Population Based Orthopaedic Care for Musculoskeletal Injuries in Economically Underdeveloped Countries

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Introduction

Surgery has been neglected as a population based health strategy by the global public health community, despite estimates suggesting that surgical conditions account for 11% of the world's DALYs (disability adjusted life years),[1-4] and data indicating that basic surgical and anesthetic services may be comparable to selected primary health services in terms of cost effectiveness.[5-8] While the number of surgeries currently performed worldwide is much greater than the number of yearly births and the number of people infected with HIV combined, only 3.5% of these procedures are performed in countries ranked in the lowest 3rd in terms of health expenditure.[9] Assuming that the surgical disease burden is relatively uniform, this data suggests that there is an enormous unmet need for surgical services that needs to be quantified. The world has witnessed an epidemiologic transition in which the burden of communicable and vaccine preventable diseases has decreased, and the burden of non-communicable diseases and injuries has increased. Injuries accounted for sixteen percent of the global burden of disease in 1998.[10,11] Road traffic crashes are predicted to be the third leading cause of disability adjusted life years by 2020, and related global economic costs are estimated to be upwards of 518 billion US dollars per year.[12,13] While musculoskeletal injuries rarely result in death, they are a major cause of long term disability[14-20].

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Gaps in access to basic surgical services represent a failure at the level of the health system, and barriers to the provision of surgical services include insufficient infrastructure and/or physical resources, inadequate human resources, inefficient systems for delivery of services in both the pre-hospital setting and when a patient arrives at a treatment facility, a lack of reliable health information, and often the inability to access a health facility due to geographic considerations or other variables.

According to the World Bank data from 2007, the average inhabitant of a low-income country earns less than 935 dollars per year[21]. For the 49 countries categorized as low income, the average life expectancy is 59 years, nearly ten years shorter than the global average, with only the best country in the low-income category surpassing the global average[22]. The number of trained physicians per capita in low income countries is 5 per 10,000 as compared with 13 per 10,000 globally[22]. Average government expenditures among low-income countries on health care are as low as $5 per capita, (versus $2862 per capita in the United States), with a substantial portion of the costs for health care being "out of pocket."[22] The burden of health care costs faced by patients in low-income countries results in more than one million families being driven below the national poverty line each year due to catastrophic health expenditures.

Orthopaedic surgeons from economically developed countries have certainly played an important role in improving conditions in low-income countries by donating money and/ or educational materials, participating in service missions, and becoming involved in the teaching and training of health care providers. However, improving the delivery of services requires far more than simply training more orthopaedic surgeons. Those traveling to these environments recognize that many of the patients present at a late stage in their disease process (Figure 1A-C), and require more complex

interventions. These treatments are much less likely to result in an adequate outcome, in comparison with simpler measures delivered early in the disease process. This suggests the importance of early and appropriate treatment, which requires adequate access to surgical care in or near the patients' home community. At the population level, this will require a comprehensive, multidisciplinary and multisector approach aimed at health system reform. Health systems have evolved over the past few decades, and there has been recent emphasis on universal access to "essential" services. "Essential" services are those that are low cost, high yield, target major health problems, and can be made available universally.[24] Given the limited financial and physical resources available in economically underdeveloped countries, health planners must select and promote a core group of services which are efficacious, cost effective, and can be delivered to all.

With this background, let us envision the scenario in which an orthopaedic surgeon is appointed to a committee charged with improving access to care for emergent musculoskeletal conditions (injuries and infections) at the district hospital level in the rural areas of a low-income country. This surgeon will serve alongside government officials, representatives from the ministry of health, other health care professionals, and representatives from non-governmental organizations/funding agencies. The group's philosophy will be based on the concept of universal access to essential services. In order to develop an effective strategy including the most appropriate policies, we will focus on several major areas, namely defining the burden of orthopaedic diseases at the local/regional/ national levels, characterizing and improving the capacity to deliver surgical services (infrastructure, physical resources, and human resources), determining the most appropriate training strategies for musculoskeletal providers, and exploring mechanisms to enhance funding.

