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The Long-Term Effects of a Medical Intervention: Determinants and Implications of Orthotic Equipment Failure

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Abstract

This paper tracks the outcomes of a medical intervention which provided lower limb orthosis to adults with disabilities between 2012 and 2018. Six years after the intervention, over one-third of the recipients were still using their orthotic devices. Using a discrete time hazard model, the analysis examines the speed at which the orthotic devices failed and evaluates how personal characteristics and clinical factors acted as potential risk markers of early equipment failure. The study finds that the peak time of failure lay between the fourth- and fifth-year post-fitting, with the probability of orthosis failure being significantly lower for women, the elderly and most importantly, those who had access to follow up care compared to their respective counterparts. The study also analysed the implications of orthotics failure on life satisfaction, health-related quality of life and severity of disability, which are designed to measure subjective wellbeing. Notably, the results indicate that access to follow up care improves functional efficiency, while failure of the orthosis consistently acts as a negative correlate of wellbeing.

JEL Classification: J22, D13, I15, I20

Keywords: disability; orthotic equipment; long-term outcomes; subjective wellbeing; Uganda

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The Long-Term Effects of a Medical Intervention: Determinants and Implications of Orthotic Equipment Failure

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1. Introduction

The "World Report on Disability" estimates that approximately 15% of the global population suffer from a disability, of whom 200 million experience difficulties in functioning (WHO & World Bank, 2011). The report also estimates that 80% of this vulnerable group reside in low-income countries (LICs hereafter), with numbers expected to rise in the coming years due to ageing populations and the global increase in chronic health conditions. Yet, national data assessing the needs and unmet needs of rehabilitation services (including mobility devices) have found services to be inadequate in developing countries (WHO, 2011). The most recent data for LICs estimates that 30 million people with disabilities require assistive devices, with only 5-15% having their needs met (WHO, 2018).

For those whose needs have been met, there is scant evidence on the success of rehabilitative interventions. While evidence surrounding prosthetic interventions in developed and developing countries are documented, there is limited empirical evidence on orthotic outcomes. In particular, there is a lack of substantive evidence able to inform intervention decisions regarding what works best and for whom and the potential factors that may influence the sustainability of orthoses in the long-term.

To fill this gap this paper uses data from a medical intervention that provided orthotic equipment to 315 adults with disabilities in 2012. In surveying these participants regularly over a six-year period, we follow the trajectory of those given assistive devices and examine the determinants of use, and its corollary, the abandonment of the devices, and the impact this has on wellbeing. Our approach is twofold. First, we use a discrete-time hazard model to estimate the determinants of equipment failure. We explore this by linking equipment use and its failure to gender, age, marital status, and clinical factors, including the type and duration of the impairment, the type of equipment received, and a measure capturing access to follow-up care. Second, we investigate the effect equipment failure has on three measures of subjective wellbeing, namely life satisfaction, health-related quality of life (HRQoL) and disability severity.

In doing so, we address a growing concern in the intervention literature, namely, that most trials or clinical studies have relatively short follow-up periods, with, in many cases, the event of interest not occurring before the end of the study for many subjects (Davies et al., 2013). There is now recognition that after an intervention, it is imperative to track subjects over a longer period to support, sustain and improve adaptation to the intervention which may considerably improve longer-term outcomes. By studying long term outcomes, we identify mechanisms that link use with sustainability and highlight specific risk factors during implementation that are likely to lead to failures.

Six years after the intervention, we find that 37% of participants are still using their orthotic equipment. Findings indicate that women, older participants, and those who have had access to follow-up care have a lower likelihood of early device failure. With respect to wellbeing, access to follow-up care also improves subjective wellbeing, reducing disability severity, while failure of the orthosis leads to a reduction in health-related quality of life and an increase in disability severity.
The remainder of the paper is organized as follows. Section 2 describes the background and existing literature. Section 3 gives a brief overview of the intervention, data collection protocols and the descriptive analysis. In Sections 4 and 5, we outline the methodological specifications and discuss our main findings, respectively, while in Section 6, we conclude.

2. Literature Review

2.1 Background: Rehabilitative care in Uganda

Uganda's population is over 41 million, with a GNI per capita of US$1,370 and a relatively low level of health expenditure (7.2% as a proportion of GDP).[1] The Uganda Bureau of Statistics (2016) noted that although significant improvements in life expectancy and infant mortality rates have been recorded recently, the prevalence of disability remains high (1 in every 7 persons – of which approximately 36% have a walking disability), with gender disparities revealing a higher prevalence of disability among women (15%) compared to men (10%). These individuals are vulnerable by virtue of their impairment, facing challenges ranging from a lack of access to appropriate equipment and associated support services, to social isolation and negative societal attitudes (Owens & Torrance, 2016; Kenney et al., 2019).

Uganda has 72 districts with only 19 Orthotic and Prosthetic (O&P) service centres dispersed across the country. In a region with poor transport infrastructure like Acholi in Northern Uganda, for instance, the average distance from a patient's home to a referral hospital is 91

1 2016 statistics retrieved from https://www.who.int/countries/uga/en/

kilometres with less than 1% of patients formally referred to rehabilitation services (Okello et al., 2019). Not only is the country significantly under-resourced in terms of facilities but also in supply chains and coordinating efforts to facilitate prescriptions and repairs (Sexton et al., 2012). Specialised components and materials are imported, often at a high cost (Sexton et al., 2012). Despite this, orthopaedic technologists in Uganda are a capable and multi-skilled group with a genuine enthusiasm to see services improve (Kenney et al., 2019).

