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Orthopedic Surgery in the Developing World: Workforce and Operative Volumes in Ghana Compared to Those in the United States

Mark A. Brouillette · Scott P. Kaiser · Peter Konadu · Raphael A. Kumah-Ametepey · Alfred J. Aidoo · Richard C. Coughlin

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Abstract

Background Musculoskeletal disease is a growing burden in low- and middle-income countries (LMICs), yet little research exists to describe the problem. The purposes of this study were to characterize orthopedic surgery in an LMIC and compare the findings to those from a developed country.

Methods The study location was the Komfo Anokye Teaching Hospital (KATH) in Kumasi, Ghana. Orthopedic surgeon, resident, and postgraduate training program numbers were compared to analogous data from a developed nation, the United States. Annual surgical volumes were compared to those at a level I trauma center in the United States, the San Francisco General Hospital (SFGH).

Results There were 24 surgeons in Ghana compared to 23,956 in the United States. There were 7 orthopedic residents and 1 residency program in Ghana versus 3,371 residents and 155 residencies in the United States. Annual case volume was 2,161 at KATH and 2,132 at SFGH. Trauma accounted for 95 % of operations at KATH compared to 65 % at SFGH. The proportion of surgeries devoted to severe fractures was 29 % at KATH compared to 12 % at SFGH. Infections comprised 15 % of procedures at KATH and 5 % at SFGH.

Conclusions Annual case volume at a referral hospital in an LMIC is equivalent to that of a level I trauma center in an industrialized country. Total case volume is similar, but the LMIC institution manages a disproportionately large number of trauma cases, severe fractures, and infections. There is a large burden of orthopedic disease in the developing nation, and there are too few providers and training programs to address these conditions.

M. A. Brouillette
University of Colorado School of Medicine, Campus Box C290, 13001 East 17th Place, Building 500, 1st Floor East, Aurora, CO 80045, USA

M. A. Brouillette (✉)
2421 West 71st Street, Prairie Village, KS 66208, USA
e-mail: mark.brouillette@gmail.com

S. P. Kaiser · R. C. Coughlin
Department of Orthopaedic Surgery, and Institute for Global Orthopaedics and Traumatology, University of California at San Francisco, 2550 23rd Street, Building 9, 2nd Floor, San Francisco, CA 94110, USA

P. Konadu · R. A. Kumah-Ametepey · A. J. Aidoo
Department of Trauma and Orthopaedics, Komfo Anokye Teaching Hospital, PO Box 1934, Kumasi, Ghana

Introduction

Musculoskeletal disease is recognized globally as a major cause of mortality, disability, chronic pain, and rising health care costs [1, 2]. In 2004, injuries alone accounted for more than 3.9 million deaths and more than 138 million disability-adjusted life years worldwide, 90 % of which occurred in low- and middle-income countries (LMICs) [3]. The burden of musculoskeletal disease is increasing in LMICs because of falling communicable disease rates, greater life expectancy, increasing obesity and sedentary lifestyles, more road traffic crashes (RTCs), and a "brain drain" of surgeons from developing nations [4–7].

Addressing this burden requires an understanding of the distribution of disease and the availability of care in LMICs [8]. Historically, epidemiologic research has focused on infectious and nutritional illnesses rather than noncommunicable and degenerative disease states, which are increasing in number with the modernization of the developing world [9]. As a result, orthopedic conditions

were not a public health priority until the turn of the century, and literature in this area has been slow to accumulate [10]. The World Health Organization (WHO), World Bank, and United Nations, as part of the Bone and Joint Decade (2000–2010), emphasized that better musculoskeletal data from LMICs is needed to inform health policy and to measure the impact of interventions [11, 12].

The purpose of this study was to establish a body of orthopedic data in an LMIC where few previous records exist. Specifically, we quantified the number of surgeons, residents, and postgraduate training programs in an LMIC and tallied annual surgical volumes at a referral hospital in that country. Results were compared to analogous statistics from a level I trauma center in a developed nation.

