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ORIGINAL ARTICLE

International comparative analysis to understand the capacity for arthroscopy training and practice in developing countries

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Abstract

Purpose Arthroscopy is an efficacious and popular treatment modality in developed nations for a variety of musculoskeletal conditions. However, arthroscopy requires specialized training, complex infrastructure, and expensive equipment, occasionally causing barriers to use in developing countries. Consequently, the utilization of resources to perform and teach arthroscopy in low- and middle-income countries (LMICs) is controversial. Through this investigation, we assessed the current capacity and barriers to arthroscopy use and training in these settings.

Methods Focused interviews were conducted with surgeons from Haiti (low-income) and Romania (middle-income) regarding their experience with arthroscopy. Based on responses, a multiple-choice survey was developed and administered to orthopaedic trainees and practicing orthopaedic surgeons during national orthopaedics conferences in each country.

Results Fifty-eight orthopaedists in Haiti, and 29 in Romania completed the survey. Most (91% from Haiti; 79% from Romania) reported that learning arthroscopy is essential or important for orthopaedic training in their country. Yet only 17% from Haiti compared to 69% from Romania indicated their primary hospital has the equipment necessary for arthroscopy. In Haiti, equipment was the main barrier to use of arthroscopy, followed by training, while in Romania, the main barrier was training, followed by equipment. Simulations and telemedicine were ranked as top choices of effective methods for learning arthroscopy.

Conclusions Regardless of their country's resource limitations, most participants place high value on the practice of arthroscopy and arthroscopic training. The results from this study highlight a hierarchy of needs in developing nations. Furthermore, local providers report a strong belief in the need for arthroscopic treatment to benefit their patients, and a clear desire for further training and development of these techniques. By identifying similarities and differences by location, we may better tailor global orthopaedic training initiatives and partnerships in LMICs.

Keywords Global surgery · Arthroscopy · Telemedicine · Education

Introduction

Orthopaedic trauma is at the forefront of global surgical needs, as the burden of disease continues to rise in developing countries [1, 2]. Arthroscopic surgical techniques may have a role to play not only in elective cases, but also in the treatment of trauma, infection and related injuries that plague low- and middle-income countries (LMICs). While arthroscopy has historically been viewed as controversial due to cost, time allocation, and a perceived lack of clinical applicability to the orthopaedic demands of the developing world, providers in these nations have expressed an interest and clinical need for arthroscopy training [3]. However, the availability of arthroscopy is often limited. Therefore, less efficacious but more

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easily accessible treatment options, such as immobilization and rehabilitation, are often chosen instead. For some injuries, such as traumatic shoulder dislocation, non-operative management alone for all patients may leave some prone to ongoing instability and recurrent injury. This, in turn, may reduce an individual's functional status, worsen disability, and prolong time out of work [4–7].

Arthroscopy is an efficacious and popular treatment modality in the United States and other developed nations for a variety of injuries. The body of literature on arthroscopy supports that, overall, arthroscopic procedures yield equal or better results compared to open surgery in terms of decreased pain and increased functionality of the affected joint, as well as decreased recovery time and a lower risk of wound complications [8–11]. One of the more common traumatic upper extremity injuries that leads to disability in the developing world, shoulder dislocation, is one of many conditions for which there may be a role for arthroscopy in these areas. Shoulder dislocation has historically been treated non-operatively with closed reduction and an initial period of rest followed by exercise and/or physical therapy but has more recently been shown to benefit from arthroscopic management, particularly in cases of recurrent instability [4, 5, 11–13]. However, arthroscopy requires specialized training and expensive equipment (in addition to consistent electrical power and running water) causing barriers to use in LMICs. As a result, the investment of resources to teach arthroscopy in developing countries remains controversial [14].

Therefore, it is important to investigate the capacity of developing nations for arthroscopy and arthroscopic training, with a particular focus on the ability of this technology to reduce pain and disability after traumatic injury. In addition, the lack of availability of advanced imaging in developing nations, such as MRI or CT scan, may elevate the role of arthroscopy as a diagnostic tool. By assessing the current capacity for arthroscopy and identifying and comparing the needs and barriers specific to the development of training programs in different locations, we can aim to tailor global orthopaedic training initiatives to local needs, making them more efficient and sustainable.

