

## EVIDENCE-BASED SYSTEMATIC REVIEWS

# The Current State of International Academic Partnerships in Orthopaedic Surgery Between High-Income and Low and Middle-Income Countries

### A Systematic Review

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**Background:** Orthopaedic academic partnerships between high-income countries (HICs) and low and middle-income countries (LMICs) are an effective method to increase research and scholarly support. The purpose of this study was to perform a systematic literature review of the current state of partnerships worldwide and assess the quality, quantity, and content of their research output.

**Methods:** A systematic review was conducted using 4 academic databases: PubMed, MEDLINE, Embase, and CENTRAL. Article eligibility criteria included articles published between January 2017 and 2022, with orthopaedic authors from at least 1 HIC and LMIC. Articles related to global orthopaedic surgery with exclusively HIC or LMIC authors were excluded.

**Results:** The database search yielded 25,928 articles, and after deduplication, 21,145 articles were included in the screening. After title and abstract screening, 408 articles underwent full-text review for eligibility. The final list of eligible articles for extraction included 310 publications in 127 journals. Published articles increased over time (46 in 2017 to 88 in 2021) and were most commonly published in the *Journal of Bone and Joint Surgery* (20, 6.5%). Open-access articles (203, 65.5%) had a significantly greater Journal Citation Indicator ( $p = 0.024$ ) than non-open-access articles. Most studies (40.7%) were observational, with few (3.6%) randomized controlled trials. Orthopaedic trauma (38.1%) was the most common subspecialty, followed by spine (14.8%) and pediatrics (14.2%). Most partnerships were sponsored by North American authors in 65 LMICs, primarily China, India, and the sub-Saharan African region.

**Conclusion:** This study identified 310 articles published by orthopaedic international academic partnerships in 106 countries over the past 5 years, demonstrating that collaborations between LMIC/HIC partners nearly doubled over the study period. Sixty-five percent of the articles were published in open-access journals.

### Introduction

Orthopaedic-related disease is one of the leading health challenges faced worldwide. Injury and trauma remain the third leading cause of death overall and the leading cause of death in individuals younger than 45 years in high-income countries (HICs). Injury-related mortality is an even greater problem in low and middle-income countries (LMICs)<sup>1</sup>. The World Health Organization (WHO) estimates that 93% of global fatalities from road traffic accidents occur in LMICs<sup>2</sup>. In

2016, musculoskeletal disorders were identified as the fourth largest source of global disease burden, affecting an estimated 138 million people (roughly 1 in 50 people) worldwide<sup>3</sup>.

The global impact of orthopaedic-related conditions is exacerbated by the lack of access to timely, appropriate care. Over two-thirds of individuals worldwide do not have access to orthopaedic surgical care<sup>4,5</sup>, in large part, due to inadequate infrastructure, supply shortages, and the lack of trained health care professionals necessary for appropriate orthopaedic

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management<sup>6-8</sup>. The Lancet Commission on Global Surgery published recommendations for improving surgical capacity worldwide in 2015<sup>9</sup>. A cornerstone of these recommendations was a movement away from surgical “volunteerism,” which often involves short-term HIC outreach focused solely on delivering operations, and toward more sustainable academic partnerships established on the pillars of clinical care, research, education, advocacy, and humanitarianism<sup>9-12</sup>.

At the heart of successful international academic partnerships in orthopaedic surgery<sup>13</sup> is a dedication to mutually beneficial relationships and a commitment to promote sustainable capacity, collaboration, and leadership within LMIC institutions<sup>10,13-15</sup>. The transition from volunteerism to academic partnerships has improved the quality and quantity of research in LMICs<sup>10,12</sup>. Research can address knowledge gaps in clinical care and provider education<sup>13</sup>. Although there is a growing body of literature on orthopaedic-related conditions in HICs, this literature is often not generalizable to low-resource settings due to disparities in orthopaedic infrastructure, availability, and training<sup>16,17</sup>. Thus, advances in orthopaedic care in LMICs will require increased high-quality, locally conducted