Materials and methods

Study location

The LMIC studied was Ghana, a nation in West Africa with a population of 24,658,823 [13]. Ghana has a low-middle-income economy with a per-capita gross national income of $1,230 [14]. In 2011, the per-capita health care expenditure in Ghana was $55 (or $114 using Purchasing Power Parity analysis) compared to $7,164 per person in the United States [15, 16]. Ghana has 9.1 doctors per 10,000 citizens compared to 26.7 per 10,000 in the United States [16].

The referral hospital studied was the Komfo Anokye Teaching Hospital (KATH) in Kumasi, Ghana. KATH is a 1,200-bed institution with 2,700 staff. KATH is the primary teaching hospital for the Kwame Nkrumah University of Science and Technology Medical School. It is the primary referral center for the northern two-thirds of Ghana. The city of Kumasi has a population of 1.5 million and is located in the Ashanti region. The population of the Ashanti region is higher than four million, but the total catchment for KATH includes more than ten million individuals when referrals are considered [17].

The developed nation studied was the United States. Surgical totals were obtained from a level I trauma center, the San Francisco General Hospital (SFGH). SFGH is a 600-bed hospital and is the only level I trauma center for the 1.5 million people living in San Francisco and northern San Mateo County.

Protocol

The institutional review boards at KATH, the University of California at San Francisco, and the University of Colorado School of Medicine granted permission to conduct the study. Data were collected in May 2010.

To describe the workforce in Ghana, a census of surgeons, residents, and postgraduate training programs was obtained from the director of the Accident and Emergency Center at KATH. To provide context, we compared the findings to published reports from an industrialized nation, the United States.

Annual surgical volumes at KATH were obtained from operating theater logs. To provide context, similar totals from SFGH were compiled and used for comparison. All cases were classified according to diagnosis to determine the rates of trauma, open fractures, and infections. Cases were also classified by subspecialty and anatomic location.

Study variables

Trauma was defined as any surgery done for an acute injury. Chronic conditions such carpal tunnel syndrome and osteoarthritis were not included in this category. The trauma was subclassified into categories of closed fractures, open fractures, femoral fractures, and amputations. Fracture totals excluded follow-up surgeries for hardware removal and failed reductions. Severe fractures were defined as open or femoral fractures.

Infections were subclassified into posttraumatic wound infections, osteomyelitis, postoperative infections, and "other"—a category that included septic arthritis, abscesses, and gangrenous disease.

Subspecialty surgeries were subclassified as arthroplasty, sports, foot and ankle, hand, spine, pediatric, and oncology operations. Arthroplasty was defined as any surgery in which a joint was reconstructed, regardless of whether external hardware or exogenous tissue was utilized. Sports surgery was defined as any operation employing arthroscopy. Pediatric surgery was defined as any surgery typically done by a pediatric orthopedist.

Surgeries by anatomic location were subclassified as upper extremity, lower extremity, hip, pelvis, and spine operations.

Statistical analysis

Our study is descriptive in design. Differences between institutions in the proportion of total care devoted to major categories of surgery were evaluated for significance using two-sample z tests.

Of note, operating theater records at KATH were partially incomplete. For example, 154 of 2,161 cases could not be identified as either trauma or nontrauma. Because incomplete entries were random, true category totals were calculated within a known confidence interval (CI) using proportional tests. As such, even though 1,908 operations for trauma were known to have been done, we determined there were actually 2,054 trauma surgeries performed

(95 % CI 1,933–2,075). Tests of significance are unaffected by this extrapolation. For clarity, CIs are not reported. We did not apply the correction factor to gross annual volume at KATH because we accounted for all operations.

Results

Resources

There were 24 orthopedic surgeons in Ghana. In contrast, there were 22,638 surgeons in the United States [18]. The density of orthopedic surgeons in Ghana was 24 per 24,658,823 citizens or 0.10 surgeons per 100,000 people [13]. The density of orthopedic surgeons in the United States was 22,638 per 308,745,538 citizens or 7.33 surgeons per 100,000 individuals [19].