O&P budgets are often inadequate and reliance on donations is common (Sexton et al., 2012; Kenney et al., 2019). Costs vary with the type of disability. Lower limb assistive devices may cost up to US$400 (Kenney et al., 2019), which is significantly more than the average monthly Ugandan household income of UGX500,000 (equivalent to US$133). A descriptive cross-sectional study conducted on a sample of 318 people with physical disabilities in Kawempe (Kampala) reported that only 26% of participants used rehabilitation services due to high costs (Zziwa et al., 2019).

2.2 Determinants of O&P outcomes

To the best of our knowledge, only a handful of researchers have explored the determinants of O&P outcomes in developing countries. What papers are available have tended to focus on prosthesis. Here evidence suggests that learning to live with a lower limb disability and to use assistive devices in daily life activities often demands good physical, as well as cognitive capacities (Spruit-van Eijk et al., 2012; Lee & Costello, 2018). Factors including age, gender, education, cultural beliefs and subjective traits such as satisfaction with the assistive device and motivation have been identified to be important determinants of use and success (Geertzen, 2008; Hussain, 2011). Nunes et al. (2014) found for a sample of 149 patients in Brazil that being female, less educated and having a long-term illness were risk factors associated with difficulty in adaptation to the prosthesis and the use of rehabilitative care. Jensen et al. (2004) found factors likely to influence the incidence of prosthesis failure for 172 patients in Uganda, Honduras and India included being young, longer hours of daily use, walking barefoot, and higher user intensity.

Papers which have considered the impact on quality of life directly have found factors such as being male, ageing, time since amputation, level of social support and the presence of comorbidities to adversely affect quality of life (Davie-Smith et al., 2017; Abdullahi et al., 2020; Shankar et al., 2020). Magnusson et al. (2019) compared the quality of life of 155 O&P users with a disability and 122 individuals without a disability and found that despite rehabilitation services, people with a physical disability experienced lower quality of life in three domains, namely, physical health, psychological wellbeing, and the environment in which they lived. For individuals with a disability those who have irregular or no income, live in urban slums, and with no formal education had the lowest scores.

Research on the long-term effects of O&P interventions is again scarce, tends to be concentrated in developed countries, and focuses on prosthetic interventions, investigating lower limb prosthesis failure and time to revision (i.e., prosthesis removal or replacement). Rand et al. (2003) using data for the US found that prosthetic survivorship was 78% at twenty years post-surgery. Women, the elderly and those with inflammatory arthritis were more likely to have higher prosthesis survival rates.[2] This is in line with other studies that find that men and youth are more likely to have lower survival rates than their counterparts (Nair et al., 2008; Nunes et al., 2014).

Papers which have examined long term use of prosthesis in developing countries have found high failure rates. Jensen et al (2004) recorded a cumulative failure rate of 71% in Uganda over their study period, with 1 in 4 needing a new component/part within the first 36 months post-fitting. Due to poor fitting, the prostheses failed after a median of 22 (2-47) months. In the hot and humid climate of Uganda, the authors found that over half of subjects had removed a soft liner, which aggravated pain, discomfort and partly worked against survival rates. In Sierra Leone and Malawi, Magnusson & Ahlström (2017) found for a sample of 222 O&P participants that within 22 months post-rehabilitation, 86% of assistive devices were in use but over half needed repair. While access to repairs and follow-up services were the most important aspects of assistive service provision, it was also found that the majority of participants had experienced high levels of pain alongside difficulty walking on uneven surfaces and stairs, concluding there was a need for improvements in adaptable, low-cost technology in LICs.

2 However, there are also studies in developed countries that have found personal characteristics to be insignificant in determining survival rates where instead, rates have been linked to the type of amputation. Where treatment and follow-up care are appropriate, the indication is individual characteristics may be less important in determining outcomes. Malawer & Chou (1995) found a prosthesis survival rate of 67% at 10 years among a sample of 82 patients in the US, with survival rates being affected only by devices fitted in the proximal part of the tibia reporting lower likelihood of survival. A more recent paper quantified the use of prosthesis among 201 individuals with lower limb amputation in Australia between 4 to 12-months post-discharge (Roffman et al., 2014) and found risk factors for non-use had again nothing to do with personal characteristics, instead, amputation above the transtibial level and the use of basic mobility aids such as crutches were the most common determinants of early prosthesis non-use.

This harks to the literature which discusses the often unsuitability of assistive devices for the topographical and cultural (social and attitudinal) contexts in many developing countries, which are then strongly linked to poor patient outcomes including dissatisfaction and limited participation in meaningful activities (Mulholland et al., 1998; Matsen, 1999; Van Brakel et al., 2010). Mulholland et al. (1998) used an exploratory case study to assess the functional needs of ten women with lower limb disabilities in Gujarat, India, finding that environmental barriers were commonly encountered due to the diverse and unpredictable terrain. Similarly, Van Brakel et al. (2010) found that Vietnamese amputees living in wet terrains were less likely to use their prosthesis frequently than those living in other environments. Added to these concerns are the compounding impacts of lack of transport and the inability to afford transportation and services, which affected access to rehabilitative care (Van Rooy et al., 2012).

