Research Article

Helping Hands: A Cost-Effectiveness Study of a Humanitarian Hand Surgery Mission

Kashyap K. Tadisina,1 Karan Chopra,2 John Tangredi,3 J. Grant Thomson,3 and Devinder P. Singh4

1 College of Medicine, University of Illinois at Chicago, Chicago, IL 60612, USA
2 Department of Plastic and Reconstructive Surgery, Johns Hopkins University, Baltimore, MD 21287, USA
3 Section of Plastic and Reconstructive Surgery, Yale University School of Medicine, New Haven, CT 06511, USA
4 Division of Plastic Surgery, University of Maryland Medical Center, Wing S8D, 22 South Greene Street, Baltimore, MD 21201, USA

Correspondence should be addressed to Devinder P. Singh; dsingh@smail.umaryland.edu

Received 15 May 2014; Accepted 1 August 2014; Published 20 August 2014

Academic Editor: Bishara S. Atiyeh

Copyright © 2014 Kashyap K. Tadisina et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Purpose. Congenital anomalies and injuries of the hand are often undertreated in low-middle income countries (LMICs). Humanitarian missions to LMICs are commonplace, but few exclusively hand surgery missions have been reported and none have attempted to demonstrate their cost-effectiveness. We present the first study evaluating the cost-effectiveness of a humanitarian hand surgery mission to Honduras as a method of reducing the global burden of surgically treatable disease. Methods. Data were collected from a hand surgery mission to San Pedro Sula, Honduras. Costs were estimated for local and volunteer services. The total burden of disease averted from patients receiving surgical reconstruction was derived using the previously described disability-adjusted life years (DALYs) system. Results. After adjusting for likelihood of disability associated with the diagnosis and likelihood of the surgery’s success, DALYs averted totaled 104.6. The total cost for the mission was $45,779 (USD). The cost per DALY averted was calculated to be $437.80 (USD), which is significantly below the accepted threshold of two times the per capita gross national income of Honduras. Conclusions. This hand surgery humanitarian mission trip to Honduras was found to be cost-effective. This model and analysis should help in guiding healthcare professionals to organize future plastic surgery humanitarian missions.

1. Introduction

Humanitarian missions to low-middle income countries (LMICs) have become a major source of medical care for underserved populations, particularly in plastic surgery. Teams consist of a variety of healthcare professionals who travel to the country in need, with all required supplies and equipment. On location, surgeons perform life-changing procedures for patients with congenital deformities, trauma, or burns, all of which cause significant disease burden on the local population [1, 2]. This service is provided free of charge to the patients. All expenses are paid by charitable donations, usually without religious, financial, cultural, or political agendas [3].

Honduras is a democratic nation in Central America with a population of approximately 7.5 million. Over half of the population lives below the poverty line and an estimated 30% are unemployed [4]. Like many LMICs, Honduras lacks both resources and an adequate health care infrastructure to provide the care for its citizens. According to the World Health Organization, “roughly 30.1% of the population receives no healthcare, 83% are uninsured, and there is marked exclusion of ethnic minorities and rural populations.” Further, there are only 8.8 physicians and 3 nurses per 10,000 citizens, compared to 26 physicians and 94 nurses per 10,000 in the United States [5]. In 2005, the per capita total expenditure on healthcare in Honduras was $91 versus $6,350 in the United States [4]. Furthermore, patients’ access to hospitals can be
2. Methods

2.1. Study Population. In May 2006, our group of 20 healthcare professionals traveled to San Pedro Sula, Honduras. Our local sponsor, the Ruth Paz Foundation, a nonprofit charitable group, assisted on site with organization, logistics, and advertising. We worked out of a local public hospital called Leonardo Martínez, which hosts a variety of medical and surgical humanitarian mission trips. Team personnel consisted of 3 hand/microsurgery trained surgeons, 1 plastic surgery trained surgeon, 1 hand/microsurgery fellow, 1 plastic surgery resident, 3 anesthesiologists, 1 pediatrician, 1 nurse anesthetist, 5 operating room nurses, 1 recovery room nurse, 1 hand therapist, 1 team administrator, and 1 photographer. All surgical supplies (including gowns, drapes, sponges, sutures, dressings, and plaster) and surgical instruments were brought with the team for the trip.

Members of the Ruth Paz Foundation set up the screening clinic and organized the follow-up visits. Potential patients were alerted about the available services, through radio announcements and fliers. The majority of the patients were screened for surgery on the primary screening day with additional patients, who missed the main screening day, screened each day. The operating schedule for the next five days was created based on the patients seen on the main screening day. Those screened for surgery were then immediately referred to waiting anesthesiologists and pediatrician for same day medical clearance. Patients were then instructed when to return for surgery before they left.

Many minor procedures were performed with local surgeons present in order to provide training for their future practice. Ganglion cysts and masses were removed for extreme size, intractable pain, or functional limitation. Because of the team’s yearly trip to Honduras, we were also able to perform more complex two-staged procedures. All surgeries were performed by either a board certified plastic surgeon or orthopedic surgeon. Each day, the team would round on all postoperative patients in the morning and in the evening. The patients were seen in follow-up clinic by local physicians, who removed splints, dressings, sutures, and k-wires, as necessary. Patients were also seen by local physical and occupational therapists that provided assistance with splints as well as therapy.