There were two postgraduate accrediting bodies in Ghana, the West African College of Surgeons (WACS) and the Ghana College of Surgeons (GCS). However, the WACS was the only organization that offered licensure in the orthopedic specialty. At the time of data collection, there were seven active orthopedic residents in Ghana. In comparison, there were 155 orthopedic residency programs and 3,371 residents in the United States [20].

Surgeon, resident, and postgraduate training program numbers are summarized in Table 1.

Surgical volumes

Annual case volume at KATH was 2,161, nearly equivalent to the 2,132 surgeries performed at SFGH. The proportion of care devoted to trauma at KATH was significantly higher than at SFGH: 95 % (2,054 cases) compared to 65 % (1,376 cases), respectively ($z = 24.24$, $p < 0.05$). There were 1,269 total fractures at KATH compared to 1,049 at SFGH. The amount of total care dedicated to closed and open fractures at KATH was 47 % (1,023 cases) and 11 % (246 cases) compared to 43 % (919 cases) and 6 (130 cases) at SFGH, respectively ($z = 2.79,6.10$; $p < 0.05$). Femoral fractures comprised 18 % (389 cases) of surgeries at KATH and 6 % (129 cases) at SFGH (11.83, $p < 0.05$). The number of amputations was 60 at KATH compared to 51 at SFGH. Annual trauma volumes are summarized in Fig. 1.

The proportion of cases done for infection at KATH was significantly higher than at SFGH: 15 % (328 cases) compared to 5 % (105 cases), respectively ($z = 11.13$, $p < 0.05$). Infection cases at KATH were overwhelmingly posttraumatic: 241 at KATH compared to 14 at SFGH. There were 30 surgeries done for osteomyelitis at KATH and 6 at SFGH. The number of débridements for postoperative infections was 11 at KATH and 6 at SFGH. Annual infection volumes are summarized in Fig. 2.

Table 1 Census of surgeons, residents, and postgraduate training programs

Country	Surgeons (no.)	Residents (no.)	Residency programs (no.)
Ghana	24 (0.10)[a]	7	1
United States	22,638 (7.33)[a]	3,713	155

[a] Per 100,000 population

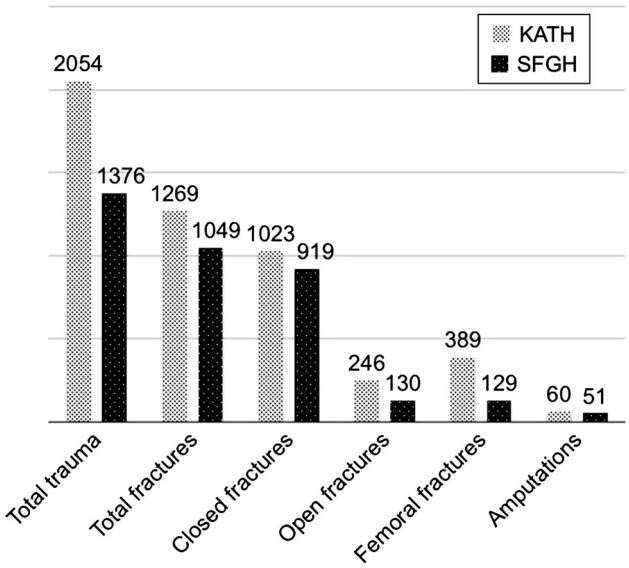

Fig. 1 Annual case volumes for trauma. *KATH* Komfo Anokye Teaching Hospital, *SFGH* San Francisco General Hospital

