Maternal Mental Health and Child Well-Being in Northwest Tanzania

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Summary

Although food insecurity, social capital, demographic characteristics, such as socioeconomic status, maternal education and marital status have been linked to maternal and child well-being individually, no studies have considered each of these variables in single model. The proposed research will do so among peri-urban and rural women and their children in Western Tanzania to test three hypotheses: (1) poverty and social capital predict maternal and child allostatic load, maternal mental health, and food insecurity, (2) food insecurity predicts maternal and child health, with the latter association moderated by actions mothers take to

restrict their own nutritional intake so as to buffer children, and (3) maternal allostatic load and mental health predict child allostatic load. For this opportunistic sample of 150 women and their children aged 3-12 years, blood samples and physical measurements will be collected, and their mothers will be interviewed concerning demographic characteristics, food insecurity, and symptoms of depression and anxiety using locally validated instruments. Maternal and child health will be quantified as allostatic load using a composite index of biological measures that evaluate the body's response to different kinds of stress across developmental time: physical measurements that reflect growth and nutritional status, and blood markers that reflect inflammation, the stress response, and immune system activity. This work will empirically test a new model for the relationship between food insecurity, social capital, demographic characteristics and maternal and child well-being and should have implications for public health strategies in Tanzania and elsewhere in the developing world.

Background

What is known:

1) *Food insecurity*: Food insecurity is a term that describes the lack of physical and economic access to sufficient and nutritious food for the entire household (Campbell et al., 2009). It is a significant public health and humanitarian problem within Northwest Tanzania (Hadley and Patil 2008), as elsewhere within the developing world (FAO 2009). While the relationship isn't consistent, food insecurity in the developing world has been linked to child stunting (Baig-Ansari et al. 2006), underweight (Isanaka, 2007) and under-five mortality (Campbell et al, 2009). Those cases where no link was found between food insecurity and child health (Palmer 2009) might be due mothers compromising their own dietary intake to preserve the adequacy of their children's diets (McIntyre et al. 2003). Among one group of agropastoralists and one group of horticulturists in rural Tanzania, food insecurity predicts maternal depression and anxiety (Hadley and Patil 2008). This is unsurprising: depression and anxiety are expectable consequences of chronic social and material insecurity or uncertainty (Patel et al. 1999).
2) *Demographic characteristics*: Low socioeconomic status has been linked with poor health outcomes for children in developed (Ashiabi and O'Neal, 2007) and developing countries (Spencer, 2000). Marital status (Kennedy and Peters, 1992) and maternal education (Desai and Alva, 1998) have been linked with child health in developing countries.
3) *Social capital*: Social capital is the extent to which people are embedded within their family relationships, social networks and communities, and have a sense of belonging and civic identity (Morrow, 1999). Maternal social capital has been linked to both maternal (Morgan and Swann, 2004) and child (DeSilva and Harpham, 2007) health in developing countries. Moreover, in addition to the effects of material insufficiency captured by demographic characteristics and food insecurity, subjective or relative social status predicts maternal and child health in both developing and more developed countries. This is likely mediated in part through psychosocial stress pathways (Hertzman and Boyce 2010).
4) *Maternal mental health*: While the relationship is inconsistent, maternal mental health has been linked to child health in developing countries (Harpham et al. 2005; Patel et al. 2004; Stewart, 2007; WHO, 2008).

What this study adds:
While each of these variables has been linked to a greater or lesser degree to maternal and child health, no research of which we are aware includes each of these in its model. In order to better understand the predictors of child and maternal health in Western Tanzania, we propose to consider all of these variables in a single model (Figure 1). We anticipate that this research model will help establish a better understanding of pathways linking food insecurity, demographic characteristics, and social capital with maternal and child well-being both in Tanzania and elsewhere in the developing world.

