

## ORIGINAL RESEARCH

# Understanding the need for hand and upper extremity surgery in sub-Saharan Africa: A survey of providers

Kiran J. Agarwal-Harding<sup>1,2</sup>, Lahin M. Amlani<sup>1,3</sup>, Takahisa Ogawa<sup>1,4</sup>, Malick Diallo<sup>5</sup>, Kushal R. Patel<sup>6</sup>, Hatim Hamad<sup>7</sup>, Linda Chokotho<sup>8</sup>, Ndeye Fatou Coulibaly<sup>9</sup>, Chaitanya S. Mudgal<sup>1,10</sup>

<sup>1</sup>Harvard Global Orthopaedics Collaborative, Boston, MA, USA • <sup>2</sup>Division of Orthopaedic Trauma, Carl J. Shapiro Department of Orthopaedics, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA • <sup>3</sup>Johns Hopkins University School of Medicine, Baltimore, MD, USA • <sup>4</sup>Foot & Ankle Research and Innovation Lab, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA • <sup>5</sup>Sourou Sanou University Hospital, Bobo-Dioulasso, Burkina Faso • <sup>6</sup>Edward-Elmhurst Medical Groups, Naperville, IL, USA • <sup>7</sup>Omdurman Islamic University, Omdurman, Sudan • <sup>8</sup>Department of Surgery, Queen Elizabeth Central Hospital, Blantyre, Malawi • <sup>9</sup>CHU Aristide Le Dantec, Dakar, Sénégal • <sup>10</sup>Hand & Arm Service, Department of Orthopaedic Surgery, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA

Correspondence: Dr Kiran J. Agarwal-Harding ([kahardin@bidmc.harvard.edu](mailto:kahardin@bidmc.harvard.edu))

© 2022 K.J. Agarwal-Harding et al. This corrected proof has been published before the article's inclusion in an upcoming issue of the *East and Central African Journal of Surgery* so that it can be accessed and cited as early as possible. This open access article is licensed under a Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.



East Cent Afr J Surg  
Published 29 August 2022

## Abstract

### Background

Injuries, disorders, and deformities of the hands and upper extremities cause significant morbidity worldwide, but in sub-Saharan Africa, the burden of disease and the availability of appropriate care remain unknown. We sought to characterize disease burden and barriers to care for hand and upper extremity conditions across sub-Saharan Africa, examining differences in burden and access by geographic region and national income level.

### Methods

From 6 June 2020 through 17 March 2021, we surveyed providers of musculoskeletal care in sub-Saharan Africa regarding the provision of care and the most common acute and chronic hand or upper extremity conditions encountered by respondents. Surveys were distributed through professional networks across sub-Saharan Africa. We categorized responses by each respondent's national income level and geographic region. Then, we examined how frequently various challenges to accessing healthcare, as well as how frequently acute or chronic conditions, were reported. Additionally, we analyzed how these data varied by income level and geographic region.

### Results

We received 193 responses from 39 countries in sub-Saharan Africa. Eighty-eight per cent of respondents reported that general orthopaedic surgeons and orthopaedic traumatologists primarily manage upper extremity conditions. A lack of adequate and timely diagnosis was reported by 142 respondents (74%); late referral for treatment was reported by 149 (77%); and inadequate physical therapy, occupational therapy, and rehabilitation was reported by 149 respondents (77%). The most commonly reported acute conditions were adult and paediatric radius/ulna fractures/dislocations, adult metacarpal/phalangeal fractures/dislocations, soft-tissue injuries (including burns), and paediatric elbow fractures/dislocations. The most commonly reported chronic conditions were tendinitis/tenosynovitis, chronic infections/osteomyelitis, neuropathies, posttraumatic stiff hand, and radius/ulna malunion/nonunion. Neglected trauma (including chronic elbow injuries and burn contractures) was frequently reported, especially in low-income countries.

### Conclusions

Trauma care should be strengthened through training of general orthopaedic surgeons in hand and upper extremity surgery throughout sub-Saharan Africa. Especially in low-income countries, particular training emphasis should be placed on the management of malunion/nonunion, osteomyelitis, acute and chronic elbow injuries, and burn contractures. These findings should inform the development of core competencies in hand surgery for providers managing musculoskeletal conditions in sub-Saharan Africa, as well as guide capacity-building activities on the continent.

**Keywords:** global surgery, hand surgery, musculoskeletal health equity, upper extremity trauma, low- and middle-income countries, sub-Saharan Africa

[PAGE NUMBERS NOT FOR CITATION PURPOSES]

## Introduction

Hand injuries, disorders, and related deformities are common, accounting for 6.6% of all emergency department visits in the United States.[1] In Denmark and the Netherlands, it has been reported that 29% of accidents and unintentional injuries seen in emergency departments involve the hand or wrist.[2],[3] While the incidence of hand trauma may be decreasing in high-income countries, over the last 30 years, it has risen by 25% in middle-income countries like China and India.[4] This corresponds with a rising incidence of musculoskeletal injuries in low- and middle-income countries (LMICs), where essential surgery and trauma care remain largely inaccessible.[5]-[7]

The effective management of hand conditions often involves surgery to prevent complications and long-term disability.[8] Upper extremity disability markedly reduces quality of life and productivity, with profound social and economic ramifications.[9],[10] This is perhaps most evident in LMICs, where many people work in the informal economy, engaging in small-scale farming, construction, and manual labour for which hand function is essential.[11] Upper extremity injuries, coupled with inadequate access to appropriate surgery and therapy, can push patients in LMICs into inescapable cycles of poverty with multigenerational repercussions.

Of the 48 countries in sub-Saharan Africa, 23 are classified as low-income, 18 as lower middle-income, and 7 as upper middle-income.[12] Although significant variation exists across the continent, as a whole, sub-Saharan Africa has the least developed healthcare systems worldwide, few surgeons per capita, and bears the burden of a high rate of surgeon migration to high-income countries.[12]-[14] Over 90% of people in sub-Saharan Africa lack access to safe and affordable surgery.[4] Data regarding the burden of hand and upper extremity conditions are lacking, though studies from Uganda and Ethiopia suggest that hand injuries could account for 5% to 12% of nonfatal injuries in these resource-limited settings.[4],[15],[16] The capacity to manage these injuries in sub-Saharan Africa also remains largely unknown, as do the barriers to care that patients may face. We sought to examine the need for hand surgery in sub-Saharan Africa and how that need is currently being met.

## Methods

### Study design and data collection

We conducted a web-based survey open to providers from all countries in sub-Saharan Africa. Consultant/attending surgeons, surgical trainees, and nonphysician clinicians with training backgrounds in orthopaedic surgery, plastic surgery, general surgery, and general medicine were included if they self-reported managing patients with musculoskeletal conditions. The survey was disseminated through our professional networks and a snowballing technique whereby participants shared the survey with others. The survey was available in English, French, and Portuguese from 6 June 2020 through 17 March 2021.

The survey solicited details regarding each provider's training background and clinical practice, the provision of and barriers to hand and upper extremity care in each respondent's home country, and the most commonly seen conditions. Potential barriers to care, as well as the explicitly stated acute and chronic conditions, were derived from peer-reviewed literature and the clinical experiences of the study's investigators.[4],[7],[17]-[26] To standardize quantification, respondents were asked whether 0% to 25%, 25% to 50%, 50% to 75%, or 75% to 100% of their patients experience each barrier. Respondents also reported the frequency ( $\geq 1$  patient per day, 1-5 patients per week, 1-5 patients per month,  $< 12$  patients per year, or never) with which they encounter acute and chronic hand or upper extremity conditions, their comfort managing these conditions, and interest in hand surgical training.

### Statistical analysis

We categorized countries by African Union geographic region (Western, Central, Southern, and Eastern Africa) and World Bank income level using 2019 gross national income per capita (low income, lower middle income, and upper middle income).[27],[28] Survey responses were analyzed in aggregate, by national income level, and by geographic region.

We defined dichotomized outcome variables—'inadequate diagnosis,' 'inadequate treatment,' and 'inadequate rehabilitation'—based on responses to corresponding survey questions (e.g., 'Do patients... receive adequate and timely diagnosis...?'). Barriers to care were dichotomized based on whether a respondent reported  $> 50\%$  of patients facing each barrier. We dichotomized acute and chronic conditions by whether respondents reported encountering  $> 1$  case per week with each condition.

For each dichotomized outcome, we conducted chi-square testing to investigate associations with national income level and geographic region ( $\alpha=0.05$ ). We used modified Poisson regression models to investigate the magnitudes of the associations.[29] Analyses were performed using Stata 16.1 (StataCorp, College Station, TX, USA). The Institutional Review Board at the Massachusetts General Hospital approved this study (Protocol#: 2020P001863).

## Results

Representing 39 countries in sub-Saharan Africa, 193 providers completed the survey ([Supplementary File](#)). Respondent characteristics are summarized in [Table 1](#). Most respondents reported working in government hospitals ( $n=129$ , 67% of respondents). There were 4 specialized hand surgeons (3%), 2 of whom were also plastic surgeons; 93 orthopaedic surgeons (48%); 7 general surgeons (4%); 7 general medical doctors (4%); 66 orthopaedic, plastic, and general surgical trainees, including registrars and fellows (34%); 5 interns/house officers (3%); 7 nonphysician clinicians (4%); and 4 others (2%). The median number of years in clinical practice was 5 (interquartile range, 2-10 years). Ninety-six respondents (50%) had received some training in the management of hand or upper extremity conditions.