1. Define the Magnitude of the Problem

While it seems obvious that an understanding of local disease burden is essential to plan the allocation of health resources, there is a paucity of data on surgical disease burden in low and middle income countries (LMICs). Formal epidemiologic study (or local audit) will be required to determine which orthopaedic problems are most prevalent, in order to define which interventions should be prioritized. The goal will be to determine the "unmet needs" for orthopaedic care. Ideally, this information would be gathered through the use community based surveys, although the methodology is costly and time consuming. While the use of hospital based data is more practical, the true need for services will be underestimated. Population level data at the national level would certainly be helpful; however information on surgical conditions is not routinely collected in national surveys. Standard indicators included in such surveys, such as maternal mortality and under-five mortality, fail to reflect the impact of surgical conditions. This underscores the need to develop health metrics for surgical disease, as suggested by the Global Burden of Surgical Diseases Working Group.[25] For our purposes, we might consider both a community based and a facilities based assessment of orthopaedic problems in several randomly selected districts within the country. Until then, in the absence of data on disease burden, we might consider defining essential orthopaedic services based upon the material from the WHOs Emergency and Essential Surgical Care project.[26,27]

2. Characterize and Strengthen the Capacity to Deliver "Essential" Orthopaedic Services

In contrast to many primary health initiatives, basic surgery and anesthesia may require a greater level of resources then some other primary care health initiatives. In order to deliver safe surgery, we need to have adequate infrastructure, physical resources and supplies, and trained health workers. A functional and sustainable surgical service at a district level facility will requires not only an initial start up fixed costs, but also ongoing variable operating costs.

	Population	GNI Per Capita	Life Expectancy (2004)	Per Capita Health Expenditure($)	Physician Density (per 1000)
United States	295,734,134	41,440	78	5711	2.56
Kenya	33,829,590	480	51	20	0.14
Sierra Leone	5,867,426	210	39	7	0.03
Mozambique	19,406,703	270	45	12	0.03
Uganda	27,269,482	250	49	18	0.08
Nigeria	128,765,768	430	46	22	0.28
Ethiopia	70,053,286	110	50	5	0.03
Malawi	12,707,464	160	41	13	0.02
Ghana	21,946,247	380	57	16	0.15
India	1,080,264,388	620	62	27	0.60
Nepal	27,676,547	250	61	12	0.21
Bangladesh	144,319,628	440	62	14	0.26
Pakistan	162,419,946	600	42	13	0.74
Afghanistan	29,928,987	?	62	11	0.19
Cambodia	13,636,398	350	54	33	0.16
Vietnam	83,535,576	540	71	26	0.53

Table 1. The "playing field" in low income countries. Sources: Population: United States Census Bureau, International Data Base (updated 4/26/05), Life Expectancy at Birth (2004). World Health Report 2006. Gross National Index per capita 2004. World Development Indicators, World Bank (18 April 2006), Per Capita health expenditures (2003). World Health Report 2006.

While there is little information available on the capacity to deliver surgical services in LMICs, a recent review of more than one hundred non randomly selected district level facilities (8 LMICs) found significant deficiencies in the capacity to provide basic surgery.[28] Our approach might involve an initial situational analysis in the country, to characterize the capacity to deliver surgery (infrastructure, physical resources, human resources) at each district facility using a facilities based questionnaire. This data would provide a benchmark, and would define the improvements required to provide our essential services.

Within the context of delivering basic *trauma* care, we recognize the importance of a well organized system, including both prehospital services, and treatment once a patient reaches a health facility. Our committee can consider incorporating selected guidelines available from the World Health Organization.

With respect to pre-hospital care, death and disability due to traumatic injury may be reduced when adequate "systems" for delivery of care are provided,[29-35] and WHO guidelines are available.[29] For example, prompt treatment reduces the incidence of complications such as osteomyelitis following open fractures (up to 80% of patients with delayed presentation).[36] Transport of the injured to a treatment facility may be hindered by a lack of phones or means for communication, inability to afford ambulances, or a lack of motorable roads. Until such an infrastructure is developed, informal mechanisms must be utilized. For example, members of the community (such as taxi drivers) can be trained in basic first aid skills including immobilization of the extremities with locally made splints, and given a financial incentive for transporting the injured.