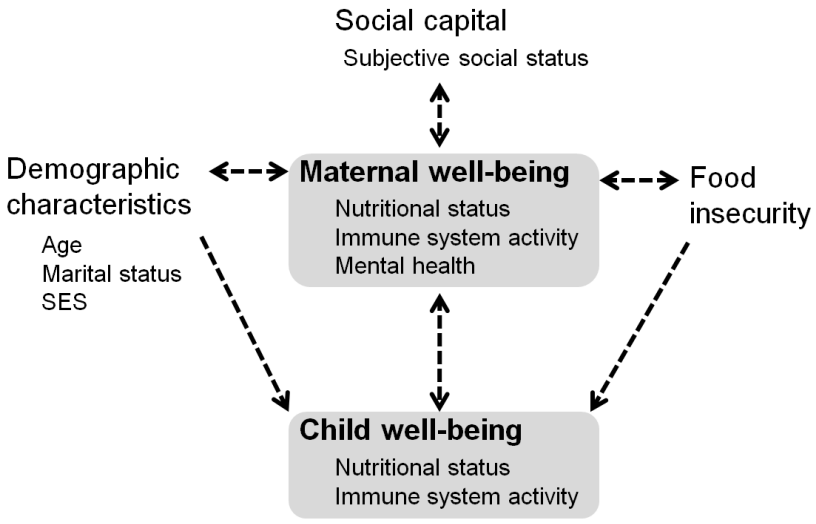

Figure 1. The conceptual framework of the study

Objective and Hypotheses

The objective of this proposed study is to determine whether food insecurity, demographic characteristics, and/or social capital are linked to maternal and child well being, and the interrelations among maternal and child well-being (Figure 1). We hypothesize that (1) poverty and social capital predict maternal and child allostatic load, maternal mental health, and food insecurity, (2) food insecurity predicts maternal and child health, with the latter association moderated by actions mothers take to restrict their own nutritional intake so as to buffer children, and (3) maternal allostatic load and mental health predict child allostatic load.

Methodology

Data and samples for this study were collected in April and May, 2011 in Mwanza, Tanzania in collaboration with Dr. Mange Mange Manyama of Weill Bugando University College of Health Sciences (BUCHS), Mwanza, Tanzania, Dr. Benedikt Hallgrimsson of the University of Calgary, and Dr. Jason DeCaro of the University of Alabama, Tuscaloosa.

Dependent variables (collected for each mother and child):

*Anthropometrics***:** Anthropometry provides the single most portable, universally applicable, inexpensive and non-invasive technique for assessing the health and nutritional status of populations (WHO, 1995). Weight, stature, and sitting height was collected following standard procedures (Lohman et al., 1988). Participants were measured without their shoes and wearing only light clothing. Weight was measured with a mechanical scale to the nearest 100 g. Stature was measured using a portable anthropometer (Seca Road Rod). Sitting height was measured to determine the Cormic Index (sitting height (cm)/leg length (cm)). All linear measurements were measured to the nearest mm. All measurements were collected twice for each subject and averaged.

Dried Blood-Spots: Until recently, methodological constraints limited efforts to investigate the ecology of immune function and health in population-based settings. Although many important markers of health are present in serum or plasma, the collection is an invasive procedure. In addition, once collected, these samples must be immediately centrifuged, separated, and quick-frozen or assayed, requiring ready access to lab facilities. Recently, researchers have developed protocols which surmount these obstacles (McDade et al 2000, 2004, McDade and Shell-Duncan 2002). The Dried Blood Spot (DBS) protocol requires only a finger prick and the resulting drops of blood placed on filter paper. The filter paper can be easily transported and subsequently assayed for biomarkers of health.

While field-based research on morbidity often relies on caregiver or self reports of overt symptoms, typically recalled over a 7- or 14-day period, this approach is subject to underreporting, particularly for longer periods of time (Martorell et al. 1975; Murray and Chen 1992). Additionally, linguistic and cultural factors help define idealized states of health, and may contribute to variation in the experience and reporting of symptoms (Hahn 1995, Kleinman 1986, Izquierdo 2005). Physical examinations by healthcare professionals can provide a more objective assessment of child morbidity, but are time-intensive and may not be feasible in some field settings. In addition, both this and the caregiver report methods cannot detect sub-clinical infectious processes that may not manifest as observable symptoms, but may nonetheless involve the activation of energetically costly antipathogen defenses (Rousham et al. 1998). The recent developments in DBS assessment inflammation and immune markers address these shortcomings, providing a powerful new tool to assess the immunocompetence of peoples in isolated locations.

The collection of DBS samples is straightforward and non-invasive in comparison with venipuncture. Unlike serum or plasma samples, DBS samples do not need to be centrifuged, separated, or immediately frozen, and samples can be stored and transported in air-tight containers at ambient temperatures (McDade et al 2007).