[PAGE NUMBERS NOT FOR CITATION PURPOSES]

**Table 1. Respondent characteristics (N=193)**

<b>Number of countries represented</b>	39
<b>Geographic region<sup>a</sup></b>	
Central Africa	25 (13.0)
Eastern Africa	38 (19.7)
Southern Africa	43 (22.3)
Western Africa	87 (45.1)
<b>Income group<sup>b</sup></b>	
Low-income country	107 (55.4)
Lower middle-income country	63 (32.6)
Upper middle-income country	23 (11.9)
<b>Language of survey completion</b>	
English	100 (51.8)
French	84 (43.5)
Portuguese	9 (4.7)
<b>Work sector<sup>c</sup></b>	
Government	129 (66.8)
Academic	65 (33.7)
Private	44 (22.8)
Faith/mission based	22 (11.4)
<b>Training background</b>	
Orthopaedic surgery	148 (76.7)
Plastic surgery	8 (4.1)
General surgery	15 (7.8)
General medicine	17 (8.8)
Other <sup>d</sup>	5 (2.6)

*Continued*

Forty-three participants (22%) reported that specialized hand surgeons are available to manage hand and upper extremity conditions, 132 (68%) reported that no hand surgeons but orthopaedic surgeons are available, and 18 (9%) reported that neither hand nor orthopaedic surgeons are available. Patients with hand conditions present to only tertiary referral or central hospitals, according to 58 respondents (30%); tertiary hospitals as well as either primary community health centres or secondary district hospitals, according to 99 (52%); and do not present to tertiary hospitals, according to 34 respondents (18%).

Inadequate diagnosis was reported by 142 participants (74%), inadequate treatment by 149 (77%), and inadequate rehabilitation by 149 (77%). The most frequently reported barriers to care were (1) materials or implants are unavailable, inadequate, or inadequately stocked (n=88, 46%);

**Table 1. Continued**

<b>Current job title</b>	
Consultant hand surgeon	4 (2.1)
Consultant orthopaedic surgeon	93 (48.2)
Orthopaedic fellow undergoing subspecialty training	11 (5.7)
Orthopaedic/plastic/general surgical resident or registrar	55 (28.5)
Consultant general surgeon	7 (3.6)
General medical physician	7 (3.6)
Intern or house officer	5 (2.6)
Nonphysician clinician	7 (3.6)
Other <sup>e</sup>	4 (2.1)
<b>Years in clinical practice (IQR)</b>	5 (2-10)
<b>Orthopaedic specialty of practice<sup>f</sup></b>	
General orthopaedics	116 (60.1)
Trauma	68 (35.2)
Hand	39 (20.2)
Arthroplasty	29 (15)
Paediatric orthopaedics	24 (12.4)
Foot and ankle	15 (7.8)
Shoulder and elbow	15 (7.8)
Spine	12 (6.2)
Limb reconstruction	11 (5.7)
Soft tissue knee/sports	8 (4.1)
Oncology	5 (2.6)
<b>Completed any subspecialization training</b>	65 (33.7)
<b>Received any training in management of hand/upper extremity conditions</b>	96 (49.7)

Values are n (%) of respondents unless otherwise indicated. Percentages may not add up to 100% because of rounding. <sup>a</sup>Geographic regions were according to the African Union.<sup>[22]</sup> The [Supplementary File](#) includes a full list of countries represented with the respective numbers of respondents. <sup>b</sup>Income groups were defined according to the World Bank classification, based on gross national income per capita (GNIpc) in 2019.<sup>[28]</sup> Low-income countries had GNIpc ≤US\$1035; lower middle-income economies had GNIpc between US\$1036 and US\$4045; upper middle-income economies had GNIpc between US\$4046 and US\$12 535. <sup>c</sup>Other training included anaesthesia (n=1), nursing (n=2), obstetrics and gynaecology (n=1), and oral and maxillofacial surgery (n=1). <sup>d</sup>Other job titles included consultant oral and maxillofacial surgeon (n=1), orthopaedic trauma plaster technician (n=1), perioperative nurse (n=1), and senior anaesthesia technician (n=1). <sup>e</sup>Multiple responses were allowed, so percentages may not sum to 100%. IQR, interquartile range

**Table 2.** Barriers to the provision of hand surgery in sub-Saharan Africa according to survey respondents (N=193)

Barrier (listed in descending order of frequency)	n (%)
1. Materials and/or implants to provide appropriate care are unavailable, inadequate, or inadequately stocked.	88 (45.6)
2. Patients face challenges paying for clinical evaluation and/or treatment.	73 (37.8)
3. Patients are frequently lost to follow-up and/or do not have access to appropriate rehabilitation.	73 (37.8)
4. Patients frequently present late, resulting in more challenging treatment.	68 (35.2)
5. Providers do not have adequate training to diagnose and/or appropriately refer patients.	61 (31.6)
6. There are few hospitals available for patients to seek care.	58 (30.0)
7. Hospitals do not have adequate facilities.	57 (29.6)
8. Patients face transportation challenges to reach a hospital.	45 (23.3)
9. Patients do not seek care after injury (fear of surgery/anesthesia, lack of information, cultural barriers).	40 (20.7)

Values are reported as the n (%) of respondents who reported that the respective barriers affected  $\geq 50\%$  of the patients they manage.

(2) patients face challenges paying for clinical evaluation or treatment (n=73, 38%); (3) patients are frequently lost to follow-up or lack access to rehabilitation (n=73, 38%); (4) patients frequently present late, increasing the complexity and difficulty of management (n=68, 35%); and (5) providers lack adequate training to diagnose or appropriately refer patients (n=61, 32%) (Table 2).

### Regional differences in access to surgical hand care

The frequency with which respondents reported inadequate diagnosis, treatment, and rehabilitation varied significantly by national income level and geographic region ( $P < 0.05$ ). Compared with those in upper middle-income countries in Africa, respondents were more than twice as likely to report inadequacy of diagnosis in lower middle-income countries of Central (relative risk [RR], 1.95; 95% confidence interval [CI], 1.14-3.33) and Eastern (RR, 2.08; 95% CI, 1.30-3.35) Africa, as well as in low-income countries of Central (RR 2.27, 95% CI 1.46-3.54) and Eastern (RR 2.10, 95% CI 1.33-3.31) Africa. Similarly, respondents in Central African lower middle-income countries, along with those in Central and Eastern African low-income countries, were twice as likely to report a lack of timely referral for treatment (RR, 2.08; 95% CI, 1.38-3.14) than in participants in upper middle-income countries. Inadequate therapy and rehabilitation were reported 47% more frequently in Central African lower middle-income countries and Eastern African low-income countries than in upper middle-income countries (RR, 1.47; 95% CI, 1.12-1.93) (Table 3).

There was a significant association between income/region and whether respondents reported patients facing payment challenges ( $P < 0.001$ ). Compared with upper middle-income countries, respondents in Eastern lower middle-income countries were twice as likely to report payment challenges (RR, 2.34; 95% CI, 1.21-4.53). Unavailable/inadequate materials/implants and patients presenting late were reported twice as frequently in Eastern lower middle-income countries and low-income countries relative to upper middle-income countries. Respondents in Eastern African lower middle-income countries were 70% more likely than respondents in upper middle-income countries to report patients lost to follow-up and receiving inadequate rehabilitation (RR, 1.70; 95% CI, 0.98-2.96) (Supplementary File).

### Acute injuries and other acute conditions

The most frequently reported acute conditions were adult radius/ulna fractures/dislocations (112 of 193 respondents [58%] reported  $>1$  case/wk), paediatric radius/ulna fractures/dislocations (107 of 193 [56%] reported  $>1$  case/wk), adult metacarpal/phalangeal fractures/dislocations (101 of 193 [52%] reported  $>1$  case/wk), soft-tissues injuries (100 of 193 [52%] reported  $>1$  case/wk), and paediatric elbow fractures/dislocations (99 of 193 [51%] reported  $>1$  case/wk). Paediatric and adult elbow fractures/dislocations and soft-tissue injuries were more frequently reported as national income levels decreased. In low-income countries,  $>60\%$  of respondents reported encountering  $>1$  case per week of adult radius/ulna fracture/dislocation (73 of 106, 69%), paediatric radius/ulna fracture/dislocation (71 of 106, 67%), soft tissue injury (65 of 106, 61%), and paediatric elbow fracture/dislocation (64 of 106, 60%) (Figure 1).