In this study, we analyse the current provider-reported capacity and needs related to arthroscopic surgery and training in two LMICs to better inform the discussion on resource allocation for arthroscopy in such settings. We test the hypothesis that an initial assessment tool will reveal the extent to which there exists a need for training in arthroscopy, along with the capacity for implementation of training per each country's available resources.

Materials and methods

Prior to the start of the study, Institutional Review Board (IRB) exemption was obtained, as well as approval of in-country host organizers in each of the two study settings (Haiti and Romania).

Focused interviews

To better understand the context of this study's primary question in each location, we conducted a series of focused interviews with four practicing orthopaedic surgeons from each country. We recruited interviewees using an email script describing the research team and purpose of the interview. Participation was voluntary, and informed consent was obtained from all individual participants included in the study. Interviews took place by telephone or an audio internet application. The first author interviewed each subject using a consistent moderator's guide regarding the interviewee's experience with arthroscopic surgery. The primary goal of these questions was to assess the current (perceived) presence of arthroscopy and arthroscopy training in each country, as well as the capacity for future training. Interviews were recorded and transcribed for review.

Survey development

Important guidance was gained from the interviews for designing a targeted survey tool for our capacity assessment. Based on the interviews and additional direction from conference organizers familiar with attendee demographics, we developed a multiple-choice style survey instrument. Responses were collected using a Likert scale or by having participants select from a multiple-choice list of options. Demographic information (nationality, age, sex, level of training, base hospital, years in practice) was obtained. The survey was available in English and French for Haitian participants, and in English for Romanian participants.

Survey administration

We administered the questionnaire in person during annual orthopaedics conferences in a low-income (Haiti) and a middle-income country (Romania); income assignments are defined by the World Bank [15]. In Haiti, this was the Haitian Annual Assembly of Orthopaedic Trauma (HAAOT), and in Romania, the American Academy of Orthopaedic Surgeons—Romania Cooperative Shoulder Course (AAOS-RCSC). Both are national continuing medical education-style conferences, co-organized by American and Haitian or Romanian orthopaedic

surgeons, respectively, with regular attendance by both trainees and attending care providers. Survey participants included orthopaedic residents, fellows and attending surgeons drawn from multiple academic centres within their respective countries. This setting provided an efficient way to assemble a convenient sample. Participation was voluntary.

Statistical analysis

Survey results were input to an electronic database [Microsoft Excel, Microsoft Office 365]. We calculated cross-sectional descriptive statistics for sample demographics and responses to Likert scale and multiple-choice questions. To compare results between study groups, two-proportion-sample z-tests were performed for dichotomous proportions, and chi-square homogeneity tests were performed for categorical counts. *P*-value less than 0.05 was considered significant.

Table 1 Demographic information for study participants

Study participant demographics			
	Haiti (%)	Romania (%)	Total (%)
Participants	**58 (67)**	**29 (33)**	**87**
Attending Surgeon	20 (34)	12 (41)	32 (37)
Resident	38 (66)	17 (59)	55 (63)
Male	52 (90)	25 (86)	77 (89)
Female	6 (10)	4 (14)	10 (11)

% reported are % of total participants in each column, except % of participants from each country (bold) reported as % of total study participants

Results

Demographics

A total of 87 orthopaedic surgeons participated in the study, 58 (67%) from Haiti and 29 (33%) from Romania (Table 1). Of these, 77 (89%) were male and ten (11%) were female. In Haiti, 20 participants identified themselves as attending orthopaedic surgeons and 38 as residents. In Romania, 12 attendings and 17 residents participated.

Arthroscopy exposure

Just under 9% of Haitian compared to 62% of Romanian participants reported that their orthopaedic residency program includes/included some form of exposure to training in arthroscopic surgery. The amount of time exposed to arthroscopy was rarely greater than six months (Fig. 1). In Haiti, if a surgeon had been exposed, the exposure was generally brief (less than one month), whereas in Romania the exposure was generally in blocks of one month or more. Thirty-four percent of Haitian participants indicated that they participated in arthroscopic surgery training courses/programs outside of their country compared to 21% of Romanian participants. These surgeons listed attending courses in higher resource nations in Europe and North America.