The process entails first cleaning the participant's finger with isopropyl alcohol, and then pricking the finger with a sterile, disposable lancet (Microtainer, Franklin Lakes, NJ, USA). The first drop of blood is wiped away with a sterile pad and 5 drops are spotted onto standardized filter paper (Scheicher and Schuell #903,NH, USA). Dr. Wilson has experience collecting DBS and will train Dr. Manyama and the two other assistants to do this. The participant's finger will not be allowed to contact the paper which could compromise the uniform absorbing properties of the filter paper. Instead, the finger will be held such that only the blood contacts the paper. The filter paper is certified to meet performance standards for sample absorption and lot-to-lot consistency set by the US National Committee on Clinical Laboratory Standards and by the Food and Drug Administration regulations for Class II medical devices (Scheicher and Schuell, NH,

USA). Variation in DBS size will be minimized by collecting samples on filter paper with pre-printed circles as guides to standardize the volume of whole blood collected. When filled to its border, each circle will contain approximately 50uL of whole blood. Samples are allowed to dry overnight at ambient temperatures, and then stored in plastic containers with desiccant at -20^{o}C prior to transport to Canada, and then to the United States for analysis. The transportation of the samples from Guyana to the United States will require approximately 20 hours at 20-25^{o}C, a time period during which dried blood spots remain stable at room temperature.

Requirements for shipping DBS samples are minimal. DBS are not considered hazardous under the IATA regulations. The Canadian Food Inspection Agency has no requirements for importing human blood (Version 4 Harmonized System Code: 300290-02). Likewise, shipment requirements into and through the United States are minimal unless the samples are known to contain an infectious or etiologic agent. Samples from normal, healthy individuals are considered "diagnostic specimens" and can be shipped without special packaging, labelling, or permitting (McDade 2007).

For this project, the dried blood spots will be analyzed in Dr. DeCaro's laboratory for markers of immune function (C-reactive protein, cytomegalovirus) and nutritional adequacy (tranferrin) using high sensitivity enzyme-linked immunosorbent assays (ELISAs). All of these assays have been validated across the age cohorts considered in this study.

C-reactive protein (CRP) is an inflammatory protein produced by liver hepatocytes in response to messenger cytokines, primarily IL-6 (Ballou and Kushner 1992). CRP is an important component of innate immunity and has been used clinically for decades as an indicator of active infection (McDade 2007). Trace amounts of CRP are normally present in circulation, but concentrations increase more than 100-fold during the 24-72 hours following infection (Fleck 1989; Baumann and Gauldie 1994). Since CRP has been shown to increase in response to a wide array of pathogenic agents as well as psychological stressors, it is a potentially useful marker of stress. Elevated CRP levels have also been associated with detrimental child growth outcomes, poor iron status, and sub-clinical infectious morbidity (Filteau et al. 1995; Lunn 2000.).

Concentrations of CRP above 5—10 mg/L have been associated with infection and inflammatory processes in many field-based studies with infants, children, and adolescents (Campbell et al. 2003, Filteau et al 1995, McDade et al. 2000, Shell-Duncan and McDade 2004). Serum/plasma CRP concentrations greater than 10 mg/L are assumed to represent an acute inflammatory response, likely to an infectious agent (Pearson et al. 2003). Within most populations, high-sensitivity CRP (hs-CRP) assays show >95% of subjects with values of <10 mg/L (Pearson et al. 2003). Although there seems to be population-to-population consistency in this, data for ethnic populations are limited and the current "normal" values are derived almost exclusively from European or European-American populations (Pearson et al. 2003).

The cytomegalovirus (CMV) assay has been validated (Dowd et al. 2011) and can provide a measure of chronic stress in adults and children. CMV is a nearly ubiquitous herpesvirus. In non-Western contexts, CMV infection at an early age - as early as infancy - isn't uncommon (Cannon et al. 2010, Hizel et al. 1999, Kangro et al. 2004, Liu et al. 1990). CMV is generally asymptomatic, becomes latent, and can be reactivated by chronic stress, in turn leading to higher antibody titers and potentially higher chronic disease risk (Dowd & Aiello 2009, Dowd et al. 2012).

