Malnutrition among Indigenous Batwa in Southwestern Uganda

by

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ABSTRACT

Both the Millennium Development Goals and Sustainable Development Goals stress a need for global improvement in regards securing adequate nutrition and reducing malnutrition. However, addressing malnutrition as a global health concern requires a better understanding of how malnutrition affects already vulnerable populations, especially Indigenous peoples. Using both descriptive statistical reporting and multilevel modeling, this study seeks to document and explore the burden of malnutrition for the Indigenous Batwa and non-Indigenous Bakiga of Southwestern Uganda from data collected in 2014. Malnutrition is high in among both Batwa children and adults, with all Batwa population age-sex groupings meeting WHO 'critical' rates (≥ 15%). In contrast, none of the Bakiga age-sex groupings meet 'critical' malnutrition rates. Multilevel modeling, using individual, household, community, and community ethnicity characteristics as levels, demonstrated a strong explanatory power for community ethnicity in malnutrition clustering in this study. This research offers not only useful information about the prevalence and patterning of malnutrition among the Batwa and Bakiga of Southwestern Uganda, but also places this unequal disease burden in a larger discussion around health inequalities that emerge along ethnic lines and the intervenable global health concern that is malnutrition.

Chapter 1: Introduction

1.1 Introduction: why malnutrition matters

Securing adequate nutrition and reducing infant and childhood malnutrition is a global health concern. Contemporary efforts attempting to address or discuss this issue are marked by the Millennium Development Goals (MDGs), a series of 8 global goals led by the United Nations (UN) Millennium Declaration in pursuit of securing the basic human rights of each person. MDG Goal 1 sought to eradicate extreme hunger and poverty (1). As the timelines for the MDGs concluded in 2015, the global commitment to fighting hunger was renewed with the Sustainable Development Goals (SDGs). SDG Goal 1 (Eradicate Extreme Hunger and Poverty) as well as Goals 4 and 5 (Reduce Child Mortality and Improve Maternal Health) are the renewed global commitments relating to the health and wellbeing of populations most at risk of suffering serious health issues and death from malnutrition and malnutrition related illnesses (2). The majority of people on earth remain at an increased risk to a variety of health issues both broad and specific, manifesting itself in forms ranging from every day hunger to an increased risk of congenital abnormalities and birth complications during pregnancy (2, 3). These health issues are intimately connected to social determinants, including education, gender, quality of environment, and wealth (4). Academic literature between 2000 and 2010 increased 40-fold on the topics of food and nutrition (5); despite this, the 2015 MDG report offers a global snapshot that highlights persistence of childhood malnutrition with observed *increases* in certain low- to middle-income regions, the overwhelming majority of which are located in Africa and Asia (6).

In addition to social determinants associated with gender and wealth, another shift in health outcomes follows the colonial, political and contested line drawn between Indigenous and non-Indigenous peoples (7). Health disparities have been observed between Indigenous and non-

Indigenous populations globally. Indigenous population's health outcomes are contextually unique, varying with the group's history of colonization, livelihood disruption, forced removal, or ethnic discrimination (8, 9, 10, 11). Although there exists a variety of health disparities for Indigenous peoples across the globe, the majority of research examining Indigenous health occurs in countries with developed health tracking capabilities, such as Australia, Canada, New Zealand, and the United States (12, 13, 14).

Indigenous peoples in Africa have a population of around 250 million and experience some of the poorest health indicators in the world (9, 15). Of articles with the keywords "Indigenous" and "Health" in Web of Knowledge searches, fewer than 3% of retrieved articles were related to Indigenous health in Africa (16). The African Commission on Human and Peoples' Rights has articulated since 2005 that Indigenous peoples are among the most vulnerable groups on the African continent. Differing and disputed understandings of Indigeneity throughout the African continent leads to insecure Indigenous rights where Indigenous peoples receive limited attention and are left in a precarious health situation (15). The years 2004-2006 were notable for the multinational commitments to the rights of Indigenous peoples – from widely cited African Commission on Human and Peoples' Rights (ACHPR) reports to the United Nations Declaration on the Rights of Indigenous Peoples – yet uncertainty persists as to the full implementation and recognition of Indigenous rights across the globe (17, 18). Although the Food and Agriculture Organization's (FAO) 2015 *The State of Food Insecurity in the World* and the World Health Organization's (WHO) 2015 *Levels and trends in child malnutrition* report an increase in the number of undernourished individuals and wasting in children for the region of Sub-Saharan Africa, there exists only a handful of researchers working with Indigenous peoples to track, understand, and develop contextually-sensitive interventions to improve health outcomes.

1.2 Research setting of the Batwa and Bakiga in Southwestern Uganda

This research is situated among the Indigenous Batwa pygmies (also known as the Abayanda or Twa) and non-Indigenous Bakiga located in southwestern Uganda. After eviction from the forest in 1991 for the creation of Bwindi Impenetrable National Park, Batwa communities lost access to customary foods and experienced a detrimental shift in livelihoods (8, 19). Past studies of Indigenous populations of Africa and abroad demonstrate higher rates of infectious and chronic disease, higher occurrence of mental illness, as well as higher rates of morality and shorter life expectancy when compared to non-Indigenous populations (9, 20, 21).

My research is a component of a larger research program, the Indigenous Health and Adaptation to Climate Change (IHACC) research group, who have been working with the Batwa in the district of Kangunu since 2009, as well as parallel research with Indigenous communities in the Canadian Arctic and Peruvian Amazon. From 2013 to 2014, the IHACC research team conducted census and partial population samples collecting individual and household level data across 10 matched Batwa and Bakiga communities. Previous research conducted by IHACC team members in the Batwa and Bakiga communities demonstrated marked differences in occurrence and experience of Indigenous and non-Indigenous populations for acute gastrointestinal illness (AGI) and malaria (5, 22, 23).

1.3 Research motivations and questions

In this thesis, I seek to characterize the burden of malnutrition in Indigenous Batwa communities, and compare these findings to malnutrition indicators among the neighboring non-Indigenous (Bakiga) communities. There are several motivations for this research. The first and foremost point of this thesis is to draw attention to the severe burden of malnutrition among Indigenous Batwa in Uganda. Secondly, this thesis uses comparisons between the Batwa and

Bakiga to argue that malnutrition among the Batwa can be understood as an Indigenous health disparity. Lastly, although this research contextualizes the Indigenous Batwa and non-Indigenous Bakiga of southwestern Uganda in a global discussion of Indigenous health disparities, specifically in regards to malnutrition and food insecurity, this research seeks to unpack whether the drivers of these disparities come from differences in local context or local composition.

The overarching thematic question of this thesis asks if, how, and why malnutrition varies between two neighboring but socially distinct populations. To explore this question, the thesis is broken up into several chapters that revolve around specific sub-questions and objectives. Chapter 2, *Background*, provides a literature review of the global burden of malnutrition and synthesizes existing statistics on malnutrition in the Batwa and Bakiga to situate them in the global discussion of hunger-related health issues. Chapters 3, *Methods*, explains both the study design and empirical methods integral to this study. Chapter 4, *Results*, presents the different rates of malnutrition among the Batwa and Bakiga (Objective 1), as well as an interpretation of the models results (Objective 2). Chapter 5, *Discussion*, concludes the thesis with a review of relevant literature to contextualize these results and assess possible mechanisms causing inequality (Objective 3). The chapter begins with a comparison of Batwa and Bakiga malnutrition rates to globally observed rates. Following the global comparison, I assess the literature surrounding ‘pygmy’ populations to examine the extent to which genetic versus social determinants could play a role in driving ethnic gradients in malnutrition. The conclusion section of Chapter 5 reviews the work of the thesis and speculates on which possible mechanisms offer the most hope for intervention.

Chapter 2: Background - *Malnutrition of the Batwa in a Global Perspective*

2.1 What is malnutrition?

Malnutrition can refer to multiple nutritional related states of the human body, mainly *under*nutrition and *over*nutrition (24). Hereafter, I will refer to malnutrition as the deficiency of nutrition (i.e. *under*nutrition) unless stated otherwise. The causes of malnutrition vary, but most are related to a poor and inconsistent diet or severe and repeated infections (24). Observing clinical signs of malnutrition are highly variable, depending on both the context of the population under inspection and the proficiency of the on-site researcher or clinician (25). There are numerous ways to identify malnutrition, including biochemical tests (assessing amino acid imbalance, serum albumin levels, blood vitamin levels, hydroxyproline excretion, and urinary creatinine levels) (25), tissue tests (e.g. examination of hair root morphology) (26), and anthropometry (measuring the human body to estimate the nutritional status). One or more of these methods may be combined to assess malnutrition in a clinical or field setting.

2.2 Types of malnutrition: moderate and severe

Malnutrition is an essential indicator of nutritional status and health at the individual level, especially in children under five (27). Malnutrition assessment methods are used to diagnose multiple clinical manifestations of nutrient deficiency, which can be broken down into either protein-energy malnutrition or micronutrient deficiency diseases (including iron deficiency, Vitamin A deficiency, Iodine deficiency, and Zinc deficiency). In this thesis, I focus on two sub-measures of acute protein-energy malnutrition: moderate acute malnutrition (MAM) and severe acute malnutrition (SAM). Although MAM and SAM categorizations change with age, sex, and population contexts, MAM and SAM are most commonly identified when an individual has a weight-for-height indicator or anthropometric measurement substantially lower than international or reference populations (24, 25). However, comparing a given population's indicators to normalized international populations can be problematic when the given population is experiencing extreme duress.

