

Pre-Analysis Plan: Impact of Clubfoot Treatment on Adolescent Life Outcomes

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Research Team:

Gianna Camacho (Student/Principal Investigator, University of San Francisco), Bruce Wydick (Principal Investigator/Advisor, University of San Francisco), Scott Klaus (Student/Assistant Investigator, University of San Francisco), Jai Sarma (Program Manager, HopeWalks), Endashawu Abera (Program Coordinator, HopeWalks), Solomon Dinku (Program Coordinator, HopeWalks),

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IRB Approval:

IRB protocol ID #1623 with the project title “Impact of Clubfoot Treatment on Adolescent Life Outcomes: Evidence from HopeWalks Clinic” has been approved by the IRB Chair at the University of San Francisco under the rules for expedited review on 08/27/2021.

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Abstract

Clubfoot is an inborn three-dimensional deformity of the leg, ankle, and foot. General consensus among the clubfoot community has been reached that treatment of clubfoot should be started as soon as possible. If left untreated, structural defects of the foot and lower leg tissues can cause abnormal positioning of the foot and ankle joints leading to long-lasting functional disability, malformation and discomfort that worsens with age. The Ponseti Method is the most common form of treatment for clubfoot and involves both a casting and brace stage that spans over the course of a few years. This study uses a difference-in-difference identification strategy with household level fixed effects to compare adolescent life outcomes with treated clubfoot to the life outcomes of their nearest-age sibling. Those differences are then compared to the difference between the life outcomes of untreated clubfoot patients and their own nearest-age sibling. This strategy allows for estimation of the impact of being born with clubfoot, as well as receiving treatment through the Ponseti Method. Key outcomes of interest include indicators associated with physical, social, and psychological outcomes.

This pre-analysis plan is submitted as data collection is on-going and has yet to be finalized at the time of filing.

Introduction: What is Clubfoot?

Talipes equinovarus, commonly referred to as clubfoot is defined as an inborn three-dimensional deformity of the leg, ankle, and foot. It is recognized as one of the most common congenital deformities in babies globally with about 80% of clubfoot cases occurring in developing countries (Gupta et al. 2006). Deformities associated with clubfoot can be characterized into four components: equinus at ankle, varus at hindfoot, forefoot adductus and cavus (See Figure 1-4 in the Appendix for a visual representation of the deformities). In the developed world, deformities associated with clubfoot are often recognized quickly after birth, or in utero through ultrasound scans. Medical professionals familiar with clubfoot advise seeking treatment as soon as possible and luckily, treatment is often widely accessible. Unfortunately, this is not the case in many developing countries, leading to individuals unnecessarily living with the pain and discomfort of clubfoot for their whole lives. According to a 2017 study by Sulman Basit and Khalid Khoshhal, uncorrected structural defects of the foot and lower leg tissues can cause abnormal positioning of the foot and ankle joints which almost always results in long-lasting functional disability, malformation and discomfort if left untreated.

In recent years the Ponseti Method has largely been embraced by medical groups, such as the Dutch Orthopedic Association (NOV), as the best way to go about correcting clubfoot deformities. Rather than treating clubfoot deformities with invasive surgery, the Ponseti Method uses serial corrective casts (over a duration of 2-3 months) followed by long-term brace use and maintenance spanning a duration of about four years (Gupta et al. 2006). Along with the Ponseti Method, some deformities of clubfoot are additionally treated with a minimally invasive surgery known as a tenotomy. In a tenotomy the Achilles tendon is cut and immediately placed in a corrective cast to allow for increased flexibility. General consensus has been reached in the orthopedic community that the Ponseti Method of treatment works most efficiently when started as early as possible and should be followed under close parental and medical supervision (Bor et al. 2009). Benefits of the Ponseti Method include decreased costs, increased accessibility, as well as better patient outcomes; all of which are crucial to successful treatment in developing countries where approximately 80% of clubfoot cases occur (Gupta et al 2006). An obvious con to the Ponseti Method is that it is a process that spans over several years and requires parental support in ensuring that the children wear the braces properly and for the adequate amount of time for the first four years of life.