Finally, there is a literature that links personality types with medical outcomes (see, Michal et al., 2011; Friedman et al., 2013; Khosravinasr, 2017; Nolan et al., 2019) and with subjective wellbeing (Vittersø, 2001; Azizan & Mahmud, 2018; Abdullahi et al., 2020; Han, 2020). Many studies find patients that are open to experiences, are agreeable and extroverted are more likely to benefit from medical interventions.[3] A systematic review of the literature by Azizan & Mahmud (2018) found mixed evidence of the effect personality type had on subjective wellbeing, with neuroticism and extraversion most commonly reported to exert significant influences on the levels of subjective wellbeing.[4]

As discussed, the use of O&Ps in developing countries is not well documented. Existing evidence is usually descriptive, cross-sectional, based on a small sample size, and the period of analysis is often short. Moreover, the majority of participants included in these studies acquired their disabilities through trauma, with people having congenital-related disabilities seldom analysed. To the best of our knowledge, no study has looked at the long-term effects of an intervention to fit orthotic equipment in a developing country context. Addressing this notable gap in the literature, this study aims to assess the potential determinants of orthotic

3 For instance, Nolan et al. (2019) found patients who were open to experiences were significantly more likely to engage with preventative healthcare in Ireland; Khosravinasr (2017) found in the US agreeable and extroverted personalities were significant predictors of assistive technology usage among respondents with disabilities.

4Additional evidence from Korea suggests that people high in extraversion, openness to experience and agreeableness experience higher levels of life satisfaction (Han, 2020); while in Nigeria, people who are less neurotic and highly conscientious, extroverted, or agreeable are more likely to be satisfied with life (Abdullahi et al., 2020) equipment failure and its implications on wellbeing using a unique sample of 315 adults with lower limb disabilities in Uganda.

3. Data and Descriptive Analysis

3.1 Orthotic intervention

Orthotic equipment are externally applied body-powered devices that support or complement weakened or abnormal joints or limbs, such as callipers, ankle and foot orthoses, crutches and orthotic shoes (ISO, 2020). In June 2012, we embarked on a unique orthotic equipment intervention in Kampala, Uganda. Orthotic devices were fitted to 315 individuals with a lower limb disability. Each participant was also asked to complete a detailed socio-economic questionnaire and health assessment. In June 2013, all participants were invited back to have their equipment reassessed and re-adjusted where necessary, and then were re-surveyed. Shorter follow-up telephone interviews also took place at four-month intervals between 2012 and 2013 and then in 2016 and 2018, creating a detailed panel data set that enabled the monitoring of equipment use over time.

It should be noted that due to a combination of budget constraints and problems contacting participants, not all participants were re-surveyed. Despite this, balance tests on the 2012 data between those surveyed and those who were not interviewed in 2013, 2016 and 2018 shows no significant difference in baseline characteristics (see Table A1 in the Appendix).[5]

In terms of items allocated during the intervention, each participant received a combination of the following six types of orthotic equipment: knee–ankle–foot orthosis (KAFO; 25%), ankle–foot orthosis (AFO; 23%), knee-ankle brace: (14%), crutches (21%), and other orthoses such as shoes, insoles and shoe raises, splints, corsets, heel and kneecaps (17%). Table A2 in the Appendix shows the total number of each type of equipment allocated to participants during the intervention, disaggregated by gender. We find no significant gender differences in terms of the type of equipment received. In the analysis that follows, we classify the first three

5 It should be noted being 'treated twice' during the intervention is significantly different between the retained and lost sample. The variable is a feature of the intervention rather than a baseline characteristic. Hence the difference should be expected considering that the lost sample was no longer part of the intervention, making them less likely to have been seen twice compared to the retained sample. While we acknowledge that this can be a potential source of bias, this is considered in the empirical methodology where we account for unobserved heterogeneity.

types of assistive devices as complex orthoses, while crutches and other equipment are classified as basic.

Examining the immediate, short-term effects of the orthotic intervention twelve months after delivering the equipment, previous work by the authors showed that there was evidence of improved functional mobility, although the beneficial effects were noticeably stronger for men than women. Men exhibited an improvement in their level of mobility, while women faced little change or in some cases a reduction in their functional performance. Likewise, it was found that those with polio fared less well with their devices, compared to those with non-polio-related disabilities. This may have arisen due to differences in the speed at which the participants adapted to the use of their orthotic devices.

To implement this extension, we re-visit the sample six years after the initial intervention to examine the trajectory of orthotic use and failure. As part of the follow-up interviews, participants were asked detailed questions on equipment usage, including whether they were currently using the equipment and frequency of use. Those who were not using their equipment were asked when they last used it and the reasons for non-use.[6]

Participants were also asked about their subjective wellbeing. To assess the potential determinants of wellbeing, we exploit three indicators of wellbeing namely: life satisfaction, health-related quality of life (HRQoL) and disability severity. The life satisfaction variable measures how satisfied respondents are with life on a scale of 1-7 with a higher value indicating a higher level of life satisfaction. HRQoL is derived from the Short-Form 8 (SF-8) - eight single-item scales that measure general health, physical functioning, role limitations due to physical health problems, bodily pain, vitality, social functioning, mental health and role limitations due to emotional problems (see Table A3 in the Appendix for the full list of questions). These scores are standardised and converted into a single index with values ranging between 0 and 100 where higher scores indicate better health.[7] Finally, disability

6 We assess recall accuracy by comparing responses from a sample of 114 participants who in 2016 were asked when they last used their orthosis and compared how they responded to the same question when it was asked two years later. Reassuringly, about 81% of these individuals reported the same year of failure.