2.2. Costs. The team’s costs for the trip were calculated by adding the team’s travel expenses, which included transportation, lodging, and donated supplies that were brought with them (Table 1(a)). The team’s 2006 costs were then adjusted for inflation to present day based on data obtained from World Bank’s data [4]. Weekly hospital personnel salaries and preoperative, intraoperative, and postoperative medication costs were obtained from the Ruth Paz Foundation (Tables 1(b) and 1(c)). We were unable to obtain operative room cost or daily hospital stay costs. Other fixed costs, such as utilities and building costs, were not included as we were not able to obtain this information. Patients were charged a symbolic fee based on their household income by the local hospital for services, but due to the nominal nature of the fee (ranging from $0 to $50), this was not included for analysis.

2.3. Outcome. The total burden of musculoskeletal disease was calculated for each patient that underwent surgery using disability-adjusted life years (DALYs) format. As no surgery performed was life-saving, all of the DALYs attributed were from years lost to disability (YLD) and none from years of life lost (YLL). YLD is calculated using disability weight and the remaining life expectancy. In previous calculations of YLD, age weighting factors and discount rate were also incorporated in the calculation; however, the recently published Global Burden of Disease 2010 study has moved away from those adjustments [11]. Every patient’s diagnosis and associated disability was matched as closely as possible to a health state based on each state’s lay description as described in Global Burden of Disease 2010 study. Each patient was then assigned a disability weight based on the closest available health state (Table 2). For each patient, the potential years lived with disability value was calculated using the patient’s age and life expectancy chart found in the Global Burden of Disease 2010 study. For each patient, the DALY value represents the burden of an untreated condition. This value has been subsequently adjusted for likelihood of permanent disability and likelihood of treatment success as described in the literature by McCord and Chowdry and modified by Gosselin et al. [12–16] and represents the DALYs averted with surgery (Table 3). To err on side of overestimating cost per DALY averted, we chose conservative weights for disability, likelihood of permanent disability, and effectiveness of treatment. The scoring system used in assigning likelihood of permanent disability and likelihood of treatment success is shown in Table 4.
### Table 1: Mission costs.

**(a) Team costs**

|                      | Value (USD) in 2006 | Cumulative inflation rate (2006 to 2013) | Inflation adjusted value (USD) in 2013 | % of total costs |
|----------------------|---------------------|----------------------------------------|----------------------------------------|-----------------|
| Transportation and lodging | $23,000             | 15.90%                                 | $26,650.34                             | 62.2%           |
| Donated supplies        | $14,000             | 15.90%                                 | $16,226.00                             | 37.8%           |
| **Total cost**          | **$37,000**         | **15.90%**                              | **$42,876.34**                         |                 |

**(b) Local personnel salary**

|                     | Weekly salary (USD) in 2013 | Number | Weekly cost (USD) | % of total costs |
|---------------------|------------------------------|--------|------------------|-----------------|
| Local surgeon       | $345                         | 2      | $690             | 45.3%           |
| Surgical tech.      | $185                         | 2      | $370             | 24.3%           |
| Nurse               | $185                         | 2      | $370             | 24.3%           |
| Cleaning            | $92                          | 1      | $92              | 6.0%            |
| **Total cost**      | **$1,522**                   |        |                  |                 |

**(c) Hospital costs**

|                          | Weekly cost (USD) in 2013 |
|--------------------------|---------------------------|
| Pre- and postoperative medications | $448.84                 |
| Intraoperative medications | $932                     |
| **Total costs**          | **$1,380.84**             |

**(d) Overall mission cost**

|                          | Cost (USD)  | % of total costs |
|--------------------------|-------------|-----------------|
| Team costs               | $42,876.34  | 93.7%           |
| Local personnel costs    | $1,522.00   | 3.3%            |
| Hospital costs           | $1,380.84   | 3.0%            |
| **Total overall costs**  | **$45,779.18** |                |

**(e) Cost-effectiveness metrics**

|                          | If 2 × TC (i.e., doubled) | If 5 × TC  |
|--------------------------|---------------------------|------------|
| Total cost (TC)          | $45,779.18                | **$91,558.36** | $228,895.90 |
| Cost per patient         | $572.24                   | $1,144.48  | $2,861.20   |
| Cost per DALY averted    | $437.80                   | $875.32    | **$2,188.30*** |

*Still below $3,890 (2 × PCGNI)

3. Results

In total, 120 patients were screened and 80 patients were found to be candidates for surgery. Over the week, 128 total procedures were performed on 54 adults (68%) and 26 children (32%). The average age of the patient undergoing surgery was 31 years with ages ranging from 10 months to 68 years. Of these patients, 27 were female (34%) and 53 were male (66%). Table 4 includes the procedures performed on each patient, as well as their age and gender. Operative time for the entire trip totaled 93 hours and 50 minutes over 5 days. Average operative time was 18 hours and 46 minutes per day and 6 hours and 15 minutes per operative table per day. Most of the procedures were very short in duration, with 43 cases (53%) lasting less than 1 hour, 25 cases (31%) took 1-2 hours, 9 cases (11%) lasted 2-3 hours, and only 4 cases (5%) were longer than 3 hours in duration. No immediate complications, such as ischemic loss or early wound infection, were noted. There were no anesthetic complications and no mortalities.