MAM increases the vulnerability of children to infection or lifelong problems from common pediatric illnesses like pneumonia or diarrheal diseases with the potential to compromise physical and intellectual development (28-30). SAM manifests in wasting (severe loss of body fat and muscle tissue) and or oedema (severe lack of protein in the body that leads to an accumulation of fluids under the skin, especially in the lower legs and ankles). These conditions put children at severe risk for common infectious diseases and death, accounting for at least 10% of deaths among children under five worldwide (nearly all of these deaths occurring in low-income and middle-income countries) (31-33).

2.3 Health impacts of malnutrition in adolescence and adulthood

Because malnutrition reduces the body's ability to activate and propagate immune cells, the nutritive status of the body often directly relates to the outcome of common illnesses such as diarrheal illnesses, acute respiratory infections, malaria, and other common immunizable diseases (34, 96). The individual health impacts of malnutrition in adolescents are complex, varying with the age, size and contextual health of each child (31, 35). Due to this synergism and its accentuated impact on children, modified relative risk calculations are necessary when estimating the effect of malnutrition on overall child morality of a population (34). Children under the age of 5 who experience untreated MAM and SAM have long-term consequences on their adult height, cognitive ability, economic productivity, reproductive performance, daily quality of life as well as increased likelihood to develop metabolic and cardiovascular diseases (35 - 37). Adolescents with MAM are also at a greater risk of deteriorating into SAM, which poses severe health impacts, such as irreversible stunting and disabilities, as well as death (35-36). In adults, malnutrition poses its greatest threat to ensuring safe deliveries, where the undernutrition of pregnant women can lead to lower offspring birthweight (a risk factor for high glucose concentrations, unstable blood pressure, and harmful lipid profiles) (38). In non-pregnant and non-nursing adults, malnutrition compromises immunocompetence, thus reducing the ability of cell-mediated immunity to protect the body from common and infectious diseases (39-41).

2.4 Global distribution of malnutrition

Estimates from the Food and Agriculture Organization (FAO) 2015 report, *The State of Food Insecurity in the World*, estimate that globally 795 million people are undernourished (6). Although the global estimates have decreased since 1990 (6), wide and uneven differences among regions continue to exist. While many regions have made positive strides, some lower income regions, specifically Sub-Saharan Africa, Eastern Africa, Middle Africa, Southern Asia and Western Asia, have seen increases in their absolute number of undernourished individuals, population prevalence of undernourishment and percent share of global undernourishment (6). The WHO's 2015 *Levels and trends in child malnutrition* reports that there are an estimated 159 million children affected by stunting and 50 million children affected by wasting, both adverse health outcomes from undernourishment (42). Additionally, the WHO reports that there are an estimated 41 million overweight children (42). Both the WHO and FAO report highlight the global unevenness in childhood malnutrition (i.e. both *under* and *over*nutrition) (42). All WHO-defined sub regions of Africa, Southern Asia, Southeastern Asia and Oceania have levels of adolescent wasting that are approaching a public health emergency (defined as a "Serious" public health crisis at 10% of the population and a "Critical" public health crisis at or greater than 15% of the population) (42). Moreover, global increases in childhood overnutrition have led to growing scholarship on the double burden of malnutrition, where populations in lower- and middle-income countries of Africa and Asia face higher levels of disease burden as they encounter the adverse health effects of persistently high levels of *under*nutrition combined with rising levels of overnutrition (5, 42 - 44).

2.5 Indigeneity in Africa

There are numerous understandings of what is reflected in the term 'Indigeneity' and Indigenous identity (15, 98, 99, 100). The African Commission on Human and Peoples' Rights (ACHPR) defines Indigenous groups in Africa as those whose: 1) cultures and ways of life differ considerably from the national majority, 2) cultures and ways of life that are, or historically have been, under threat (in some cases to the point of extinction), 3) survival depends on access and rights to traditional land and resources, 4) population suffers from discrimination due to being regarded as less developed and less advanced from the national majority, 5) the population typically lives in inaccessible regions (which also serves as a form of political and social marginalization), and 6) individuals are subject to domination and exploitation within structures suited to the interests and activities of the national majority (15, 98). The ACHPR also recognizes that Indigeneity in Africa is connected to a history and present-day violation of human rights as peoples and communities, which "prevents them from being genuinely able to participate in deciding their own future and forms of development" (15, 98).

There is a limited legislation protecting the rights of Indigenous peoples across the African continent (98). In 2010, the Republic of the Congo was the first to adopt a law for the "promotion and protection of indigenous peoples' rights" – the first of its kind for the continent (98, 101). For the rest of the continent, there is limited legislation and representation of Indigenous peoples', limiting Indigenous political power, agency in decision-making processes, or advocacy for their own causes (98). Injustices frequently arise from land dispossession (105, 106), victimization due to violent conflicts (104), and sexual violence against Indigenous women (98, 102, 103). In Uganda, there is no core legislation and representation to recognize and protect Indigenous status. The Batwa of Kanungu District — or any other ethnicity or sub-population in Uganda — are thus not officially recognized by the state as an Indigenous population.

2.6 Inequalities in vulnerable populations: Indigenous health and malnutrition

Indigenous populations are more likely to experience poorer health status and higher burden of disease compared to non-Indigenous populations. Numerous reasons have been proposed as to why Indigeneity is an observable health gradient; these arguments are broadly organized around socio-political reasons (focusing on the consequences, past and ongoing, caused by the colonial process), the inadequacy of medicine-based health intervention (which fails to address Indigenous perspectives of holistic health), and the disruption of the life-course (whereby social determinants and physical environments put Indigenous peoples at risk as beginning with the gestation period) (46).

Beyond a few widely-cited seminal reports, there persists a distinct lack of representation of Indigenous health disparities in academic literature and multinational development agendas (8, 9). The lack of routinely collected, high-quality public health data collected on Indigenous peoples is a key gap in producing longitudinal knowledge and understanding about the status of Indigenous health (46). This lack of data is complex in both meaning and impact. The lack of routine infrastructure to collect such data has been criticized as part of broader normative practices that seek to exclude Indigenous populations from the colonizer’s society (46), with implications for Indigenous health. Firstly, with poor data availability, there is an inability to quantify health issues and inequalities, thus leading to possible scenario where there is a lack of evidence of health inequalities when trying to change policy (46). Secondly, data-centric analysis is subject to misrepresentation when there is a lack of consultation with local Indigenous authorities, sometimes pushing locally insensitive solutions that exacerbate existing issues (46). Even when contemporary states take initiatives to establish Indigenous-specific or Indigenous-inclusive data efforts, the results are often less than what is accepted for the main population of the state. For example, Canada introduced the Aboriginal Peoples Survey in 1991, which sought to create a routine health-related specific to Aboriginal populations in Canada. Although it was a significant step forward, it still receives criticism for its incomplete list of all Aboriginal groups, lack of consistent sampling methodology across time, failure to include culturally relevant health measures (i.e. Indigenous holistic perspectives of health), and fundamental brevity compared to the primary surveys of Statistics Canada (46). While this example is Canada-specific, it is meant to serve highlight how post-Industrial states with existing census and public health infrastructure experience significant difficulty trying to establish, let alone measure, the health status of Indigenous peoples.

In regards to malnutrition, identifying literature explicitly related to quantifying the amount of *under*nutrition in a given Indigenous population can prove challenging. Several studies have identified Indigenous malnutrition gradients in adolescent stratifications of the population (47, 48) or incarcerated Indigenous individuals (49), with a few population-wide malnutrition assessments (50-52). However, examination of the existing literature revealed fewer post-colonial period studies on the malnutrition-related health status of Indigenous peoples in Africa. By reviewing and quantifying recent health data from the Batwa located in southwestern Uganda, I hope to draw attention to an observed Indigenous health gradient.

Although there is a necessary nuance to recognizing the different experiences of Indigenous peoples across the globe - to avoid harmful homogenization and stereotyping - a uniting link between many Indigenous peoples is the experience of discrimination and racism. These social exchanges have been explicitly linked to worse health outcomes (21, 53-55). The result of racism against Indigenous peoples manifests on multiple levels: systematic levels (i.e. negative ideologies and stereotypes around Indigeneity as the *other* in a colonial culture), institutional levels (i.e. inequitable access and structures required to support the healthy lives of Indigenous peoples), and individual experiences (i.e. higher levels of engagement in unhealthy activities, disengagement from health activities, and higher risk of physical injury due to racially motivated assault or isolation) (56, 57). Motivating this thesis is a desire to adapt this framework of multiple manifestations of discrimination to the situation of malnutrition in the Batwa.

Chapter 3: Methods

3.1 Study population: The Batwa of southwestern Uganda

The Batwa, also known as the Twa or Abatwa, are groups of people located throughout central Sub Saharan Africa (SSA) in the modern states of Angola, Botswana, Congo, Namibia, and Uganda (57, 58). The Batwa self-identify as Indigenous and are recognized as Indigenous by the local populations, although the Ugandan government has failed to follow ACHPR and international protocol in regards to the formal complaints submitted by the Batwa (107, 108, 109). This self-identified status is accompanied by an externally-imposed racial pejorative of ‘Pygmy’ by which the Batwa are frequently discriminated against (59). The Batwa’s marginalization is not only social but also spatial. Beginning in the early 20th century with the gazetting of forest areas by colonial powers and continuing when independent states demarcated protected areas, the Batwa have experienced nearly a century of evictions from their forest homes and sustainable hunter-gatherer livelihoods (60, 61). When Bwindi was designated as a national park in 1991, the Batwa were no longer permitted to enter their forest homelands. Forced to live on the periphery of their former forest homes, integration of the Batwa into non-forest settings has been mixed. When compared to nearby non-Indigenous and non-Pygmy populations, the Batwa experience a range of poorer health outcomes and lower socioeconomic status (16, 22, 23, 75). Reports on the status of the Batwa indicate a high reliance on aid and missionary support – employment opportunities are limited and surviving on traditional forest livelihoods is not a viable option due to the government allowing only limited excursions into the forest since their eviction (62, 63).