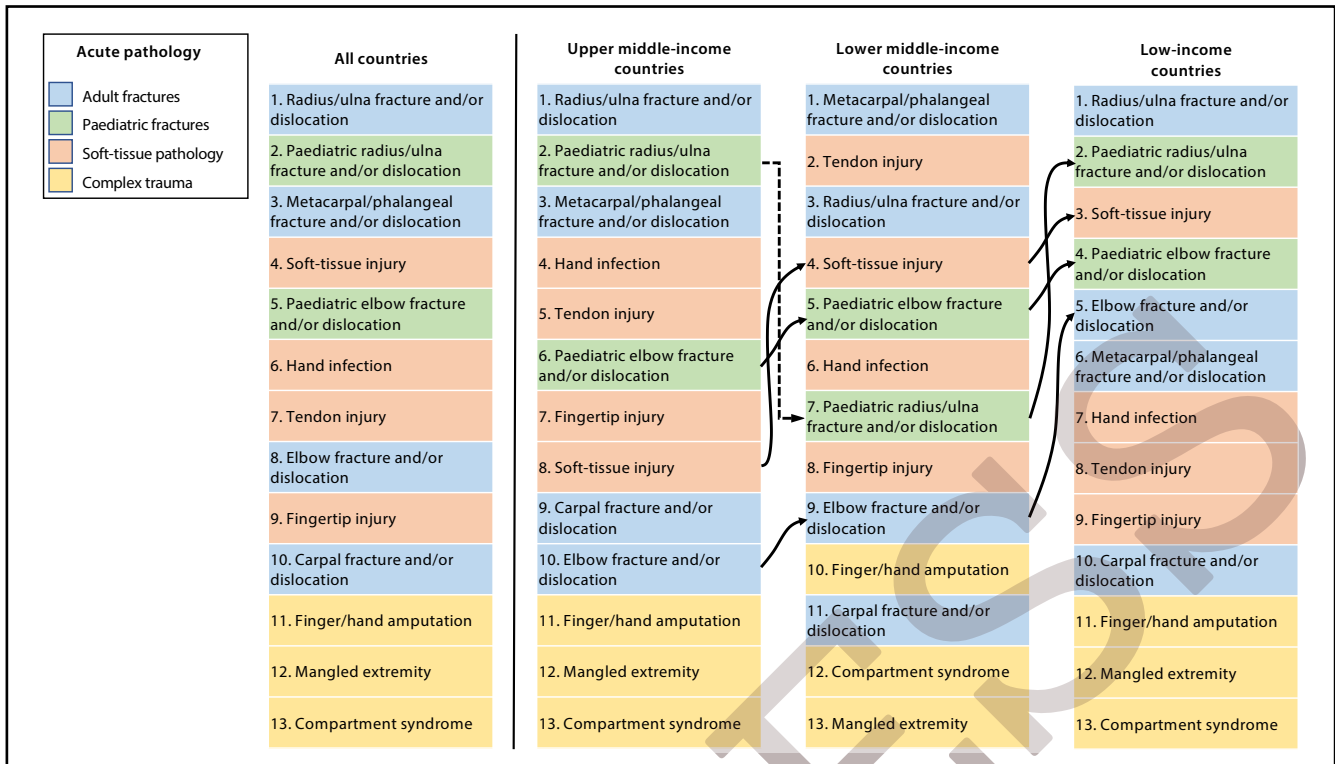
[PAGE NUMBERS NOT FOR CITATION PURPOSES]

**Table 3.** Adequacy and timeliness of hand diagnosis, treatment, and rehabilitation in sub-Saharan Africa (N=193)

Outcome variable	Country income level/ geographic region <sup>a</sup>	Rate <sup>b</sup>	RR <sup>c</sup>	P value <sup>d</sup>
<b>Inadequate diagnosis (Responded 'No' to 'Do patients with hand injuries/pathology receive adequate and timely diagnosis in your country?')</b>	<b>Upper middle-income countries</b>	44% (11 of 25)	Reference	<0.001
	<b>Lower middle-income countries</b>			
	Central Africa	85.7% (6 of 7)	1.95 (1.14-3.33)	
	Eastern Africa	91.7% (11 of 12)	2.08 (1.30-3.35)	
	Southern Africa	77.8% (7 of 9)	1.77 (1.00-3.11)	
	Western Africa	55.9% (19 of 34)	1.27 (0.74-2.17)	
	<b>Low-income countries</b>			
	Central Africa	100.0% (10 of 10)	2.27 (1.46-3.54)	
	Eastern Africa	92.3% (24 of 26)	2.10 (1.33-3.31)	
	Southern Africa	76.5% (13 of 17)	1.74 (1.04-2.91)	
	Western Africa	77.4% (41 of 53)	1.76 (1.10-2.80)	
	<b>Inadequate referral for treatment (Responded 'No' to 'Do patients with hand injuries/pathology receive timely referral for treatment?')</b>	<b>Upper-middle income countries</b>	48.0% (12 of 25)	Reference
<b>Lower-middle income countries</b>				
Central Africa		100.0% (7 of 7)	2.08 (1.38-3.14)	
Eastern Africa		83.3% (10 of 12)	1.74 (1.07-2.81)	
Southern Africa		77.8% (7 of 9)	1.62 (0.95-2.78)	
Western Africa		61.8% (21 of 34)	1.29 (0.79-2.10)	
<b>Low-income countries</b>				
Central Africa		100.0% (10 of 10)	2.08 (1.38-3.14)	
Eastern Africa		100.0% (26 of 26)	2.08 (1.38-3.14)	
Southern Africa		76.5% (13 of 17)	1.59 (0.98-2.59)	
Western Africa		81.1% (43 of 53)	1.69 (1.10-2.60)	
<b>Inadequate rehabilitation (Responded 'No' to 'Do patients with hand injuries/ pathology receive adequate physical/ occupational therapy and rehabilitation?')</b>		<b>Upper-middle income countries</b>	68.0% (17 of 25)	Reference
	<b>Lower-middle income countries</b>			
	Central Africa	100.0% (7 of 7)	1.47 (1.12-1.93)	
	Eastern Africa	83.3% (10 of 12)	1.23 (0.85-1.77)	
	Southern Africa	88.9% (8 of 9)	1.31 (0.92-1.87)	
	Western Africa	61.8% (21 of 34)	0.91 (0.62-1.33)	
	<b>Low-income countries</b>			
	Central Africa	80.0% (8 of 10)	1.18 (0.78-1.78)	
	Eastern Africa	100.0% (26 of 26)	1.47 (1.12-1.93)	
	Southern Africa	88.2% (15 of 17)	1.30 (0.94-1.79)	
	Western Africa	69.8% (37 of 53)	1.03 (0.74-1.42)	

<sup>a</sup>Countries were categorized by geographic regions and income groups. Geographic regions were defined according to the African Union.<sup>[27]</sup> Income groups were defined according to the World Bank classification,<sup>[28]</sup> based on gross national income per capita (GNIpc) in 2019. Low-income countries had GNIpc ≤US\$1035; lower middle-income economies had GNIpc between US\$1036 and US\$4045; upper middle-income economies had GNIpc between US\$4046 and US\$12535. <sup>b</sup>Values are given as the percentage of respondents, with—in parentheses—the number of respondents who responded 'No' to questions regarding the adequacy/timeliness of diagnosis, treatment, and rehabilitation of hand conditions in their home countries. <sup>c</sup>Bivariate modified Poisson regression analysis was performed between national income level/geographic region and each outcome variable. The values are given as the relative risk (RR) with the 95% confidence interval (CI) in parentheses. <sup>d</sup>Type III P values are shown, as calculated using the chi-squared test.

[PAGE NUMBERS NOT FOR CITATION PURPOSES]



**Figure 1.** The most commonly reported acute conditions overall and categorized by national income levels.

The acute conditions are listed in descending order of frequency based on the percentage of respondents who reported encountering >1 patient per week with each acute condition. The solid arrow stems indicate acute conditions that were reported more frequently as the national income level decreased. The dashed arrow stem indicates an acute condition that was reported less frequently as the national income level decreased. Acute conditions included in the survey are classified as adult fractures, paediatric fractures, soft tissue conditions, and complex trauma.

Reported frequencies varied significantly by national income/region for adult elbow fractures/dislocations ( $P=0.014$ ), paediatric radius/ulna fractures/dislocations ( $P=0.046$ ), and paediatric elbow fractures/dislocations ( $P=0.002$ ). Relative to the African upper middle-income countries represented among the survey responses, elbow injuries were most frequently reported in Central (RR, 8.04; 95% CI, 2.06-31.39), Eastern (RR, 6.14; 95% CI, 2.01-18.73), Southern (RR, 5.89; 95% CI, 1.67-20.80), and Western (RR, 3.29; 95% CI, 1.21-8.98) African low-income countries. Similarly, paediatric radius/ulna fractures/dislocations were most frequently reported in Eastern African low-income countries (RR, 2.89; 95% CI, 1.00-8.38), and paediatric elbow fractures/dislocations in Southern (RR, 4.46; 95% CI, 1.50-13.28) and Eastern (RR, 9.61; 95% CI, 2.66-34.75) African low-income countries, relative to the represented upper middle-income countries.