As shown in Table 4, the total number of DALYs potentially avertable totaled 220.5. Adjusting for likelihood of disability associated with the diagnosis and likelihood of the surgery's success, DALYs avertated totaled 104.6. The total cost (in current USD) for the volunteer trip including the team’s travel and lodging cost of $45,779.18 and local hospital's cost of $2,903 (USD) is detailed in Table 1. On average, it costs $572.24 (USD) per patient that was surgically treated. Cost-effectiveness was measured using cost per DALY averted and, for this trip, the cost for each DALY averted was conservatively estimated to be $437.80 (USD), which is significantly less than the accepted threshold of two times the per capita gross national income of Honduras, $3,890 (USD). Further, a brief sensitivity analysis provided in Table 1(e) displays that even if total costs were to increase by 500%, the cost per DALY averted would still be below the threshold of $3,890 (USD).
| Age | Sex | Diagnosis                                                                 | Available disability weight                                                                 | Disability weight |
|-----|-----|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-------------------|
| 9   | F   | Tendon adhesion                                                          | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 16  | M   | Finger flexor tendon injury                                               | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 26  | M   | Finger flexor tendon injury and nerve laceration                          | Injured nerves: long term                                                                      | 0.136             |
| 60  | M   | Posttraumatic joint contracture                                           | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 68  | F   | Trigger finger                                                            | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 3   | F   | Finger flexor tendon injury                                               | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 13  | M   | Cubitus varus                                                             | Disfigurement: level 1                                                                        | 0.013             |
| 14  | M   | Polydactyly                                                              | Disfigurement: level 1                                                                        | 0.013             |
| 47  | M   | Lipoma                                                                    | Disfigurement: level 1, with itch or pain                                                     | 0.029             |
| 57  | F   | Trigger finger                                                            | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 11  | M   | Burn scar contracture                                                     | Burns of <20% total surface area or <10% total surface area if head or neck or hands or wrist involved: long term, with or without treatment | 0.018             |
| 12  | M   | Burn scar contracture                                                     | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 21  | F   | Partial traumatic amputation                                              | Amputation of finger(s), excluding thumb: long term, with treatment                           | 0.03              |
| 30  | F   | Nerve laceration                                                          | Injured nerves: long term                                                                      | 0.136             |
| 34  | M   | Skin contracture                                                          | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 47  | M   | Radius and ulna fracture                                                  | Fracture of radius or ulna: short term, with or without treatment                             | 0.065             |
| 8   | M   | Metacarpal fracture                                                       | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 11  | M   | Cubitus varus                                                             | Disfigurement: level 1                                                                        | 0.013             |
| 21  | M   | Burn scar contracture                                                     | Burns of <20% total surface area or <10% total surface area if head or neck or hands or wrist involved: long term, with or without treatment | 0.018             |
| 45  | M   | Posttraumatic joint contracture                                           | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 48  | M   | Carpal tunnel syndrome                                                    | Injured nerves: short term                                                                     | 0.065             |
| 51  | F   | Ganglion cyst                                                             | Disfigurement: level 1, with itch or pain                                                     | 0.029             |
| 67  | M   | Dupuytren's contracture                                                   | Musculoskeletal problems: arms, moderate                                                       | 0.14              |
| 5   | M   | Burn scar contracture                                                     | Burns of <20% total surface area or <10% total surface area if head or neck or hands or wrist involved: long term, with or without treatment | 0.018             |
| 7   | M   | Polydactyly                                                               | Disfigurement: level 1                                                                        | 0.013             |
| 19  | F   | Tumor                                                                     | Disfigurement: level 1, with itch or pain                                                     | 0.029             |
| 21  | M   | Tumor                                                                     | Disfigurement: level 1, with itch or pain                                                     | 0.029             |
| 31  | M   | Dorsal ganglion cyst                                                      | Disfigurement: level 1, with itch or pain                                                     | 0.029             |
| 42  | F   | Nonunion radius                                                           | Fracture of radius or ulna: long term, without treatment                                      | 0.05              |
| 56  | F   | De Quervain's syndrome                                                    | Musculoskeletal problems: arms, moderate                                                       | 0.14              |
| 11mo| M   | Thumb hypoplasia                                                          | Amputation of thumb: long term                                                                | 0.013             |
| 23  | M   | Burn scar contracture                                                     | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 33  | M   | Burn scar contracture                                                     | Musculoskeletal problems: arms, moderate                                                       | 0.14              |
| 37  | F   | Hook nail deformity                                                       | Disfigurement: level 1                                                                        | 0.013             |
| 48  | M   | Dupuytren's contracture                                                   | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 8   | M   | Flexor tendon injury                                                      | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 10  | F   | Scar contracture                                                          | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 20  | M   | Flexor tendon injury with nerve laceration                                | Injured nerves: long term                                                                      | 0.136             |
| 55  | M   | Carpal tunnel syndrome                                                    | Injured nerve: short term                                                                      | 0.065             |
| 5   | M   | Syndactyly                                                                | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 17  | M   | Thumb hypoplasia                                                          | Musculoskeletal problems: arms, moderate                                                       | 0.14              |
| 18  | M   | Foreign body with ulnar neuropathy                                        | Injured nerves: short term                                                                      | 0.065             |
| 23  | M   | Foreign body                                                              | Musculoskeletal problems: arms, mild                                                          | 0.024             |
| 34  | M   | Radial head fracture                                                      | Fracture of radius or ulna: short term, with or without treatment                             | 0.065             |
4. Discussion

This study demonstrates that hand surgery mission trips are a cost-effective means of providing surgical care at HNQCP in San Pedro Sula, Honduras, using an established economic evaluation model. We also inherently validate the effectiveness of the DALY system as a useful and versatile method of evaluating surgical mission trips. While it is one of the first quantitative systems of evaluating such trips, it is also only one of the many possible ways to analyze mission trips. However, this analysis also represents an important step in standardizing the evaluation of such trips to better optimize foreign intervention by surgical teams, as proposed by McCord [13].