This research project on which this study is based partners with the Batwa and the neighboring non-Indigenous Bakiga ethnic populations in the Kanungu District of Southwest Uganda. Kanungu borders the Democratic Republic of the Congo and is a travel destination for mountain gorillas in Bwindi Impenetrable National Park (Bwindi). The population of Kanungu is estimated at 250,000, with the majority of the population being of Bakiga ethnicity. Batwa are estimated to number between 750 and 900. The Bakiga are a non-Indigenous, non-Pygmy population who engage in subsistence farming and small-scale livestock trade, with some employment in gorilla tourism.

3.2 Study Design

Retrospective cross-sectional face-to-face surveys were administrated to 10 Batwa communities (attempted census) and 10 Bakiga Local Councils (LCs, the smallest unit of government administration). For the Bakiga, a two-step proportional systematic random-sample of households was carried out. The result of the random sample represents approximately 40% of the Bakiga adults in each LC and a randomly chosen child from each household. Due to frequent travel for employment, household membership was verified by an LC chairperson. A locally hired field assistant administered two surveys in the local language of Rukiga: (1) an individual-level health questionnaire for all ages and (2) a household-level Food Security questionnaire for the head of the household (or a household representative above the age of 18). The survey was informed with local research assistants, local partners, and the communities themselves during pilot testing in July and October 2012. In total, 471 Batwa completed surveys in April 2014, and 696 Bakiga in April 2014, totaling 1,167 respondents (survey breakdown in Table X). Female adults were overrepresented in both surveys, with more overrepresentation among Bakiga than among Batwa. This overrepresentation is likely due to the migratory employment of both Batwa and Bakiga adult men.

3.3 Measuring malnutrition and food security

IHACC team members used middle-upper arm circumference (MUAC) to detect the presence of malnutrition in Batwa and Bakiga individuals. MUAC is advantageous in community-based programs due to ease of administration (i.e. low technology, ease of use) and global validation across many populations (high ROC curve, known constant increase with age) (64). While MUAC can be adjusted for age or height, the incredible diversity of population contexts makes international adjustment guidelines difficult to prescribe. MUAC predicts death and aligns to many established protein-energy malnutrition cutoffs. MUAC has been used in anthropometric assessment of pygmy populations (65-67); however, there exists little literature on the methodological implications of using a non-pygmy-derived diagnostic in pygmy populations. For the purposes of this research, MUAC was deemed as the most appropriate measure for malnutrition as it is the least subject to the anthropometric difficulties of using height or weight in a Pygmy population, and for comparisons between Pygmy and non-Pygmy peoples.

The USDA Household Food Security Survey Module (HFSSM) is an internationally used method in gauging the relative food security of an individual, household, population. The HFSSM has been deployed in a variety of populations, from children and adults (68) the elderly (69), and settings, including low income countries (70, 71), crisis events (72, 73) and Indigenous populations (74, 75, 76). The HFSSM has also proven adaptable to local conditions, producing locally accurate results even after translation or application in harsh environmental conditions (77, 78). While an evaluation in 2003 of the standard HFSSM indicated its validity in measuring food insecurity over time in an American setting (79), other settings require modification of the method. To adapt the HFSSM to the context of the Batwa and Bakiga populations in Uganda, Patterson developed an Adapted Vulnerable Populations Score (AVPS) (75). The AVPS aims to explicitly address the high food insecurity and severe hunger present in the Batwa. This is important because several questions from the standard HFSSM have baseline expectations that are unable to capture variation in populations with high baseline food insecurity. For example, Patterson highlights how meal skipping questions on the original survey assumes that baseline participants have access to three meals per day (75). Such a question fails to capture the severity of meal skipping in the Batwa, whose baseline is only one or two meals per day. The AVPS uses a 26-point metric to capture a "wider continuum of food security" – key modifications to the HFSSM include an additional 6 points for households that do not have any children as well as an additional 8 points for households that do have children. Households without children can have a maximum score of 16 while those without can have a maximum score of 26, with scores standardized between households with and without children.

To establish locally appropriate MAM and SAM cutoffs, I used both the WHO and Republic of Uganda's Ministry of Health Integrated Management of Acute Malnutrition Guidelines (IMAMG) (Table 1). The WHO provides global MUAC cutoff guidelines, whereas the IMAMG provides locally-situated assessment and diagnostic criteria (as well as medical classification and action plans) for SAM and MAM in the following age ranges: 6-59 months, 5-9 years, 10-14 years, 15-18 years, and >18 years (see Table X for full MUAC assessment breakdown). Ongoing debates continue about the broad-scale implications of prescribing global cutoffs, especially in populations experiencing violence, fame, or chronic undernourishment (80 - 84). Tang et al provides an extensive review of the varying cutoffs used in adolescents, adults, the elderly and pregnant women for both cross-sectional and longitudinal studies when malnutrition presents itself both alone and alongside a variety of negative health outcomes (85). In general, adults are given higher MUAC cutoffs than children to account for the increase in body mass.

However, adults in a context-specific elderly category may have a MUAC cutoff in-between children and adults to account for the bodily degradation. As an adult enters a context-driven elderly category, the MUAC cutoff is likely to decrease rapidly.

Table 1. IMAMG MAM and SAM MUAC Cutoff Guidelines

IMAMG Age Ranges	Expected MUAC Measurement*	MAM MUAC Cutoff+	SAM MUAC Cutoff+
6-59 Months	>13.5 cm	11.5 to < 12.5 cm	<11.5 cm
5-9 Years	>14.5 cm	13.5 cm to < 14.5 cm	<13.5 cm
10-14 Years	>18.0 cm	16.0 to < 18.5 cm	<16.0 cm
15-18 Years	>22.0 cm	18.5 cm to < 21.0 cm	<18.5 cm
>18 Years	>23.0 cm	19.0 cm to < 22.0 cm	<19.0 cm

*Adopted from WHO Guidelines for Integrated Approach to the National Care of HIV infected Children (2008)
+IMAMG Integrated Management of Acute Malnutrition Guidelines, Republic of Uganda Ministry of Health (2010)

There are also guidelines for specific populations including: Pregnant/Lactating women, lactating women with infants under 6 months, special needs individuals, HIV infected individuals, tuberculosis infected individuals, and the elderly. The IMAMG guidelines are highly specific to the context of Uganda; however, there are no specific instructions within the IMAMG regarding Indigenous populations within Uganda (i.e. the Batwa). In this analysis, I use unadjusted MUAC measurements to classify individuals qualifying as SAM or MAM within their age- and sex-specific thresholds.

3.4 Measuring Indigeneity

To explicitly model Indigeneity – which this study proposes is a meaningful driver of a health gradient - I chose to create a binary variable called 'ETHNICITY' (where 0 = membership to the Bakiga ethnicity and 1 = membership to the Batwa ethnicity). In this way, all individuals in the dataset can be empirically separated into two overarching ethnicity categories, either Batwa or Bakiga. The 'ETHNICITY' variable is thus meant to supersede the existing societal hierarchies captured in the dataset through individual, household, and community variables. The 'ETHNICITY' variable represents a substantively meaningful social division that operates *above* the aforementioned individual, household, and community divisions.

This 'ETHNICITY' variable labels all individuals within a particular community as having either Batwa or Bakiga ethnicity, assuming homogeneity of ethnicity by community. Communities in the area are largely distinct and segregated by ethnicity, even though there is substantial Batwa and Bakiga interaction. There are a low number of Bakiga living in Batwa communities and vice versa. Many children have mixed Batwa and Bakiga heritage, but these children typically live in

Batwa communities and are raised Batwa. Individual-level data on ethnic composition (i.e. around mixed heritage) was not available. If such data were available, it would have been preferable to have both individual-level ethnicity data as well as community-level ethnic membership and composition to further unpack the ways in which ethnicity contributes to health gradients. 'ETHNICITY' here is meant to capture a social construct that reflects the experiences of living in an Indigenous community. Due to the way the variable is structured, a Bakiga living in a Batwa community is presumed to be exposed to some of the same health inequalities related to the Batwa.

3.5 Data analysis

MAM prevalence was calculated by dividing the number of individuals whose MUAC measurements were within the MUAC cutoff for their age (ex. A 12-year-old individual with a MUAC of 16.5 would be experiencing MAM) by the total number of individuals for that age category. SAM prevalence was calculated by dividing the number of individuals whose MUAC measurements were less than the MUAC cutoff for their age (ex. A 12-year-old with a MUAC of 14.5 would be experiencing SAM) by the total number of individuals for that age category. I used confidence intervals when assessing significant differences between groups. I then centered each individual's MUAC measurement on the mean MUAC value for their age-sex class (86).

For multivariable models, we considered two primary outcome variables: MAM status (binary outcome where 1 = MAM status and 0 = no MAM status) and age- and sex-adjusted MUAC percentile (continuous numeric value between 0 and 100). SAM was not included as an outcome because there were an insufficient number of cases that allowed for multivariable statistical testing, and modeling on the few observed cases would risk overfitting. To estimate MUAC percentiles for each individual, prevalence estimates of MAM and SAM for each age-sex stratum were calculated by taking the number of individuals meeting MAM and SAM MUAC cutoffs divided by the total number of individuals in that age-sex stratum. The obtained age- and sex-centered adjusted percentiles were then smoothed in STATA 13 using the -*smooth*- command – this applies a robust nonlinear moving-window smoother to a variable of interest such that the resulting smoothed data represents a new median-based sample (in the hopes that the general shape of a variable will become more apparent by reducing the unsystematic random noise in the variable) (87).

