethnicity, and sex, leading to poorer outcomes for patients with public or no insurance, non-white ethnicity, and female sex. *Therefore, the treating physicians must be aware of the modifiable practices that lead to poorer outcomes in these demographics and recognize any implicit bias that may exist.* Outcomes after total joint replacements based on race show higher mortality, complication rates at 30 and 90 days, and readmissions among specific and mixed-race patients compared with white patients [18–20]. Similarly, recent analyses showed that black patients may derive less benefit from total knee arthroplasty, have higher revision rates, and have worse patient-reported outcomes compared with white patients who also live in high-poverty areas. The explanations for these disparities in outcomes may be care

at hospitals that perform a lower volume of knee replacements, increased rate of comorbidities such as obesity, diabetes, and hypertension, and poor preoperative education by primary and subspecialty healthcare providers [21, 22]. Disparities are also evident in terms of whether surgery is recommended and the type of surgery performed in spinal surgery operations. Quality of care may also be in jeopardy for minority populations having less access to high volume centres, more postoperative complications, shorter preoperative and postoperative follow-up, and more variability in terms of postoperative discharge destination [23–25].

Decreasing disparities by increasing the proportion of women is one solution

While the presence of women in surgery appears recent to many, history shows that more than 4000 years ago this was common.

Lady Peseshet (Fig. 4) is believed to be one of the earliest known female physicians [8, 9] in history, dating back to the Old Kingdom of ancient Egypt. The Old Kingdom, known as the "Pyramids Age," spanned from 2686 to 2181 BCE. Lady Peseshet lived during the Fourth Dynasty, around 2500 BCE. Even the Egyptians of Nefertiti's day could not have imagined living in such remote antiquity as hers. She was born during the early era of pyramid construction. It was twenty-four centuries before Julius Caesar was slain in Rome, seven centuries before King Tut was born, and eleven centuries before the famed Code of Laws was created by the Babylonian King Hammurabi. She is mentioned in several ancient Egyptian inscriptions, including a mastaba (tomb) in Giza. The mastaba is associated with a man named Akhetetep, a high-ranking official during the reign of Pharaoh Djoser. In the mastaba, an inscription refers to Lady Peseshet as "the lady overseer of the female physicians."

While population growth increases the overall demand for orthopaedic care, inequitable distribution will directly affect the accessibility and quality. Without addressing the root

Fig. 4 Around 2400 BC, Peseshet, the first known female physician, served as the lady overseer of the female physicians of the Egyptian royal court. During this time, no distinction was made between doctors and surgeons



causes of resource disparity, simply increasing the global healthcare resources will not suffice.

Interestingly, the majority of medical students are now women (50%). Yet, the number of female orthopaedic trainees, around 20%, exceeds that of female orthopaedic consultants, which averages only 9%, in almost every country. Even though there has been an increase in female representation in orthopaedic residency programs over the past decade, the percentage of women remains lower than in most other medical fields in Europe and the United States.

Urban centres tend to have a higher physician density, showcasing a preference for specialized services like surgery and a tendency for doctors to work in city environments. This disparity is much more pronounced in low-income countries. Furthermore, projecting future orthopaedic workforce needs is complex due to uncertainties around retirement, migration, and shifts in service demand, with many countries failing to adequately plan for the looming retirement of a significant portion of their medical workforce.

The escalating demand for orthopaedic care raises concerns about the adequacy of orthopaedic specialist supply. Addressing these challenges necessitates improving hospital work and training conditions, offering economic incentives and social support for female orthopaedic surgeons, to ensure the workforce can meet future demands.

The reality today about Female Orthopaedic Surgeons: Only 10% after a 4,000 years history

Marie Wilbouchewitch-Nageotte is among the first female orthopedic surgeons in modern times [26, 27]. Born into a wealthy Russian family in 1864, she left Russia in 1882 to pursue medical studies in France. At that time, the Faculty of Medicine in Paris had a total of 4,000 students, 78 being women, 13 were French, and the majority Russian or American. Marie Wilbouchewitch passed the resident exam in 1888 and completed four years of surgery studies. In 1891, she married her colleague, Jean Nageotte. Throughout her training, she worked in pediatric surgery services at Georges Felizet's Tenon Hospital and the Hospital for Sick Children. For 25 years, she dedicated herself to pediatric orthopedics, becoming a highly active member of the Pediatric Society of Paris. As a pediatric orthopedist (Fig. 5), she led the orthopedics department at the Hospital for Sick Children. From 1914 to 1919, driven by a desire to be helpful, she volunteered to assist Professor Adolphe Jalaguier, a surgeon and chief physician at the Val de Grâce Military Hospital.

Ruth Jackson, originally from a farm near Scranton, Iowa, relocated to Dallas, Texas. Despite expressing her initial intention to pursue premedical studies at the University of Texas at Austin, her father's disapproval led her to opt for a major in sociology. However, a pivotal moment during her



Fig. 5 Portrait of Marie Nageotte Wilbouchewitch

graduation in 1924, witnessing a family's struggles due to a father's incapacitating knee injury prompted her to switch to medicine. Jackson (Fig. 6) was one among four females in a class of one hundred students. Despite her aspirations to become a general surgeon, the absence of internships for women in that field forced her to undertake a rotating internship at Worcester Massachusetts Memorial Hospital in 1928. Later, she took advantage of a chance to study orthopaedic surgery at the University of Iowa with Dr. Arthur Steindler, finishing her orthopaedics residency at Worcester. In 1933, when the American Academy of Orthopaedic Surgeons (AAOS) was founded [28], Ruth Jackson's admission was contingent on passing the American Board of Orthopaedic Surgery examination, which she achieved in 1937, being the first woman to be a board-certified orthopaedic surgeon in USA. Dr. Ruth Jackson, a pioneer in her field, passed away at 91 in 1994 at the Baylor University Medical Center in Dallas, concluding a remarkable life.

