# Measurement and Intervention: Two Projects to Address and Its Effects in Guatemala

The Efficacy of Sagittal Photography in the Analysis of Body Proportions
The Exploration of Liquid Vehicles for Nutritional Supplementation

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Borlaug-Ruan internship through the World Food Prize Organization in partnership with Hormel Foods Corporation

# INTRODUCTION

Malnutrition is a far-reaching problem that affects communities around the world and manifests in economic and physical repercussions for both individuals and society as a whole. Malnutrition is not simply a result of too little food, but rather a consequence of inadequate nutrition—which can stem from an unbalanced diet, inadequate nutrient intake, disproportionate consumption of empty calories, or the typical image of insufficient food availability. The impact of malnutrition is intangibly large, affecting the affected individuals' own growth and development, but also leading to similar devastating consequences for their offspring, loss of economic productivity, and reduced ability to contribute to society.

In Guatemala, malnutrition has led to an overwhelming prevalence of stunting in the population, often coupled with obesity— a pairing that reflects the consumption of excess calories from a diet which does not contain adequate nutrition with a proper balance of protein, carbohydrates, fats, vitamins, etc. to sustain a person. Stunting has become an epidemic in Guatemala, with a rate of 46.5% in children under the age of five nationally. In some regions of Guatemala, such as Totonicapán, the rate of stunting in this age group reaches as high as 70.0% (USAID, 2016) which has a dramatic health and economic impact. In fact, in 2004, it was estimated that 11.4% of the national GDP, or \$3.1 million, was lost. With dramatic effects on the individual's health and the nation as a whole, stunting is a critical issue to study and resolve in Guatemala. Although nutrition throughout an individual's life is relevant, there are certain periods that have critical importance in growth and development. In particular, the mother's nutrition before conception and the child's nutrition in the first 1,000 days of life (beginning at conception through the first two years of life) play a vital role in their later physical and cognitive development. Lack of education and resources has led to inadequate water and nutrient intake of Guatemalan women during pregnancy and lactation. One study conducted in the Western Highlands region of Guatemala documented deficits in protein intake of Guatemalan women of up to 19g daily (Escobar et. al., 2017), out of the recommended 26 g of protein consumption in the third trimester of pregnancy and the recommended 21g of protein daily in the first semester of breastfeeding (Marangoni et. al., 2016). To the further detriment of the growing infant, studies have also shown water intake by Guatemalan women to frequently fall short of adequacy by as much as one liter per day during this critical stage, leading to hypohydration (Diaz--Jereda, 2017).

Together, these factors lead to the very early manifestations of chronic malnutrition, or stunting, which are present throughout the nation and necessitate intervention. Consequently, there is a primary research focus on identifying potential nutritional supplementation vehicles, particularly for Guatemalan women whose nutrition has a trickle-down effect to their children's health. Current practices concentrate on nutritional fortification of the typical Guatemalan beverages 'atoles' which are thin gruel drinks (Escobar et.al., 2017), but offering a wider variety of options has potential to increase the efficacy and reach of supplementation programs. As a culture of soup and smoothie consumption is known to exist in Guatemala, this study investigated the acceptability to Guatemalan women of three cream soups, three cold soups, and three milk-based smoothies with added whey protein fortification.

Additionally, there is significant scientific interest in knowing the exact effects of stunting on the body, its systems, and its growth. Current studies show that the loss of height in stunting occurs in the legs, rather than the trunk, as the body prioritizes resource distribution to the vital organs which are housed in the trunk (Shiu, 2016). An efficient, minimally intrusive method of data collection is needed to collect large data sets in many populations to confirm these results and allow further study of body proportions. Physical measurement of height and sitting height are much more time consuming than taking a sagittal photograph. Determining the accuracy of the sagittal photograph with respect to the physical measurements is the second goal of this study. Secondarily, data collected to compare the two measurement systems can also be used to compare the body proportions of non-Guatemalans, who are known to be taller on average, to Guatemalan people to further analyze how various body proportions vary with the height reduction.

Both projects build on past work by CeSSIAM in order to produce more statistically robust results and expand the focus of research. The supplementation project built on several past years of research into appropriate vehicles. Several years ago, Incaparina was identified as a potential source of supplementation (Platte, 2016), as well as Atol (Escobar 2016). Last year, research was conducted to explore the use of cream soups and to gain a general understanding of the Guatemalan women's background knowledge on various liquid vehicles. This year, the study conducted a second survey to confirm and add to the information gathered in 2017 (Dougherty, 2017) and performed sensory panels for two more possible liquid vehicles—cold soups and milk-based smoothies—and additional flavors of cream soups. Past data collection for the sitting height project primarily focused on data collection for females (Shiu, 2016; Silverhus, 2017). Thus, to create a more demographically even distribution of the studied population, 2018 data collection focused on the recruitment of male participants, aiming to also balance the number of non-Guatemalan and Guatemalan people measured.