We calculated an asset-based wealth index as a stand-in proxy for wealth measurements; this approach has been validated in rural and resource poor settings in other health studies (89). We used a principle component analysis to estimate this index. Asset variables included ownership of a radio, ownership of animals, ownership of soap, ownership of a cellphone, ownership of a bicycle, receiving remittances, and owning land.

Multilevel multivariable regression models with random intercepts at the household, community, and ethnic levels were built for both dependent variables of interest. To reach these final models, I began by conducting univariate linear and logistic models possible predictor/control variables of interest and the two primary dependent variables. Collinearity was assessed through graphical analysis of the Pearson residuals as well as an examination of relative variance inflation factors (VIF). To check for confounding, variables were added and removed to detect changes in coefficient values or odds ratios greater than 25% (see discussion in Appendix X). Age- and sex-stratified models were specified in a sensitivity analysis to see how results would change when stratified (see Appendix X). Final models were compared through both Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC). In post-estimation, Pearson's residuals were graphically assessed to validate assumptions of normality and homogeneity (BLUPs).

I then contextualized the overall prevalence of malnutrition in the Batwa to the reported Uganda population prevalence, the SSA regional population prevalence average, and the average population prevalence undernourished across developed regions.

3.6 Using multilevel modeling to unpack a health gradient

In order to unpack the causes of ethnic gradients in malnutrition between the Batwa and Bakiga, I used multilevel modeling and variation partitioning to explore the extent to which differences in malnutrition are attributable to the *composition* of the populations (e.g. are more Batwa who are poorer, young, or less educated than Bakiga, leading to differences in apparent malnutrition) or the *context* of the population (e.g. regardless of individual or household wealth, or even geographic location, does the *ethnicity of the community* matter?). Variance partitioning seeks to identify the level of aggregation — in this case individual, household, community, or community ethnicity — at which malnutrition varies the most, or the extent to which each level of clustering can explain differences in malnutrition between individuals. These analyses thus sought to unpack the potential causal mechanisms underlying the ethnic gradient in health between the Batwa and Bakiga, exploring whether Batwa individuals are more malnourished due to *who they are* or by characteristics of *where they live*, with a focus on community ethnicity as a social gradient and higher-level social construct influencing health.

I built a multilevel mixed linear regression predicting age- and sex-centered, smoothed MUAC percentiles. Multilevel modeling allows a statistical analyst to look at clustering as substantively interesting, rather than nuisance that needs to be controlled (90). Certain assumptions of the widely used Ordinary Least Squares (OLS) regression method force the analyst into a series of assumptions about their data, such as, complete independence between observations, homogeneity in the underlying variance, and linear relationships between parameters of interest.

When an analyst thoroughly – and correctly – abides by the required assumptions of OLS regression, a tradeoff occurs wherein a story's true complexity is traded for the truest *average* version of that story. However, if an analyst seeks to explore a story's true complexity, multilevel modelling allows for a more robust way to model *compositional* characteristics (e.g., individual characteristics), *contextual* characteristics (e.g., collective characteristics), and the *compositional-contextual* interactions between (91, 92).

To quantify these contextual and compositional-contextual interaction, multilevel modeling makes use of variance partitioning. In a standard OLS regression model, variation in y_i is accounted for by a single σ^2 parameter, for example (Eq. 1):

(Eq. 1) $$y_i = X_i\beta + e_i, e_i \sim N(0, \sigma^2)$$

However, in a multilevel model, the variance components are broken up into however many levels a given model has (in Eq. 2, there are 2-levels):

(Eq. 2) $$y_{ij} = X_{ij}\beta + u_j + e_{ij}, u_j \sim N(0, \sigma_u^2), e_{ij} \sim N(0, \sigma_e^2)$$

The above variance is partitioned into the two components u_j and e_{ij}, where σ_u^2 represents between-level variance and σ_e^2 represents residual-level variance. These are known to represent between- and residual-level variance as they are the derivations of the variance when examining the OLS regression in matrix form (also known as the 'variance-covariance matrix', for proofs see 109).

Once models have been fully specified, I calculated the variance partitioning coefficient (VPC) with the following equation (Eq. 3, for proofs see 109):

(Eq. 3) $$VPC = \sigma_u^2 / (\sigma_e^2 + \sigma_u^2)$$

The VPC allows me to calculate the percentage of the variance explained by the highest level of the model (109). I built four models in total, each with different hypothesized social hierarchies of empirical interest thought to shape the outcome of malnutrition in the Batwa and Bakiga: (1) Individual, Household, and Community Levels (excluding covariates), (2) Individual, Household, and Community Levels (including covariates), (3) Individual, Household, community, and Ethnicity Levels (excluding covariates), and (4) Individual, Household, Community, and Ethnicity Levels (including covariates). Models 1 and 2 are meant to demonstrate the multilevel mixed regression results if we were to only model Individual, Household, and Community characteristics. Models 3 and 4 include community ethnicity as a level, which we explicitly modeled to account for difference in malnutrition clustering at different social levels between Batwa and Bakiga populations. As per the recommendations of Subramanian (personal communication), the following figure illustrates the hierarchy used in to construct multilevel model (Figure 1).

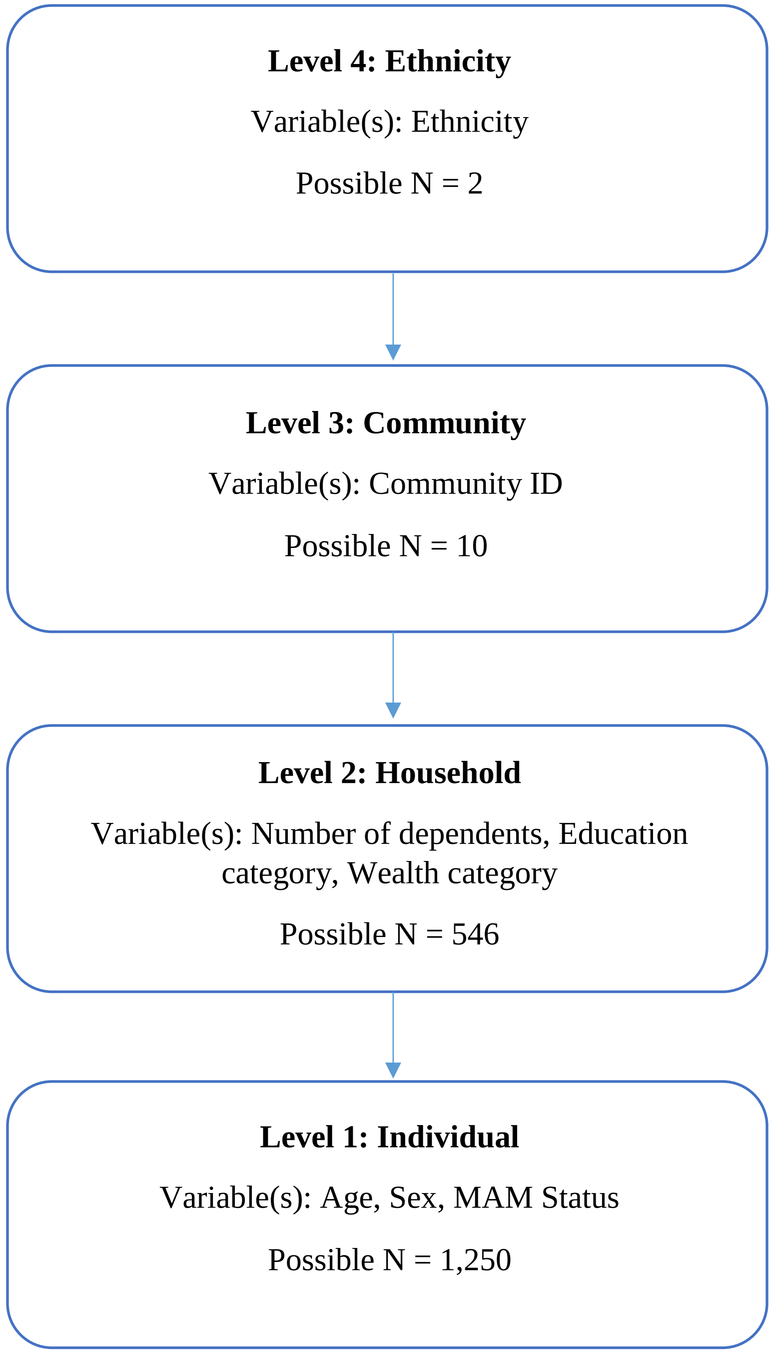

Figure 1. Visualization of hierarchical data structure used in multilevel model

I also modeled MAM status as a binary outcome variable. The results did not substantially differ, and I thus only present the results of the continuous outcome variable (MUAC). The logistic regression results for MAM status are presented in the supplementary materials (Appendix 1a). For the Individual and Household levels, control parameters were selected based on Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), wherein I selected a model with the lowest AIC and BIC values to minimize the estimated effect of missing data in the model (for more information on a comparison of AIC and BIC, see 93).

Chapter 4: Results

4.1 Malnutrition among Batwa and Bakiga

Malnutrition is high in among both Batwa children and adults. Nearly half of all Batwa adults and nearly a quarter of all Batwa children experienced moderate acute malnutrition (MAM) (Table 2, Figure 2). SAM was highest among male Batwa adults at 11.60% (95% CI: 4.83-18.37%), followed by male Batwa children (prevalence: 8%; 95% CI: 3.3-12.7%). The prevalence of MAM and SAM was high among all age- and sex-strata of Batwa: all Batwa strata met the WHO criteria for a 'Critical health situation crisis' for malnutrition (Table 2, 88).