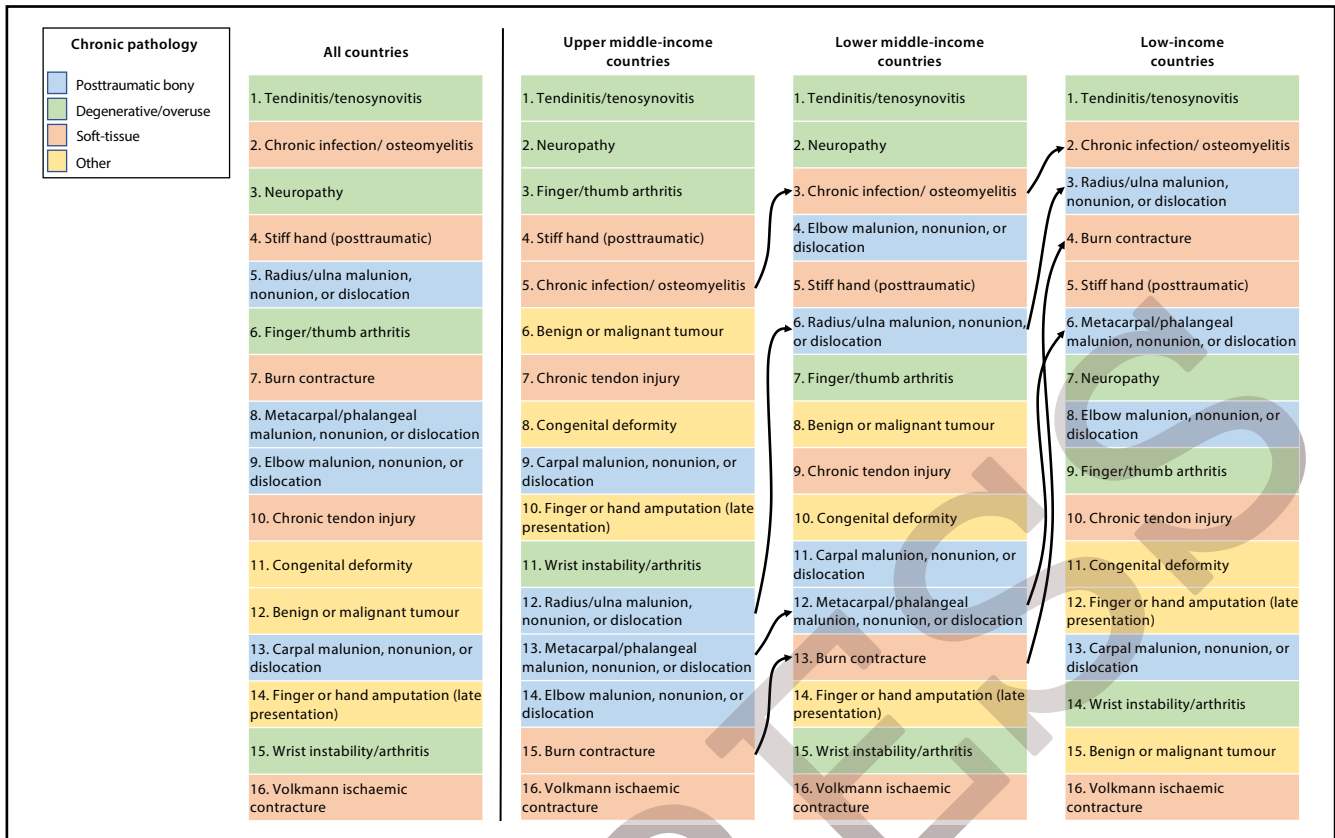
Compared with respondents in the upper middle-income countries represented among the responses, participants in Central African low-income countries were >4 times as likely to report encountering >1 patient per week with a soft tissue injury (RR, 4.69; 95% CI, 1.17-18.73), compartment syndrome (RR, 5.16; 95% CI, 1.43-18.58), or a mangled extremity (RR, 4.08; 95% CI, 1.15-14.48). Respondents in Southern African low-income countries also more frequently reported soft tissue injuries (RR, 4.25; 95% CI, 1.27-14.19), and respondents in Eastern African low-income countries more frequently reported radius/ulna fractures/dislocations

(RR, 3.43; 95% CI, 1.12-10.49) than those in upper middle-income countries (Table 4).

### Chronic injuries and other chronic conditions

Respondents most often reported encountering >1 patient per week with the following chronic conditions: tendinitis/tenosynovitis (67 of 193, 35%), chronic infection/osteomyelitis (59 of 193, 31%), neuropathy (56 of 193, 29%), posttraumatic stiff hand (49 of 193, 25%), and radius/ulna malunion/nonunion (47 of 193, 24%). With decreasing income levels, the following conditions were more frequently reported: chronic infections/osteomyelitis, radius/ulna malunions/nonunions, and burn contractures. More than 30% of respondents in low-income countries reported encountering >1 patient per week with tendinitis/tenosynovitis (40 of 106, 38%), chronic infection/osteomyelitis (40 of 106, 38%), radius/ulna fracture malunion/nonunion (33 of 106, 31%), burn contracture (33 of 106, 31%), and posttraumatic stiff hand (32/106, 30%) (Figure 2).

Reported frequencies varied significantly by national income/region for elbow fracture malunions/nonunions or chronic dislocations ( $P<0.001$ ), as well as for burn contractures ( $P=0.006$ ). Compared with respondents in the African upper middle-income countries represented among the participants, respondents in nearly every other country were more likely to report encountering >1 patient per week with a chronic elbow injury; the largest RRs were from respondents in Eastern African low-income countries (RR, 13.35;



**Figure 2.** The most commonly reported chronic conditions overall and categorized by national income levels.

The chronic conditions are listed in descending order of frequency based on the percentage of respondents who reported encountering >1 patient per week with each acute condition. The arrows indicate chronic conditions that were reported more frequently as the national income level decreased. Chronic conditions included in the survey are classified as posttraumatic bony, degenerative/overuse, soft tissue, and other.

95% CI, 3.21-55.57), Southern African low-income countries (RR, 35.36; 95% CI, 7.49-166.86), Southern African lower middle-income countries (RR, 13.05; 95% CI, 2.52-67.61), and Western African lower middle-income countries (RR, 11.33; 95% CI, 2.85-45.08). Burn contractures were most frequently reported in Central (RR, 14.19; 95% CI, 3.13-64.40) and Southern (RR, 13.88; 95% CI, 3.77-51.06) African low-income countries, where >40% of respondents reported encountering >1 case per week.

Compared with respondents in African upper middle-income countries, respondents in Central (RR, 15.72; 95% CI 3.12-79.19) and Southern (RR 18.58, 95% CI 4.42-78.06) African low-income countries were >15 times more likely to encounter >1 chronic hand or upper extremity infection per week. Furthermore, respondents in low-income countries in Central (RR, 9.29; 95% CI, 1.94-44.42) and Southern (RR, 10.46; 95% CI, 2.68-40.80) Africa were approximately 10 times more likely than respondents in African upper middle-income countries to encounter Volkmann ischemic contractures (Table 5).

## Referral and training

Ninety-six participants (50%) reported referring patients with hand conditions to someone else for treatment. Referral rates were highest among interns/house officers (n=5, 100%), general medical doctors (n=6, 86%), and nonphy-

sician clinicians (n=6, 86%), followed by surgical trainees (n=38, 58%), general surgeons (n=4, 57%), orthopaedic surgeons (n=33, 35%), and hand surgeons (n=1, 25%). The most frequently reported reason for referring patients was feeling uncomfortable managing hand conditions (34 of 96, 35%). All respondents felt that training in the management of hand and upper extremity conditions was important (7%) or extremely important (93%) (Table 2).

## Discussion

To characterize the need for hand and upper extremity surgery in sub-Saharan Africa, we surveyed 193 providers from 39 African countries. Respondents reported that there are few fellowship-trained hand surgeons and general orthopaedic surgeons managing the majority of hand and upper extremity conditions. Patients with a variety of acute and chronic conditions—often associated with trauma—are seen frequently, and significant barriers to care manifest as inadequate diagnosis, treatment, and rehabilitation of these patients. All respondents regarded training in hand and upper extremity management as important.