For trauma and emergency care, the "Guidelines for Essential Trauma Care"[37-39] provide a flexible template for health care planners, and outline the resources that should be in place to deliver trauma services at four levels of health care facility [*basic* (health post), *GP* (general practitioner, has basic surgical capability), *specialist* (has a general surgeon), and *tertiary* (has an orthopaedic surgeon)]. For each of these levels, selected services are classified as essential, desirable, possibly required, or irrelevant. Our focus will be on the GP level, or perhaps at the specialty level if we

Figure 1. In the developing world, many patients present at a late stage in their disease process. When untreated, burns may result in dramatic deformities of the limbs (top left). Musculoskeletal tuberculosis involves the spine in 50% of cases, often resulting in a severe kyphosis (middle). Congenital abnormalities such as this congenital dislocation of the patella (associated with other deformities in this case) can be difficult to treat at a late stage (far right), as can the neglected clubfoot (bottom left).

can recruit a general surgeon. With regard to services for musculoskeletal trauma care at the GP level, essential services would include basic immobilization/splinting, monitoring of neurologic function, and assessment of hand injuries. Services which are "possibly required" (depending upon the resources available locally) include closed reduction, skeletal traction, operative wound management, and external fixation. Depending upon the funds available, the equipment checklist for a GP level facility ("district" hospital or equivalent) would be limited to a basic surgical instrument set, splinting and casting materials, and the supplies needed for skeletal traction. Our "wish list" might include an image intensifier and a system for basic external fixation, however an implant system for internal fixation should probably only be made available at a higher level of service.

With regard to human resources, it is clear that training orthopaedic surgeons alone will be insufficient. There are many facets to the global human resource crisis, in which there is a shortage of 4 million health care workers.[40,41] In addition to a deficiency in the absolute number of health providers, caregivers migrate both within (rural to urban) and between (low to higher income) countries, resulting in the so called "brain drain".[41-46] This problem is most pronounced in sub-Saharan Africa, where orthopaedic surgeons are rarely available outside of tertiary facilities in urban centers.[47,48] The primary referral level for much of the population is the "district" hospital or equivalent, staffed by a general medical doctor and/or other health professionals. (nurses, technicians), and where in some circumstances, a general surgeon may also be available.[48,49] Referral to higher levels of service may be complicated, costly, and inefficient. Many patients in these rural communities have relied upon traditional practitioners for medical care, and a significant subset receive no care at all.

We need to determine how to effectively staff district hospitals, and this requires recruitment, training, and retention with emphasis on financial incentives and opportunities for ongoing education and personal development. Since staffing with orthopaedic surgeons – and for the most part any highly trained medical specialty – is an unachievable goal, there has been considerable interest in task shifting, which may be defined as the "allocation of tasks in health-system delivery to the least costly health worker capable of doing that task reliably".[50-55] Paraprofessionals or other health

care professionals have been successfully trained to perform selected surgical procedures through both short term educational courses and formally certified programs[56-64], most commonly in sub-Saharan Africa.

In Malawi, where there are only 9 orthopaedic surgeons for 27 million people, with orthopedic clinical officers providing care for the majority of musculoskeletal problems[64]. Another approach has been to train medical doctors to become "rural" surgeons, who are competent in a selected group of procedures drawn from all of the surgical subspecialties including orthopedics[65-68]. A postgraduate program in rural surgery has been developed, and is currently being piloted, by the National Board of Examinations of India. Candidates are medical doctors who will complete a 3 year curriculum leading to a diploma in rural surgery. Musculoskeletal education may also be extended to traditional practitioners, who will continue to play a major role in caring for musculoskeletal injuries in rural areas. Short training courses may also be helpful. In Nigeria, a recent initiative in which traditional bonesetters attended a one day instructional course led to a significant decrease in the rates of gangrene, infection, malunion, and nonunion.[69]

3. Training for the Delivery of Essential Orthopaedic Services

Training programs for surgeons in industrialized countries have evolved towards greater subspecialization, which does not meet the needs of caregivers in the rural environment of economically underdeveloped nations. In a study from Pakistan, only 37% of the general surgical procedures required were taught in western training programs[70]. Students must be trained in the environment in which they will practice, focusing on the common diseases they will treat and using the resources available locally. While recognizing that the training of orthopaedic surgeons should be encouraged and supported, an alternate approach is required to provide services for the majority of patients in a low-income country.