In contrast, none of the Bakiga sex-age strata presented MAM or SAM rates meeting WHO criteria for a malnutrition crisis based on presence of wasting (i.e. MAM or worse) in a given population (Table 2) (88). MAM and SAM prevalence was significantly higher ─ across all age- and sex-strata ─ among Indigenous Batwa compared to the non-Indigenous Bakiga (Table 2, Figure 2), with the exception of female children (whose prevalence of SAM was similar at 3.36% and 3.4%, respectively). The highest rates of malnutrition among Bakiga were male children, with 2.2% (95% CI: 0.03–4.37%) of the population classified as MAM.

Table 2. Age- and sex- specific prevalence of MAM and SAM for the Bakiga and Batwa of SW Uganda, April 2014

Gender and ethnicity grouping	Total	Mean MUAC (CI)	MAM % (CI)	SAM % (CI)	WHO Crisis Cutoffs (-- for acceptable, - for poor, + for serious, ++ for Critical)
Children (<18 years of age)					
Male Bakiga	175	19.65 (19.08-20.22)	2.2% (0.03-4.37)	0.57% (-0.55-1.69)	--
Male Batwa	128	16.04 (15.58-16.50)	20% (13.07-26.93)	8% (3.3-12.7)	++
Female Bakiga	176	19.83 (19.25-20.40)	1.7% (-0.21-3.61)	3.40% (0.72-6.08)	--
Female Batwa	124	16.47 (15.96-16.99)	25.2% (17.56-32.84)	3.36% (0.19-6.53)	++
Adults (>=18 years of age)					
Male Bakiga	106	27.47 (26.99-27.94)	0.90% (-0.90-2.70)	0% (NA)	--
Male Batwa	86	22.21 (21.57-22.85)	45.34% (34.82-55.86)	11.60% (4.83-18.37)	++
Female Bakiga	239	28.55 (28.16-28.94)	0.42% (-0.40-1.24)	0% (NA)	--
Female Batwa	133	22.68 (22.24-23.11)	45.86% (37.39-54.33)	3% (0.10-5.90)	++

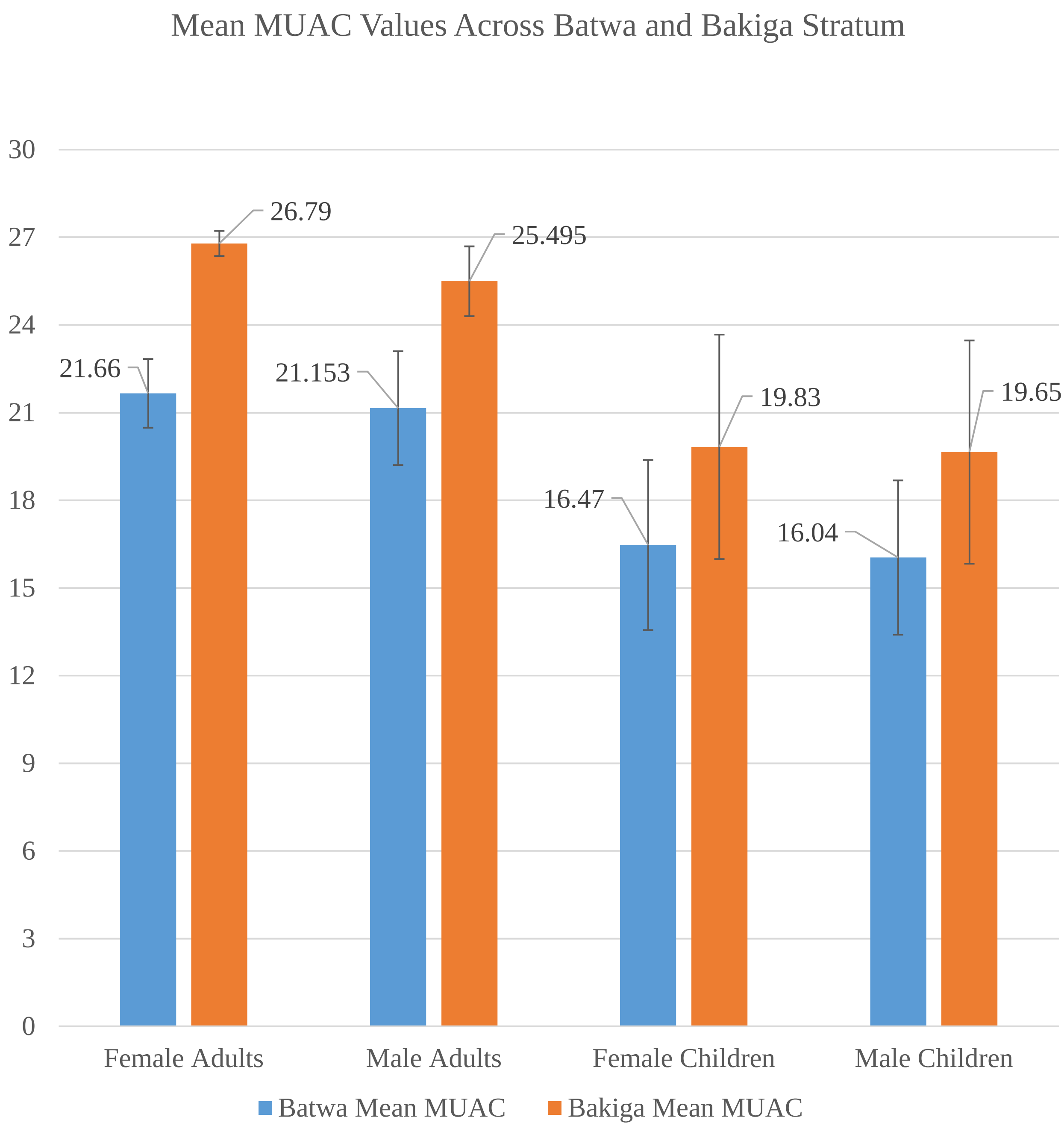

Figure 2. Comparison of Batwa and Bakiga MUAC means across population strata

4.2 Unpacking the malnutrition gradient

In order unpack the Indigenous malnutrition gradient observed between the Batwa and Bakiga, the I used multilevel models and variation partitioning to explore variation in the data at different levels to ask why and where this health gradient emerges. The best-fit model retained age (categorical) and sex as individual-level controls. Number of dependents, maximum education of household head, and relative wealth were retained as household-level controls (Table 3).

Clustering of malnutrition (MUAC) between individuals within the same household and community (Model 1) indicated substantial clustering of MUAC within households; household-level clustering explained 57% of variation in the distribution of smoothed MUAC percentiles. An additional 4% of variation in MUAC was explained by clustering between households in the same community, with 39% left unexplained (i.e. random effects). The addition of covariates at the household and community levels added predictive and explanatory power to the model, and highlighted the role of household wealth in driving clustering of malnutrition among individuals within the same household (Model 2).

The addition of community ethnicity as a higher-level variable resulted in a significant shift in model results (Models 3 and 4), with community ethnicity explaining 64-66% of variation in MUAC. The inclusion of community ethnicity led to a drop in the explanatory power of household-level clustering, with community-level variance remaining minimal. There was minimal change in results when covariates were included in the model (Model 4). The greatest portion of variance in malnutrition was explained by community ethnicity (>60%), both with and without controls (Table 3, Figure 5). When community ethnicity was included in the model, household level predictors dramatically lowered their explanation of variance. Community level variance changed only incrementally between models (changing between 2-3%). These results point to a significant and strong clustering effect of malnutrition between Batwa and Bakiga that cannot be explained by compositional factors associated with risk factors or unmeasured characteristics of individuals, households, or community location.

Table 3. Multilevel mixed regression results for Batwa and Bakiga malnutrition

Model name (description)	*All models control for household and community level clustering, and control for individual age and sex*			
	Model 1 Baseline with household and community clustering, controlling for age and sex	**Model 2** Model 1 + household-level predictors	**Model 3** Model 1 + clustering by ethnicity	**Model 4** Model 1 + household-level predictors and clustering by ethnicity
Variance partitioning (explanatory ability of clustering by household, community, and ethnicity)				
Total variation (%)	373.94 (100)	325.45 (100)	438.74 (100)	445.03 (100)
Explained by Household (%)	215.67 (57)	183.10 (56)	4.34e^-14 (<1)	5.7e^-14 (<1)
Explained by Community (%)	14.25 (4)	6.13 (2)	21.53 (4.9)	21.76 (5)
Explain by Ethnicity (%)	-	-	280.92 (64)	296.26 (66)
Random effects/ Unexplained (%)	144.02 (39)	126.22 (42)	136.29 (31)	127.01 (28)
Intercept/Constant	57.78	45.098	49.97	46.152
Individual Predictors (controls)				
Age category				
<5	Ref.	Ref.	Ref.	Ref.
5-18	-2.38 (-4.76 - -0.008)	**-3.186 (-6.27 – 0.093)***	-1.36 (-3.24 – 0.524)	-2.00 (-4.44 – 0.44)
18-45	7.08 (4.83 – 9.32)	**6.235 (3.43 – 9.03)***	6.76 (4.83 – 8.70)	**6.202 (3.88 – 8.52)***
>45	3.94 (1.24 – 6.65)	**5.047 (2.04 – 8.05)***	4.13 (1.94 – 6.32)	**4.622 (2.22 – 7.02)***
Sex				
Female	Ref.	Ref.	Ref.	Ref.
Male	-2.87 (-4.56 - -1.18)	**-1.912 (-3.65 - -0.165)***	-2.45 (-3.81 - -1.09)	**-1.88 (-3.27 - -0.49)***
Household-level Predictors				
Number of dependents	-	**1.027 (0.260 – 1.795)***	-	**0.686 (0.30 – 1.06)***
Max education category				
No formal schooling				
Primary incomplete	-	Ref.	-	Ref.
Primary complete or Above	-	1.28 (-1.09 – 3.66)	-	1.42 (-0.442 – 3.29)
	-	2.45 (-2.37 – 6.86)	-	0.498 (-3.07 – 4.07)
Wealth category				
Least wealthy	-	Ref.	-	Ref.
Middle wealthy	-	**8.17 (4.67 – 11.67)***	-	-1.19 (-2.93 – 0.542)
Most wealthy	-	**14.36 (10.81 – 17.91)***	-	0.571 (-1.32 – 2.46)
AIC of model	10255.77	9210.81	9484.77	8517.34
BIC of model	10296.58	9275.83	9530.68	8587.35

*Denote significance using a 95% confidence interval.