Only two attendings (17% of attendings) from the Romanian cohort, and six (30% of attendings) from Haiti reported performing arthroscopic surgery as part of their current

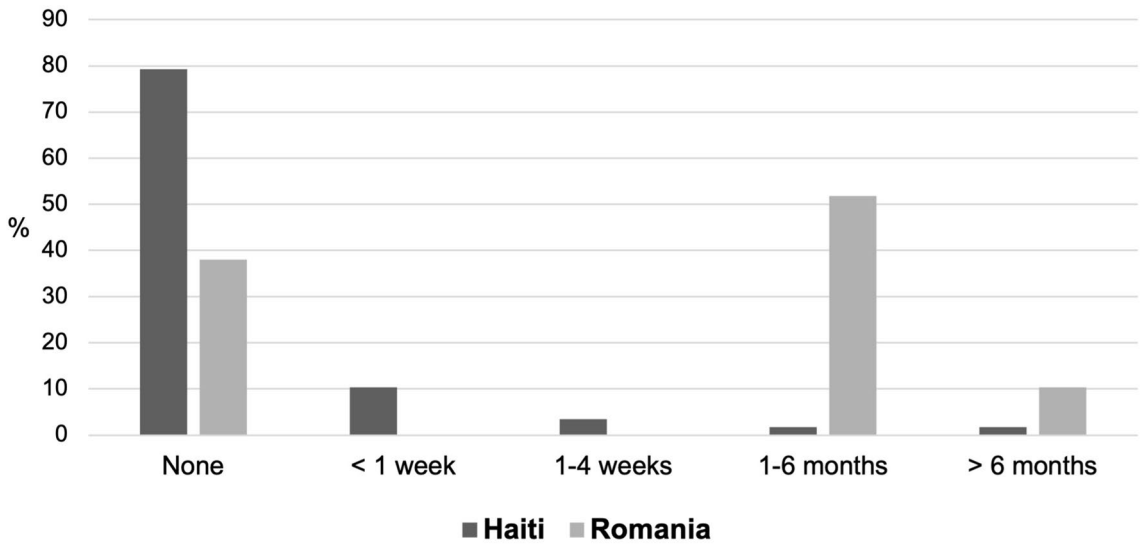

Fig. 1 Amount of time exposed to arthroscopy during orthopaedic surgery residency in Haiti compared to in Romania

orthopaedic surgery practice. Residents from Haiti who reported observing arthroscopic surgery noted that arthroscopy of the knee with meniscectomy or meniscal repair was the most common procedure observed.

Regarding treatment of patients presenting with recurrent shoulder instability (that has not improved despite a full course of physical therapy), the largest group of Haitian participants (48%) reported they would perform open surgery as a next step, while most Romanian participants (55%) reported their next step would be to obtain advanced imaging, such as MRI (p-value < 0.001) (Fig. 2).

Barriers to arthroscopy

Sixty-nine percent of participants from Romania indicated that their primary hospital has the equipment necessary for arthroscopy, while 17% from Haiti indicated this. In Haiti, lack of equipment was reported as the main barrier followed