### **METHOD**

#### The Efficacy of Sagittal Photography in the Analysis of Body Proportions

In the first analysis of the data, which studied the accuracy of sagittal photography for body proportion measurement, the independent variable was the method of measurement used, either physical anthropometric measurements or sagittal photographic measurements. The resulting dependent variable was the body proportions measured. In this analysis, the person and tools conducting measurement and method of analyzing the photograph were held constant.

In the second analysis, which aimed to confirm and add data to past studies which examined the differences in body proportions between stunted and standard growth populations, the independent variable was demographic background: Guatemalan or non-Guatemalan. The dependent variable were the body

proportions measured by the standardly accepted physical measurement system, with similar controls to analysis one. Data collection was conducted as follows. The participant began by completing a consent form and removing all pocket contents, shoes, hats, and other accessories. A series of anthropometric measurements were taken, as follows. First, the participant stood with his heels against the wall and head in a Frankfort plane gaze by the vertically extended tape measure. A layout square was then used to compress the participant's hair and record a measurement of height to the apex of the head to the nearest 0.5 cm. Second, the participant stood on an electronic balance, facing forward. The weight was recorded in kg as displayed on the scale (to the nearest 0.1 kg). Weight was then adjusted according to clothing worn, with 1 kg subtracted if dressed in heavyweight clothing and 0.45 kg for light clothing. Third, the participant was instructed to sit on a table with his right hand placed on his chest, back straight, and head in a Frankfort plane gaze in order to measure pelvic height. A mark was placed at the midpoint between his Iliac crest (apex of hip bone) and lowest rib on his right side. Then, a layout square and vertical ruler were used to determine the height of the mark to the nearest 0.5 cm. The final anthropometric measurement recorded was sitting height. The participant was instructed to sit with his back straight against the vertical ruler on the sitting height platform and his head in a Frankfort plane gaze (looking straight ahead). A layout square was then used to compress his hair and measure his sitting height to the nearest 0.5 cm. A sagittal (side view) photograph was taken for the photographic measurements. The participant stood on a stool, facing to the right with the right edge of his right foot aligned with the front edge of the stool and his head in a Frankfort plane gaze. He then placed his right hand on his chest and a mark was placed on his Iliac crest. The code on the stool was changed to match the participant code and a vertical photograph was taken by a camera approximately 3 meters away, positioned vertically (attached to a wooden plank at 90 degree angle from floor). The setup is seen above. The sagittal photograph was printed to fill an 8.5 x 11 inch sheet of paper and proportions of the body were transferred onto a translucent piece of vegetable paper for measurement (with marks made at the apex of the head, base of the feet, and the iliac crest mark). The distance between each pair of marks was measured and recorded

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to the nearest hundredth centimeter (trunk length, leg length, and total height).

The two-part concept of survey and sensory panel (tasting session) was designed to collect data on both the cultural acceptability and palatability with supplement of the potential liquid vehicle. A standard set of questions were developed to identify likely success in households based on prior knowledge and current frequency of consumption. For the sensory panel, a typical approach of double blind taste tasting was used, but careful thought was put into developing a procedure to eliminate bias based on soup location on the tray, order tried, prior conceptions, and peer influence. A randomization system was developed for soup location on the tray which was presented with a double-blind system by one interviewer conducting the panel with a single participant at a time. Each tray was randomized individually using a roll of a die to randomize order of sample flavors on the tray, as well as position (top versus bottom) of the fortified version of each. First, the location of each flavor of the liquid vehicle was determined: left, middle, or right. Then, the location of the protein was randomized: front or back within the designated column for each flavor. Location of each sample was recorded for each participant to allow analysis of bias based on location and the evaluation of lasting bias. The independent variable was the presence or absence of protein fortification. The dependent variable was the consequently perceived taste, specifically whether there was an identifiable difference between the two samples of the same base flavor and which sample was preferred. The influence of method of presentation, base recipe used, and location of samples on the tray on the participant preference was controlled for.