The $437.80 per DALY averted for this week long surgical mission trip is similar to those previously reported in
### Table 3: DALY averted.

| Case # | Age | Remaining life expectancy | Sex | Diagnosis | Procedure | Disability Week | DALY | Likelihood of permanent disability | Likelihood of treatment success | DALY averted |
|--------|-----|---------------------------|-----|-----------|-----------|----------------|------|-------------------------------|---------------------------------|--------------|
| 1      | 9   | 77.27                     | F   | Tendon adhesion | L wrist exploration w/tenolysis FDP | 0.024 | 1.85448 | 0.7 | 0.7 | 0.9086952                     |
| 2      | 16  | 70.3                      | M   | Finger flexor tendon injury | R index finger Hunter rod placement | 0.024 | 1.6872 | 0.7 | 0.7 | 0.826728                     |
| 3      | 26  | 60.41                     | M   | Finger flexor tendon injury and nerve laceration | R FPL repair w/tendon grafts; nerve repair with sural nerve graft | 0.136 | 8.21576 | 0.7 | 0.7 | 4.0257224                   |
| 4      | 60  | 27.81                     | M   | Posttraumatic joint contracture | R long finger PIP joint arthrodesis | 0.024 | 0.66744 | 0.7 | 0.7 | 0.3270456                   |
| 5      | 68  | 20.68                     | F   | Trigger finger | R LF trigger finger release | 0.024 | 0.49632 | 0.7 | 0.7 | 0.2431968                   |
| 6      | 3   | 83.23                     | F   | Finger flexor tendon injury | L ring finger FDS/FDP-Hunter rod implant | 0.024 | 1.99752 | 0.7 | 0.7 | 0.9787848                   |
| 7      | 13  | 73.29                     | M   | Cubitus varus | L lateral closing wedge osteotomy of supracondylar for cubitus varus | 0.013 | 0.95277 | 0.7 | 0.7 | 0.4668573                   |
| 8      | 14  | 72.29                     | M   | Polydactyly | B/I thumb partial duplication repair; anlage excision | 0.013 | 0.93977 | 0.7 | 0.7 | 0.4604873                   |
| 9      | 47  | 39.9                      | M   | Lipoma | Excision of L forearm mass | 0.029 | 1.1571 | 0.7 | 0.7 | 0.566979                     |
| 10     | 57  | 30.55                     | F   | Trigger finger | R LF and L trigger finger release | 0.024 | 0.7332 | 0.7 | 0.7 | 0.359268                     |
| 11     | 11  | 75.28                     | M   | Burn scar contracture | L forearm excision of burn scar; STSG | 0.018 | 1.35504 | 0.3 | 0.7 | 0.2845384                   |
| 12     | 12  | 74.28                     | M   | Burn scar contracture | R hand thumb webs space deepening with split thickness skin graft | 0.024 | 1.78272 | 0.3 | 0.7 | 0.3743712                   |
| 13     | 21  | 65.36                     | F   | Partial traumatic amputation | L RF amputation completion | 0.03 | 1.9608 | 0.7 | 0.7 | 0.960792                     |
| 14     | 30  | 56.46                     | F   | Nerve laceration | Nerve graft L ulnar nerve; anticlaw tendon transfer | 0.136 | 7.67856 | 0.7 | 0.7 | 3.7624944                   |
| 15     | 34  | 52.52                     | M   | Skin contracture | L middle PIP contracture release and skin graft | 0.024 | 1.26048 | 0.7 | 0.7 | 0.6176352                   |
| 16     | 47  | 39.9                      | M   | Radius and ulna fracture | ORIF L radius/ulna | 0.065 | 2.5935 | 0.3 | 0.7 | 0.544635                     |
| Case # | Age  | Remaining life expectancy | Sex | Diagnosis                                      | Procedure                                                                 | Disability Wt. | DALY  | Likelihood of permanent disability | Likelihood of treatment success | DALY averted |
|-------|------|--------------------------|-----|-----------------------------------------------|---------------------------------------------------------------------------|----------------|-------|----------------------------------|--------------------------------|--------------|
| Day 2 |      |                          |     |                                               |                                                                           |                |       |                                  |                                |              |
| 17    | 8    | 78.26                    | M   | Metacarpal fracture                          | R LF pinning of metacarpal fracture                                       | 0.024          | 1.87824 | 0.7                              | 0.7                            | 0.9203376    |
| 18    | 11   | 75.28                    | M   | Cubitus varus                                 | R supracondylar osteotomy                                                 | 0.013          | 0.97864 | 0.7                              | 0.7                            | 0.4795336    |
| 19    | 21   | 65.36                    | M   | Burn scar contracture                        | RIF burn contracture release; FTSG                                        | 0.018          | 1.17648 | 0.7                              | 0.7                            | 0.5764752    |
| 20    | 45   | 41.8                     | M   | Posttraumatic joint contracture              | L index and long finger PIP fusion                                        | 0.024          | 1.0032 | 0.7                              | 0.7                            | 0.491568     |
| 21    | 48   | 38.95                    | M   | Carpal tunnel syndrome                       | L carpal tunnel release                                                  | 0.065          | 2.53175 | 0.7                              | 0.7                            | 1.2405575    |
| 22    | 51   | 36.12                    | F   | Ganglion cyst                                | Excision of R wrist mass                                                 | 0.029          | 1.04748 | 0.7                              | 0.7                            | 0.5132652    |
| 23    | 67   | 21.55                    | M   | Dupuytren's contracture                      | L hand excision of Dupuytren's contracture                               | 0.114          | 2.4567 | 0.7                              | 0.7                            | 1.203783     |
| 24    | 5    | 81.25                    | M   | Burn scar contracture                        | R hand burn contracture release                                           | 0.018          | 1.4625 | 0.7                              | 0.7                            | 0.716625     |
| 25    | 7    | 79.26                    | M   | Polydactyly                                   | Reconstruction of R thumb polydactyly                                    | 0.013          | 1.03038 | 0.7                              | 0.7                            | 0.504862     |
| 26    | 19   | 67.34                    | F   | Tumor                                        | Excision of L hand mass                                                  | 0.029          | 1.95286 | 0.7                              | 0.7                            | 0.9569014    |
| 27    | 21   | 65.36                    | M   | Tumor                                        | Excision of bony tumor ×2 of L humerus                                    | 0.029          | 1.89544 | 0.7                              | 0.7                            | 0.9287656    |
| 28    | 31   | 55.48                    | M   | Dorsal ganglion cyst                          | Excision of ganglion cyst                                                | 0.029          | 1.60892 | 0.7                              | 0.7                            | 0.7883708    |