research<sup>11</sup>. Collaborating with high-resource partners has been shown to increase research capacity and quality in LMICs, by providing funding, resources, training, and mentorship to develop, advance, and support research<sup>15,18</sup>. While the literature contains studies related to global orthopaedic research and the impact of partnerships, to our knowledge, there has not been a comprehensive overview of the current state of these collaborations worldwide<sup>14,18,19</sup>. The purpose of this study was to perform a systematic review of the current state of orthopaedic academic partnerships worldwide as well as assess the quality, quantity, and content of their research output.

## Methods

A systematic literature review analyzing the current state of orthopaedic academic partnerships between HICs and LMICs was conducted with the objective of identifying the number, type, and content of research articles published by orthopaedic academic partnerships. The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO; CRD42022290249), and the search was performed in accordance with the Preferred

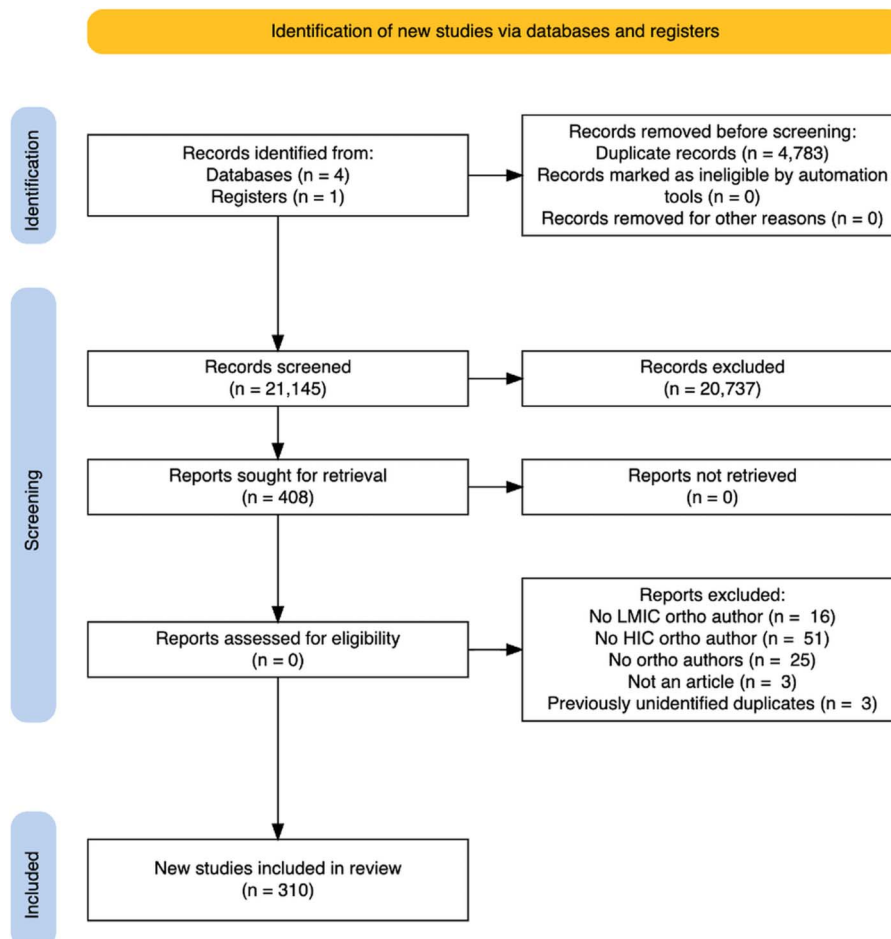


Fig. 1  
PRISMA flow diagram of the screening process.