Inadequate diagnosis, treatment, and rehabilitation of upper extremity conditions were reported by most respondents, especially in low-income countries and lower middle-income countries in Eastern and Central Africa. Indeed, safe and affordable surgical care is inaccessible to over 90% of

**Table 4.** Acute hand and upper extremity conditions seen by survey respondents practising in sub-Saharan Africa (N=193)

Acute condition	Country income level/ geographic region <sup>a</sup>	Respondents reporting seeing >1 case per week <sup>b</sup>	RR <sup>c</sup>	P value <sup>d</sup>
Soft tissue injury (burn, wound, degloving injury)	Upper middle-income countries	36% (9 of 25)	Reference	0.089
	Lower middle-income countries			
	Central Africa	57.2% (4 of 7)	2.48 (0.49-12.55)	
	Eastern Africa	16.7% (2 of 12)	0.88 (0.26-2.99)	
	Southern Africa	55.6% (5 of 9)	1.37 (0.35-5.30)	
	Western Africa	44.1% (15 of 34)	1.52 (0.55-4.24)	
	Low-income countries			
	Central Africa	80% (8 of 10)	4.69 (1.17-18.73)	
	Eastern Africa	65.4% (17 of 26)	2.03 (0.73-5.63)	
	Southern Africa	70.6% (12 of 17)	4.25 (1.27-14.19)	
Western Africa	52.9% (28 of 53)	2.28 (0.91-5.67)		
Radius/ulna fracture and/or dislocation (both bone forearm, Galeazzi, distal radius, etc.)	Upper middle-income countries	52% (13 of 25)	Reference	0.12
	Lower middle-income countries			
	Central Africa	42.9% (3 of 7)	0.52 (0.11-2.42)	
	Eastern Africa	41.7% (5 of 12)	0.76 (0.20-2.86)	
	Southern Africa	44.4% (4 of 9)	0.55 (0.12-2.42)	
	Western Africa	41.2% (14 of 34)	0.85 (0.29-2.48)	
	Low-income countries			
	Central Africa	90% (9 of 10)	2.20 (0.57-8.41)	
	Eastern Africa	76.9% (20 of 26)	3.43 (1.12-10.49)	
	Southern Africa	64.7% (11 of 17)	2.16 (0.61-7.66)	
Western Africa	62.3% (33 of 53)	1.52 (0.57-4.05)		
Elbow fracture and/ or dislocation (distal humerus, Monteggia, olecranon, etc.)	Upper middle-income countries	28% (7 of 25)	Reference	0.014
	Lower middle-income countries			
	Central Africa	57.1% (4 of 7)	2.35 (0.48-11.55)	
	Eastern Africa	16.7% (2 of 12)	1.27 (0.33-4.79)	
	Southern Africa	55.6% (5 of 9)	2.51 (0.60-10.59)	
	Western Africa	26.5% (9 of 34)	1.77 (0.60-5.22)	
	Low-income countries			
	Central Africa	90% (9 of 10)	8.04 (2.06-31.39)	
	Eastern Africa	69.2% (18 of 26)	6.14 (2.01-18.73)	
	Southern Africa	58.8% (10 of 17)	5.89 (1.67-20.80)	
Western Africa	47.2% (25 of 53)	3.29 (1.21-8.98)		

Continued

[PAGE NUMBERS NOT FOR CITATION PURPOSES]



Table 4. Continued

Acute condition	Country income level/ geographic region <sup>a</sup>	Respondents reporting seeing >1 case per week <sup>b</sup>	RR <sup>c</sup>	P value <sup>d</sup>
Paediatric radius/ ulna fracture and/or dislocation (both bone forearm, Galeazzi, distal radius, etc.)	Upper middle-income countries	52% (13 of 25)	Reference	0.046
	Lower middle-income countries			
	Central Africa	57.2% (4 of 7)	1.18 (0.25-5.54)	
	Eastern Africa	25% (3 of 12)	0.53 (0.14-1.90)	
	Southern Africa	55.5% (5 of 9)	0.83 (0.19-3.54)	
	Western Africa	32.3% (11 of 34)	0.60 (0.21-1.74)	
	Low-income countries			
	Central Africa	80% (8 of 10)	2.01 (0.54-7.50)	
	Eastern Africa	80.8% (21 of 26)	2.89 (1.00-8.38)	
	Southern Africa	64.7% (11 of 17)	2.47 (0.73-8.39)	
	Western Africa	58.5% (31 of 53)	1.61 (0.62-4.15)	
	Paediatric elbow fracture and/ or dislocation (supracondylar humerus, lateral condyle, nursemaid's elbow, etc.)	Upper middle-income countries	40% (10 of 25)	
Lower middle-income countries				
Central Africa		28.6% (2 of 7)	0.71 (0.16-3.15)	
Eastern Africa		58.3% (7 of 12)	2.71 (0.73-10.07)	
Southern Africa		66.6% (6 of 9)	3.18 (0.71-14.35)	
Western Africa		29.4% (10 of 34)	0.87 (0.30-2.56)	
Low-income countries				
Central Africa		80% (8 of 10)	3.28 (0.88-12.23)	
Eastern Africa		73% (19 of 26)	4.46 (1.50-13.28)	
Southern Africa		76.5% (13 of 17)	9.61 (2.66-34.75)	
Western Africa		45.3% (24 of 53)	1.83 (0.70-4.78)	

Continued

people in sub-Saharan Africa, with health systems in many LMICs facing challenges in the provision of adequate pre-hospital care, treatment, and rehabilitation of the injured. [4],[17]-[19] We observed notable exceptions, however. More than 50% of respondents from Gabon and South Africa, both upper middle-income countries, reported adequate diagnosis and treatment. Similarly, adequate diagnosis, treatment, and rehabilitation were reported by half of the respondents from Senegal, a lower middle-income country. There likely exist 'centres of excellence' in sub-Saharan Africa where high-quality hand and upper extremity care is available; these may serve as models for building capacity throughout the continent.

Eighty-two per cent of respondents reported that patients receive care at urban referral hospitals. Unfortunately, most people in sub-Saharan Africa live in rural areas. [28] Remoteness from an urban centre and high transportation costs can limit access to care for those living in rural areas. [20],[30],[31]

Payment challenges, patients presenting late, and patients lost to follow-up were barriers commonly reported by our respondents. Out-of-pocket payments and indirect costs associated with transportation and lost wages contribute to a high risk of impoverishment for patients seeking surgical care in sub-Saharan Africa. [32] Loss to follow-up is also well documented in LMICs, and it is associated with remoteness of residence from the nearest hospital, cost of transportation, and patient unemployment. [33],[34] As hand and upper extremity care is scaled up across the continent, consideration must be given to the needs of rural populations, either by improving physical and virtual access to tertiary centres or training local providers in rural hospitals. [35]

Inadequate materials and implants, as well as providers lacking adequate training to diagnose or appropriately refer patients, were also barriers commonly reported by survey respondents. Many medical supplies in sub-Saharan Africa are imported, costly, and are not designed with resource-limited

[PAGE NUMBERS NOT FOR CITATION PURPOSES]

Table 4. Continued

Acute condition	Country income level/ geographic region <sup>a</sup>	Respondents reporting seeing >1 case per week <sup>b</sup>	RR <sup>c</sup>	P value <sup>d</sup>
Compartment syndrome (hand, forearm)	Upper middle-income countries	16% (4 of 25)	Reference	0.11
	Lower middle-income countries			
	Central Africa	28.6% (2 of 7)	1.32 (0.28-6.26)	
	Eastern Africa	16.6% (2 of 12)	0.53 (0.13-2.21)	
	Southern Africa	33.3% (3 of 9)	2.20 (0.57-8.56)	
	Western Africa	23.5% (8 of 34)	1.37 (0.48-3.89)	
	Low-income countries			
	Central Africa	60% (6 of 10)	5.16 (1.43-18.58)	
	Eastern Africa	26.9% (7 of 26)	2.33 (0.83-6.53)	
	Southern Africa	35.2% (6 of 17)	1.72 (0.48-6.24)	
	Western Africa	28.3% (15 of 53)	2.38 (0.93-6.10)	
	Mangled extremity (traumatic amputations/avulsions, crush injuries, blast injuries)	Upper middle-income countries	20% (5 of 25)	
Lower middle-income countries				
Central Africa		42.9% (3 of 7)	1.27 (0.26-6.31)	
Eastern Africa		16.6% (2 of 12)	0.91 (0.23-3.68)	
Southern Africa		22.2% (2 of 9)	0.85 (0.22-3.35)	
Western Africa		14.7% (5 of 34)	1.12 (0.43-2.95)	
Low-income countries				
Central Africa		70% (7 of 10)	4.08 (1.15-14.48)	
Eastern Africa		30.7% (8 of 26)	1.24 (0.44-3.44)	
Southern Africa		47% (8 of 17)	2.99 (0.92-9.77)	
Western Africa		30.2% (16 of 53)	1.46 (0.58-3.66)	

<sup>a</sup>Countries were categorized by geographic regions and income groups. Geographic regions were defined according to the African Union.<sup>[27]</sup> Income groups were defined according to the World Bank classification,<sup>[28]</sup> based on gross national income per capita (GNIpc) in 2019. Low-income countries had GNIpc ≤US\$1035; lower middle-income economies had GNIpc between US\$1036 and US\$4045; upper middle-income economies had GNIpc between US\$4046 and US\$12 535. <sup>b</sup>Values are given as the percentage of respondents, with—in parentheses—the number of respondents who reported encountering >1 patient per week with each acute condition. <sup>c</sup>Bivariate modified Poisson regression analysis was performed between national income level/geographic region and each acute condition. The values are given as the relative risk (RR) with the 95% confidence interval (CI) in parentheses. <sup>d</sup>Type III P values are shown, as calculated using the chi-squared test.

settings in mind.<sup>[12]</sup> The establishment of sustainable supply chains for affordable implants, manufactured locally in Africa or in other LMICs, could significantly improve access to care.<sup>[36]</sup> Limited resources are compounded by inadequate knowledge among frontline health workers, leading to suboptimal treatment methods and a lack of care standardization.<sup>[21]</sup> Alongside investment in infrastructure and essential materials, training frontline health workers, especially in rural areas, on early management and appropriate referral according to standardized protocols may help address the challenges of delayed presentation and inadequate diagnosis reported by respondents. Others have documented the lack of physical and occupational therapy in sub-Saharan