Iron deficiency (ID) is the most common micronutrient deficiency worldwide (WHO, 2013), and transferrin receptor (TfR) level has been identified as an important measure of iron status that is not confounded by inflammation (Asobayire et al. 2001, Ferguson et al. 1992,

Olivares et al. 1995, Verhoef et al. 2001). TfR is upregulated in conditions of iron deficiency (Tong et al. 2002) Concentrations of TfR remain stable for at least 4 weeks when blood spots are stored at room temperature (McDade & Shell-Duncan, 2002). The DBS protocol for TfR is precise and reliable in the detection of ID both the presence and absence of infection, agrees well with plasma TfR, and is feasible in remote settings (Shell-Duncan & McDade, 2004).

Independent variables (collected for each mother):

Sociodemographics: As it has been found to influence health (Marmot & Wilkinson, 1999), objective socioeconomic status (OSS) will be determined on the basis of household production, composition, wage labor, and assets (Appendix). Material goods and duration of wage labor will be summed to create an OSS score (Hadley and Patil 2008). In addition, standard sociodemographic information such as age, marital status, and family size will be collected.

Social capital: As noted above, social capital is the extent to which people are embedded within their family relationships, social networks and communities, and have a sense of belonging and civic identity (Morrow, 1999). Subjective social status, a strong predictor of ill-health, will be used here to measure social capita (Singh-Manoux et al. 2003). Subjective social status will be measured using a MacArthur Subjective Social Status Scale (MSSSS), an instrument validated for use in developing countries with minor adaptations to local contexts (Goodman et al. 2001) (Appendix).

Food insecurity: Food insecurity will be measured using the USAID's Household Food Insecurity Access Scale for measurement of Food Access (HFIAS) (Appendix). This instrument is designed to capture the experience of household food insecurity across cultures and has been validated for use in developing countries with minor adaptation to local contexts (Coates et al. 2007). The instrument is composed of 9 occurrence questions that represent a generally increasing level of food insecurity, and 9 frequency-of-occurrence questions asked as a follow-up to each occurrence question to determine how often the condition occurred (Coates et al. 2007). The HFIAS is based on the observation that the experience of food insecurity causes predictable reactions and responses that can be captured, quantified, and summarized in a scale (Coates et al. 2007).

Maternal mental health: Patel (2001) persuasively argues for more attention to be paid to mental health in developing countries, noting that social factors known to be linked to poor mental health are on the rise throughout the developing world. As such, maternal symptoms of anxiety and depression will be assessed using the Hopkins Symptom Checklist 25 question screening tool (HSCL-25), an instrument which shows both high criterion-related and construct validity (Derogatis et al. 1974, Rickels et al. 1976, Winkour et al. 1984) (Appendix). The HSCL-25 shows high validity (Winkour et al. 1984) and has been used extensively in vulnerable populations across a range of cultural contexts (Mollica et al. 2004) including Tanzania (Hadley and Patil, 2006 and 2008). Originally developed in the 1950s (Derogatis et al. 1974) and refined in the early 1980s by the Harvard Program in Refugee Trauma to screen psychiatric distress in a refugee setting (Miyazaki et al. 2006), this instrument has been used extensively in vulnerable populations across a range of cultural contexts (Hadley and Patil, 2006 and 2008, Kaaya et al., 2002; Mollica et al. 2004, Pike and Patil 2006, Tinghog & Carstensen 2010). The HSCL-25 elicits information about common psychoneurotic complaints and can be completed within five minutes, enabling researchers to screen large groups of patients in a busy medical setting where it would be impractical to perform more extensive evaluations of emotional symptomatology

(Winkour et al. 1984).

The HSCL-25 contains 10 items to address symptoms of anxiety (suddenly scared for no reason; feeling fearful; faintness, dizziness, or weakness; nervousness or shakiness inside; heart pounding or racing; trembling; feeling tense or keyed up; headaches; spells of terror or panic; feeling restless, can't sit still) and 13 items to address symptoms of depression (feeling low in energy, slowed down; blaming yourself for things; crying easily; loss of sexual interest or pleasure; feeling hopeless about the future; feeling blue; feeling lonely; thoughts of ending your life; feeling of being trapped or caught; worrying too much about things; feeling no interest in things; feeling everything is an effort; feelings of worthlessness). It also contains two additional items, "poor appetite" and "difficulty falling asleep or staying asleep," contributing in this version to the depression factor score (Winkour et al. 1984). Both the anxiety and depression symptoms are derived from DSM-4 criteria (Miyazaki et al. 2006). Participants will be asked to score to score their experience with each of these symptoms during the previous two weeks on a four-point Likert scale ranging from "not at all" [1] to "extremely" [4]. The HSCL-25 score will be calculated by summing the participant's total responses. While the HSCL-25 score has elsewhere been compared to a cut-off to initially assess the presence or absence of anxiety or depression (Winkour et al. 1984, Miyazaki et al. 2006), the score will be treated as a continuous variable for two reasons. First, the cut-off has not been clinically determined in this setting and therefore may be misleading (Hadley and Patil 2008, Ventevogal et al. 2007). Second, and more importantly, even subclinical levels of depressive and anxiety symptomology are associated with impairment, elevated risk of major depression, and may influence mother-child interactions (Sohr-Preston and Scaramella, 2006 in Hadley and Patil 2008).