TABLE 1 Article Characteristics

Category	N	%*
Articles	310	
Year		
2017	46	14.8
2018	53	17.1
2019	56	18.1
2020	67	21.6
2021	88	28.4
First author		
HRP	170	54.8
LRP	113	36.5
Both	27	8.7
Last author		
HRP	200	64.5
LRP	87	28.1
Both	23	7.4
Other authors		
HRP	25	8.1
LRP	33	10.7
Both	249	80.3
N/A	3	1.0
Multicenter collaboration		
Yes	105	33.9
No	205	66.1
Study type		
Retrospective observational study	64	20.7
Prospective observational study	62	20.0
Cross-sectional study	36	11.6
Narrative review	33	10.7
Systematic review	20	6.5
Cross-sectional study	16	5.2
Consensus study	11	3.6
Randomized controlled trial	11	3.6
Case series	9	2.9
Economic analysis	9	2.9
Qualitative study	9	2.9
Validation study	9	2.9
Case-control study	5	1.6
Meta-analysis	4	1.3
Basic science	3	1.0
Other†	9	2.9

\*Percent of the total articles (n = 310). †“Other” article types include commentary/letter to the editor, probability modeling, systems approach, mixed methods, and other special articles.

of author affiliations. Established partnership-related research must include authors affiliated with orthopaedic departments from both income groups. A medical librarian performed the literature search using criteria consistent with that published previously on the topic<sup>18</sup>. The search involved orthopaedic-related terms as well as LMIC-related terms (i.e., countries identified by the World Bank as low and middle-income countries) (Appendix I). The LMIC terms were obtained from the Cochrane Effective Practice and Organization of Care LMIC filters, developed by the Cochrane, WHO, and Campbell Collaboration<sup>21</sup>.

The review process was conducted using the Covidence application (Melbourne, Australia). Three reviewers (M.J.F., M.C.M., and K.E.B.) independently screened article titles and abstracts. Each article was screened by at least 2 reviewers. Eligibility criteria included articles published by authors with an orthopaedic affiliation from at least 1 HIC and LMIC between January 2017 and 2022. Country income levels were determined by the 2022 World Bank Data and Lending Groups, which are based on a country's gross national income (GNI) per capita (i.e., dollar value of a country's final income in a year divided by its population) and are a commonly used designation in international orthopaedic research<sup>22</sup>. In 2022, low-income, lower middle-income, upper middle-income, and HICs were defined by having GNIs per capita of <\$1,135, \$1,136 to \$4,465, \$4,466 to \$13,845, and >\$13,846, respectively<sup>22</sup>. LMICs were defined as any country that was low, low-middle, or upper-middle income (i.e., all countries that were not “high income”). Though China has a heterogeneous health care landscape, it is categorized as upper-middle income. Articles that passed the title and abstract screening were further screened by the same process using the full-text article. In both screening stages, 2 reviewers (M.J.F. and M.C.M.) met to resolve any conflicts regarding inclusion/exclusion. Four team members, consisting of a MD, PhD, and 2 medical students (M.J.F., M.C.M., J.M.O., and P.R., respectively), extracted relevant data from the articles identified in the review. Extracted data were collected and stored in the secure database REDCap (Nashville, TN). Extracted data included general article characteristics (e.g., title, journal, and publication year), content (e.g., study design, orthopaedic subspecialties, and specific topics), and authors' countries. Journals were evaluated based on the 2021 Journal Citation Reports, Journal Impact Factor (JIF), Journal Citation Indicator (JCI), and Article Impact Factor (AIF)<sup>23</sup>. The JIF is the most common metric for evaluating journals. The JCI relates to the number of citable items published in the past 3 years (average 1.00), and the AIF relates to the frequency that the articles are cited (average 1.00). Clinical studies with a multicenter design and multicenter collaboration, defined as more than 3 unrelated orthopaedic author affiliations, were noted. Level of evidence was determined using the Orthopaedic Trauma Association guidelines<sup>24</sup>.

### Source of Funding

This study was supported by funding from the Wyss Medical Foundation.

Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines using 4 academic databases: PubMed, MEDLINE, Embase, and CENTRAL<sup>20</sup>. Articles published by HIC and LMIC partnerships were identified through the surrogate

TABLE II Journal Characteristics\*

Journal	N	JIF†	JCI‡
<i>Journal of Bone and Joint Surgery</i>	20	6.56	2.21
<i>European Spine Journal</i>	13	2.72	0.88
<i>OTA International</i>	13		
<i>Journal of Orthopaedic Trauma</i>	12	2.88	0.97
<i>Injury</i>	11	2.69	0.86
<i>International Orthopaedics</i>	11	3.48	1.25
<i>Malawi Medical Journal</i>	9	1.41	0.29
<i>Tropical Doctor</i>	8	0.83	0.22
<i>Global Spine Journal</i>	7	2.23	0.64
<i>Journal of Pediatric Orthopaedics</i>	7	2.54	0.98
<i>Journal of the AAOS</i>	6	4	1.26
<i>PLoS One</i>	6	3.75	0.88
<i>BMC Musculoskeletal Disorders</i>	5	2.56	0.73
<i>Journal of Orthopaedic Surgery</i>	5	1.48	0.46
<i>SICOT-J</i>	5		0.7
<i>World Journal of Surgery</i>	5	3.28	1.12
<i>World Neurosurgery</i>	5	2.21	0.64
Other (110 journals)	162		
Total/weighted average	310	2.98	0.90

\*Variables with no official 2021 JCR data were left blank. †The 2021 JCR Journal Impact Factor (see Methods). ‡The 2021 JCR Journal Citation Index (see Methods). JCI = Journal Citation Indicator, JCR = Journal Citation Reports, and JIF = Journal Impact Factor.

## Results

The database search yielded 25,928 articles, and after de-duplication, 21,145 articles were included in the screening. After title and abstract screening, 408 articles underwent full-text review for eligibility. The final list of eligible articles for extraction included 310 publications. Fig. 1 shows a PRISMA flow diagram of the screening process.

The 310 articles included in the study extraction were published in 127 journals (Table I). Research articles related to partnerships between HICs and LMICs increased notably over time, nearly doubling from 2017 (46, 14.8%) to 2021 (88, 28.4%), consistent with publications from other medical specialties<sup>25</sup>. Articles were most commonly published in the *Journal of Bone and Joint Surgery (JBJS)* (20, 6.5%), and the overall weighted average JIF was 2.98 (Table II). The majority of articles were published as open access (203, 65.5%), substantially increasing in number from 2017 to 2022 (26-63, respectively;  $p = 0.008$ ). In addition, open-access articles had a significantly greater JCI ( $p = 0.024$ ) than non-open-access articles. The most common study design was retrospective (64, 20.7%). Level III evidence was predominant, with retrospective (level III), prospective (level II), and cross-sectional survey (level III) methods comprising over half of all studies (52.3%). Few studies attained level I evidence (15, 4.9%), which consisted of meta-analysis studies and randomized controlled trials. There were 46 (14.8%)

clinical studies with a multicenter study design, with significantly more last authors from HICs in these studies ( $p = 0.009$ ). The majority of first (171, 54.6%) and last (202, 64.5%) authors were from HICs. Last authors were from HICs also published in journals with a significantly increased JCI ( $p = 0.012$ ) and AIF ( $p = 0.041$ ); however, differences in JIF were not significant in authorship trends.

There were 41 HICs (51.3% of HICs) and 65 LMICs (47.1% of LMICs) represented in the academic partnerships (Table III). The most common HIC represented was the United States (170 articles, 54.8%), followed by the United Kingdom (70, 22.6%) and Canada (32, 10.3%). The most common LMIC represented was China (50, 16.1% of total articles), followed by India (41, 13.2%) and Malawi/Tanzania (31, 10.0%).