| 29    | 42   | 44.71                    | F   | Nonunion radius                              | Repair nonunion radius                                                  | 0.05           | 2.2355  | 0.7                              | 0.7                            | 1.095395     |
| 30    | 56   | 31.47                    | F   | De Quervain's syndrome                       | De Quervain's release                                                    | 0.114          | 3.58758 | 0.7                              | 0.7                            | 1.7579142    |
| 31    | 8mo  | 85.21                    | M   | Thumb hypoplasia                             | R thumb amp, and pollicization                                            | 0.013          | 1.10773 | 0.7                              | 0.7                            | 0.5427877    |
| 32    | 23   | 63.38                    | M   | Burn scar contracture                        |PIP arthrodesis; debulk flap                                              | 0.024          | 1.52112 | 0.7                              | 0.7                            | 0.7453488    |
| 33    | 33   | 53.5                     | M   | Burn scar contracture                        | Contracture release of all fingers R hand; flexor tendon division         | 0.114          | 6.099   | 0.7                              | 0.7                            | 2.98851      |
| 34    | 37   | 49.58                    | F   | Hook nail deformity                          | V-Y advancement L index fingertip                                          | 0.013          | 0.64454 | 0.7                              | 0.7                            | 0.3158246    |
| 35    | 48   | 38.95                    | M   | Dupuytren's contracture                      | L little finger arthrodesis and k-wire for palmar scar revision w/FTSG   | 0.024          | 0.9348  | 0.7                              | 0.7                            | 0.458052     |
| Case # | Age | Remaining life expectancy | Sex | Diagnosis | Procedure | Disability | DALY | Likelihood of permanent disability | Likelihood of treatment success | DALY averted |
|-------|-----|--------------------------|-----|-----------|-----------|------------|------|----------------------------------|-------------------------------|--------------|
| 36    | 8   | 78.26                    | M   | Flexor tendon injury | 2nd stage flexor tendon reconstruction; removal hunter rod and tendon graft from leg to finger | 0.024 | 1.87824 | 0.7 | 0.7 | 0.9203376 |
| 37    | 10  | 76.27                    | F   | Scar contracture    | L hand scar revision; tenolysis; removal of k-wire | 0.024 | 1.83048 | 0.7 | 0.7 | 0.8969352 |
| 38    | 20  | 66.35                    | M   | Flexor tendon injury with nerve laceration | Repair flexor tendons wrist with tendon grafts, ulnar nerve repair with sural nerve graft | 0.136 | 9.0236 | 0.7 | 0.7 | 4.421564 |
| 39    | 55  | 32.38                    | M   | Carpal tunnel syndrome | R carpal tunnel release | 0.065 | 2.1047 | 0.7 | 0.7 | 1.031303 |
| 40    | 5   | 81.25                    | M   | Syndactyly           | Sydenclty release L 4th web space | 0.024 | 1.95 | 0.7 | 0.7 | 0.9555 |
| 41    | 17  | 69.32                    | M   | Thumb hypoplasia     | R thumb opponensplasty; R 1st web deepening; R thumb UCL reconstruction | 0.114 | 7.90248 | 0.7 | 0.7 | 3.8722152 |
| 42    | 18  | 68.33                    | M   | Foreign body with ulnar neuropathy | Excision of foreign body L hypothenar eminence; neurolysis ulnar nerve | 0.065 | 4.44145 | 0.7 | 0.7 | 2.1763105 |
| 43    | 23  | 63.38                    | M   | Foreign body         | Bullet removal ×2 R hand | 0.024 | 1.52112 | 0.7 | 0.7 | 0.7453488 |
| 44    | 34  | 52.52                    | M   | Radial head fracture | L radial head excision | 0.065 | 3.4138 | 0.7 | 0.7 | 1.672762 |
| 45    | 44  | 42.77                    | M   | Extensor tendon contracture | L LF, RF, and SF PIP joint fusion | 0.024 | 1.02648 | 0.7 | 0.7 | 0.5029752 |
| 46    | 49  | 38                       | M   | Extensor tendon laceration | Tendon transfer for thumb extension PL → EPL | 0.024 | 0.912 | 0.7 | 0.7 | 0.44688 |
| 47    | 20  | 66.35                    | M   | Flexor tendon injury | Zone II IF, MF, and RF hunter rods | 0.114 | 7.5639 | 0.7 | 0.7 | 3.706311 |
| 48    | 22  | 64.37                    | F   | Posttraumatic joint contracture | L LF PIP joint arthrodesis | 0.024 | 1.54488 | 0.7 | 0.7 | 0.7569912 |
| 49    | 22  | 64.37                    | M   | Posttraumatic joint contracture | L thumb IP fusion | 0.024 | 1.54488 | 0.7 | 0.7 | 0.7569912 |
| 50    | 47  | 39.9                     | M   | Shoulder lipoma      | Excision of R shoulder lipoma | 0.029 | 1.1571 | 0.7 | 0.7 | 0.566979 |
| 51    | 61  | 26.91                    | F   | Ganglion cyst and ulnocarpal abutment | R dorsal ganglion/L matched ulnar arthroplasty | 0.114 | 3.06774 | 0.7 | 0.7 | 1.5031926 |
| Case # | Age | Remaining life expectancy | Sex | Diagnosis | Procedure | Disability Wt. | DALY | Likelihood of permanent disability | Likelihood of treatment success | DALY averted |
|-------|-----|--------------------------|-----|-----------|-----------|----------------|------|-----------------------------------|-------------------------------|--------------|
| 52    | 5   | 81.25                    | M   | Burn scar contracture | R hand burn scar contracture release; FTSG | 0.018 | 1.4625 | 0.7 | 0.7 | 0.716625 |
| 53    | 32  | 54.49                    | M   | Flexor tendon injury | R FDS → FDP transfer 2–5 | 0.114 | 6.2186 | 0.7 | 0.7 | 3.043814 |
| 54    | 60  | 27.81                    | F   | Ganglion cyst | L dorsal wrist excision of ganglion cyst | 0.029 | 0.80649 | 0.7 | 0.7 | 0.3951801 |
| 55    | 61  | 26.91                    | M   | Finger flexor tendon injury | L wrist ECRL to FDP; transfer of w/palmaris graft | 0.114 | 3.06774 | 0.7 | 0.7 | 1.5031926 |
| 56    | 65  | 23.29                    | F   | L ulna nonunion | ORIF with iliac crest bone graft | 0.05 | 1.1645 | 0.7 | 0.7 | 0.570605 |
| 57    | 10  | 76.27                    | M   | Syndactyly | Release syndactyly 2nd and 4th web spaces with flaps and grafts | 0.024 | 1.83048 | 0.7 | 0.7 | 0.8969352 |
| 58    | 24  | 62.39                    | M   | Malunion | R thumb MCP joint arthrodesis | 0.114 | 7.11246 | 0.7 | 0.7 | 3.4851054 |
| 59    | 35  | 51.53                    | F   | Nerve laceration | Tendon transfer for L wrist extension and thumb extension; FCU → ECRB, PL → EPL | 0.136 | 7.00808 | 0.7 | 0.7 | 3.4339592 |
| 60    | 38  | 48.6                     | M   | Nerve laceration | R forearm sural nerve graft | 0.136 | 6.6096 | 0.7 | 0.3 | 1.388016 |
| 61    | 10mo| 85.21                    | M   | L MF-RF syndactyly | L MF-RF syndactyly release | 0.024 | 2.04504 | 0.7 | 0.7 | 1.0020696 |
| 62    | 17  | 69.32                    | M   | Malunion | Thumb osteotomy and alignment-ORIF; removal of foreign body thumb | 0.016 | 1.10912 | 0.7 | 0.7 | 0.5434688 |
| 63    | 18  | 68.33                    | M   | Flexor tendon injury | L forearm FDS → FDP tendon transfer | 0.114 | 7.78962 | 0.7 | 0.7 | 3.816938 |
| 64    | 28  | 58.44                    | M   | Radial nerve laceration | Tendon transfer radial nerve palsy; FCR → EDC; PT → ECRB; ring sublimis → EPL | 0.136 | 7.94784 | 0.7 | 0.7 | 3.8944416 |
| 65    | 42  | 44.71                    | F   | Carpal tunnel syndrome | L carpal tunnel release | 0.065 | 2.90615 | 0.7 | 0.7 | 1.4240135 |
Table 3: Continued.