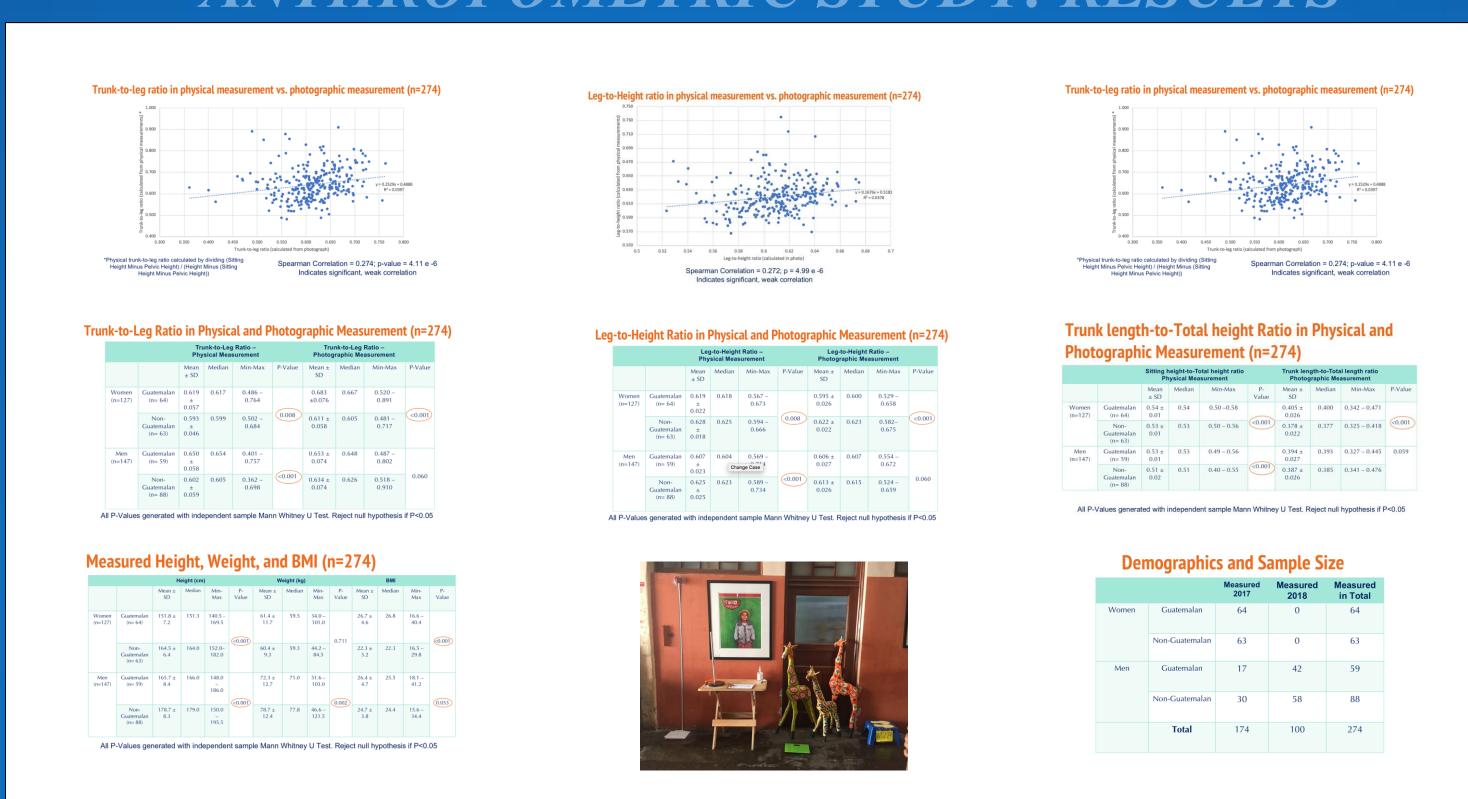
The study was conducted as follows. Liquid vehicles were prepared. The produced quantity was divided into two parts and a 6-gram whey protein supplement was stirred into one half. For each sensory panel, the liquid dish was served in a 100 mL portion in a coded plastic cup. The 6 cups were then arranged in a randomized order in a two row, three column grid. Each column represented a single flavor, with one cup offering the protein supplemented version and the other offering the plain version. A roll of a die was used to randomize the order of the three liquid dish flavor columns (left, center, or right) and the respective location of the supplemented version within the column (top or bottom). Participants completed a paper and pen survey about their background knowledge and frequency of consumption of the liquid dish. Participants were seated at a table and presented with a tray of six samples of one liquid dish type. After the interviewer explained the procedure, the participant is allowed to select which cup is sampled first. She takes three sips of the sample and then drinks water. The participant was instructed to try the other sample in the column (the pair to the one first selected). The participant was then allowed to retry either of the two samples but is not required to finish the provided amount. They gave their feedback to the interviewer, indicating whether they tasted a difference between the two samples, which sample they preferred, and whether they liked the samples. This was repeated for the remaining two flavors of the liquid vehicle.