7 The SF-8 has been validated in developing countries and Uganda specifically. See Roberts et al (2008) for details. *Alpha*, expressed as a number between 0 and 1 was developed by Lee Cronbach in 1951 to assess how well a construct or instrument measures what it should (reliability). A range between 0.65 and 0.9 is considered good and thought to show high reliability of the construct (Tavakol & Dennick 2011). Here alpha is 0.87, which shows that the SF-8 score displays good internal consistency implying that it is a good measure of health-related quality of life for our sample.

severity, measured using the 12-item version of the World Health Organisation Disability Assessment Schedule (WHODAS 2.0), tracks changes in the severity of disability over time. It produces specific scores for six different functioning domains: cognition, mobility, self-care, getting along, life activities (household and work/school) and participation. (See Table A4 in the Appendix for the full set of questions). The World Health Organization's simple scoring method gives a score ranging from 12 to 60 which is obtained by taking the sum of the scores of the items across all domains. Higher scores indicate higher disability or loss of function (Ustun et al., 2010).[8]

3.2 Descriptive statistics

We start the preliminary analysis by presenting an overview of the baseline characteristics of the sample in 2012, disaggregated by gender. Table 1 reports mean responses together with the respective standard deviations and p-values to test the equality of the means between men and women.

The sample is 43% female, with a mean age of 41 years, and an average of 9 years of schooling (which equates to a lower secondary education). Just over half of the sample are married and 74% are the household head, with an average of five members and one dependent child within the household.

The most common cause of disability is congenital (e.g., polio or clubfoot - 69%) with traumatic or acquired disabilities accounting for the rest (e.g., road traffic accidents, stroke, conflict-related). Around 62% received complex orthoses as part of the intervention, and 51% were seen twice by the orthotists to have their equipment fitted or adjusted, once in June 2012 and then again when the orthotists returned in June 2013.

With regards to subjective wellbeing, the table shows that average life satisfaction is 3.3 (out of 7). If we compare to Uganda's national average which was 3.8 in 2012, our sample is less happy. The other two measures, while internally comparable, are less comparable across studies due to differing standardisation methods. The HRQoL index is around 67 in 2012 (out of 100) and the average index for disability severity is 24 out of 60 points. Remembering that for life satisfaction and HRQoL scores, the higher the score the better the level of wellbeing

8 The score displays internal consistency with a Cronbach's alpha of 0.89 indicating that the construct is a good measure of disability severity (or functional efficiency) for our sample.

and the lower the disability severity score the lower the severity of the disability.

Table 1: Baseline summary statistics, disaggregated by gender

	All	Men	Women	p-value
Demographic characteristics:				
Age (years)	41.10	43.29	38.13	0.000
	[12.82]	[12.87]	[12.18]	
Schooling (years)	9.03	9.22	8.78	0.335
	[3.91]	[3.82]	[4.04]	
Married (=1)	0.52	0.67	0.32	0.000
	[0.50]	[0.47]	[0.47]	
Household characteristics:				
Household head (=1)	0.74	0.88	0.58	0.000
	[0.44]	[0.33]	[0.50]	
Household size	5.08	5.13	5.02	0.705
	[2.42]	[2.53]	[2.28]	
No. of dependent children	1.33	1.57	1.01	0.001
	[1.53]	[1.68]	[1.23]	
Clinical factors:				
Congenital (=1)	0.69	0.67	0.73	0.318
	[0.46]	[0.47]	[0.45]	
Complex orthosis (=1)	0.62	0.59	0.66	0.157
	[0.49]	[0.49]	[0.47]	
Treated twice (=1)	0.51	0.50	0.51	0.832
	[0.50]	[0.50]	[0.50]	
Subjective wellbeing:				
Life satisfaction	3.33	3.48	3.12	0.091
	[1.89]	[1.91]	[1.84]	
Health-related quality of life (HRQoL)	66.65	67.98	64.89	0.098
	[15.34]	[15.55]	[14.95]	
Disability severity (WHODAS 2.0)	23.84	23.76	23.94	0.842
	[7.55]	[7.78]	[7.25]	
Labour market outcomes:				
Employed (=1)	0.76	0.81	0.70	0.030
	[0.43]	[0.40]	[0.46]	
Self-employment (=1)	0.77	0.78	0.76	0.648
	[0.42]	[0.42]	[0.43]	
Wage employment (=1)	0.24	0.23	0.26	0.693
	[0.43]	[0.42]	[0.44]	
Monthly earnings (in 000s of UGX)	286.90	345.49	196.53	0.093
	[670.20]	[828.26]	[271.42]	
Observations	315	181	134	

Notes: UGX= Ugandan Shillings. Statistics for earnings and employment type are for the sample of employed workers only. The proportion in wage and self-employment adds up to more than one because three participants have both a wage and self-employed job. Monthly earnings = wages + profits from self-employment. Standard deviations are in parentheses.

In terms of economic activities, participants are predominantly employed, with those employed most likely to be in self-employment (77%). Monthly earnings are UGX286,900 (equivalent to US$ 115), on average.

Important gender differences also emerge. Compared to women, men tend to be older, married, the household head, and have more children. They are also more likely to be in some form of employment and have higher monthly earnings. Although there is no significant difference between men and women in terms of the cause of the disability or the treatment received, men report higher levels of life satisfaction and have a higher HRQoL, although there is no significant difference in the severity of their disability.

Table 2 shows the evolution of key variables over time. It reports mean responses disaggregated by gender.

Although usage declines over time, frequency of use is consistently high; 37% are still using their equipment in 2018. Of these, 93% report that they are using the equipment every day. By gender, we find that no significant difference in usage and frequency of use.