As mentioned previously, while the training orthopaedic surgeons is important and should be encouraged in low-income nations, our focus should be on training non-orthopedists or non-medical personnel to provide "essential" orthopedic services. The training should emphasize acute problems such as trauma and infection, and we must assume that elective, reconstructive procedures will only be available at higher levels of service within the health system. Specifics of the curriculum need to be addressed, as any treatment strategies should minimize complications, maximize outcomes, and stay within a limited budget. Given these constraints, and the recognition that the majority of our patients will be unable to be transferred to a higher level of service, the armentarium of the rural musculoskeletal provider must include the splinting and closed treatment of fractures (as well as indications for referral), various traction techniques (femoral, tibial, calcaneal, olecranon), and adequate wound care (debridement of open fractures, drainage of abscesses, and split thickness skin grafting).[71-74] In the absence of radiographs or an image intensifier, physical findings must be relied upon to assess the quality of reduction (extremity length and alignment), and to determine when traction can be removed (clinical union). Basic skills in external fixation would be desirable, or even the pins in plaster technique, especially in the case of open fractures.[75-83] While it is possible to manufacture screws or pins, Schanz pins or the equivalent may be available at a reasonable cost, and a host of materials have been used to connect the screws (wooden blocks, plaster of Paris, bone cement, galvanized iron pipe, stainless steel bars, and old Kitschier nails). A circular fixate, in which the rings were cut from aluminum drums, has also been used successfully.[80] The "pins and plaster" technique may serve as an alternative to external fixation in treating unstable fractures.[82-84] For example, Kirschner wires (forearm), Steinmann pins (tibia), or half pins (femur) can be placed above and below the fracture site and incorporated into the cast. It should be emphasized that in settings with minimal resources, open reduction and internal fixation (especially with a plate and screws) has been associated with a high rate of complications such as osteomyelitis.[85-89] These techniques should be reserved for selected indications, such as irreducible fractures, fractures associated with a neurovascular injury, or in cases where there are no other good options, such as displaced fractures of the olecranon or patella.[89] Displaced intraarticular fractures have been treated by splinting and early range of motion in the absence of surgical resources[73]. For basic surgical implants, one approach would be to allocate funds to purchase equipment from local or regional vendors. An alternate strategy might be to build a workshop, in which supplies can be produced from the materials available locally.[90]

We might also incorporate the training materials used by the World Health Organization into our program. Recognizing that strengthening the delivery of surgical and anesthetic services is essential, the Clinical Procedures Unit of the Department of Essential Health Technologies (WHO) has developed the Emergency and Essential Surgical Care project. With the goal of improving the delivery of surgical and anesthetic services at facilities with limited resources, the WHO coordinates "training the trainers" workshops in association with local and international partners.[2,26,27,91] These workshops promote local capacity and are based on the Integrated Management for Emergency and Essential Surgical Care (IMEESC) toolkit. In addition to basic orthopedic skills (reduction, splinting/casting, open fractures/soft tissue wounds, traction), elements of this diverse learning program include team responsibility and organization, basic anesthetic and resuscitation techniques, record keeping, and the management of burns. Programs have been initiated in more than 20 countries; the related reference text is entitled "Surgical Care at the District Hospital".[27]

Finally, access to health care information is extremely important, and is limited in many LMICs; even when computer services and the internet are available, it may be difficult to extract relevant data from the voluminous amount of information available.[92-95] While the most useful information often comes from local or regional journals, 98% of the journals indexed on Medline originate in economically developed nations.[92,96] We would need to develop a strategy to obtain the most useful reference materials, and also to provide access to medical and surgical journals. The WHOs HINARI project would be helpful in providing access to a large number of journals. To gain access to textbooks and a variety of other materials, the Ptolemy project might be considered.[98,99] This partnership would further promote both the generation from and dissemination to of critical health data from and to LMICs.