Over one-third of orthopaedic academic partnerships were multicenter collaborations (105, 33.9%). Articles published by multicenter collaborations significantly increased from 2017 to 2021 (16 to 34, respectively;  $p = 0.013$ ). Articles published by multicenter collaborations were more likely to have an HIC author listed as the first author ( $p = 0.004$ ), but there were no significant associations between multicenter collaborations and other article/journal metrics.

TABLE III Country Characteristics

Category	N	%*
LMICs	138	
China	50	16.1
India	41	13.2
Malawi	31	10.0
Tanzania	31	10.0
South Africa	26	8.4
Brazil	23	7.4
Argentina	22	7.1
Turkey	15	4.8
Colombia	13	4.2
Haiti	13	4.2
Other LMICs (55)	172	55.5
HICs	80	
United States	170	54.8
United Kingdom	70	22.6
Canada	32	10.3
France	17	5.5
Switzerland	17	5.5
Australia	16	5.2
Japan	16	5.2
Norway	15	4.8
Italy	14	4.5
South Korea	13	4.2
Other HICs (31)	105	33.9

\*Percentage of total articles ( $n = 310$ ). HICs = high-income countries, and LMICs = low and middle-income countries.

TABLE IV Institution Characteristics

Category	HIC*	%	LMIC†	%	Total	%
Academic institution	257	60.9	190	44.4	447	52.6
Hospital/clinic	136	32.2	223	52.1	359	42.2
Nongovernmental organization/foundation	24	5.7	10	2.3	34	4.0
Government	3	0.7	5	1.2	8	0.9
Private	2	0.5	0	0.0	2	0.2

\*High-income country. †Low and middle-income country.

Most author affiliations were tied to an academic institution (52.6%) or hospital (42.2%) (Table IV). The majority of HIC authors were affiliated with academic institutions while the majority of LMIC authors were associated with a hospital. There was a significant increase in the number of publications by nongovernmental organizations (NGOs) ( $p = 0.012$ ) and hospitals ( $p = 0.025$ ) over time. Multicenter collaborations were statistically associated with academic institutions ( $p = 0.004$ ), NGOs ( $p = 0.007$ ), and private organizations ( $p = 0.002$ ).

The articles identified in this study were most often studies in adult populations (134, 43.2%) related to the following subspecialties: trauma (118, 38.1%), spine (46, 14.8%), and pediatrics (44, 14.2%). Except for elective pediatric topics such as clubfoot, articles related to the distal extremities were least represented. Sports medicine had a significantly increased JIF ( $p = 0.032$ ) and AIF ( $p = 0.036$ ) compared with the other specialties (Table V). Oncology had the highest percentage of open-access articles (100%), spine had the highest percentage of multicenter collaborations (63.0%), and oncology had the

highest percentage of multicenter studies (28.6%). Hand/wrist had the highest percentage of first authors from LMICs (75%), while hand/wrist and shoulder/elbow had the highest percentage of last authors from LMICs (50%). The most common topics discussed included injury (121, 39.0%), surgical management/approach (81, 26.1%), and epidemiology (57, 18.4%) (Table VI).

## Discussion

International academic partnerships have successfully been implemented across several medical and surgical fields<sup>26-31</sup>. However, few reviews analyzing the scope of these partnerships have been conducted. A recent study provided the current status of neurosurgery partnerships worldwide, identifying 137 partnerships from 62 countries<sup>32</sup>. Another study conducted by the authors evaluated ophthalmic surgical partnerships and identified 209 partnerships in 92 countries<sup>33</sup>. This study identified 310 articles, with an increasing number in recent years. This increase is likely due to improved awareness of international initiatives like those outlined by the Lancet Commission on Global Surgery, a global health initiative to improve access to safe, affordable surgical and anesthesia care worldwide<sup>9</sup>. There also has been growing interest in global surgery among surgical trainees, partly due to greater availability of resources (e.g., personnel, funding, and institutional support) to engage in global surgery<sup>34-36</sup>. JBJS published the most articles between HIC and LMICs, likely in recognition of the importance of global musculoskeletal initiatives. Interestingly, there were other journals with high orthopaedic visibility, such as *The Bone and Joint Journal*, that did not have any articles cited in this literature review; the reason for this is unclear.