With respect to subjective wellbeing, the statistics for life satisfaction align with the notion of adaptation which states that although life satisfaction is sensitive to extreme events, over time individuals adjust to their new normal. Barazzetta et al. (2019) tracked changes in the life satisfaction of these individuals during the first twelve months after the intervention and found that life satisfaction had returned to pre-baseline levels one year later. Tracking these respondents over a longer period, we find that average life satisfaction declines in 2016, but returns to baseline levels by 2018. We interpret this finding as a response to equipment failure, which for most individuals occurred around 2016 and then they adjust to their new normal by 2018. For HRQoL which is a combination of functioning and mental wellbeing, we find an initial increase in the score between 2012 and 2013, which may reflect the increase in expectations from the intervention, before a fall in June 2013 when their expectations are not met, perhaps due to problems adapting to the new equipment. By 2016, they have adapted and by 2018 we see a return to their baseline level of wellbeing. In terms of disability severity, we see an increase in severity over time which is expected as the sample ages.

Table 2: Evolution of key variables overtime, disaggregated by gender

	June 2012	Nov. 2012	Apr. 2013	June 2013	June 2016	June 2018
All:						
Equipment in use (=1)	.	0.96	0.91	0.86	0.64	0.37
Every-day usage (=1)	.	0.83	0.90	0.76	0.97	0.93
Life satisfaction (1-7)	3.33	3.83	3.78	3.42	2.67	3.83
HRQoL (0-100)	66.65	67.30	67.83	62.11	63.74	65.50
Disability severity (0-60)	23.84	.	.	24.08	.	29.82
Employed (=1)	0.76	0.68	0.70	0.77	0.48	0.59
Self-employment (=1)	0.77	0.70	0.77	0.79	0.80	0.82
Wage employment (=1)	0.24	0.30	0.24	0.25	0.20	0.18
Real monthly earnings (000s UGX)	221.17	170.88	148.22	353.48	104.55	.
Observations	315	253	253	241	114	265
Men:						
Equipment in use (=1)	.	0.95	0.93	0.87	0.60	0.35
Every day (=1)	.	0.85	0.90	0.75	0.94	0.96
Life satisfaction (1-7)	3.48*	3.76	3.80	3.50	2.78	3.85
HRQoL (0-100)	67.98*	67.35	68.78	63.04	65.54	65.68
Disability severity (0-60)	23.76	.	.	24.13	.	29.03
Employed (=1)	0.81**	0.69	0.72	0.80	0.49	0.61
Self-employment (=1)	0.78	0.67	0.77	0.77	0.81	0.76**
Wage employment (=1)	0.23	0.33	0.24	0.27	0.19	0.24**
Real monthly earnings (000s UGX)	266.33*	192.75	164.41	488.04	128.39*	.
Observations	181	147	147	135	63	150
Women:						
Equipment in use (=1)	.	0.97	0.89	0.84	0.69	0.38
Every day (=1)	.	0.80	0.90	0.78	1.00	0.90
Life satisfaction (1-7)	3.12*	3.93	3.75	3.32	2.53	3.80
HRQoL (0-100)	64.89*	67.24	66.51	61.00	61.53	65.27
Disability severity (0-60)	23.94	.	.	24.03	.	30.85
Employed (=1)	0.70**	0.65	0.67	0.73	0.47	0.57
Self-employment (=1)	0.76	0.75	0.76	0.83	0.79	0.91**
Wage employment (=1)	0.26	0.26	0.24	0.23	0.21	0.09**
Real monthly earnings (000s UGX)	151.50*	137.41	123.20	161.51	73.76*	.
Observations	134	106	106	106	51	115

Notes: Data on usage and frequency of use are missing for June 2012 because participants had only just been fitted with their new equipment. Information on monthly earnings was not collected in June 2018. Data on disability severity was only collected for 2012, 2013 and 2018. *** p<0.01, ** p<0.05, * p<0.1 indicate sample t-tests of significance between men and women.

Finally, in terms of labour market outcomes, only 59% of participants are in employment in 2018, compared to 76% in 2012, and there is a large decrease in real monthly earnings. This job loss is more pronounced for those in wage employment than self-employment, especially for women. Previous analysis of the data looking at the short-term outcomes found a significant increase in earnings one year after the intervention which is observed in Table 2.

We therefore put the drop in earnings down to a combination of a failure in equipment but also acknowledge there was a general downturn in the economy. The trend in earnings follows GDPpc over this period which saw a significant drop in 2016 before starting to recover by 2018.[9]

Next, we look in detail at the reasons why participants stopped using their orthosis and how this differs by gender (Table 3).

Table 3: Reasons why equipment failed

	All	Men	Women	p-value
Fail (=1)	0.54	0.55	0.53	0.764
	[170]	[99]	[71]	
Year equipment failed:				
June 2012-May 2013	0.05	0.06	0.04	0.601
	[9]	[6]	[3]	
June 2013-May 2014	0.13	0.13	0.13	0.931
	[22]	[13]	[9]	
June 2014-May 2015	0.15	0.20	0.08	0.036
	[26]	[20]	[6]	
June 2015-May 2016	0.25	0.27	0.23	0.486
	[43]	[27]	[16]	
June 2016-May 2017	0.27	0.23	0.32	0.187
	[46]	[23]	[23]	
June 2017-May 2018	0.14	0.10	0.20	0.077
	[24]	[10]	[14]	
Reasons for failure:				
Pain or poor fit (=1)	0.12	0.12	0.11	0.866
	[n=20]	[n=12]	[n=8]	
Broken (=1)	0.84	0.82	0.86	0.480
	[n=142]	[n=81]	[n=61]	
Other reasons (e.g., theft =1)*	0.04	0.05	0.03	0.473
	[n=7]	[n=5]	[n=2]	
Unknown (=1)	0.01	0.01	0.00	0.399
	[n=1]	[n=1]	[n=0]	
Maintenance efforts made due to breakage:				
Too expensive (=1)	0.49	0.43	0.56	0.151
	[n=66]	[n=32]	[n=34]	
Repaired several times (=1)	0.22	0.26	0.18	0.291
	[n=30]	[n=19]	[n=11]	
Unaware of how/who could fix it (=1)	0.29	0.31	0.26	0.539
	[n=39]	[n=23]	[n=16]	