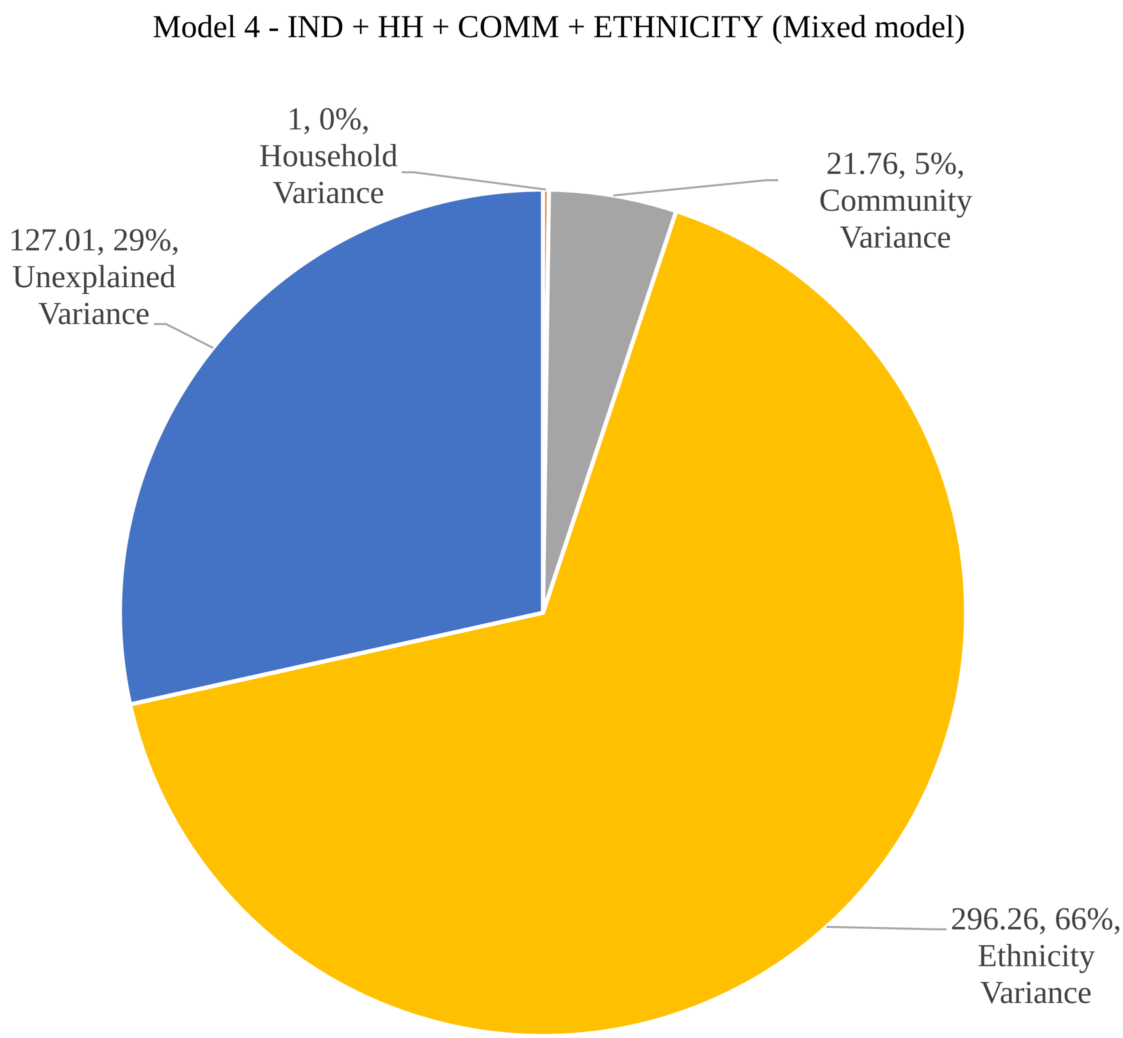

Figure 5. Variance partitioning from Model 4 (Table 3)

Chapter 5: Discussion

5.1 Comparison of Batwa malnutrition to national, regional, and global prevalence rates

This thesis highlights severe malnutrition among all Batwa age- and sex-strata in Kanungu District, Uganda, with Batwa malnutrition rates meeting WHO criteria for a critical malnutrition crisis. The Batwa's population prevalence of malnutrition (ranging from 20% to 45% of a given population stratum) is higher than the reported national Ugandan population prevalence, which UNICEF estimated to be between 13.8% and 20% in 2008-2012 (21). The Batwa's population prevalence of malnutrition is also higher than the regional population prevalence for Sub-Saharan Africa, which the FAO estimated to be 23.2% from 2014-2016 (6). FAO estimates the average population prevalence of undernourishment in developed countries is less than 5% (6). If health inequalities emerge both between- and within- groups of people and places of inhabitance (following Marmot's 2006 understanding of health inequalities), the malnutrition prevalence of the Batwa who reside in Kanungu demonstrates a health inequity across multiple dimensions. The Batwa have a between-ethnic group inequality when compared to the nearby Bakiga. The Batwa have a within-area inequality when compared to the greater population prevalence rates of malnutrition in greater Uganda. The Batwa have a global between-places inequality when compared to populations in developed regions. Malnutrition is one of numerous health inequalities faced by the Batwa. Table 4 compares health and socioeconomic indicators for the Batwa and comparison groups, displaying a consistent gradient in health inequity (4, 7).

Table 4. Table comparing socioeconomic and health indicators of the Batwa and Bakiga

Indicator	Batwa	Bakiga	SW Uganda	Uganda
Health				
Life Expectancy at birth (years)	28[a]	n/a	n/a	59[b]
Child mortality (% under 5 years)	38[b]	n/a	12.8[g]	9[g]
HIV/AIDS (%)	2.3[c]	9[j]	3.8[c]	7.4[h]
Malaria Prevalence Among Adults (proportion of population in July 2013 and April 2014 – all adults Batwa, sample adults Bakiga)	29 (6.45)[d]	20 (4.46)[d]	n/a	19%[k]
Education				
Adult literacy (% 15-49 years)	<10[e]	n/a	Women: 75.5, Men: 77.4[g]	Women: 64.2, Men: 77.5[g]
Livelihoods and Income				
GDP per capita (Constant 2000 USD)	160[f]		n/a	696[f]
Household mosquito net use (did not have nets, proportion of population)	93 (70.99)[d]	218 (53.56)[d]	n/a	71.6%[k]
Assets (did not have any assets, proportion of population)	82 (62.12)[d]	77 (19.01)[d]	0.30 Gini Coefficient[l]	0.29 Gini Coefficient[l]
Access to handwashing facilities (did not have access to handwashing facilities, proportion of population)	96 (73.85)[d]	229 (56.40)[d]	86.8%[m]	86.0%[m]
Access to soap (did not have access to soap, proportion of population)	98 (75.38)[d]	252 (62.06)[d]	*8.3% of people had access to handwashing facilities with both water and soap*[m]	*Average of 7.2% of people had access to handwashing facilities with both water and soap*[m]

a As of 2000 (BDP, 2003)
b As of 2011 (World Bank, 2015)
c As of 2009 for Mpungu and Kayonza subcountines in Kanungu District (Birugni, 2010)
d As of 2013 and 2014 (Donnelly et al., 2016)
e As of 2012 (Berrang-Ford et al., 2012)
f Patterson et al., 2015
g As of 2011 (UBOS, 2011)
h As of 2014 (UNAIDS, 2015)
i As of 2014 (World Bank, 2015)
j As of 2011 (Ugandan Ministry of Health AIDS Indicator Survey, 2011)
k As of 2015 - Estimated population prevalence (Uganda Ministry of Health Malaria Indicator Survey, 2015)
l As of 2015 – Gini coefficient based on composite wealth index (Uganda Ministry of Health Malaria Indicator Survey, 2015)
m As of 2012/2013 (Uganda National Household Survey, 2012-2013)

The health inequality faced by the Batwa is similar to inequalities faced by Indigenous peoples around the world, especially amongst Indigenous children (148, 149). Across Latin American Indigenous children, rates of malnutrition are double to that of the general population (94). Among Aboriginal peoples living in Australia, Indigenous children under five years old from the Northern Territory had a higher prevalence of underweight (14.5%) and stunting (11.3%) compared to the healthy population profile for the area where the underweight prevalence was expected to be 2.3% (95). The *Orang Asli* of Peninsular Malaysia demonstrated high proportions of underweight (49%) and stunted (64%) children compared to Malaysian national averages (11%) (42, 96). Despite differences in the magnitude of the malnutrition inequality from one Indigenous context to another, there is persistent evidence of an Indigenous gradient in health associated with malnutrition in diverse contexts.

5.2 Does 'pygmy' status matter? Genetic determinants of malnutrition

An essential consideration when comparing anthropometric results between the Batwa and Bakiga is the extent to which the Batwa heritage as a 'pygmy' population might explain differences in malnutrition estimates. Some literature theorizes that 'pygmy' stature emerges due to persistent environmental stressors that lead to malnutrition across generations (111), potentially indicating that historical — rather than current — contextual conditions and inequalities are driving lower anthropometric measures among pygmy peoples compared to non-pygmy neighbors. This theory is challenged by others, however, including Migliano, whose research on the Efe and Lese of the Philippines suggests that the effect of chronic malnutrition on stature trajectory is incompatible with the growth rate in ‘pygmy’ adolescence, thus suggesting a possible genetic component that drives ‘pygmy’ stature rather than malnutrition (111).