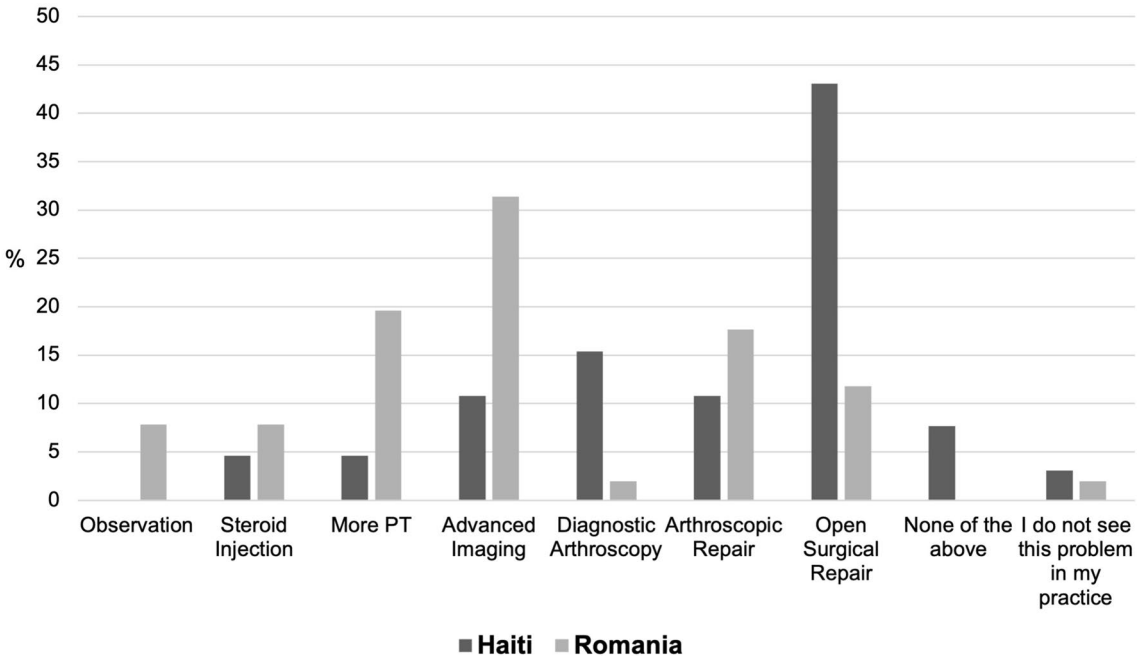

Fig. 2 Participant responses in Haiti and Romania when asked his or her next step in management of a patient with recurrent shoulder instability that has not improved despite a full course of physical therapy (PT)

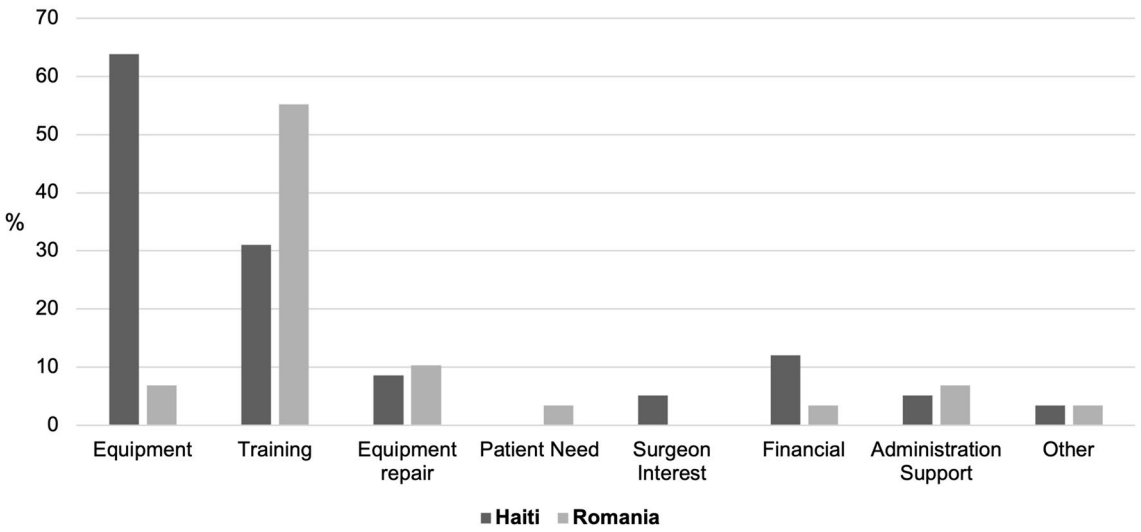

Fig. 3 Primary current barrier to arthroscopy training and practice in Haiti and Romania

by lack of training, while in Romania, lack of training was followed by lack of equipment (p-value = 0.002) (Fig. 3).

Interest in arthroscopy

Ninety-one percent of participants from Haiti and 79% from Romania stated that learning arthroscopy is essential or important for orthopaedic training in their country. When asked to choose the most important reason for orthopaedic residents in their country to learn arthroscopy, 95% of participants from Haiti and 90% of participants from Romania chose responses indicating patient need and well-roundedness of orthopaedic education (Fig. 4a and 4b). Zero participants indicated that residents in their country should not learn arthroscopy. Outside of formal courses or dedicated training during residency, simulations and telemedicine were ranked as top choices for effective methods for learning arthroscopy in these countries (Fig. 5).