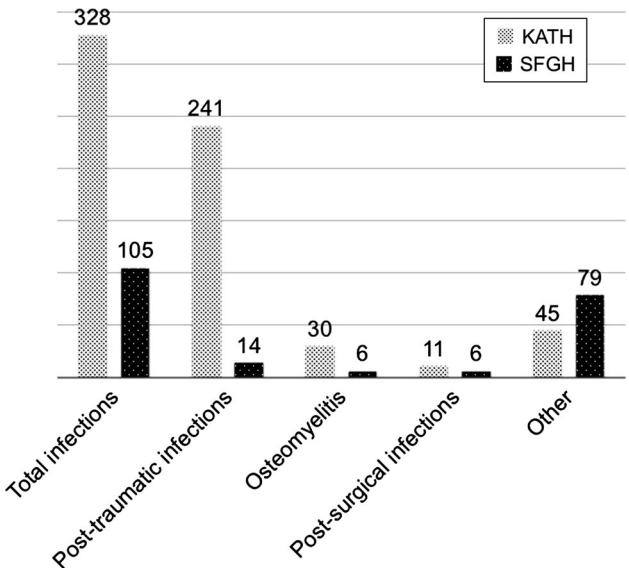

Fig. 2 Annual case volumes for infections

There were significantly fewer subspecialty surgeries performed at KATH than at SFGH. Subspecialty procedures accounted for 31 % of care (660 cases) at KATH and 61 % of care (1,311 cases) at SFGH ($z = 18.81$, $p < 0.05$). Joint reconstruction constituted 10 cases at KATH compared to 166 cases at SFGH. As sports surgeries were defined as those employing arthroscopy, there were 0 cases done at KATH and 145 cases done at SFGH. Foot and ankle surgeries accounted for 346 cases at KATH and 620 cases at SFGH. The number of hand surgeries at KATH was 134 compared to 252 at SFGH. The number of spine surgeries at KATH was 6 compared to 83 at SFGH. At both institutions, an unknown number of hand and spine surgeries were managed by plastic surgeons and neurosurgeons, respectively. There were 64 pediatric cases done at KATH and 23 at SFGH. For supracondylar fractures, there were 43 surgeries done at KATH and 15 at SFGH. Galeazzi and Monteggia fractures totaled 3 and 2 at KATH compared to 3 and 1 at SFGH, respectively. Epiphysiodesis and osteotomy accounted for 8 and 4 operations at KATH versus 1 and 1 at SFGH, respectively. There were 4 tenotomies done at KATH and 1 at SFGH. There were 27 oncologic surgeries done at KATH compared to 22 at SFGH. Annual subspecialty volumes are summarized in Fig. 3.

At KATH, 99 % of surgeries (2,143 cases) were performed on the extremities compared to 93 % (1,978 cases) at SFGH. There were 555 upper extremity procedures done at KATH and 491 at SFGH. The number of lower extremity cases at KATH was 1,588 compared to 1,487 at SFGH. Hip surgery cases totaled 189 at KATH and 202 at SFGH. The number of pelvic surgeries done at KATH was 13 compared to 27 at SFGH. The number of procedures done on the spine at KATH was 5 compared to 85 at SFGH. Annual surgical volumes by anatomic location are shown in Fig. 4.

A summary of the percentages of surgeries done for trauma, severe fractures, infections, and subspecialty care is presented in Fig. 5.

Discussion

Surgeons

There were three attending orthopedic surgeons at KATH, meaning there is one surgeon per 1,027,451 citizens in Ghana and one surgeon per 500,000 persons in Kumasi. These densities are much less than the one surgeon per 13,638 individuals in the United States. Ghana has one-third the density of doctors but one-seventieth the density of orthopedic surgeons when compared to the United States. This may suggest that specialists, in particular, are in short supply in LMICs. Physician "brain drain" is a primary cause of low provider numbers in the developing world [6, 7, 21]. Brain-drain theory suggests that when LMIC doctors train in developed nations they are drawn away from their native countries by opportunities for advanced training, employment, and political freedom [22]. At the time of our research, we learned that all orthopedists at KATH had completed their postgraduate training abroad. Many more who left Ghana to study orthopedics never returned home to practice. These patterns suggest that brain drain may be an important cause of low surgeon numbers