4. Financing

Financing health care systems in the developing world poses a two-fold problem. Not only do appropriate funds need to be generated/allocated to set up the initial infrastructure, but also the system must continue to either draw or generate funds yearly in order for it to be sustainable. This proves to be particularly challenging, as health care resources are limited in LMICs, there exists a number of competing social and economic priorities, and health care costs are a major burden on the majority of the population. Heath care funding may be conceived as public (originating from taxes and government), private (originating from free enterprise), or a mix of the two. In the context of an LMIC one can imagine a three-tiered system involving a public-private partnership that might provide sufficient support for a health care system. In urban areas the most appropriate scenario is likely a parallel public and private infrastructure, where advanced, rare, and "luxury" orthopaedic care should be available. At the district hospital level, a more selected level of essential services are to be provided, funded primarily though public means. This tier will be the primary point of delivery of critical surgical services, providing universal care for the population based on need. However, as much of the population likely will not be covered regularly by district hospitals due to geographic or transportation difficulties, communities themselves play an important role as the foundation to maintaining a stable health care system. By encouraging a public-private partnership at the level of the community, a sustainable and incentivized health care mini-industry may be developed, maintaining health professional retention and community investment. This may be accomplished by micro-loans or public entrepreneurial stimulus to local health workers, augmented by training opportunities. By integrating private endeavors into the system and supporting/stimulating them where necessary with public funds, a foundation can be formed where the population values and trusts health care, thereby increasing its utilization.

It is very important to note that the impetus for health care development should primarily emerge from within the LMIC itself. If any health care system design, or means for delivery of essential surgical services is based primarily on foreign aid, it is highly susceptible and reliant on international trends, which are unpredictable. Furthermore, if the system were internally driven, there would be a greater sense of community self-sufficiency and a perspective that healthcare is a means of economic growth and stability. Most importantly, an effective LMIC health care system that does not rely on external international funding is sustainable.

In considering the delivery of essential surgical services in an LMIC, another important

factor must be recognized. Especially in a self-sustaining public-private partnership, the independent functioning of the system is at important, as market forces do play a role. International surgeons need to be particularly careful not to disrupt emerging health care systems. For example, imagine the situation where an international surgeon from the developed world travels to a community or district in an LMIC and provides short-term free care independent of the existing system, as happens often in "health missions" or "health camps." Patients will flock to the foreign surgeon, depriving the existing private infrastructure of patients, essentially forcing local practitioners out of business and away from the region; therefore, when the foreign surgeon leaves, a health care void is effectively created. While the intentions likely are very much altruistic in this example, the outcome is damaging. This is not to suggest that surgeons should not travel abroad to do work at all, but instead emphasizes the fact that surgeons who have the intention of volunteering their skill may have the most beneficial impact working through or in conjunction with existing local channels, or devoting their invaluable time to training local practitioners in needs directed procedures.

Conclusions

This review highlights some of the challenges associated with caring for acute musculoskeletal problems in economically underdeveloped nations. Barriers to the delivery of services occur at multiple levels, and include deficiencies in infrastructure, physical resources (equipment and supplies), trained health professionals, and access to reliable health care information. Improving the quality of services at the population level can only be achieved through reforms at the level of the health system. While orthopedic services in industrialized nations have become increasingly dependent upon technology, and there will always be some debate over the optimal treatment for any given condition, a "public health" approach aimed at reducing disability from acute musculoskeletal problems must rely upon the effective use of simple, low risk, cost effective, and time honored methods of treatment. Furthermore, focus must be placed on developing public-private partnerships that lead towards sustainable financing structures for essential health care, including orthopaedic procedures. A multidisciplinary, multisectoral effort will be required to provide universal access to "essential" orthopaedic services in an economically underdeveloped nation.

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