Genetic arguments for the emergence of ‘pygmy’ stature in a population point to environmental pressures that favored the short stature of pygmies (113, 114, 115, 116, 118). Theories purport that the emergence of the ‘pygmy’ phenotype was environmentally advantageous, such that a given population could adapt to environmentally harsh situations (such as a dense wooded environment) to increase thermoregulation, increase forest-environment mobility (i.e. scaling trees, avoiding continuous crouching), or to facilitate a relatively early age of reproduction (i.e.) (113, 114, 115, 116, 119). Rather than attribute ‘pygmy’ status to ever-present malnutrition driven by a deterministic environment (111), genetic theories suggest a genetic adaptation by peoples living in a harsh environment that maximizes fitness under conditions of limited lifespan.

Other notable explanations for the emergence of the ‘pygmy’ stature are important to mention even if they do not address malnutrition or environmental pressures. One explanation for ‘pygmy’ population draws upon the possibility that the ‘pygmy’ phenotype is an historic artefact rather than an advantageous evolutionary adaptation or environmentally-induced change (117, 118). Somewhat similarly, other authors have suggested that difference in stature may be attributable to a genetic split that drove height in opposite directions (120, 121). Although these are less frequent and poorly supported explanations — their explanation for the 'pygmy' phenotype is that it comes from random mutations in the reproductive cycle — they are recurring narratives that appear in pygmy literature.

In the context of the results presented in this thesis for Batwa and Bakiga, genetic explanations for the observed ethnic gradients in my results are plausible. Evolutionary theories could explain adult differences in malnutrition between the Batwa and Bakiga that reflect historic contexts and pressure. In this case, however, we should observed a narrower gradient for malnutrition inequality among Batwa and Bakiga children, who have no experience with forest livelihoods, and in many cases whose parents lived outside of the forest much of their life as well. I additionally used an anthropometric measure, MUAC, that is the least likely to be biased due to differences in stature (weight or height) between Batwa and Bakiga.

5.3 Why ethnicity matters: social gradients in health

The social gradients in health literature points to the potential role of social context in explaining community-level ethnic gradients in health. In this context, community ethnicity can be understood and interrogated as a determinant of health among the Batwa and Bakiga of Kanungu District (4). There has been substantial literature theorizing such links between ethnicity and health, ranging in both approach and focus (122-128).

As a social determinant of health, ethnicity has been posited as a proxy for socio-economic factors (such as employment, education, and income), environmental factors (such as the quality of the physical environment) and social power relations (both within communities and in regards to political empowerment, sometimes referred to as distal determinants of health) (122). When ethnicity stratifies available employment options, marginalized ethnicities are less likely to obtain similar levels of social support from their peers and are more likely to find means of employment with hazardous or insecure working conditions that negatively affect health (129, 130, 131). In Indigenous and Aboriginal peoples, there is a unifying history of colonialism, racism, and social exclusion, within which all other determinants can be constructed (137, 138, 139). One important legacy of colonialism on Indigenous peoples was — and continues to be — the dispossession and displacement from traditional lands, wherein Indigenous peoples were restricted from continuing established social activities (such as hunting, trapping, and gathering) that are integral to survival and cultural continuity (140-143). Research on Aboriginal peoples in Canada found that traditional harvesting was linked to "a greater rapport with the land, an increased sense of self-reliance and enhanced overall health." (140).

When discussing ethnicity as a social determinant of health, ethnicity is confounded by other social determinants (such as class) (132, 133). It was only in the mid-1980s that the idea that other social aspects of health could be both "intertwined with as well as independent of race" (122). These types of understandings would foreshow the intersectional approach that is now increasingly common in the social determinants of health literature, wherein researchers are increasingly recognizing how each aspect of a given person's identity can *intersect* with another aspect to alter health status (134, 135, 136). Through such intersectional approaches, previously overlooked, nuanced aspects of identity, such as geographic isolation, sexuality, disease stigmatization, and Indigeneity, among others, are slowly being folded into the established social determinants of health literature.

In regards to the Batwa, ethnicity captures differences in health and social outcomes. Previous work conducted by the IHACC research team found that the proportion of Batwa households facing chronic and very low food security ranged from 79%-92% (75). In the same study, Patterson found that Batwa who sought employment in the seasonal tourism industry as an alternative to focusing on growing food for themselves may have generated more income to purchase food in markets but demonstrated no quantitative evidence of improved food security (75). Additionally, Donnelly (22) found that Batwa experienced a higher risk of malaria compared to Bakiga even after controlling for wealth and other socioeconomic factors, pointing primarily to differences in the physical structure of houses. The origins of these inequalities are mixed and cannot be reduced to a single point. Major historical moments that shifted Batwa livelihoods include their initial contact with British colonizers during the initial dividing of Uganda into 'ethnic' and 'tribal' provinces (145) as well as the forest gazetting processes that led to their eviction from Bwindi Forest in 1991 (109, 143, 144). This prolonged and substantial dispossession of land parallels other instances of Indigenous dispossession and may be a driving force in inequalities of health, livelihoods, and socioeconomic access (140). Moreover, the Batwa's 'pygmy' identity and its inextricable connection to their ethnic identity has posed a series of recognition problems with the contemporary Ugandan government, demonstrating another parallel with previous research that posited negative health impacts when an ethnicity was marginalized in societal power relationships (122, 146, 147). Without formal recognition and representation in contemporary Ugandan institutions, the Batwa are forced to not only overcome existing resource and social inequalities but also act as advocates for their own issues from a marginalized place in Ugandan society (148).

5.4 Conclusions

This research analyzed the prevalence of malnutrition in the Indigenous Batwa and non-Indigenous Bakiga of Southwestern Uganda through a mixed methods approach. Drawing from field surveys conducted by the IHACC research group, the quantitative analysis estimated the prevalence of malnutrition in both the Batwa and Bakiga, and conducted variation partitioning at individual, household, community, and ethnic levels to explain variation in malnutrition distributions. These results suggest that ethnicity is a strong explanatory force for the distribution of malnutrition between the Batwa and Bakiga of Kanungu District, Uganda, and supports the existing body of research that argues for understanding Indigeneity as a social determinant of health.

As a social determinant of health, many of the inequalities that emerge along ethnic lines are intervenable. To understand *and* begin remedying these inequalities, future research must approach through the perspective of advocacy to provide evidence and arguments that can be incorporated into policy suggestions or new legislation. A promising type of research would be intervention studies, which could provide "immediate adaptation support" while "building evidence for broader project implementations" (75). These research projects should prioritize what the Batwa articulate as necessary and consent to.

While a reading of this thesis might incline the reader to see the Batwa's situation as hopeless or dire, the Batwa are a people with extreme adaptive capabilities and resilience. The Batwa have survived and persisted through both the European colonial period in Uganda as well as the 'post-colonial' eviction from their forest homelands. The Batwa have mobilized through the United Organization for Batwa Development in Uganda (UOBDU), and are currently seeking to address issues of land, housing, education, income, forest access and more. Researchers interested in Indigenous social determinants of health can provide collaborative support with the Batwa to amplify their voices on the path of addressing historical injustice.

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APPENDIX A: Multilevel logit regression results for MAM outcomes

Multilevel logit results - MAM (Odds Ratio, CI, p-value in stars, ** = 90% and * at 95%) (predicting MAM, v1)

Model name (description)	**IND + HH + COMM (No controls)**	**IND + HH + COMM**	**IND + HH + COMM + ETHNICITY (No controls)**	**IND + HH + COMM + ETHNICITY**
Intercept/Constant	0.19 (0.006 – 0.053)	0.358 (0.010 – 0.118)	0.0138 (0.001 – 0.179)	0.018 (0.001 – 0.277)
Controls				
Age category				
<5	Ref.	Ref.	Ref.	Ref.
5-18	3.022 (1.48 – 6.13)*	4.45 (1.77 – 11.20)*	3.26 (1.65 – 6.42)*	3.50 (1.48 – 8.24)*
18-45	3.568 (1.75 – 7.27)*	4.51 (1.90 – 10.68)*	4.00 (2.01 – 7.96)*	3.83 (1.72 – 8.53)*
>45	4.674 (2.18 – 10.00)*	4.91 (2.03 – 11.85)*	4.75 (2.298 – 9.85)*	5.16 (2.24 – 11.91)*
Sex	1.16 (0.77 – 1.75)	1.08 (0.682 – 1.71)*	1.33 (0.904 – 1.96)	1.32 (0.863 – 2.04)
Number of dependents	-	1.02 (0.889 – 1.189)	-	0.970 (0.864 – 1.089)
Max education category				
-No formal schooling	-	Ref.	-	Ref.
-Primary incomplete	-	0.517 (0.284 – 0.939)*	-	0.609 (0.343 – 1.080)**
-Primary complete or Above	-	0.206 (0.038 – 1.11)**	-	0.348 (0.069 – 1.756)
Wealth category				
-Least wealthy	-	Ref.	-	Ref.
-Middle wealthy	-	0.67 (0.360 – 1.25)	-	1.72 (1.06 – 2.78)*
-Most wealthy	-	0.201 (0.090 – 0.446)*	-	0.939 (0.499 – 1.769)
Clustering measurements				
Area level variance (S.E.)				
-Household	1.28 (0.638 – 2.595)	1.921 (0.971 – 3.802)	1.48e-40 (NA)	0.0616 (0.000 – 74.728)
-Community	0.150 (0.024 – 0.902)	0.269 (0.000 – 47.11)	6.94e-34	4.45^-15 (N.A.)
-Ethnicity	-	-	3.04 (0.41 – 22.50)	3.273 (0.442 – 24.227)
Median OR				
-Household	2.92	3.57	3.14e^-20	0.640
-Community	1.00	1.33	6.80e^17	1.72^-7
-Ethnicity	-	-	4.50	4.674
Interclass correlation coefficient				
-Household	0.63	0.368	0.00* (So small)	0.018
-Community	0.04	0.075	0.00* (So small)	1.35^-15
-Ethnicity	-	-	0.577	0.498
Model fit parameters				
AIC of model	878.92	757.91	696.22	609.15
BIC of model	914.63	817.92	726.83	669.17