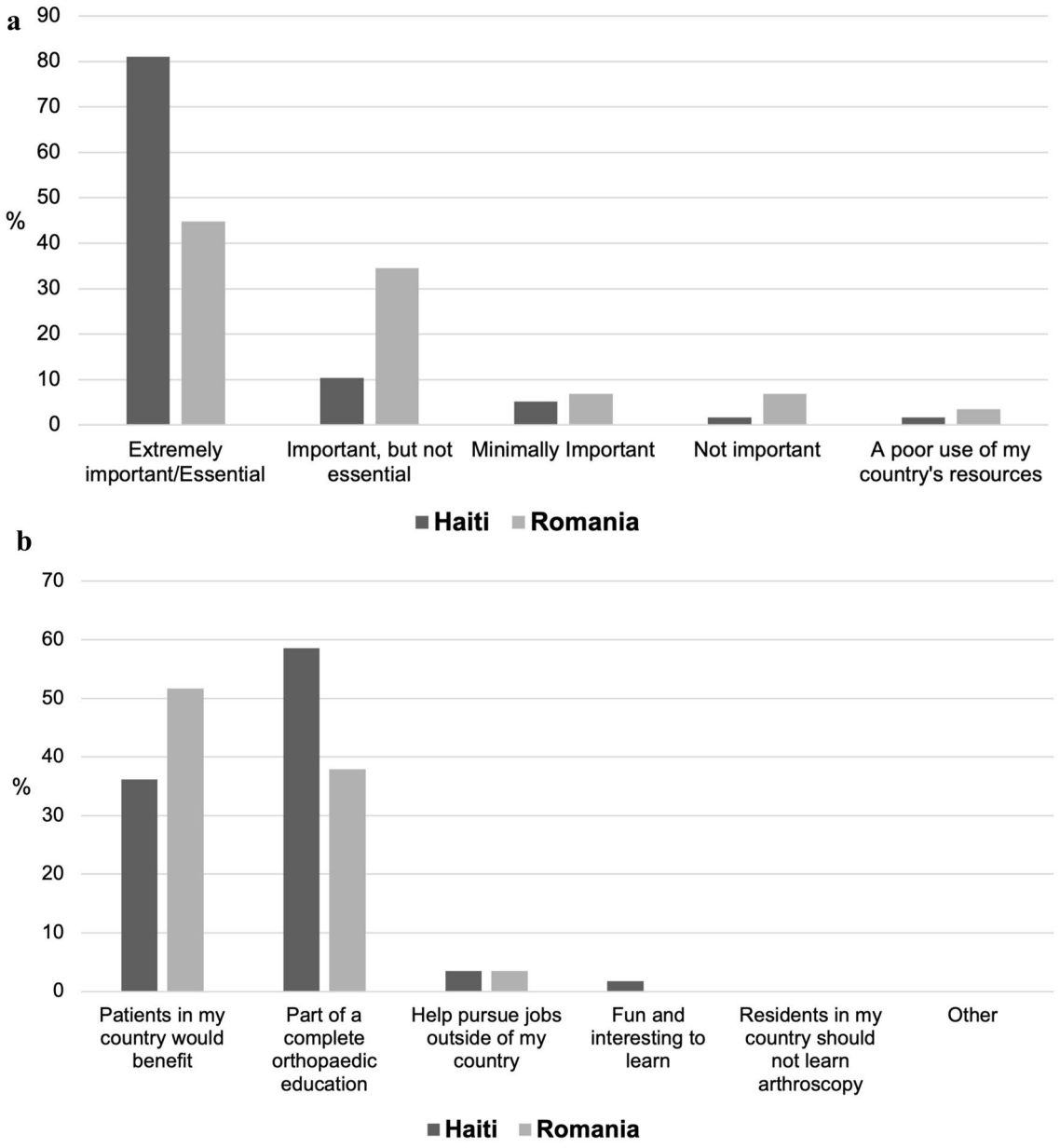

Fig. 4 **a** The level of importance of learning arthroscopy as part of orthopaedic training, and **b** the most important reason for learning arthroscopy as part of orthopaedic training in Haiti and Romania