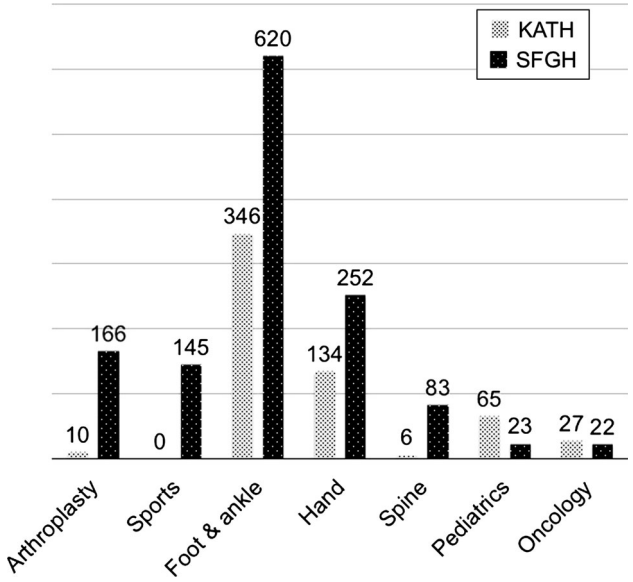

Fig. 3 Annual case volumes by subspecialty

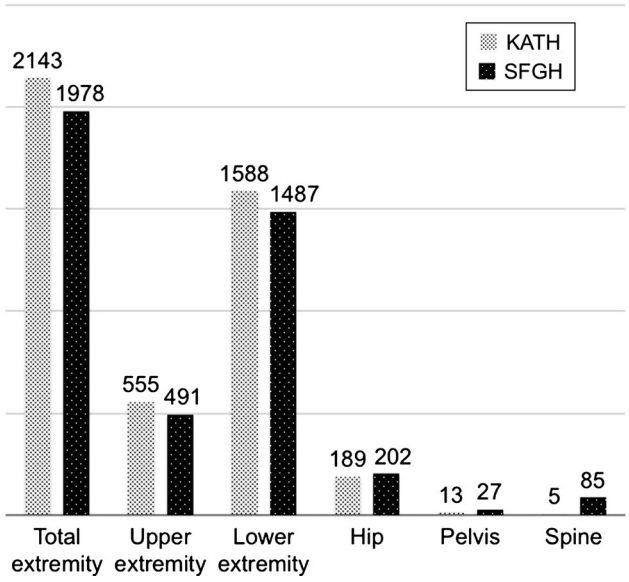

Fig. 4 Annual case volumes by anatomic location

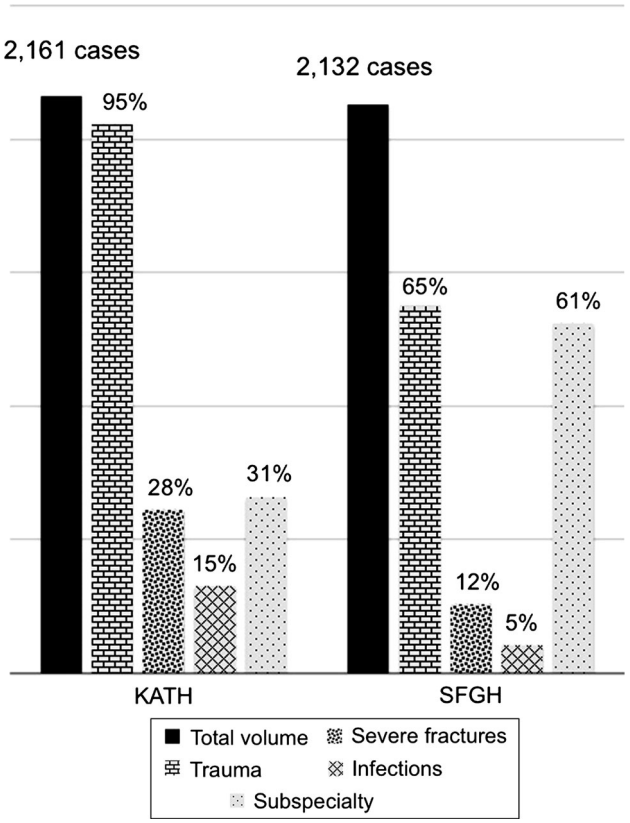

Fig. 5 Summary of operative volumes

in Ghana. Sub-Saharan Africa has the highest rate of physician emigration in the world, and Ghana has the highest rate in the region, with 30 % of its doctors currently practicing in the United States, United Kingdom, Canada, and Australia [7]. Within 3 years of graduation, as many as two-thirds of Ghanaian physicians leave home to practice abroad [23]. In Ghana, a culture of emigration exists among faculty and students in which training outside of the country is seen as a desirable achievement [24]. Numerous proposals to curb the flight of doctors from LMICs have been made with an emphasis on the establishment of more in-country training programs [21, 22, 24–27].