APPENDIX C: Multilevel logit results for SAM outcomes

Multilevel logit results - SAM (Odds Ratio, CI, p-value in stars, ** = 90% and * at 95%) (predicting MAM, v2)

Model name (description)	**Individual variables (n=1,214)**	**IND + HH**	**IND + HH + COMM**	**IND + HH + COMM + ETHNICITY**
Intercept/Constant	0.045 (0.020 – 0.099)	0.036 (0.011 – 0.119)	0.358 (0.010 – 0.118)	0.018 (0.001 – 0.277)
Independent variables				
Age category				
<5	Ref.	Ref.	Ref.	Ref.
5-18	2.88 (1.50 – 5.51)*	4.46 (1.77 – 11.22)*	4.45 (1.77 – 11.20)*	3.50 (1.48 – 8.24)*
18-45	3.08 (1.60 – 5.94)*	4.50 (1.90 – 10.67)*	4.51 (1.90 – 10.68)*	3.83 (1.72 – 8.53)*
>45	3.74 (1.88 – 7.43)*	4.89 (2.03 – 11.78)*	4.91 (2.03 – 11.85)*	5.16 (2.24 – 11.91)*
Sex	1.09 (1.88 – 7.43)	1.08 (0.681 – 1.716)	1.08 (0.682 – 1.71)*	1.32 (0.863 – 2.04)
Number of dependents	-	1.02 (0.888 – 1.189)	1.02 (0.889 – 1.189)	0.970 (0.864 – 1.089)
Max education category				
-No formal schooling	-	Ref.	Ref.	Ref.
-Primary incomplete	-	0.515 (0.283 – 0.935)*	0.517 (0.284 – 0.939)*	0.609 (0.343 – 1.080)**
-Primary complete or Above	-	0.206 (0.038 – 1.11)**	0.206 (0.038 – 1.11)**	0.348 (0.069 – 1.756)
Wealth category				
-Least wealthy	-	Ref.	Ref.	Ref.
-Middle wealthy	-	0.66 (0.367 – 01.217)	0.67 (0.360 – 1.25)	1.72 (1.06 – 2.78)*
-Most wealthy	-	0.196 (0.089 – 0.428)*	0.201 (0.090 – 0.446)*	0.939 (0.499 – 1.769)
Clustering measurements				
Area level variance (S.E.)				
-Household	-	1.95 (1.00 – 3.81)	1.921 (0.971 – 3.802)	0.0616 (0.000 – 74.728)
-Community	-	-	0.269 (0.000 – 47.11)	4.45^-15 (N.A.)
-Ethnicity	-	-	-	3.273 (0.442 – 24.227)
Median OR				
-Household	-	3.60	3.57	0.640
-Community	-	-	1.33	1.72^-7
-Ethnicity	-	-	-	4.674
Interclass correlation coefficient				
-Household	-	0.372	0.368	0.018
-Community	-	-	0.075	1.35^-15
-Ethnicity	-	-	-	0.498
Model fit parameters				
AIC of model	901.92	755.99	757.91	609.15
BIC of model	927.43	811.00	817.92	669.17

APPENDIX D. Smoothed MUAC Percentile OLS regression results (variables of interest)

Table C. Results for univariate OLS regressions between smoothed MUAC percentile and different variables of interest (Odds Ratio, CI, p-value in stars, ** = 90% and * at 95%)

Variable Name	Entire population	Children (<18)	Adult Males	Adult females
Ethnicity (Ref. = Bakiga)	27.17 (14.15 – 52.14)*	13.20 (5.92 – 29.41)*	42.29 (5.63 – 317.50)*	84.48 (20.22 – 352.91)*
AVPS	1.01 (0.973 – 1.048)	1.00 (0.945 – 1.060)	1.028 (0.936 – 1.129)	1.024 (0.966 – 1.085)
Dependents	1.07 (0.980 – 1.17)	0.943 (0.816 – 1.090)	1.035 (0.859 – 1.247)	1.244 (1.070 – 1.445)*
Education category				
No schooling	Ref.	Ref.	Ref.	Ref.
Primary incomplete	0.817 (0.568 – 1.175)	1.96 (1.04 – 3.72)*	0.462 (0.189 – 1.126)**	0.464 (0.256 – 0.843)
Primary complete or higher	0.229 (0.054 – 0.970)*	0.791 (0.097 – 6.427)	0.206 (0.024 – 1.754)	Omitted.
Wealth				
Least wealthy	Ref.	Ref.	Ref.	Ref.
Middle wealthy	0.796 (0.551 – 1.15)	0.968 (0.557 – 1.683)	0.461 (0.191 – 1.110)**	0.783 (0.424 – 1.446)
Most wealthy	0.258 (0.156 – 0.428)*	0.237 (0.1016 – 0.5527)*	0.165 (0.051 – 0.526)*	0.324 (0.151 – 0.695)*
Alcohol	3.62 (1.87 – 7.01)*	-	1.99 (0.533 – 6.31)	5.58 (2.42 – 12.87)*
Land ownership	0.993 (0.701 – 1.406)	1.00 (0.591 – 1.713)	0.932 (0.416 – 2.085)	0.967 (0.544 – 1.718)
Bednet use	0.193 (0.026 – 1.427)	0.357 (0.468 – 2.727)	Omitted.	Omitted.
Land Quality				
Flat	Ref.	Ref.	Ref.	Ref.
Mixed	0.675 (0.452 – 1.010)**	0.626 (0.343 – 1.143)	0.542 (0.237 – 1.736)	0.754 (0.388 – 1.468)
Hilly	0.905 (0.560 – 1.462)	0.749 (0.359 – 1.562)	1.389 (0.477 – 4.049)	0.986 (0.433 – 2.244)

APPENDIX E: Logit MAM status regression results (variables of interest)

Table D. Results for univariate logit regressions between MAM status and different variables of interest (coefficient, CI, p-value in stars, ** = 90% and * at 95%)

Variable Name	Entire population	Children (<18)	Adult Males	Adult females
Ethnicity (Ref. = Bakiga)	-33.06 (-34.56 - -31.56)*	-27.33 (-28.81 - -25.85)*	-32.21 (-36.42 - -28.00)**	-50.67 (-55.71 - -45.63)*
AVPS	-0.183 (-0.44 – 0.077)	0.036 (-0.255 – 0.328)	-0.047 (-0.750 – 0.656)	-0.421 (-1.16 – 0.321)
Dependents	-0.151 (-0.789 – 0.486)	0.274 (-0.442 – 0.991)	-0.622 (-2.10 – 0.863)	-1.26 (-3.20 – 0.67)
Education category				
No schooling	Ref.	Ref.	Ref.	Ref.
Primary incomplete	2.05 (-0.55 – 4.66)	-3.56 (-6.44 - -0.677)*	6.79 (-0.88 – 14.48)**	13.82 (6.52 – 21.12)*
Primary complete or higher	11.3 (5.37 – 17.39)*	4.23 (-3.79 – 12.25)	14.10 (1.69 – 26.51)*	21.52 (5.52 – 37.52)*
Wealth				
Least wealthy	Ref.	Ref.	Ref.	Ref.
Middle wealthy	9.24 (6.54 – 11.96)*	7.30 (4.40 – 10.20)**	10.73 (3.54 – 17.93)*	13.51 (5.38 – 21.63)*
Most wealthy	17.41 (14.68 – 20.15)*	14.98 (12.02 – 17.94)**	18.42 (11.24 – 25.59)**	27.05 (19.04 – 35.07)*
Alcohol	-10.04 (-15.24 - -4.83)*	-	-3.76 (-11.15 – 3.63)	-20.95 (-31.68 - -10.21)*
Land ownership	1.90 (-0.56 – 4.36)	2.377 (-0.293 – 5.049)**	2.71 (-3.66 – 9.10)	2.34 (-5.02 – 9.71)
Bednet use	14.59 (8.05 – 21.13)*	13.56 (6.76 – 20.36)*	16.23 (-2.96 – 35.42)**	28.43 (5.64 – 51.22)*
Land Quality				
Flat	Ref.	Ref.	Ref.	Ref.
Mixed	3.21 (0.240 – 6.18)**	3.94 (0.732 – 7.155)*	0.679 (-7.18 – 8.54)	7.74 (-1.06 – 16.55)**
Hilly	2.70 (-0.926 – 6.34)	2.88 (-1.02 – 6.80)	1.332 (-7.97 – 10.63)	10.55 (-0.684 – 21.79)**

APPENDIX F: MUAC Average by community

Community	Average percentile [95% CI] for smoothed MUAC	N (1,250)
1	48.32 [45.25 – 51.40]	122
2	56.03 [53.15 – 58.92]	159
3	43.96 [38.77 – 49.14]	113
4	53.65 [49.78 – 57.51]	125
5	48.35 [45.04 – 51.66]	130
6	47.08 [42.87 – 51.28]	130
7	46.97 [43.94 – 49.99]	144
8	41.72 [38.26 – 45.18]	128
9	51.17 [47.09 – 55.24]	96
10	64.27 [61.51 – 67.03]	103