| Case # | Age | Remaining life expectancy | Sex | Diagnosis | Procedure | Disability Wt. | DALY | Likelihood of permanent disability | Likelihood of treatment success | DALY averted |
|--------|-----|--------------------------|-----|-----------|-----------|----------------|------|----------------------------------|---------------------------------|-------------|
| 66     | 14  | 72.29 M                  | Flexor tendon injury with nerve laceration | R FDS/FDP ring and small finger tenorrhaphy and digital nerve repair | 0.114 | 8.24106 | 0.7 | 0.7 | 4.038194 |
| 67     | 23  | 63.38 F                  | Burn scar contracture | L hand burn scar contracture release | 0.018 | 1.14084 | 0.7 | 0.7 | 0.559016 |
| 68     | 50  | 37.05 M                  | Radial nerve laceration | Tendon transfer of radial nerve palsy; FCR → EDC; PT → ECRB; ring sublimis → EPL | 0.136 | 5.0388 | 0.7 | 0.7 | 2.469012 |
| 69     | 9   | 77.27 F                  | Burn scar contracture | Web space deepening and scar revision | 0.018 | 1.39086 | 0.7 | 0.7 | 0.681521 |
| 70     | 16  | 70.3 F                   | Malunion | RF MCP arthrodesis | 0.024 | 1.6872 | 0.7 | 0.7 | 0.826728 |
| 71     | 31  | 55.48 F                  | Ganglion cyst | Excision of R wrist dorsal ganglion | 0.029 | 1.60892 | 0.7 | 0.7 | 0.7883708 |
| 72     | 47  | 39.9 F                   | Ulnocarpal abutment | L ulnar shortening | 0.114 | 4.5486 | 0.7 | 0.7 | 2.228814 |
| 73     | 55  | 32.38 F                  | Carpal tunnel syndrome | R carpal tunnel release | 0.065 | 2.1047 | 0.7 | 0.7 | 1.031303 |
| 74     | 14  | 72.29 F                  | Burn scar contracture | L LF PIP burn contracture release and fusion; STSG; Z plasty L elbow burn scar | 0.114 | 8.24106 | 0.7 | 0.7 | 4.038194 |
| 75     | 39  | 47.62 F                  | Ganglion cyst | Excision of R volar wrist ganglion cyst | 0.029 | 1.38098 | 0.7 | 0.7 | 0.6766802 |
| 76     | 42  | 44.71 M                  | Posttraumatic joint contracture | L thumb MCP arthrodesis | 0.024 | 1.07304 | 0.7 | 0.7 | 0.5257896 |
| 77     | 46  | 40.85 M                  | Posttraumatic joint contracture | L long finger PIP joint arthrodesis | 0.024 | 0.9804 | 0.7 | 0.7 | 0.480396 |
| 78     | 57  | 30.55 F                  | Carpal tunnel syndrome | L carpal tunnel release | 0.065 | 1.98575 | 0.7 | 0.7 | 0.973075 |
| 79     | 23  | 63.38 M                  | Finger mass | Excision of L ring finger mass | 0.029 | 1.83802 | 0.7 | 0.7 | 0.9006298 |
| 80     | 62  | 26 M                     | Skin lesion | Excision of L hand skin lesion | 0.029 | 0.754 | 0.7 | 0.7 | 0.36946 |