This study demonstrated a significant association between open-access articles and the JCI. Open-access articles are available free of charge, potentially increasing article citations. However, an increased JCI and similar types of metrics are not a direct measure of research quality<sup>37</sup>. In addition, of note, while open-access

TABLE V Subspecialty Characteristics

Subspecialty	N	JIF*	JCI†	Open Access	Multi-Center Collaboration‡	Multicenter Studies§	First Author - LMIC#	Last Author - LMIC**
Trauma	118	3.66	0.96	63.6%	27.1%	14.4%	31.4%	19.5%
Spine	46	2.96	0.82	56.5%	63.0%	23.9%	50.0%	39.1%
Pediatrics	44	3.57	0.97	72.7%	34.1%	13.6%	34.1%	22.7%
General (nonspecific)	43	4.85	1.07	72.1%	34.9%	9.3%	34.9%	37.2%
Hip and knee (reconstruction)	31	3.93	1.17	71.0%	25.8%	19.4%	35.5%	29.0%
Oncology	7	4.09	1.08	100%	57.1%	28.6%	28.6%	28.6%
Sports medicine	7	6.86	1.33	57.1%	0.0%	0.0%	28.6%	42.9%
Shoulder and elbow	6	2.70	0.69	66.7%	16.7%	0.0%	50.0%	50.0%
Foot and ankle	4	4.21	1.23	75.0%	25.0%	0.0%	50.0%	25.0%
Hand and wrist	4	1.88	0.61	0.0%	0.0%	0.0%	75.0%	50.0%

\*The 2021 JCR Journal Impact Factor (see Methods). †The 2021 JCR Journal Citation Index (see Methods). ‡Multicenter collaboration (>3 unaffiliated institutions). §Multicenter study (as defined by the article). #First author from a LMIC. \*\*First author from a HIC. JCI = Journal Citation Indicator, JCR = Journal Citation Reports, and JIF = Journal Impact Factor.



TABLE VI General Topics Discussed in Articles

General Topics	N	%*
Injury	121	39.0
Surgical management/ approach	81	26.1
Epidemiology	57	18.4
Surgical outcomes	35	11.3
Congenital/metabolic	33	10.6
Education and training	33	10.6
Deformity/dysplasia	32	10.3
Adverse events	30	9.7
Predictors/risk factors	29	9.4
Reconstruction/ replacement	26	8.4
Degenerative	25	8.1
Health care delivery/ administration	24	7.7
Infection	23	7.4
Validation	21	6.8
Consensus/priorities/ guidelines	17	5.5
COVID-19	16	5.2
Pharmacology	15	4.8
Orthopaedic research	14	4.5
Basic science	13	4.2
Economic analysis	13	4.2
Public health/prevention	13	4.2
Nonsurgical management/ approach	10	3.2
Nonsurgical outcomes	10	3.2
Orthopaedic partnership review	9	2.9
Pain management/ anesthesia	9	2.9
Genetics	7	2.3
Imaging/radiology	7	2.3
General orthopaedics	6	1.9
Bone healing	4	1.3
Traditional medicine	4	1.3
Anatomy	3	1.0
Rehabilitation	3	1.0
Perioperative management	2	0.6

\*Percentage of total articles (n = 310).

articles allow for more equitable access to researchers and clinicians, the associated high fees for open-access publication may limit authors' abilities to publish in these journals.