Statistical analyses

Anthropometric and dried blood spot assay data will be combined with standardized measures of growth and nutritional status to construct a multi-measure indices of child and maternal well-being as the main dependent variables. This approach is more attractive than a single measure because it quantifies the cumulative burden of adversity reflected in the body's responses to multiple stressors across developmental time (Worthman and Panter-Brick, 2008). Ordinary least squares regression will be used to test the model, relying on the procedures of Baron and Kenny (1986) to identify mediation.

Data collection team

The data collection team consisted of three medical students in the last one to two years of their residencies at the Weill Bugando University College of Health Sciences (BUCHS) in Mwanza and the director of the anatomy lab at BUCHS. Wilson trained the team in data collection procedures over a period of seven days and subsequently supervised data collection.

Instrument refinement and team training

We adapted the sociodemographics, subjective social status (MacArthur Subjective Social Status Scale), maternal mental health (Hopkins Symptom Checklist 25), and food insecurity (USAID's Household Food Insecurity Access Scale for measurement of Food Access) instruments to the local context in three steps. First, we spent one day practicing with the instruments. As all team members, besides me, were from the region, their local knowledge lead to refinements of each instrument. Second, under my supervision, the team spent one day at a health post in Mwanza conducting focus group interviews with two groups of six key informants

who were familiar with the conditions and experiences of mothers in the region to ensure that the instruments were culturally relevant. Focus group members were mothers from the Mwanza region with children under the age of five years. Wilson compensated all participants for their time with beverages and snacks. We altered the instruments accordingly after the focus groups. Third, on the following day, we used the refined instruments in individual interviews with eight mothers of children under five years of age from the Mwanza region. Wilson then used pooled respondent feedback to rephrase portions of the interview that were unclear, then spent the next three days training the team to conduct interviews using the refined questionnaires. Training elements included explanation and discussion of each item, learning how to interview by role playing and with real respondents. As well, Wilson spent half a day training the team members to collect anthropometric and dried blood spot data. Training was followed by a half-day field test with seven participants at a health post in Mwanza.

Wealth measures

Following Kneuppel et al. (2009), to measure household wealth we recorded the type and number of assets that a household owned. Asset categories were determined in two focus groups of six key informants and subsequently refined with input from eight individual key informants. Wealth measures included material and livestock assets (Table 1). For each asset, a household was given a score of 1 (low wealth), 2 (medium wealth) or 3 (high wealth), based on information from the key informants described above. For example, focus group informants stated that a household of low wealth would own no chickens, a household of medium wealth would own 1-5 chickens and a household of high wealth would own >5 chickens. A household wealth score was produced by summing the scores for both material and livestock assets.

Table 1: Key informants' categorization of households into low, medium and high wealth based on the number of assets: peri-urban Mwanza, Tanzania, April/May 2011

Household assets	Low wealth (score = 1)	Medium wealth (score = 2)	High wealth (score = 3)
kiosk (n)	0	1	>1
goat (n)	0	1-3	>3
cow (n)	0	1	>1
sheep (n)	0	1-3	>3
chicken (n)	0	1-5	>5
pig (n)	0	1-2	>2
donkey (n)	0	1	>1
plow (n)	0	1	>1 (score = 2)
no. of different crops planted (n)	0	1-2	>2
radio (n)	0	1-2	>2
bed (n)	0	1	>1
land (acres)	0	0.25-1	>1
bicycle (n)	0	1-2	>2
sewing machine (n)	0	1	>1
watch (n)	0	1	>1
television (n)	0	1	>1
DVD player (n)	0	1	>1
satellite dish (n)	0	1	>1 (score = 2)
generator (n)	0	1	>1 (score = 2)
mosquito net (n)	0-1	2-3	>3
brick house (Y/N)	No	Yes	Yes (score = 2)
metal roof (Y/N)	No	Yes	Yes (score = 2)

Sample:

For this study, the team recruited 150 mother-child or caregiver-child dyads opportunistically in April and May 2011 at four regional health clinics in and around Mwanza, Tanzania. One-to-two days prior to data collection, the team visited potential clinics to assess the feasibility of data collection. If the clinic's director gave their permission for data collection, provided the team with a space for data collection, and indicated that they expected a sufficient number of potential participants, the clinic was deemed feasible and included in the study.