Africa, with more than half of the countries in sub-Saharan Africa lacking training programmes altogether.<sup>[37],[38]</sup> Our results highlight the need to train general orthopaedic surgeons, physical therapists, and occupational therapists on the management of common upper extremity pathology to improve treatment and rehabilitation. The most commonly reported conditions were trauma related, corresponding to a well-documented rise in trauma in sub-Saharan Africa.<sup>[1],[5],[6]</sup> Common causes of hand trauma in sub-Saharan Africa include road traffic injuries, occupational injuries, burns, falls, and interpersonal conflict.<sup>[9],[39]</sup> The livelihoods of many people in sub-Saharan Africa rely on the informal sector, including small-scale farming, construction,

[PAGE NUMBERS NOT FOR CITATION PURPOSES]

**Table 5.** Chronic hand and upper extremity conditions seen by survey respondents practising in sub-Saharan Africa (N=193)

Chronic condition	Country income level/ geographic region <sup>a</sup>	Respondents reporting seeing >1 case per week <sup>b</sup>	RR <sup>c</sup>	P value <sup>d</sup>
Chronic infection (osteomyelitis)	Upper middle-income countries	12% (3 of 25)	Reference	0.072
	Lower middle-income countries			
	Central Africa	14.3% (1 of 7)	2.84 (0.45-18.01)	
	Eastern Africa	16.6% (2 of 12)	2.12 (0.37-12.24)	
	Southern Africa	33.3% (3 of 9)	5.29 (1.08-25.77)	
	Western Africa	29.4% (10 of 34)	4.29 (1.18-15.62)	
	Low-income countries			
	Central Africa	50% (5 of 10)	15.72 (3.12-79.19)	
	Eastern Africa	38.5% (10 of 26)	10.59 (2.75-40.76)	
	Southern Africa	58.9% (10 of 17)	18.58 (4.42-78.06)	
	Western Africa	28.3% (15 of 53)	5.56 (1.74-17.73)	
	Elbow fracture malunion/nonunion, chronic dislocations	Upper middle-income countries	4% (1 of 25)	Reference
Lower middle-income countries				
Central Africa		28.6% (2 of 7)	6.31 (0.82-48.51)	
Eastern Africa		0% (0 of 12)	2.46 (0.47-12.93)	
Southern Africa		33.3% (3 of 9)	13.05 (2.52-67.61)	
Western Africa		26.4% (9 of 34)	11.33 (2.85-45.08)	
Low-income countries				
Central Africa		30% (3 of 10)	8.88 (1.54-51.27)	
Eastern Africa		34.6% (9 of 26)	13.35 (3.21-55.57)	
Southern Africa		41.2% (7 of 17)	35.36 (7.49-166.86)	
Western Africa		18.9% (10 of 53)	8.97 (2.57-31.28)	

*Continued*

and manual labour. Occupations in these fields often lack safety regulations and carry a high risk of injury.[9],[11]

Elbow injuries were increasingly reported with decreasing national income levels, with approximately 60% of respondents in low-income countries encountering >1 adult and >1 child per week with an elbow fracture/dislocation. Paediatric supracondylar humerus fractures are common and sometimes treated non-operatively in LMICs with inadequate surgical capacity, resulting in poor outcomes.[40],[41] Adult elbow injuries are technically challenging to treat and benefit from early treatment, with delayed care making treatment more difficult and increasing the risk of complications.[42],[43] For example, neglected elbow dislocations, which are more common in low-resource settings, often can no longer be treated nonoperatively and require surgical intervention.[44],[45] In our survey, chronic elbow injuries were far more commonly reported in low-income countries and lower middle-income countries, especially in

Southern Africa, where approximately 40% of respondents reported encountering >1 case per week. Training on acute and chronic elbow injury management, especially with limited resources, may be helpful to early-career providers managing a high volume of these complex injuries.

The most commonly reported chronic conditions in our study were tendinitis/tenosynovitis, chronic infections/osteomyelitis, neuropathies, posttraumatic stiff hand, and radius/ulna malunions/nonunions. The management of tendinitis/tenosynovitis and chronic neuropathies—which represent the most common hand conditions worldwide—is within the skillset of a hand surgeon.[26] However, with the limited availability of hand surgeons in sub-Saharan Africa, these skills should perhaps be transferred to general orthopaedic surgeons or—in the absence of orthopaedic surgeons—general surgeons or nonphysician clinicians, depending on the national context. Most chronic conditions were posttraumatic entities, emphasizing the need for effective

[PAGE NUMBERS NOT FOR CITATION PURPOSES]

Table 5. Continued

Chronic condition	Country income level/ geographic region <sup>a</sup>	Respondents reporting seeing >1 case per week <sup>b</sup>	RR <sup>c</sup>	P value <sup>d</sup>
Burn contracture	Upper middle-income countries	0% (0 of 25)	Reference	0.006
	Lower middle-income countries			
	Central Africa	14.3% (1 of 7)	1.10 (0.17-7.31)	
	Eastern Africa	0% (0 of 12)	1.92 (0.44-8.33)	
	Southern Africa	33.3% (3 of 9)	4.35 (0.89-21.29)	
	Western Africa	20.5% (7 of 34)	3.50 (1.09-11.25)	
	Low-income countries			
	Central Africa	40% (4 of 10)	14.19 (3.13-64.40)	
	Eastern Africa	26.9% (7 of 26)	5.59 (1.59-19.61)	
	Southern Africa	47% (8 of 17)	13.88 (3.77-51.06)	
	Western Africa	26.4% (14 of 53)	4.40 (1.54-12.61)	
	Volkman ischemic contracture	Upper middle-income countries	0% (0 of 25)	
Lower middle-income countries				
Central Africa		14.3% (1 of 7)	1.33 (0.19-9.44)	
Eastern Africa		0% (0 of 12)	1.48 (0.33-6.59)	
Southern Africa		22.2% (2 of 9)	4.30 (0.87-21.21)	
Western Africa		14.7% (5 of 34)	3.52 (1.07-11.53)	
Low-income countries				
Central Africa		30% (3 of 10)	9.29 (1.94-44.42)	
Eastern Africa		15.4% (4 of 26)	7.72 (2.34-25.47)	
Southern Africa		29.4% (5 of 17)	10.46 (2.68-40.80)	
Western Africa		18.9% (10 of 53)	6.49 (2.25-18.70)	

<sup>a</sup>Countries were categorized by geographic regions and income groups. Geographic regions were defined according to the African Union.<sup>[27]</sup> Income groups were defined according to the World Bank classification,<sup>[28]</sup> based on gross national income per capita (GNIpc) in 2019. Low-income countries had GNIpc  $\leq$ US\$1035; lower middle-income economies had GNIpc between US\$1036 and US\$4045; upper middle-income economies had GNIpc between US\$4046 and US\$12 535. <sup>b</sup>Values are given as the percentage of respondents, with—in parentheses—the number of respondents who reported encountering >1 patient per week with each chronic condition. <sup>c</sup>Bivariate modified Poisson regression analysis was performed between national income level/geographic region and each chronic condition. The values are given as the relative risk (RR) with the 95% confidence interval (CI) in parentheses. <sup>d</sup>Type III P values are shown, as calculated using the chi-squared test.

tive trauma systems to prevent late complications and for provider training on the management of neglected trauma. Others in sub-Saharan Africa have documented the link between neglected trauma and osteomyelitis, especially after open fractures, which occur in approximately 11% of fractures in sub-Saharan Africa.<sup>[46],[47]</sup> In rural Uganda, Ibingira et al.<sup>[48]</sup> found that osteomyelitis after open fractures was most common in the phalanges, and 85% of patients were initially treated by traditional bonesetters, delaying definitive treatment. Osteomyelitis can be prevented by improving early open fracture and infection care,<sup>[49]</sup> though the management of chronic infections must be included in the skillset of sub-Saharan African orthopaedic surgeons.

Soft tissue injuries, including burns, were frequently reported in low-income countries. Worldwide, >80% of burns involve an upper extremity, and the majority occur in LMICs.<sup>[50],[51]</sup> Associated with poverty and dangerous working environments, burns are unsurprisingly more common in low-income countries.<sup>[52]</sup> Delayed presentation—associated with burn severity, poverty, and a lack of education—can result in burn contractures.<sup>[53]</sup> Burn contractures were most commonly reported in Central and Southern African low-income countries, where >40% of respondents reported encountering >1 such case per week. Hand burn contractures are most common in unsupervised children near cooking fires, so burn prevention education emphasizing

[PAGE NUMBERS NOT FOR CITATION PURPOSES]

child supervision could reduce the severity and incidence of burns.[54] There has been support in sub-Saharan Africa for improving acute burn management and early surgical correction of contractures with appropriate physiotherapy through training, early referral, and a multidisciplinary team approach to care.[55]-[57]

## Limitations

This study had several limitations. First, social desirability bias might have caused respondents to overreport barriers and burdens, assuming study investigators desired these responses. Anonymizing the survey and deidentifying all responses might have partly mitigated this bias. Second, we surveyed a subset of providers who may not be representative of each country or of sub-Saharan Africa as a whole. Several countries were not represented at all or had only 1 representative. Our methods for survey dissemination also favoured responses from orthopaedic-trained providers; however, in many countries with few orthopaedic surgeons, general surgeons or nonphysician clinicians may be managing the majority of upper extremity conditions. Future studies should investigate the need for hand surgery in a granular, country-specific manner and include more providers from different training backgrounds, especially where orthopaedic surgeons are still few in number. Third, sampling bias—with responses preferentially coming from providers who manage high volumes of hand and upper extremity conditions—might have led to an overrepresentation of the burden of hand and upper extremity conditions in sub-Saharan Africa. This study's findings should be corroborated through further investigations using clinical data. Despite its limitations, this study provided unique insight into the challenges of providers in sub-Saharan Africa who care for patients with musculoskeletal pathology.