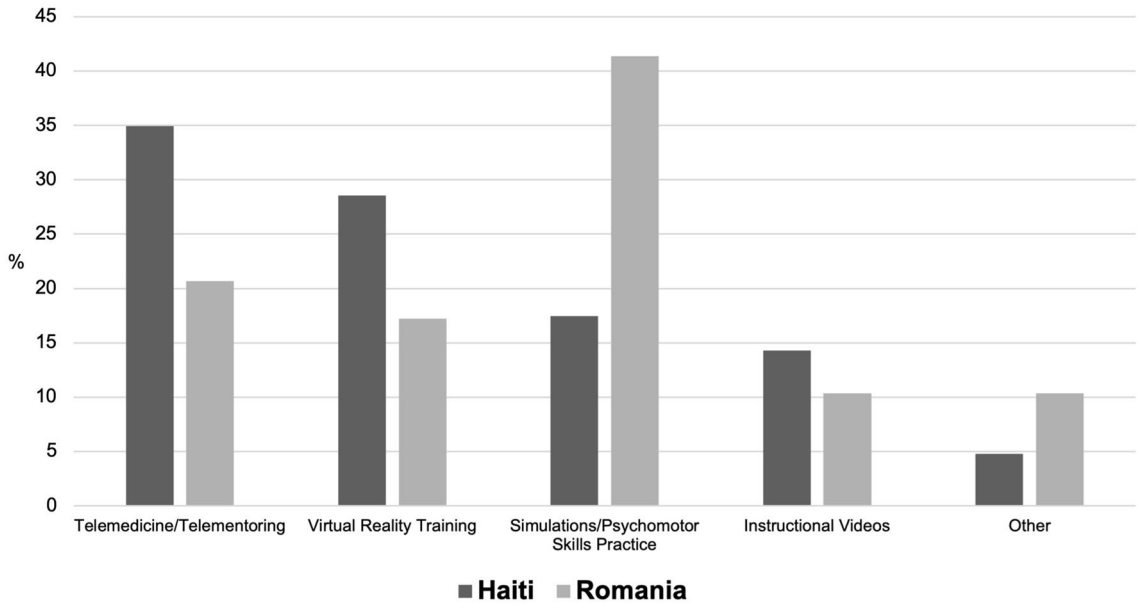

Fig. 5 Effective methods for learning arthroscopy outside of formal courses or dedicated training during orthopaedic surgery residency reported in Haiti and Romania

Discussion

Arthroscopic surgery and training are common in high-income countries, but arthroscopy can be an expensive enterprise. Currently, there are limited providers, too few training programs, and inadequate equipment for many nations in the developing world [16]. Consequently, surgeons from industrialized countries have travelled to LMICs to impart their expertise in an effort to bolster surgical programs, including in arthroscopy. Previous studies have demonstrated that visiting surgical teams can provide at least short-term improvements to the continuing medical education (CME) of physicians in low-income nations [17]. However, the actions and effectiveness of surgical volunteers are limited by incomplete comprehension of the capacity and specific needs of orthopaedic surgeons in these areas. This understanding has sparked debate over how to provide proper arthroscopy training and/or equipment to doctors in LMICs.

This project serves as the first comparative capacity assessment and analysis of arthroscopy in developing nations. In Haiti and Romania specifically, a provider-reported, "felt needs" (what people say they need) capacity assessment of all orthopaedic surgery was conducted at an orthopaedic-focused CME conference, and it identified a significant interest and perceived need for arthroscopy training [3]. While it has been shown that adult learning is most successful when "felt" or perceived needs are addressed, it is important to examine the capacity for addressing and sustaining new initiatives before sparse resources are allocated [3, 18]. Our results demonstrate the consistent belief in both settings, at least by providers, that arthroscopy training and utilization is both needed and important for patient care.

The economic and political statuses of Haiti and Romania make these nations particularly disadvantaged in healthcare. According to the 2022 Economic Index, Haiti is considered the poorest country in the western hemisphere, with the 145th "freest economy" in the world [19]. Haiti is comprised of approximately 10.8 million people, and it is estimated that about 40% of the population lacks access to essential health services [20]. Haiti therefore maintains a heavy reliance on international funding and constantly struggles to attract and retain health professionals. The 2022 Economic Index ranks Romania as the 47th "freest economy" in the world [19]. Although considered above regional and world economic averages due to macroeconomic stability since 2015, Romania is ranked last in the European Health Consumer Index and is considered the weakest European nation in healthcare [21]. Based on the information from the Economic Freedom Index of 2022, Romania ranks near the 75th percentile while Haiti ranks close to the 25th percentile of economic freedom globally. There are a variety of other American, African, and Middle Eastern countries listed above and below each location, which supports the potential for generalizability of the results of this study. Additionally, Romania's and Haiti's geographic locations provide adequate representation from each hemisphere.