Mean: 30.759 55.938 | Total: 220.009 | Total: 104.349028

R = right; L = left; IF = index finger; LF = long finger; RF = ring finger; SF = small finger; PIP = proximal interphalangeal; MCP = metacarpal phalangeal; FPL = flexor pollicis longus; FDS = flexor digitorum superficialis; FDP = flexor digitorum profundus; FCR = flexor carpi radialis; FCU = flexor carpi ulnaris; PL = palmaris longus; EPL = extensor pollicis longus; ECRL = extensor carpi radialis longus; ECRB = extensor carpi radialis brevis; EDC = extensor digitorum communis; FCU = flexor carpi ulnaris; UCL = ulnar collateral ligament; STSG = split thickness skin graft; FTSG = full thickness skin graft; ORIF = open reduction internal fixation.
the literature that have ranged between $343 and $362 perDALY [14, 15]. Our cost per DALY is well within the two times per capita gross national income, an accepted metric for program cost-effectiveness as suggested by earlier studies [15]. We believe our slightly higher cost per DALY averted can be attributed to multiple factors. First, we have used conservative estimations for all DALY and disability weight. Second, previous studies did not use the 2010 version of the Global Burden of Disease (GBD) system to evaluate cost-effectiveness and consequently may have contributed to differences in the cost per DALY averted value. Third, bringing more staff, such as residents, anesthesiologists/anesthetist, pediatrician, nurses, and hand therapist, may have added to travel and lodging cost. As the availability of more locally trained medical professionals is available in Honduras, fewer anesthesiologists, or nurses, and therapists from the United States will be needed for each trip thus making each subsequent mission trip more cost-effective than the previous. With local capacity to care for simple cases like ganglion cyst removal, trigger finger release, and arthrodesis, subsequent trips can focus on more disabling complex conditions such as nerve injuries which require advance surgical training. Since a volunteer mission trip’s costs are relatively fixed, focusing on these conditions can contribute to more DALYs averted lowering the trip’s cost per DALY averted.