According to an article written for Acta Orthopaedica, the official publication of the Nordic Orthopedic Federation, it is recommended that newborns with any clubfoot deformity be referred to a clubfoot center preferably within 48 hours but no more than one week following delivery (Besselaar et al 2017). This recommendation stems from the fact that the Ponseti Method is most efficient following early treatment, although there are multiple reasons why this recommendation is not being followed in developing countries. Drew et al (2016) analyzed how socio-cultural factors affect patient access and engagement with clubfoot treatment in low- and

middle-income countries. Their study found that faith in alternative belief systems, economic constraints, fear or disbelief in surgical interventions, and stigma associated with clubfoot were all barriers to seeking treatment. Drew et al (2016) found that although there was not a direct relationship between beliefs and treatment-seeking behavior, in some cases beliefs about causation of clubfoot stemming from witchcraft or God, meant caregivers often sought traditional medicine instead of, or in addition to biomedical interventions. The same study found that stigma affected treatment seeking behaviors in different ways. For some families, the stigma surrounding clubfoot provided an accelerant to seek either biomedical treatment or traditional methods of treatment. For other families, stigma proved to be a hindrance because they did not want to ‘advertise’ that their child was different to others (Drew et al 2016).

Previous research examining the impact of clubfoot treatment frequently compares post treatment outcomes to those of the general population. Given that local environment, and the adherence to the recommended treatment method may influence life outcomes, existing studies may present biases in estimates of clubfoot status and restorative treatment. Expanding knowledge on the long-term physical, psychological and social impacts of clubfoot treatment can help provide more information to communities suffering with untreated clubfoot as well as help to decrease the rate of multidimensional poverty in those suffering from clubfoot. The purpose of this research is to determine what impact the Ponseti Method has on the physical, psychological, and social outcomes for children born with clubfoot.

Data Sources

This research aims to use data gathered through surveys created specifically for this study that were randomly distributed in clinics associated with the non-profit HopeWalks or Cure International Hospitals in the Addis Ababa region of Ethiopia. The intended goal is to understand the impact of clubfoot status and correction of clubfoot by examining the physical, psychological, and social well-being of Ethiopian teenagers. All the individuals surveyed for this research are patients or previous patients of HopeWalks or a member of one of their partner clinics such as Cure International.

To obtain data for our research, surveys will be distributed to the parental guardian or main caregiver, (preferably the mother) that will include information on both children being surveyed pertaining to their physical and mobility outcomes, psychological and faith outcomes, social integration, and education. The survey will additionally discuss the treatment plan and physical health status of the child born with clubfoot. Within this study there are two distinct sample groups. The first of the two groups will look at treated patients and their nearest age sibling. The sample of treated patients will be approximately 150 randomly selected adolescents who have participated in a minimum level of treatment. To be included in the sample the treated patients must have a deformity associated with clubfoot, must be between the ages of six to eighteen years old, and have a sibling who also falls into this age range. Additionally, the patient should *at least* be in the final stages of casting to be considered. The second group to be

examined in our sample will be the control patients and their siblings. The individuals who will make up the comparison group, must be between the ages of six and eighteen years old, have a deformity associated with clubfoot, and have not yet begun treatment but are scheduled to begin treatment with one of the associated organizations. These individuals must also have a sibling within the designated age range. To find these individuals we will use a roster of patients who are scheduled to start treatment within the 2022 calendar year. Patients and their siblings for both groups will be surveyed in the same location using the same survey to ensure that there are no confounding influences in survey responses. Our target sample size for both groups will be approximately 150 children which will give us approximately 600 treated and control observations when we consider the data pertaining to the nearest age sibling.

The survey created for this research project covers a vast list of topics with the aim of establishing a better understanding of clubfoot status on the physical, psychological, and social outcomes of these adolescents. The survey is constructed into two main sections. The first section aims to develop a respondent profile by asking questions about basic demographic data as well as questions about the treatment plan and physical health of the child with clubfoot. In this section we ask questions about contact information, number of children in the family unit, religious affiliations, as well as specific information about the child born with clubfoot. Additionally, the survey respondent is also asked information about their initial diagnosis such as age at diagnosis and initial Pirani score. To conclude this section, we note their current stage of treatment.

The second section of the survey focuses solely on gathering data on life outcomes. The first outcome analyzed within this section relates to physicality and mobility. Questions in this section ask parents to rate their child with clubfoot and their nearest age sibling on a mobility scale (See Figure 5 in the Appendix for the mobility scale used). Other questions asked in this section include how easily their children can complete everyday activities such as walking or partaking in sports. The next section focuses on psychological and faith outcomes. Parents are asked about the hopes and aspirations, of their children. Specific questions look at the experience their children have with anxiety and depression, happiness and religious and or spiritual outcomes. The last two outcomes analyzed within this section relate to social integration and education. Parents are asked questions about the pro-social behavior of their children, and how socially included they feel their children are within the community. We then ask questions related to education attainment such as if their children are currently enrolled in school, when and why they unenrolled in school (if applicable), and what their overall performance looks like in school. To distinguish answers between the child born with clubfoot and their nearest age sibling, the sibling responses are indicated as sections CC, DD, EE, FF.