Training programs

The WACS and the CGS are accrediting postgraduate training bodies in Ghana, but the WACS was the only organization that offered specialty training in orthopedics. Since 2005, the WACS has produced four orthopedic surgeons. At the time of data collection, there were seven orthopedic residents in Ghana. These numbers are low when compared to the 155 residency programs and 3,371 residents in the United States.

Presently, KATH leadership is in the process of establishing an accredited residency program through the GCS. The creation of additional residency spots is likely to improve physician retention in Ghana. Expanding postgraduate training alone may not be a sufficient remedy for brain drain, however. Even with the existing opportunity to pursue a residency at KATH through the WACS, house officers we spoke with avoided orthopedics because they perceive that the training involves long hours, provides low remuneration for challenging work, and offers an unreliable path to licensure. House officers pointed out that the West African College does not have a fixed program length, and promotion through the program is determined by subjectively graded examinations that can prevent matriculation. The proposed Ghana College residency has a shorter program length. Unfortunately, house officers at KATH worry that a GCS program at their institution may have inadequate educational infrastructure in its developing stages. Although more postgraduate programs are needed in LMICs, efforts to recruit and retain students are necessary if these programs are to be successful.

Trauma

The proportion of care devoted to trauma at KATH was significantly greater than at SFGH: 95 % compared to 65 %, respectively. In addition to the high volume of cases, the overrepresentation of open fractures and femoral fractures demonstrates that injuries are more severe at the LMIC institution. Although pelvis and spine surgeries can serve as surrogates for acuity, the low number of these operations performed at KATH is a reflection of the facts that pelvic fractures meeting surgical criteria by SFGH standards are usually managed with extended period traction, and spine surgeries are done primarily by neurosurgeons. Higher prehospital mortality in Ghana likely contributes to the lower number of pelvis and spine surgeries as well.

A comparison of our data to those from a previous study suggests that the volume of trauma surgery at KATH is increasing. London et al. [28] reported that 2,022 trauma patients were admitted to KATH between 1995 and 1996. In all, 844 of these patients were operated on and 65 % of the operations were orthopedic in nature. Assuming that this is a linear trend, trauma cases at the LMIC tertiary center are not only more prevalent and severe but are increasing at a rate of 25 % per year. Although this is likely due to a real increase in injuries, it also reflects a greater surgical capacity at KATH resulting from addition of the Accident and Emergency Center to the hospital in 2009.

It is important to note that our depiction of the burden of trauma may be too modest. A previous study found that 51 % of trauma deaths occurred in a prehospital setting [29]. Another study of mortuary records from KATH showed that 80 % of injury-related deaths occurred outside

the hospital [30]. This means that a significant number of patients die before reaching the operating room and are not accounted for in theater records.

In the developing world, the high trauma burden is largely a result of poor road traffic safety [5, 31]. In Ghana, RTCs are the leading cause of trauma-related morbidity and mortality [30, 32]. As LMICs have become increasingly motorized, roads have not expanded fast enough to accommodate the increase in traffic. Cars now compete with vulnerable motorbikes and pedestrians for space on narrow streets. Pedestrians alone account for 46 % of RTCs in Ghana [33]. A new study of femoral fractures at KATH found that 58 % result from RTCs [34]. The greater volume and severity of injuries we observed at KATH is likely due to the increasing number of automobiles in Ghana in combination with unprotected populations using the roadways.