Notes: Failure data is retrospective. * Other reasons for non-use include theft, misplacement, the device being too hot, tiring, not liked, or only needed for certain activities. Seven respondents whose equipment broke did not respond to the question on maintenance efforts. Number of observations are reported in squared brackets.

9 2012 US$788; 2013 US$807; 2016 US$733; 2018 US$770.

Of those who stop using their devices, over half of these failure rates occurred between the 4th and 5th year after the intervention,[10] with the devices for men being likely to have failed much earlier than those of women. The leading cause is that the equipment broke (84%), followed by pain or poor fit (12%). As already mentioned, as part of the follow-up surveys, participants with broken equipment were asked whether they tried to fix their device. Nearly half report that they could not afford a repair, 22% stating that their equipment had already been repaired several times to no avail, while 29% said that they did not know how or who could fix it. Similar results hold for both men and women. These findings highlight the importance of ensuring that affordable maintenance programs are in place to support individuals after interventions end.

4. Empirical Methodology

4.1 Survival analysis: Discrete-time hazard

We begin by estimating the determinants of equipment failure, using a discrete-time hazard, h_{it}, where we define failure as non-use and survival time as the time until equipment failure. This approach models the baseline hazard flexibly and avoids any restrictive parametric assumptions about its shape. Imposing a parametric specification on the shape of the hazard can bias the estimated effects of the time varying variables and the baseline hazard (Narendranathan & Stewart, 1993). The discrete-time hazard represents the instantaneous probability of leaving the state at time t, conditional on survival in the state until time t and can be written as:

$$h_i(t) = \Pr(T_i = \mathrm{t} \mid T_i \geq \mathrm{t}, X_{it}) \quad (1)$$

where X_{it} is a vector of covariates that may vary with time, t, and T_i is a discrete random variable representing the time until equipment failure.

The log-likelihood function of the observed duration data can be simplified by defining a dummy variable which takes the value 1 in the year the equipment failed i.e. $f_{it} = 1$ if $t = T_i$ and $f_{it} = 0$ (or censored) otherwise. As such, for those whose equipment does not fail, $f_{it} = 0$ for all periods, while for those whose equipment fails, $f_{it} = 0$ for all periods, except the period in which the failure occurs when $f_{it} = 1$. The log-likelihood can then be written in a

10 The median equipment survival time was approximately 4.8 years post fitting.

form that is the same as that used for the analysis of a binary variable f_{it} (see Allison, 1982; Jenkins, 1995):

$$\log L = \sum_{t=1}^{n_i} \sum_{k=1}^{t_i} f_{it} \log \frac{h_{ik}}{1-h_{ik}} + \sum_{t=1}^{n_i} \sum_{k=1}^{t_i} f_{it} \log (1 - h_{ik}) \quad (2)$$

In the analysis that follows, we assume that the functional form for the hazard is logistic[11]:

$$h_i(t) = 1 \Big/ \{1 + \exp[-\theta(t) - \beta' X_{it}\}\} \Leftrightarrow \log[-\log(1 - h_i(t)] = \theta(t) + \beta' X_{it} \quad (3)$$

where we model the baseline hazard, θ(t) as a step function, by specifying dummy variables to represent each period or time interval. This leads to a semi-parametric specification of the discrete-time duration model.

The model discussed so far assumes homogeneity of the survival distribution across individuals. However, if there are systematic individual differences in the distribution after controlling for observables, problems of interpretation can arise (see Lancaster, 1979). Hence, we control for heterogeneity by conditioning the model on an individual's unobserved characteristics, v_i. Now the discrete-time hazard function becomes:

$$h_i(t) = \theta(t) + \beta' X_{it} + v_i \quad (4)$$

where v_i is a normally distributed random variable with mean zero.

4.2 Subjective wellbeing

Next, we use the unbalanced raw panel data to assess the effect of orthosis failure on subjective wellbeing using a regression of the form:

$$SW_{it} = \alpha + \gamma f_{it} + \beta Z_{it} + \delta_t + u_i + \varepsilon_{it} \quad (5)$$

where SW_{it} represents the respective subjective wellbeing measures outlined in Section 3 and the parameter γ captures the extent to which wellbeing is affected by failure of the orthosis. The term Z_{it} is a vector of person-specific characteristics, δ_t captures time fixed effects, u_i

11 The logistic distribution is a commonly used non-proportional hazard. An alternative specification is the complementary log-log model. The logistic model is very similar to the complementary log- log used in most empirical applications. This is because the logistic model converges to a proportional hazard model as the hazard rate becomes increasingly small. The rate is sufficiently small in most applications.

captures time invariant individual specific effects that are constant over time, and ε_{it} a random disturbance. For life satisfaction and HRQoL, random effects is the preferred specification; a comparison between the fixed and random-effects linear regression leads to a rejection of the model with fixed-effects. In contrast, for disability severity the pooled regression is preferred.