Pre-Analysis Plan

The idea of understanding the impact of being born with clubfoot and subsequent treatment is a novel one in economics. An overwhelming majority of the literature pertaining to clubfoot and

treatment procedures, are done in medical journals which, more often than not compares post treatment outcomes to those of the general population. These research articles often fail to establish a proper counterfactual; and fail to consider how local environment and the adherence to the recommended treatment method may influence life outcomes. The plan for achieving causal identification to make up for these shortcomings begins by generating a counterfactual. To ensure that local environment and upbringings are as similar as possible we decided to use the patients nearest-age siblings as a counterfactual. This is true for the patients who are currently in treatment, those who have completed treatment, as well as for those who have yet to begin treatment. Using the nearest age siblings as the counterfactual is likely the best method to ensure that there are no confounding factors to establish causality. The following section will lay out the hypotheses that will be tested within this study. The hypotheses are divided into four sections focusing on the life outcomes aforementioned.

Section 1: Hypotheses for Physical and Mobility Outcomes

I. H₀/H_a: “No impact/ Positive impact of being born with clubfoot (and subsequent treatment) on the index of overall physical health and well-being.” These hypotheses are measured using a mobility scale and responses about physical health and independence. (not penalized)

II. H₀/H_a: “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on an index of general health and physical independence.” These hypotheses are measured by testing whether the child can walk comfortably to and from different locations, if the child is able and willing to partake in outdoor activities, and how often the child feels tired or needs rest while walking.

III. H₀/H_a “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on observed physical appearance.”

IV. H₀/H_a “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on the occurrence of foot pain.”

V. H₀/H_a “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on the ability to wear shoes of one’s choice.”

VI. H₀/H_a “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on the ability to walk on the soles of one’s feet.”

VII. H₀/H_a “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on the size of both feet.”

VIII. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on the visible size of one’s feet or legs.”

IX. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on the perception of one’s feet relative to other children of the same age.”

X. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on mobility capabilities based on the Hope Walks mobility scale.”

XI. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on how far one is able to walk, even considering that he or she may need the help of sticks, crutches, or a walker?”

XII. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on the ability to walk comfortably to school, to the store, and to visit friends or family.”

XIII. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on the ability to play/partake in sports.”

XIV. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on how much one enjoys playing sports or participating in outdoor activities.”

XV. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on how often one complains of legs or feet that are tired or in need of rest.”

XVI. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on a general index of mobility consisting of responses to X to XV.”

Section 2: Hypotheses for Psychological and Faith Outcomes

- I. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on an index of overall psychological well-being.” These hypotheses are tested based on questions relating to self-esteem, hope and aspirations, anxiety, depression, and happiness. (not penalized)

- II. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on an index of five questions relating to self-esteem.” (penalized)
- III. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on an index of six questions relating to hope and aspirations.” (penalized)
- IV. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on an index of three questions relating to anxiety.” (penalized)
- V. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on an index of three questions relating to depression.” (penalized)
- VI. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on an index of three questions relating to religious and spiritual outcomes.” (not penalized)

Section 3: Hypotheses for Social Inclusion, Family Relationships, and Behavior

- I. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on an index of social inclusion and pro-social behavior.” These hypotheses will be tested using questions that relate to how perceptive the family and community is to the child as well as what their pro-social behavior is like.
- II. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on individual variables related to social inclusion, family relationships, and behavior.” (penalized)
- III. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on an index of seven questions related to how socially inclusive the community is to the child diagnosed with clubfoot.”
- IV. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on an index of five questions that relate to the pro-social behavior of the child diagnosed with clubfoot.”