The demand for arthroscopic techniques requires a supply of specialized training and functional equipment, which have been inadequate up to this point in these settings. The setup cost for an arthroscopic tower with the arthroscope and

needed equipment is approximately $75,000 in the United States. For developing countries, this can be reduced by about 50%; however, the cost still exceeds the budget of most hospitals in developing countries. That is why used equipment (first- or second-generation equipment) is popular in these LMICs and is an alternative to purchasing new equipment. However, many companies are reluctant to donate their older equipment, as they want hospitals to purchase their newer models, even in these developing countries. Maintenance of this specialized equipment, including sterilization and breakage of equipment needing replacement, can easily run approximately $1000 per month per system, and also poses significant cost to users of arthroscopic tools, particularly challenging in LMICs.

In Haiti, participants reported that the highest barrier of entry remains an insufficient and inconsistent supply of functional equipment to perform arthroscopic surgery. This result highlights a hierarchy of needs in developing nations, specific to the economic status of each setting. A discussion regarding properly equipping surgeons in this country should precede a strategy to improve training. In contrast, a majority of participants in Romania reported that their primary hospitals possess necessary equipment, but that the deficiency of arthroscopic practice is a result of the scarcity in training. It is interesting to note, however, that 67% of attendings compared to 47% of residents felt the training deficiency to be the primary barrier, which may indicate a developing trend toward more arthroscopy training already for younger orthopaedic surgeons.

Participants in this study identified possible substitutes to formal courses or dedicated training during residency, including simulations and telementoring. While arthroscopy has traditionally been taught to residents through one-on-one in-person guided training in the operating room, primarily at tertiary academic institutions, simulators have also been used to increase the availability of exposure to arthroscopy training. Several simulators have been developed and "validated" but have significant limitations and cannot be definitively correlated to improvement in arthroscopy skills in the operating room [22–27].

Telemedicine and telementoring have become increasingly popular due to the perceived ability to overcome barriers of global medical education, which traditionally relies heavily on visiting mentors from developed countries or attrition (both temporary and permanent) of locals to developed countries. Telementoring involves an expert physician guiding another physician at a different geographic location through a virtual interactive training platform. The use of telementoring through augmented reality has been demonstrated in orthopaedic education [28], in addition to several established strategies in general surgery, particularly for laparoscopic procedures [29–32]. A virtual interactive video platform has been shown to be a reliable and useful tool to teach arthroscopic shoulder surgery in developing nations [33], and more trials are needed. The ability to provide real-time surgical instruction has the power to enhance knowledge transfer, skill acquisition, and surgical technique. Therefore, its successful application in this context has the potential to shape the future of global orthopaedic training where the capacity is present. More studies must be procured to establish the extent of educational efficiency and patient safety under these training practices.

The approaches used in this study are limited by small sample size. This limitation was minimized by conducting the survey in person, in a setting of maximal attendance of orthopaedic surgeons from throughout the host country (largest feasible sampling of the population of interest). While prepared paper packets containing the survey were administered to 100% of conference attendees, and 100% of the packets were returned, the investigators cannot be sure that each attendee received a packet due to logistical challenges, though this was the intent. It is conceivable that as many as 10% of attendees did not receive a packet. In addition, the survey is limited by its self-reported nature. This structure depends on participant recall, and is vulnerable to bias, specifically recall bias and social desirability bias [34]. We do not expect these metrics to be significantly over- or under-estimated by responders, and therefore presume a random variation pattern in any misclassification, but quantitative study of arthroscopy resources would be required to confirm. This self-reported approach, however, engages local providers as an initial assessment of their perspectives and views, and questions were as objective as possible to minimize bias.

Further research is warranted to objectively quantify true capacity for arthroscopy, at least in teaching hospitals. In the interim, it may be useful to derive an algorithm based on the hierarchy of needs demonstrated in this study combined with publicly available epidemiological data to model which countries would be the most appropriate to introduce and benefit the most from introducing arthroscopy. Orthopaedic surgeons from additional countries may also be surveyed to aid in determination of their capacity for arthroscopy and arthroscopy training.

Conclusions

The utilization and training of arthroscopy in low-resource settings remains controversial. To better inform this discussion, we demonstrate differences in capacity and a hierarchy of needs between a low-income nation (equipment) and a middle-income nation (training). Furthermore, local providers report a strong belief in the need for arthroscopic treatment to benefit their patients, and a clear desire for further training and development of these techniques. By

identifying similarities and differences by location such as those examined in this study, we may better tailor global orthopaedic training initiatives and partnerships in LMICs.

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Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request in deidentified form.

Declarations

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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