5. Results and Discussion

5.1 Discrete-time hazard: The determinants of orthosis failure

The maximum likelihood estimate of the determinants of orthosis failure are given in Table 4. The likelihood ratio test at the bottom of the table rejects the null hypothesis that unobserved heterogeneity is zero. This suggests that the current model which accounts for unobserved heterogeneity is appropriate.

Consistent with the preliminary findings, Table 4 shows that the baseline hazard increases monotonically over time; the hazard of device failure increases from 16.2 percentage points after two years to 53.9 percentage points after six years. The results also show that after controlling for socio-demographic characteristics, women are at a lower risk of orthosis failure than men; the conditional probability of failure is 7.2 percentage points lower for women compared to men. Although we do not observe any gender differences in the type of equipment received, nor usage and frequency of use, for those in employment intensity of use may be greater for men than women due to types of employment undertaken. Employment is usually low-skilled, men are typically employed as street vendors, laundrymen, or iron benders[12], while women are employed as secretaries, hairdressers, or clothes vendors.

The effects on age and age squared show that the relationship between age and orthosis failure has a positive effect on orthosis failure with some diminishing returns as the sample ages.

12 Iron bending was a common activity amongst the sample. It involves bending reinforcement bars to required angles in civil and construction engineering; usually performed on a construction site. Manual bar bending involves strenuous upper body physical activity.

Table 4. Maximum likelihood estimates of the determinants of orthosis failure

	Coefficient	Marginal Effect
Year equipment failed:		
June 2013-May 2014	3.677***	0.162***
	(0.826)	(0.034)
June 2014-May 2015	5.835***	0.257***
	(1.030)	(0.036)
June 2015-May 2016	8.560***	0.377***
	(1.229)	(0.035)
June 2016-May 2017	10.897***	0.480***
	(1.389)	(0.036)
June 2017-May 2018	12.231***	0.539***
	(1.532)	(0.040)
Demographic characteristics:		
Female (=1)	-1.635**	-0.072**
	(0.828)	(0.033)
Age (years)	0.398*	0.018**
	(0.214)	(0.008)
Age squared	-0.005*	-0.000**
	(0.003)	(0.000)
Married (=1)	-1.766**	-0.078**
	(0.832)	(0.033)
Employed (=1)	-0.399	-0.018
	(0.894)	(0.039)
Clinical factors:		
Congenital (=1)	0.323	0.014
	(0.781)	(0.034)
Complex orthosis (=1)	0.479	0.021
	(0.779)	(0.034)
Treated twice (=1)	-1.643*	-0.072**
	(0.886)	(0.035)
Obs.	1309	
LR test of rho=0: chi-squared (01)	5.07	

Note: Similar results hold if we control for personality type. We do not find any significant results when the regressions are estimated separately for men and women, which is possibly due to the small sample size. It should be noted that the following variables are not statistically significant and are therefore excluded from the final specification: level of education, years of schooling, the type of employment, monthly earnings, and household characteristics (including being the household head, household size, and the number of dependent children). The marginal effects with unobserved heterogeneity are computed by additionally setting the error term equal to its mean value. Rho is the proportion of the total variance contributed by the panel-level variance component. Robust standard errors are reported in parenthesis *** p<0.01, ** p<0.05, * p<0.1.

This may arise due to differences in activity levels between older and younger adults, which might lead to early device failure.[13] Similarly, married participants have a lower likelihood of

13 We also compared the survival probabilities of those in wage employment versus self-employment by age group and gender and find no distinctive pattern. Hence these activity levels may not be necessarily linked to work-related engagements. These results are omitted from the paper but available upon request.

experiencing orthosis failure than their unmarried counterparts, which is potentially due to the availability of informal social or spousal support.

In terms of the clinical factors, the only significant variable is follow-up care. Here we find that receiving follow-up care reduces the hazard of failure by 7.2 percentage points. Earlier work by the authors highlighted the importance of follow-up care in interventions of this kind. Many participants struggled to adapt to their new equipment and required adjustments to be made when the orthotists returned one year later.

Since the empirical literature on orthosis is rare, we mainly compare our findings with studies on prosthesis. Our findings resonate with Rand et al. (2003) on the effects of age and gender on prothesis failure. Rand et al. (2003) found that younger patients and men had lower prosthesis survival rates than their respective counterparts. Similar to Jensen et al. (2004), we suspect that the intensity of equipment use may have worked against the equipment's survival. Moreover, during the intervention, some participants in our sample removed the soft liner in their equipment due to the heat as they left the hospital, which might have aggravated pain and poor fit, hence partly working against the equipment's survival.

5.2 Subjective wellbeing

Next, we report the effects of orthosis failure on subjective wellbeing (Table 5). The linear estimates for life satisfaction, HRQoL, and disability severity are reported in columns 1, 2 and 3, respectively.

Table 5 shows that failure of the orthosis has a negative and significant effect on wellbeing. It is associated with a reduction in HRQoL and an increase in disability severity. This resonates with Shankar et al. (2020) who found that those who had a prosthetic device had a higher quality of life as opposed to those who had not. Being female and ageing is also negatively associated with HRQoL In contrast, schooling has a positive effect on life satisfaction, while being employed has a beneficial effect on all three measures of wellbeing.