Section 4: Hypotheses for Education

- I. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on school attainment, and performance in school.”
- II. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on missed days in school.” (penalized)
- III. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on the level of school attainment only.” (penalized)
- IV. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on the performance of the child in school.” (penalized)

Section 5: Hypothesis for General Human Flourishing

- I. H0/Ha “No impact/Positive impact of being born with clubfoot (and subsequent treatment) on human flourishing as defined by the grouping of indices related to physical health, psychological wellbeing, faith, education, and social inclusion/prosocial behavior.” (not penalized)

All variables collected will be taken from survey data. For the purposes of our study, we will not penalize the main indexed outcomes with Hotchberg q -values and instead use p -values. The individual outcome variables within indices and sub-indices within a broader life-outcomes category will be penalized using Hotchberg q -values. Indices will be constructed using methods developed in a 2007 paper by Kling et al, in which the variables of the index will be oriented in a single direction of impact, standardized, and summed; at which point the index itself will be standardized. The Kling index will then be robustness-checked using an Anderson Index (Anderson 2008). The Anderson Index assigns a weight on each impact variable by the sum of its row entries across the inverted variance-covariance matrix of the impact variables in the group j . The weight is assigned such that a variable within the scenario that exhibits lower covariance with the other variables becomes weighted proportionally higher in the index because it contains more independent information.

Plan for Achieving Causality

To analyze the causal impact of clubfoot status and treatment of clubfoot on the categories of life outcomes, a cross-sectional difference-in-differences method nested within a household fixed effect will be used. In a difference-in-differences approach a natural experiment is used to mimic the randomization in some naturally occurring event that happens in one place, but not in a similar place over that time period. The difference between the two groups before and after the event is contrasted to create a difference-in-differences estimator of the policy

impact. For the purposes of our study, we will compare adolescent life outcomes with treated clubfoot to the life outcomes of their nearest-age sibling. Those differences are then compared to the difference between the adolescent life outcomes of untreated clubfoot patients and their own nearest-age sibling. This strategy allows for estimation of the impact of being born with clubfoot, as well as receiving treatment through the Ponseti Method

In this case, using a cross-sectional model allows us to have *some* individuals (i) in a subset of the groups with household fixed effects δ_j who are treated. The counterfactuals generated with this estimation strategy reference the outcomes of other members of an individual's group, j that are untreated. Four assumptions are applied to this evaluation to develop a model to estimate these impacts. The first assumption is that the occurrence of any deformity associated with clubfoot is random within a household. Second, receiving treatment for clubfoot is random conditional on household characteristics that are held constant via the household fixed effect. Third, the potential outcomes for clubfoot patients and siblings (conditional or observable) are constant. Four, clubfoot status on one sibling does not affect the potential outcomes of the other sibling.

Given these assumptions we can estimate the model as follows:

$$Y_{ij} = \alpha + \delta_j + \tau_1 \text{Casting} + \tau_2 \text{Bracing} + \tau_3 \text{Tenotomy} + \beta_1 \text{BCF} + \lambda'x + \epsilon_i$$

In this model Y_{ij} (the dependent variable) represents the outcome index for person i in household j . δ_j represents a household level fixed effect. *Casting*, *Bracing* and *Tenotomy* represent treatment outcomes, *BCF* is a binary variable indicating whether an individual was born with clubfoot or not. $\lambda'x$ represents a vector of controls that include age, gender, and birth order. We also will test whether the impact of treatment is different for patients who started treatment earlier in life than others with the same/similar deformities. In addition, we will be estimating this equation replacing casting, bracing, and tenotomy with a summary variable for all children born with clubfoot who have received some clubfoot treatment. Many of the hypotheses can be tested jointly in created indices or individually. When testing individually, we will control the family-wise error rate using q -values from the Hochberg Step-Up procedure. When testing jointly the multiple variables within a scenario, we will use summary indices over all variables in our survey of the same family created as presented in Kling et al (2007). We will then perform a robustness check using Anderson Index as presented in Anderson 2008.

Summary and Discussion

In conclusion, researchers estimate that worldwide, roughly 1.2 people per 1,000 births are born with clubfoot annually (Basit and Khoshhal 2017). This makes clubfoot one of the most common congenital deformities on the planet. While not much is known about the molecular

players and signaling pathways that cause deformities associated with clubfoot; treatment is fairly inexpensive and accessible even in developing countries. Findings from this study aim to expand knowledge on the benefits of treatment that can be used by the medical community, the economics community as well as the non-profit community. The ultimate goal is to provide information on the impact clubfoot and subsequent treatment has on the physical, psychological and social outcomes of those suffering from any of the four categories of clubfoot. The hope is that this information will drive donor participation within the clubfoot community to ensure that treatment is available to all who need it. This project is one that can be applied internationally, especially with the partnership of HopeWalks as they have clinics in 16 countries around the world. The same specifications and hypotheses can be tested on an international level and would be a great addition to this project.