We all know that gender diversity in orthopaedic surgery it's lacking [29, 30], and we know why [31–34]! It is evidence and not a secret. Women make up a large portion of the orthopaedic surgeon training pipeline. Orthopaedic surgery is the surgical subspecialty where residents are training the least number of women; it is followed by neurosurgery, urology, plastic surgery, general surgery, and colorectal surgery.



Fig. 6 Portrait of Ruth Jackson: While Jackson was attending Baylor University, male students were permitted to examine patients of either sex, but female students were not permitted to examine male patients. It was announced during orientation that female students would not be able to graduate with "equal standing" unless they achieved grades ten points higher than those of male students

A study [35] in United States of America has shown that, assuming constant growth at the current rate, and starting at the beginning of the twentieth century, the time to reach 36% women in orthopaedics is projected to need 217 years, or arriving by the year 2236. But starting the study from the beginning 4,000 years ago with Lady Peseshet, it could be 12,000 years to arrive at 30% women in orthopaedics!

SICOT stands at the forefront of addressing disparities reduction in orthopaedic healthcare

There are essential steps clinicians should take to aid in lessening healthcare disparities in orthopaedics. These include identifying the disparities, providing patient-centred healthcare, obtaining training and creating patient education materials, learning languages, making commitments to visit patients with public or no insurance, and using resources from Organizations and Societies. In the latter, the role of SICOT is essential.

SICOT is dedicated to advancing orthopaedic surgery across the globe, placing significant emphasis on surgeons education as a core approach to fulfil this mission. While medical student education in musculoskeletal medicine shows variability in curriculum breadth and instructional time, the responsibility of universities in providing this foundational education is comparably stable worldwide. This consistency does not extend to postgraduate orthopaedics and traumatology training, which varies widely both internationally and within individual nations. In certain countries, universities remain influential in postgraduate education, while in others, they play no role, with specialist training instead managed by local or national governments, independent educational bodies, professional surgical or specialist associations, or specific hospitals or groups of hospitals. There is a lack a global standard or agreed-upon curriculum for specialist training. Nevertheless, passing the SICOT exam signifies a recognized milestone, validating the completion of training. This achievement suggests that a specialist certified by SICOT is part of a workforce capable of practicing in various countries, despite the absence of universal training standards.

Significant gaps exist in the publication rates of orthopaedic research, heavily influenced by the income level of the author's home institution, with notable discrepancies in high-impact journals [36–38]. There's a pressing need to facilitate more research publication opportunities for scholars from lower-income countries in influential journals [39]. Gender disparities in the field of surgery are complex, rooted in a combination of organizational and personal factors, such as upbringing, work-life balance choices, personal interests, working conditions, the absence of role models and mentorship, and institutional policies, all contributing to the prominence of these disparities.

Global collaboration and technological advancements

The Importance of Transferring Technology.

Technology transfer involves transforming innovations and inventions conceived in research settings into marketable products. This process usually occurs by licensing intellectual property rights to companies or fostering the development of start-up ventures. Successful technology transfer initiatives in healthcare that could serve as models for SICOT's efforts in orthopaedics may include securing patents and intellectual property rights, educating researchers on commercialization principles and strategies, and tactics, supporting the establishment and growth of faculty-led start-ups, obtaining financing for preliminary research and emerging companies, coordinating educational programs and entrepreneurial contests, developing support systems

and innovation networks that facilitate ongoing medical training, and establishing initiatives that motivate both students and faculty to pursue innovation in laboratories.

These technology transfer initiatives are expected to have substantial benefits for researchers, members of SICOT, healthcare providers, regional and national economies for improved national and global health. The standard technology transfer process encompasses stages such as generating knowledge, revealing innovations, conducting assessments and evaluations, securing funding and advancing technology, marketing efforts, bringing the technology to market, developing the product, and assessing its societal impact. The objective of technology transfer is to make scientific and technological advancements available to a wider audience, enabling them to further refine and apply the technology into novel products, processes, applications, materials, or services [40]

Developing countries have specific needs for technology transfer in orthopaedic care, including the lack of infrastructure, trained personnel, and access to advanced medical technologies.

Technology transfer provides developing countries cutting-edge knowledge, research, and expertise worldwide [41, 42]. This access allows them to upgrade their educational and technological capabilities, fostering innovation and enabling local industries and companies to remain competitive globally. The challenges inherent to technology transfer include cultural and language barriers, maintenance and sustainability of technology, and ensuring that technology transfer does not become a one-way imposition of foreign solutions on local problems. Tailoring technology and training programs to developing countries' specific needs and contexts, ensuring local ownership and sustainability are essential.

Will technology drive orthopaedic surgery in the future?

SICOT and its members should be encouraged to take a proactive role in technology transfer, emphasizing the benefits for recipient countries and the global orthopaedic community. In this setting, the need for collaboration with local governments, healthcare institutions, and other international organizations to ensure that efforts are well-coordinated and effective is paramount.

Current technology trends are improving, and novel technologies are constantly developing. Managing patient expectations is crucial [43–45]. Technology transfer can potentially transform orthopaedic care in developing countries, making it more accessible, efficient, and effective. The future of global orthopaedic care is promising, where advancements are shared equitably across borders and every patient has access to the care they need. As innovative technology and artificial intelligence take hold, it is evident that orthopaedics is entering a period of immense change [46–51].

Nonetheless, it is crucial to identify priority technologies in orthopedic care. Future strategies should emphasize integrating technology in a cost-effective and environmentally sustainable way, through worldwide collaboration among clinicians, researchers, and the industrial sector to enhance patient care significantly.

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