During days of data collection, mothers or caregivers accompanied by their child under five years of age who were visiting the clinic were asked if they would like to participate in the study. The study was described and consent form read to the mothers in Swahili or Sukuma by the team members. Mothers and caregivers who completed the consent form were included in the study. Data collection required approximately 45 minutes per dyad.

The mother's or caregiver's and child's age was determined by asking her age upon her last birthday and her date of birth. The child's age was determined by asking the mother or caregiver the child's age upon their last birthday and the child's date of birth. In those cases where the age upon the last birthday and the date of birth were not in agreement, the mother or caregiver was asked for clarification. If possible the mother's and child's age was confirmed using either their birth certificates or regional health cards.

Interviews were conducted by female team members with each mother or caregiver. They were completed prior to the collection of health outcome data and in the following order: 1) maternal mental health (Hopkins Symptom Checklist 25), 2) sociodemographics, 3) subjective social status (MacArthur Subjective Social Status Scale), 4) food insecurity (USAID's Household Food Insecurity Access Scale for measurement of Food Access).

Following interviews, health outcome data were collected for each participant. Anthropometric data, weight and stature, were collected following standard procedures (Lohman et al., 1988). Participants were measured without their shoes and wearing only light clothing. Weight was measured with an electronic scale to the nearest 100 g (Beurer BG64). The stature of those over 24 months of age was measured using a portable stadiometer (Seca 213). The length of those less than or equal to 24 months of age was measured recumbently using a portable measuring mat (Sec 210). All linear measurements were measured to the nearest mm. All measurements were collected twice for each subject and averaged.

Dried blood-spots were collected for each participant following standard procedures (McDade et al 2000, 2004). Dried blood spots were collected from the fingers for those over 24 months of age and the heel from those aged 24 months and younger. The dried blood spots were placed individually into a sealed "Zip-Lock" plastic bags with a desiccant then put into a -40^{o}C freezer 4.9$\pm$1.5 (mean$\pm$SD) hours after collection. Dried blood spots were shipped from Tanzania on June 7, 2011 and arrived at the University of Alabama on June 13, 2011 where they wre placed into a -30 ^{o}C freezer.

Institutional Ethical Clearance

The research was approved by both the National Institute for Medical Research in Tanzania's Ministry of Health and Social Welfare and the Conjoint Health Research Ethics Board in the Faculty of Medicine at the University of Calgary (Ethics ID: 23245).

Presentations

DeCaro, J., Wilson, W., Manyama, M., Hallgrimsson, B., Thomas, M., Taghvai, B., Riley, B., and Carroll, G. 2012. Food Insecurity, Maternal Mental Health, and Immune System Function in Mwanza, Tanzania: Pathways toward Differential Child Wellbeing Paper presented at the Society for Applied Anthropology, 72nd Annual Meeting, Baltimore, March.

Wilson, W., DeCaro, J. 2013 Defining, operationalizing, and assessing the relationship between stress and health in contemporary Tanzanian mothers and children. Invited paper for the

symposium "Reconciling 'stress' and 'health': What can bioarchaeologists learn from the other sub-disciplines." Paper accepted for presentation at the 82nd annual meeting of the American Association of Physical Anthropology. Knoxville, April.

DeCaro, J., Wilson, W., Manyama, M., Hallgrimsson, B. 2013 Pathways toward differential maternal and child well-being amidst food insecurity in Tanzanian households: the role of child age and maternal affect. Paper accepted for presentation at the 38th Annual Meeting of The Human Biology Association, Knoxville, April.

Wilson, W., DeCaro, J., Manyama, M., Hallgrimsson, B. 2013 Maternal mental health as a mediator of the impact food insecurity on child health in a peri-urban region of Tanzania. Paper accepted for presentation at the 41st annual meeting of the Canadian Association for Physical Anthropology. Toronto, Canada. October.

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