There was worldwide geographic representation of partnerships, identified in 106 countries, which is more than previous

studies on global partnerships<sup>18,32</sup>. However, this represents less than half of countries worldwide (48.6%). Given the importance of collaboration in improving research capacity and its potential effects on clinical care in LMICs, increased efforts and extramural funding should be provided to augment the quantity and quality of orthopaedic academic partnerships worldwide. Such collaborations could be forged through academic institutions and NGOs.

The majority of articles identified were related to traumatic injury. This is likely due to the high burden of these injuries in LMICs, particularly from road traffic accidents. The orthopaedic subspecialties of spine, pediatrics, sports medicine, and arthroplasty also were represented. Surgical management and outcomes were the most highly represented topics in the articles identified, followed by epidemiology. It has been shown that many LMICs lack local data and guidelines related to orthopaedic management strategies, which have been shown to decrease complications and delays<sup>38</sup>. The development of protocols applicable to local settings is a priority for many LMIC surgeons<sup>39</sup>. Given that this study was conducted during the COVID-19 pandemic, multiple articles referenced COVID-19 infections, including their disproportionate impact and influence on orthopaedic management and outcomes in low-resource settings<sup>40-42</sup>.

Despite its benefits, research between HIC and LMIC investigators has generated negative perceptions and controversies, including lack of capacity building, equal authorship credit, and trust among collaborators<sup>43,44</sup>. In this study, multiple orthopaedic-related articles were excluded for not having both a HIC and LMIC author or a HIC investigator was listed as both first and last author. This disparity has been shown in other studies as well; one study reported that 73.6% of orthopaedic-related articles in LMICs had no LMIC authors<sup>18</sup>.


There is also a history of lower-quality research conducted in low-resource settings. One study evaluated all articles published in JBJS from 1980 to 2010, identifying only 2 level I evidence studies from a LMIC, both from China<sup>44</sup>. In addition, LMIC authors consistently published fewer level I-II evidence studies compared with those from HICs<sup>18,44</sup>. Nevertheless, it has been shown that properly conducted orthopaedic academic partnerships can increase both research quality and quantity. This study identified 11 randomized controlled trials published within the 5-year period. The proportion of lower to higher level-of-evidence studies showed an increase relative to previous reports<sup>18</sup>. However, this work demonstrates that the majority of publications by orthopaedic academic partnerships are still level III-V studies, highlighting the need for continued improvements in quality.

There were several limitations to note with this study. While the 4 common databases (PubMed, MEDLINE, Embase, CENTRAL) index a majority of articles, additional literature may have been identified in other databases (e.g., Global Health, Africa Index Medicus, and ClasePeriodica). Nonetheless, these 4 databases likely contained most of the published articles on this topic and were felt to provide a suitable

representation of the literature. In addition, the search used for this work only encompassed a period of 5 years. While this period was selected to focus on the recent state of orthopaedic academic partnerships, it will not have included longer-term associations. Furthermore, this work analyzed articles with an English title and some publications not written in English or without English translations may have been missed. Moreover, countries were stratified according to the World Bank classification, which does not account for individual in-country variation and limits the ability to distinguish the economic nuances of individual countries. This was especially problematic in China that has a large variability of resources in the country. However, this designation has been used in other studies and is sufficient for a general overview as presented in this work<sup>32</sup>.

In summary, this systematic review identified 310 articles published by orthopaedic international academic partnerships in 106 countries over the past 5 years, demonstrating that collaborations between HIC and LMIC partners nearly doubled over the study period. Many of these studies were published in higher-impact journals such as JBJS and were available as open-access publications, with most being observational studies in the field of orthopaedic trauma. Most partnerships were sponsored by North American authors in partnership with LMICs, primarily China, India, and the sub-Saharan African region. These findings highlighted a growing interest in collaborative partnerships to address global orthopaedic care.

## Appendix

 Supporting material provided by the authors is posted with the online version of this article as a data supplement at [jbjs.org \(http://links.lww.com/JBJSOA/A664\)](http://links.lww.com/JBJSOA/A664). This content was not copy-edited or verified by JBJS. ■

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