In addition to providing direct care, our team has been able to lecture at the medical school in San Pedro Sula and invite local surgeons to come and learn how to manage surgical hand cases. Our nurses and therapists have also worked with local staff to improve pre-, peri-, and postoperative care of patients. Such training and educational efforts are often difficult to quantify and are not reflected in the cost per DALY averted, but they are important in the long-term development of adequately trained local health care professionals and healthcare infrastructure. While the capacity to care for these surgical conditions is being developed in Honduras, surgical mission trips such as ours serve as an important bridge until that day arrives.

The limitations of this study include the inability to include certain costs, such as operating room, hospital stay, utilities, and building costs; however, given the large margin between the cost per DALY averted and the twice per capita gross national income (PCGNI) of Honduras ($3890 in 2012) [4], we believe that the underreported costs have only a minor impact on the cost per DALY averted. Even if total costs (TC) were five times higher, the cost per DALY averted would still be the threshold value of $3890 (2* PCGNI), as illustrated in Table 1(e). As in previous cost-effectiveness studies, a rough trade-off is used to assign hand conditions with disability weights as the Global Burden of Disease 2010 study does not have many specific disability weights for various hand conditions. There are also instances where disability weights make little sense from a functional standpoint: amputation of finger(s) excluding thumb has a disability weight of 0.030 which compares poorly to disability weight of 0.013 for amputation of thumb, long term. One can argue that the loss of a thumb is more functionally debilitating than the loss of a finger as opposition-apposition function is lost in a thumb amputation and grip maybe minimally affected with a finger amputation [11]. The nature of short volunteer mission trip makes obtaining long-term outcomes data difficult. However, with greater capacity in host countries, prospective studies that assess patient outcomes will enable us to more objectively determine patient outcomes without relying on assumptions. Until then, we feel that using the correctional factor “probability of successful treatment” is needed to account for treatment success/failures as there is a lack of follow-up data. Imperfect as it maybe, the DALY method for assessing cost-effectiveness has been used in a number of previous studies in LMICs and offers a more objective and standardized way to assess the impact of surgical mission trips, cost-effectiveness and serves as a benchmark for future trips.

Conflict of Interests

The authors have no conflict of interests to report.

References

[1] P. Voche and P. Valenti, “Humanitarian surgery of the hand. Our experience in Vietnam,” Annales de Chirurgie Plastique et Esthétique, vol. 44, no. 1, pp. 64–71, 1999.
[2] M. Beveridge and A. Howard, “The burden of orthopaedic disease in developing countries,” Journal of Bone and Joint Surgery A, vol. 86, no. 8, pp. 1819–1822, 2004.
[3] C. N. Baran and Y. O. Tifitiocgiolu, “Physicians for peace and interplast Turkiye: combined humanitarian surgical activities and conferences,” Plastic and Reconstructive Surgery, vol. 119, no. 3, pp. 1077–1090, 2007.
[4] World Bank, http://www.worldbank.org/.
[5] World Health Organization, Honduras, 2013, http://www.who.int/countries/hnd/en/.
[6] D. S. Walsh, “A framework for short-term humanitarian health care projects,” International Nursing Review, vol. 51, no. 1, pp. 23–26, 2004.
[7] S. Bunyavanich and R. R. Walkup, “US public health leaders shift toward a new paradigm of global health,” The American Journal of Public Health, vol. 91, no. 10, pp. 1556–1558, 2001.
[8] K. C. Chung, “Volunteering in the developing world: the 2003-2004 sterling bunnell traveling fellowship to Honduras and Cambodia,” Journal of Hand Surgery, vol. 29, no. 6, pp. 987–993, 2004.
[9] T. E. E. Goodacre, “Plastic surgery in a rural African hospital: spectrum and implications,” *Annals of the Royal College of Surgeons of England*, vol. 68, no. 1, pp. 42–44, 1986.

[10] V. K. L. Yeow, S. T. Lee, T. J. Lambrecht et al., “International task force on volunteer cleft missions,” *Journal of Craniofacial Surgery*, vol. 13, no. 1, pp. 18–25, 2002.

[11] C. J. Murray, T. Vos, R. Lozano et al., “Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010,” *The Lancet*, vol. 380, no. 9859, pp. 2197–2223, 2010.

[12] C. McCord and Q. Chowdhury, “A cost effective small hospital in Bangladesh: what it can mean for emergency obstetric care,” *International Journal of Gynecology and Obstetrics*, vol. 81, no. 1, pp. 83–92, 2003.

[13] C. McCord, “Volunteer orthopedic surgical trips in Nicaragua: a cost-effectiveness evaluation,” *World Journal of Surgery*, vol. 36, no. 12, pp. 2809–2810, 2012.

[14] R. A. Gosselin, G. Gialamas, and D. M. Atkin, “Comparing the cost-effectiveness of short orthopedic missions in elective and relief situations in developing countries,” *World Journal of Surgery*, vol. 35, no. 5, pp. 951–955, 2011.

[15] A. T. Chen, A. Pedtke, J. K. Kobs, G. S. Edwards Jr., R. R. Coughlin, and R. A. Gosselin, “Volunteer orthopedic surgical trips in Nicaragua: a cost-effectiveness evaluation,” *World Journal of Surgery*, vol. 36, no. 12, pp. 2802–2808, 2012.

[16] R. Gosselin, D. Ozgediz, and D. Poenaru, “A square peg in a round hole? Challenges with DALY-based “Burden of Disease” calculations in surgery and a call for alternative metrics,” *World Journal of Surgery*, vol. 37, no. 11, pp. 2507–2511, 2013.