The WHO has made recommendations to address the surge of road traffic injuries in developing nations [35, 36]. In Ghana, speed bumps and rumble strips installed between Accra and Kumasi reduced crashes by 35 % and fatalities by 55 % [37]. Televised campaigns for road traffic safety have had some success in Ghana, especially in urban areas [38]. In addition to preventive measures, trauma training programs for nonphysician providers have been designed for use in LMICs and have proven successful [39–46]. In one program, Ghanaian commercial drivers were taught basic first aid and reported applying these skills in the field [47, 48]. Although programs such as these are beneficial, revised medical school and postgraduate curriculums are likely to have the greatest impact on care [49]. The medical school in Kumasi has developed a continuing medical education course for rural general practitioners that focuses on improving the management of injured patients [50]. In urban centers such as Kumasi, training programs for specialists can bolster services for the severe injuries seen at tertiary care institutions.

Infections

Our data show there are substantially more surgeries done for infections at KATH than at SFGH: 328 cases annually versus 105, respectively. Posttraumatic infections accounted for 241 operations at KATH compared to 14 at SFGH. The reason for the greater number of trauma-related infections at KATH is unclear. Possible factors contributing to this finding include differences between institutions in timing and frequency of antibiotic administration, proportion of open fractures, severity of fractures, degree of contamination of open fractures, time to definitive wound closure, postoperative dressing technique, nutritional status, and rates of preexisting infection. Interestingly, time to débridement for open fractures has not been associated with increased rates of infection [51].

In contrast to traumatic causes, KATH and SFGH had similar postoperative infection rates: 0.51 % (11 cases) versus 0.28 % (6 cases), respectively. Yet, surgeons at KATH report that many surgery-related infections are not recorded in the operative logs and the true infection rate is probably much higher. Surgical-site infections are endemic in the developing world and occur at an average rate of 5.6 per 100 procedures (compared to 2.6 per 100 surgeries in the United States) [52]. In Ghana, the overall health care-related infection rate has been estimated to be 6.7 %, although the proportion of these resulting from surgery has not been specified [53]. Future research is needed to determine the true incidence of postoperative infection at KATH. Several infection surveillance programs have been introduced in LMICs in recent years [52]. Identifying problem areas through surveillance can facilitate targeted interventions for gaps in care.

Subspecialty care

We found that 31 % of surgeries at KATH and 61 % of surgeries at SFGH fell under our definition of subspecialty care. These findings demonstrate that subspecialty services at the LMIC referral center are limited.

Joint reconstruction consisted of 8 cases at KATH compared to 166 cases at SFGH, although the number of hip operations were similar at the two institutions. These results indicate there is an unmet demand for joint replacement at least for the hip. Total hip arthroplasty and knee replacement for osteoarthritis is a potentially cost-effective intervention in developing countries if the expertise to perform these operations is available [54]. Although KATH surgeons were trained in this technique, implants for arthroplasty were unavailable. Disease prevalence data and cost estimates are needed to determine if the implementation of arthroplastic services is worthwhile.

Similarly, no arthroscopy was done at KATH. Although KATH surgeons were trained in this technique, the necessary equipment was lacking. The large trauma burden at KATH indicates there is a substantial demand for arthroscopic care in Ghana. The diagnosis and treatment of meniscal tears and degenerative joint disease with arthroscopy can be cost-effective in LMICs if adequate programs for rehabilitation are in place [55]. Rehabilitative services are available at KATH and will play an important role in patient outcomes if arthroscopic care is initiated.

Lower-extremity procedures were similar in number for KATH and SFGH. They were done primarily for trauma. The large number of lower-extremity cases at KATH demonstrates an unmet demand for foot and ankle surgery. Outside the theater, in the clinic, we observed a large number of patients with clubfoot. More detailed outpatient

records are needed to determine how many of these cases require surgery.

With respect to hand surgery, although KATH performed half as many operations as SFGH, it is difficult to draw conclusions about the provision of, or demand for, these services because plastic surgeons were responsible for an unknown number of cases at both institutions. The same is true for spine surgeries. There were 4 spine operations performed at KATH compared to 83 at SFGH. At KATH, neurosurgeons are responsible for the majority of spine cases.