Appendix



Figure 1: Equinus at Ankle

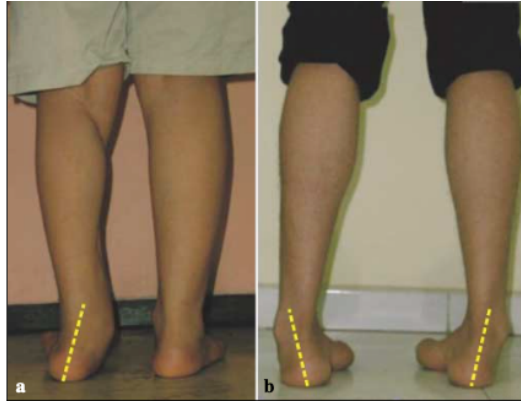


Figure 2: Varus at Hindfoot

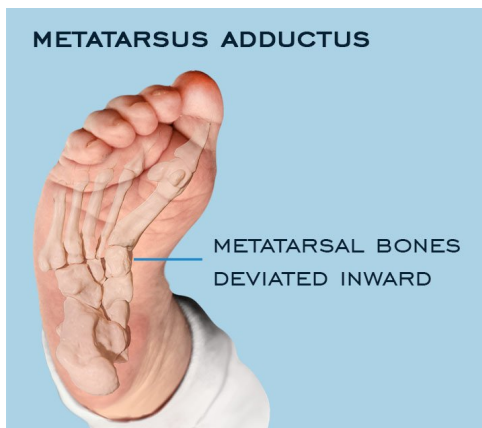


Figure 3: Forefoot Adductus



Figure 4: Cavus

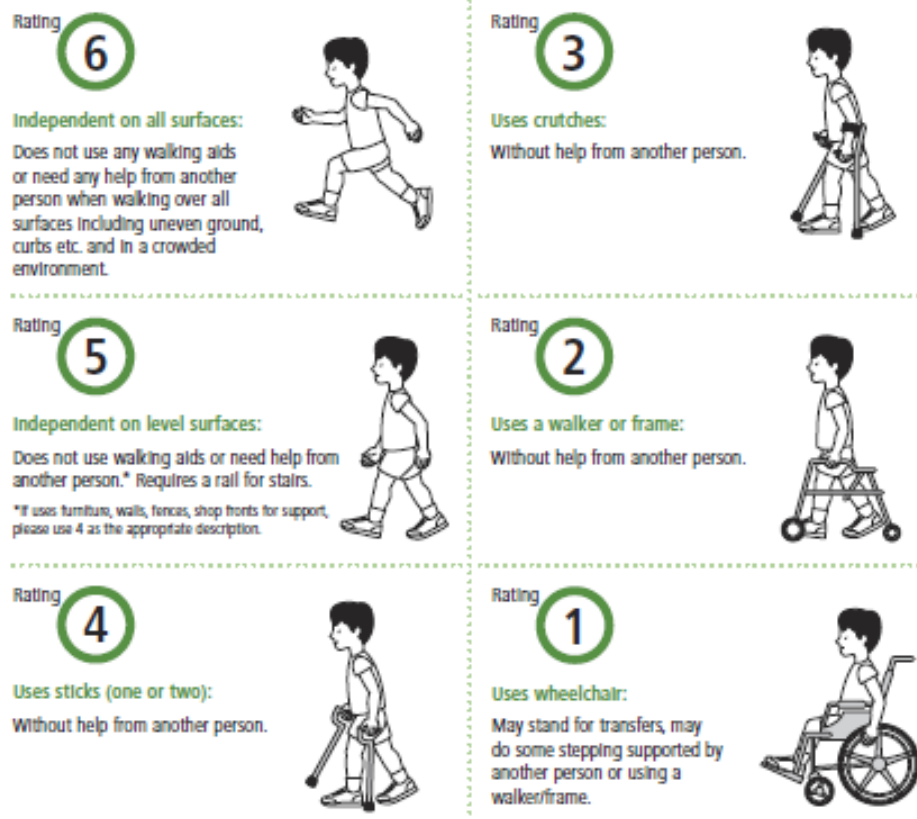


Figure 6: Mobility Scale used “Physical and Mobility Outcomes” Section (Hope Walks)

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