## Conclusions

Survey respondents representing 39 countries articulated an urgent need for improving the availability of hand and upper extremity surgery and therapy in sub-Saharan Africa. Most participants reported that general orthopaedic surgeons typically manage hand and upper extremity conditions. Inadequate diagnosis, treatment, and rehabilitation were reported by the majority of respondents, with significant barriers to care including delayed presentation, loss to follow-up, payment challenges, scarce materials and implants, and insufficient training. Most conditions managed by respondents were traumatic in nature, emphasizing the need to improve acute trauma care and to strengthen the training of general orthopaedic surgeons in hand and upper extremity surgery. Especially in low-income countries, particular training emphasis should be placed on the management of malunions and nonunions, osteomyelitis, acute and chronic elbow injuries, and burn contractures. These findings should inform the development of core competencies in hand surgery for orthopaedic surgeons and other providers managing musculoskeletal conditions in sub-Saharan Africa as part of continuing efforts to expand training and capacity-building activities on the continent.

## References

- Colen DL, Fox JP, Chang B, Lin IC. Burden of Hand Maladies in US Emergency Departments. *Hand (N Y)*. 2018;13(2):228-236. doi:10.1177/1558944717695749 [View Article] [PubMed]
- Angermann P, Lohmann M. Injuries to the hand and wrist. A study of 50,272 injuries. *J Hand Surg Br*. 1993;18(5):642-644. doi:10.1016/0266-7681(93)90024-a [View Article] [PubMed]
- Larsen CF, Mulder S, Johansen AM, Stam C. The epidemiology of hand injuries in The Netherlands and Denmark. *Eur J Epidemiol*. 2004;19(4):323-327. doi:10.1023/b:ejep.0000024662.32024.e3 [View Article] [PubMed]
- Crowe CS, Massenburg BB, Morrison SD, et al. Global trends of hand and wrist trauma: a systematic analysis of fracture and digit amputation using the Global Burden of Disease 2017 Study. *Inj Prev*. 2020;26(Suppl 1):i115-i124. doi:10.1136/injuryprev-2019-043495 [View Article] [PubMed]
- Gosselin RA, Spiegel DA, Coughlin R, Zirkle LG. Injuries: the neglected burden in developing countries. *Bull World Health Organ*. 2009;87(4):246-246a. doi:10.2471/blt.08.052290 [View Article] [PubMed]
- Spiegel DA, Gosselin RA, Coughlin RR, Josphura M, Browner BD, Dormans JP. The burden of musculoskeletal injury in low and middle-income countries: challenges and opportunities. *J Bone Joint Surg Am*. 2008;90(4):915-923. doi:10.2106/JBJS.G.00637 [View Article] [PubMed]
- Meara JG, Leather AJ, Hagander L, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet*. 2015;386(9993):569-624. doi:10.1016/S0140-6736(15)60160-X [View Article] [PubMed]
- Lankester BJ, Paterson MP, Capon G, Belcher J. Delays in orthopaedic trauma treatment: setting standards for the time interval between admission and operation. *Ann R Coll Surg Engl*. 2000;82(5):322-326. [PubMed]
- Elzinga K, Chung KC. Treating hand trauma in low-resource setting: a challenge for low- and middle-income countries. *Hand Clin*. 2019;35(4):479-486. doi:10.1016/j.hcl.2019.07.012 [View Article] [PubMed]
- de Putter CE, Selles RW, Polinder S, Panneman MJ, Hovius SE, van Beeck EF. Economic impact of hand and wrist injuries: health-care costs and productivity costs in a population-based study. *J Bone Joint Surg Am*. 2012;94(9):e56. doi:10.2106/JBJS.K.00561 [View Article] [PubMed]
- International Labour Office. *Women and Men in the Informal Economy: A Statistical Picture*. 3rd ed. International Labour Organization; 2018. [https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms\\_626831.pdf](https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/publication/wcms_626831.pdf)
- International Finance Corporation. *The Business of Health in Africa: Partnering with the Private Sector to Improve People's Lives*. World Bank Group; 2008. <https://documents1.worldbank.org/curated/en/878891468002994639/pdf/441430WPOENGL11an10110200801PUBLIC1.pdf>
- Lantz A, Holmer H, Finlayson SRG, et al. Measuring the migration of surgical specialists. *Surgery*. 2020;168(3):550-557. doi:10.1016/j.surg.2020.04.014 [View Article] [PubMed]
- Frimpong-Boateng K, Edwin F. Surgical leadership in Africa - challenges and opportunities. *Innov Surg Sci*. 2019;4(2):59-64. . doi:10.1515/iss-2018-0036 [View Article] [PubMed]
- Elias A, Tezera C. Orthopedic and major limb trauma at the Tikur Anbessa University Hospital, Addis Ababa - Ethiopia. *East Cent Afr J Surg*. 2005;10(2):43-50.
- Makobore P, Galukande M, Kalanzi E, Kijjambu SC. The burden of hand injuries at a tertiary hospital in sub-Saharan Africa. *Emerg Med Int*. 2015;2015:838572. doi:10.1155/2015/838572 [View Article] [PubMed]