In terms of the clinical factors, the results show that those with a congenital disability experience higher levels of HRQoL than those who acquired their disability later in life, which may indicate that those with a congenital disability are more likely to have adapted to their impairment. Findings for other developing countries are mixed. Shankar et al. (2020) using data for India found that those with long-term disabilities have higher quality of life, this contrasts with the finding of Gailey et al. (2010) for Vietnam. Receiving follow-up care also has a role to play, lowering disability severity, although it has no effect on the other two measures of wellbeing.

Table 5. Determinants of subjective wellbeing

	(1)	(2)	(3)
	Life satisfaction	HRQoL	Disability severity
Fail (=1)	-0.107	-3.184***	5.690***
	(0.132)	(1.179)	(1.104)
Female (=1)	0.006	-2.256**	0.323
	(0.113)	(1.138)	(0.960)
Age (years)	0.005	-0.140***	0.009
	(0.005)	(0.041)	(0.037)
Schooling (years)	0.021*	0.135	0.204*
	(0.013)	(0.126)	(0.116)
Married (=1)	-0.024	-0.930	-0.853
	(0.112)	(1.110)	(0.992)
Employed (=1)	0.521***	8.465***	-4.043***
	(0.105)	(0.945)	(0.997)
Congenital (=1)	0.176	2.815**	-0.340
	(0.113)	(1.141)	(0.947)
Treated twice (=1)	-0.052	0.797	-2.716***
	(0.112)	(1.048)	(0.950)
Openness	0.026	-0.193	0.038
	(0.017)	(0.157)	(0.138)
Conscientiousness	0.016	0.357**	0.066
	(0.016)	(0.145)	(0.135)
Extraversion	0.002	0.028	0.039
	(0.016)	(0.132)	(0.128)
Agreeableness	-0.032*	-0.065	-0.068
	(0.019)	(0.173)	(0.158)
Neuroticism	-0.030	-0.422**	0.229
	(0.020)	(0.196)	(0.158)
Constant	3.528***	73.313***	25.393***
	(.846)	(7.677)	(5.66)
Year dummies	✓	✓	✓
Obs.	1096	1076	466
Breusch-Pagan LM	21.03***	32.22***	0.10
Hausman	0.152	0.134	n/a

Note: Estimates are for the 2nd to 6th wave of the data because information on equipment usage was not collected in June 2012. Results are for those who responded to the subjective wellbeing measures during the survey. Data on disability severity was only collected for the 1st, 4th, and 6th waves, respectively. Column 3 is estimated using a pooled logit regression. Only fail, employment status and age have longitudinal variation. Other variables are insignificant, including age squared. Robust standard errors are reported in parenthesis *** p<0.01, ** p<0.05, * p<0.1.

Since these measures of wellbeing are also subjective, we account for any potential endogeneity by controlling for the Big 5 personality traits. Here we find that being conscientious is positively associated with HRQoL. Being agreeable has a negative effect on life satisfaction; perhaps because these individuals tend to put the happiness of others above their own, while being emotionally unstable (neuroticism) has a negative effect on HRQoL. These findings are in line with that of other studies (see, Azizan & Mahmud, 2018; Abdullahi et al., 2020; Han, 2020).

Finally, at the bottom of Table 5, in columns 1 and 2 the Breusch-Pagan Lagrangian Multiplier test for random effects rejects the null hypothesis that unobserved heterogeneity is zero, while the Hausman test also confirms that the random effects estimator is preferred to the fixed effects estimator. This is not the case in column 3, where we fail to reject the null hypothesis that the unobserved heterogeneity is zero, which might be because only two waves of data on disability severity is analysed. Hence in column 3, we estimate a pooled OLS regression.

Taken together, these findings highlight the important role continued access to rehabilitative care plays in determining subjective wellbeing. Equipment failure has a negative effect on life satisfaction and HRQoL, while access to follow-up care reduces disability severity. It follows from this that interventions that help to maintain the equipment for longer would also have long lasting effects on subjective wellbeing.

6. Conclusion

To the best of our knowledge, this is the first study to assess the long-term effects of an orthotic equipment intervention using a unique sample of adults with lower limb disabilities in a developing country context, namely Uganda. Using a discrete-time hazard, the analysis evaluates the time to orthotic failure and the variables correlated with that failure. We then extend the analysis to investigate the effect of orthotic equipment failure on three measures of subjective wellbeing, namely life satisfaction, health-related quality of life, and disability severity.

Six years after the intervention, we find that 37% of participants are still using their orthotic equipment. The analysis shows that in line with the conventional view on prostheses, orthoses for women, older adults, and those who had access to follow-up care have a lower likelihood of early device failure. With respect to wellbeing, the findings show that orthotic device failure has a negative effect on life satisfaction and health-related quality of life, while access to follow-up care reduces disability severity.

Taken together, this study highlights the long-term effectiveness of the intervention; just over one-third of the sample were still using the equipment six years later. This compares to usage in a developed country where equipment is often replaced every 18 months. However, at the same time the study clearly highlights the need to ensure that interventions of this kind also include follow-up care, both to delay device failure and to improve wellbeing.

Declaration of interest statement: The authors report there are no competing interests to declare.

Ethics: Ethical approval was granted by both the University of Nottingham and the Uganda National Council for Science and Technology, June 2012, reference SS 2781. All subjects were informed that they did not have to participate in the survey to receive treatment, and that they could terminate their involvement at any time. Questionnaires were administered to patients in their local language by a team of enumerators from the University of Makerere and Rights for Disability Development Foundation, with experience of completing surveys, and supervised by a Health Economist based at the University. Two of the eight enumerators had a lower limb disability.

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