Pediatric surgery included operations for supracondylar humeral fractures, Galeazzi and Monteggia fractures, epiphysiodesis, osteotomy, and tenotomy. There were 64 pediatric surgeries performed at KATH and 23 at SFGH. The SFGH total is an underestimate, however, because there are two children's hospitals that manage much of the region's care.

In all, 43 operations at KATH were done for supracondylar humeral fractures compared to 15 at SFGH. Supracondylar fractures are the most common fractures in the pediatric population [56]. They typically occur when the elbow is hyperextended during a fall and can result in neurovascular damage if not repaired promptly. A previous study found that general orthopedic surgeons are able to manage these injuries surgically as effectively as pediatric subspecialists [57].

Epiphysiodesis and osteotomy were the next most common pediatric operations. KATH performed eight and four of these surgeries, respectively, and SFGH performed one of each. These surgeries are typically done for angular deformities of the lower extremities in children. In LMICs, angular deformities are frequently the result of nutritional rickets [58]. In equatorial countries, the vitamin D deficiency that precipitates nutritional rickets is often due to exclusive breast feeding and corn-based diets [56]. We observed a large number of patients with angular deformities in the outpatient clinic at KATH, but more complete records are needed to quantify the demand for surgical intervention.

The least common pediatric surgery was tenotomy, an operation that is employed in the management of clubfoot. Only four of these procedures were done at KATH compared to two at SFGH. Clubfoot, or talipes equinovarus (TEV), is the most common congenital malformation in children and is the most prevalent orthopedic disease in LMICs [59, 60]. TEV has been a neglected disease in developing countries because of the complex, multistage surgeries required to correct these deformities. In recent years, the management of early clubfoot has advanced significantly in LMICs with the use of the Ponseti method [61]. The Ponseti technique consists of nonsurgical manipulations and casting that can be employed by nonphysicians with up to 98 % efficacy [56, 62]. A program employing the Ponseti method in Uganda has proven sustainable, meaning this technique may be economical in limited-resource settings [61]. At KATH, patients with early TEV are managed by physical therapists using the Ponseti method. Better outpatient data are needed to determine the number of late TEV cases requiring surgery.

Deciding whether to provide subspecialty services can be challenging for hospitals and health care planners. Presently, there is little research describing the pros and cons of diverting limited resources to the implementation of these services in LMICs. Tibor and Hoenecke [55] recognized this dilemma and devised a three-tiered approach to prioritize subspecialty care. Tier one includes basic trauma and infection care; tier two arthroscopy, soft-tissue repair, and deformity correction; and tier three spine surgery and arthroplasty. Higher tier procedures should be implemented only when the provision of more essential services in lower tiers is deemed adequate. Other important considerations are the availability of subspecialty-trained surgeons and technicians who can repair high-tech equipment locally [63]. Further studies are needed at KATH to determine if a basic level of care is being met and if investment in subspecialty services is cost-effective.

Limitations

Our data describe orthopedic care in a single LMIC, so our findings cannot be applied ubiquitously throughout the developing world. For example, a tertiary care center in a large city such as Kumasi is likely to see more RTCs and severe injuries than a district hospital in a rural location. For this reason, our conclusions are most applicable to large referral hospitals in urban areas. Limited resources are common to all LMICs, however, and are a primary cause of physician brain drain, trauma, and inadequate surgical services. As such, our conclusions on these topics are likely to hold true for many developing nations.

Conclusions

The burden of bone and joint disease is increasing in LMICs. To curb this trend, baseline epidemiologic and treatment data are needed to inform effective health care policy. Unfortunately, little such research exists. The purpose of this study was to quantify providers, postgraduate training programs and operative volumes in an LMIC and to compare the findings to those from an industrialized nation. Our results show that annual case volume at a large referral hospital in an LMIC is equivalent to that at a level I trauma center in a developed country. Although total case volume is similar, the LMIC institution performs a

disproportionately larger number of surgeries for traumas, severe fractures, and infections. Despite a large burden of disease in the LMIC, there are few providers and training programs available to address these conditions.

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Conflict of interest None.

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