17. Spiegel DA, Gosselin RA, Coughlin RR, Kushner AL, Bickler SB. Topics in global public health. *Clin Orthop Relat Res*. 2008;466(10):2377-2384. doi:10.1007/s11999-008-0413-2 [\[View Article\]](#) [\[PubMed\]](#)
18. Chokotho L, Jacobsen KH, Burgess D, et al. Trauma and orthopaedic capacity of 267 hospitals in east central and southern Africa. *Lancet*. 2015;385 Suppl 2:S17. doi:10.1016/S0140-6736(15)60812-1 [\[View Article\]](#) [\[PubMed\]](#)
19. Agarwal-Harding KJ, Chokotho L, Young S, et al. Assessing the capacity of Malawi's district and central hospitals to manage traumatic diaphyseal femoral fractures in adults. *PLoS One*. 2019;14(11):e0225254. doi:10.1371/journal.pone.0225254 [\[View Article\]](#) [\[PubMed\]](#)
20. Agarwal-Harding KJ, Chokotho LC, Mkandawire NC, Martin C Jr, Losina E, Katz JN. Risk factors for delayed presentation among patients with musculoskeletal injuries in Malawi. *J Bone Joint Surg Am*. 2019;101(10):920-931. doi:10.2106/JBJS.18.00516 [\[View Article\]](#) [\[PubMed\]](#)
21. Agarwal-Harding KJ, Kapadia A, Banza LN, Chawinga M, Mkandawire N, Kwon JY. Improving management of adult ankle fractures in Malawi: an assessment of providers' knowledge and treatment strategies. *J Bone Joint Surg Am*. 2021;103(4):326-334. doi:10.2106/JBJS.20.00660 [\[View Article\]](#) [\[PubMed\]](#)
22. Agarwal-Harding KJ, von Keudell A, Zirkle LG, Meara JG, Dyer GS. Understanding and addressing the global need for orthopaedic trauma care. *J Bone Joint Surg Am*. 2016;98(21):1844-1853. doi:10.2106/JBJS.16.00323 [\[View Article\]](#) [\[PubMed\]](#)
23. Funk LM, Weiser TG, Berry WR, et al. Global operating theatre distribution and pulse oximetry supply: an estimation from reported data. *Lancet*. 2010;376(9746):1055-1061. doi:10.1016/S0140-6736(10)60392-3 [\[View Article\]](#) [\[PubMed\]](#)
24. Holmer H, Lantz A, Kunjumen T, et al. Global distribution of surgeons, anaesthesiologists, and obstetricians. *Lancet Glob Health*. 2015;3 Suppl 2:S9-S11. doi:10.1016/S2214-109X(14)70349-3 [\[View Article\]](#) [\[PubMed\]](#)
25. Chokotho L, Jacobsen KH, Burgess D, et al. A review of existing trauma and musculoskeletal impairment (TMSI) care capacity in East, Central, and Southern Africa. *Injury*. 2016;47(9):1990-1995. doi:10.1016/j.injury.2015.10.036 [\[View Article\]](#) [\[PubMed\]](#)
26. Sears ED, Larson BP, Chung KC. A national survey of program director opinions of core competencies and structure of hand surgery fellowship training. *J Hand Surg Am*. 2012;37(10):1971-1977.e7. doi:10.1016/j.jhssa.2012.06.034 [\[View Article\]](#) [\[PubMed\]](#)
27. Member states. African Union. <https://au.int/en/member-states/countryprofiles2>
28. World development indicators. The World Bank. <https://datacatalog.worldbank.org/dataset/world-development-indicators>
29. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol*. 2004;159(7):702-706. doi:10.1093/aje/kwh090 [\[View Article\]](#) [\[PubMed\]](#)
30. Juran S, Broer PN, Klug SJ, et al. Geospatial mapping of access to timely essential surgery in sub-Saharan Africa. *BMJ Glob Health*. 2018;3(4):e000875. doi:10.1136/bmjgh-2018-000875 [\[View Article\]](#) [\[PubMed\]](#)
31. Grimes CE, Bowman KG, Dodgion CM, Lavy CB. Systematic review of barriers to surgical care in low-income and middle-income countries. *World J Surg*. 2011;35(5):941-950. doi:10.1007/s00268-011-1010-1 [\[View Article\]](#) [\[PubMed\]](#)
32. Okoroh JS, Riviello R. Challenges in healthcare financing for surgery in sub-Saharan Africa. *Pan Afr Med J*. 2021;38:198. doi:10.11604/pamj.2021.38.198.27115 [\[View Article\]](#) [\[PubMed\]](#)
33. Badenhorst DHS, Van der Westhuizen CA, Britz E, Burger MC, Ferreira N. Lost to follow-up: Challenges to conducting orthopaedic research in South Africa. *S Afr Med J*. 2018;108(11):917-921. doi:10.7196/SAMJ.2018.v108i11.13252 [\[View Article\]](#) [\[PubMed\]](#)
34. Patterson JT, Albright PD, Jackson JH, et al. Travel barriers, unemployment, and external fixation predict loss to follow-up after surgical management of lower extremity fractures in Dar es Salaam, Tanzania. *OTA Int*. 2020;3(1):e061. doi:10.1097/OI9.000000000000061 [\[View Article\]](#) [\[PubMed\]](#)
35. Chu K, Maine R, Duvenage R. We asked the experts: the role of rural hospitals in achieving equitable surgical access in low-resourced settings. *World J Surg*. 2021;45(10):3016-3018. doi:10.1007/s00268-021-06271-5 [\[View Article\]](#) [\[PubMed\]](#)
36. Agarwal-Harding KJ, Amlani LM, Dyer GSM, Mudgal CS. Addressing the global need for hand surgery. *IFSSH eZine*. 2021;11(41):18-25.
37. Agho AO, John EB. Occupational therapy and physiotherapy education and workforce in Anglophone sub-Saharan Africa countries. *Hum Resour Health*. 2017;15(1):37. doi:10.1186/s12960-017-0212-5 [\[View Article\]](#) [\[PubMed\]](#)
38. Beling J, Chisati E. Advancing physical therapy practice through curriculum revision: the Malawi experience. *Front Public Health*. 2017;5:216. doi:10.3389/fpubh.2017.00216 [\[View Article\]](#) [\[PubMed\]](#)
39. Adoga AA, Ozoilo KN. The epidemiology and type of injuries seen at the accident and emergency unit of a Nigerian referral center. *J Emerg Trauma Shock*. 2014;7(2):77-82. doi:10.4103/0974-2700.130875 [\[View Article\]](#) [\[PubMed\]](#)
40. Challa S, Agarwal-Harding KJ, Levy P, Barr-Walker J, Sabatini CS. Supracondylar humerus fractures in low- and lower middle-income countries: a scoping review of the current epidemiology, treatment modalities, and outcomes. *Int Orthop*. 2020;44(11):2443-2448. doi:10.1007/s00264-020-04694-8 [\[View Article\]](#) [\[PubMed\]](#)
41. Mlinda E, Amlani LM, May CJ, Banza LN, Chokotho L, Agarwal-Harding KJ. Outcomes of nonoperatively treated pediatric supracondylar humeral fractures at the Nkhotakota District Hospital, Malawi. *JBJS Open Access*. 2021;6(3):e21.00011. doi:10.2106/JBJS.OA.21.00011 [\[View Article\]](#) [\[PubMed\]](#)
42. Savvidou OD, Zampeli F, Koutsouradis P, et al. Complications of open reduction and internal fixation of distal humerus fractures. *EFORT Open Rev*. 2018;3(10):558-567. doi:10.1302/2058-5241.3.180009 [\[View Article\]](#) [\[PubMed\]](#)
43. Ostergaard PJ, Tarabochia MA, Hall MJ, et al. What factors are associated with reoperation after operative treatment of terrible triad injuries? *Clin Orthop Relat Res*. 2021;479(1):119-125. doi:10.1097/CORR.0000000000001391 [\[View Article\]](#) [\[PubMed\]](#)
44. Jupiter JB. Trauma to the adult elbow fractures of the distal humerus. In: Browner BD, Levine AM, Trafton PG, eds. *Skeletal Trauma: Fractures, Dislocations, Ligamentous Injuries*. Saunders; 1992:1141.
45. Islam S, Jahangir J, Manzur RM, Chowdury AA, Tripura N, das A. Management of neglected elbow dislocations in a setting with low clinical resources. *Orthop Relat Res*. 2012;4(3):177-181. doi:10.1111/j.1757-7861.2012.00190.x [\[View Article\]](#) [\[PubMed\]](#)
46. Rickard J, Beilman G, Forrester J, et al. Surgical infections in low- and middle-income countries: a global assessment of the burden and management needs. *Surg Infect (Larchmt)*. 2020;21(6):478-494. doi:10.1089/sur.2019.142 [\[View Article\]](#) [\[PubMed\]](#)
47. Pouramin P, Li CS, Sprague S, Busse JW, Bhandari M. A multicenter observational study on the distribution of orthopaedic fracture types across 17 low- and middle-income countries. *OTA Int*. 2019;2(3):e026. doi:10.1097/OI9.000000000000026 [\[View Article\]](#) [\[PubMed\]](#)

48. Ibingira CB. Chronic osteomyelitis in a Ugandan rural setting. *East Afr Med J*. 2003;80(5):242-246. doi:10.4314/eamj.v80i5.8694 [View Article] [PubMed]
49. Stanley CM, Rutherford GW, Morshed S, Coughlin RR, Beyeza T. Estimating the healthcare burden of osteomyelitis in Uganda. *Trans R Soc Trop Med Hyg*. 2010;104(2):139-142. doi:10.1016/j.trstmh.2009.05.014 [View Article] [PubMed]
50. Mock C, Peck M, Peden M, Krug E, eds. *A WHO Plan for Burn Prevention and Care*. World Health Organization; 2008. <https://apps.who.int/iris/handle/10665/97852>
51. Sasor SE, Chung KC. Upper extremity burns in the developing world: a neglected epidemic. *Hand Clin*. 2019;35(4):457-466. doi:10.1016/j.hcl.2019.07.010 [View Article] [PubMed]
52. Corlew DS, McQueen KA. International disease burden of hand burns: perspective from the global health arena. *Hand Clin*. 2017;33(2):399-407. doi:10.1016/j.hcl.2016.12.010 [View Article] [PubMed]
53. Meng F, Zuo KJ, Amar-Zifkin A, Baird R, Cugno S, Poenaru D. Pediatric burn contractures in low- and lower middle-income countries: A systematic review of causes and factors affecting outcome. *Burns*. 2020;46(5):993-1004. doi:10.1016/j.burns.2019.06.001 [View Article] [PubMed]
54. Sanyang E, Peek-Asa C, Young T, Fuortes L. Child supervision and burn outcome among admitted patients at major trauma hospitals in the Gambia. *Int J Environ Res Public Health*. 2017;14(8):856. doi:10.3390/ijerph14080856 [View Article] [PubMed]
55. Kibadi K, Moutet F. Traitement des séquelles de brûlures de la main dans les pays à ressources limitées ; notre expérience en république démocratique du Congo. *Ann Burns Fire Disasters*. 2015;28(1):32-38. [View Article] [PubMed]
56. Chukwuanukwu TO, Opara KO, Nnabuko RE. Paediatric post-burn contractures in Enugu, Nigeria. *Niger J Plast Surg*. 2007;3(1):1-4. [View Article]
57. Forjuoh SN. Burns in low- and middle-income countries: a review of available literature on descriptive epidemiology, risk factors, treatment, and prevention. *Burns*. 2006;32(5):529-537. doi:10.1016/j.burns.2006.04.002 [View Article] [PubMed]

**Peer reviewed****Competing interests:** None declared**Received:** 31 Dec 2021 • **Revised:** 17 May 2022**Accepted:** 18 May 2022 • **Published:** 29 Aug 2022

**Cite this article as:** Agarwal-Harding KJ, Amlani LM, Ogawa T, et al. Understanding the need for hand and upper extremity surgery in sub-Saharan Africa: a survey of providers. *East Cent Afr J Surg*. Published online August 29, 2022. doi:10.4314/ecajs.v27i4.1

© K.J. Agarwal-Harding et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are properly cited. To view a copy of the license, visit <http://creativecommons.org/licenses/by/4.0/>.