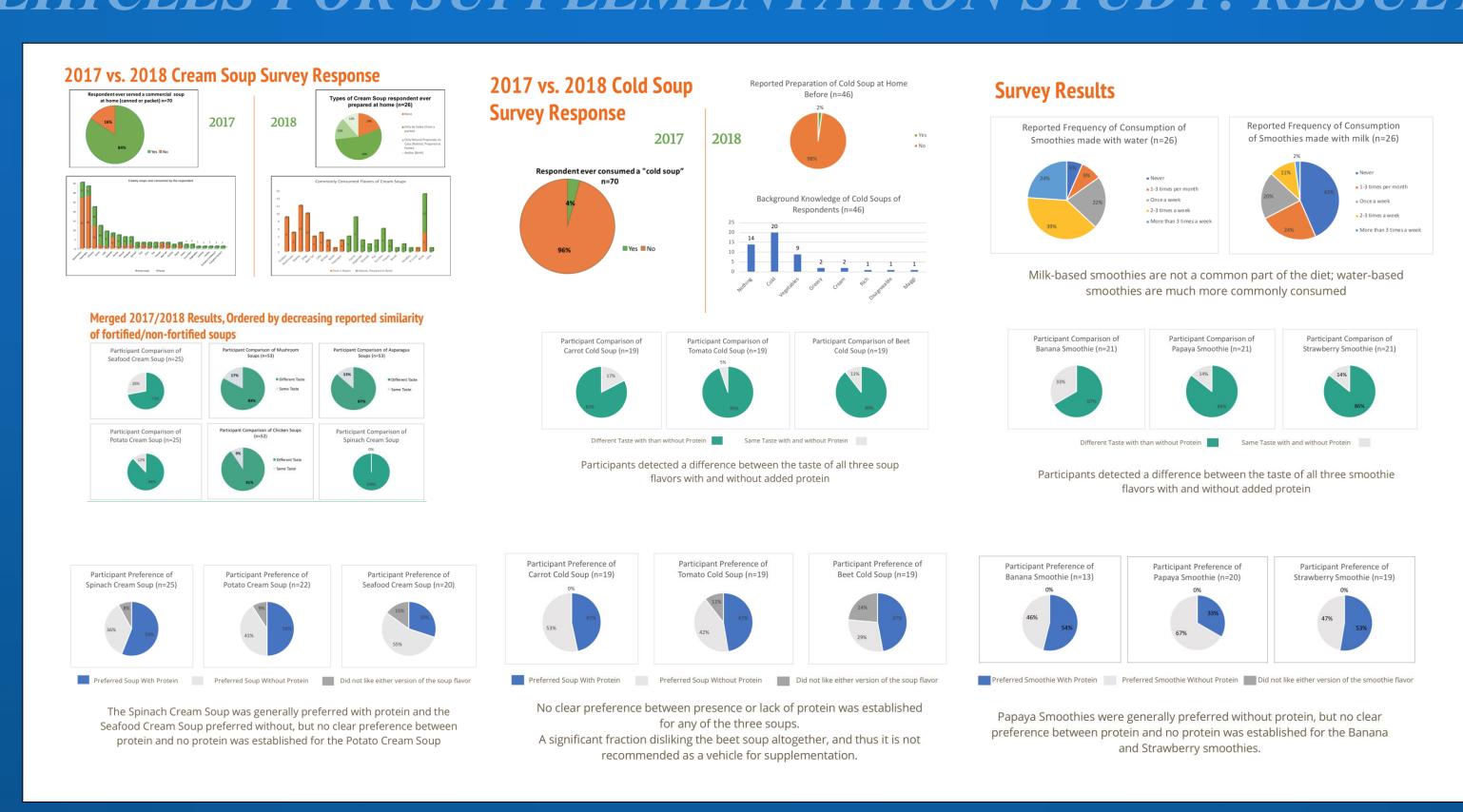
# ANTHROPOMETRIC STUDY: RESULTS







### VEHICLES FOR SUPPLEMENTATION STUDY: RESULTS



## CONCLUSIONS

Having compiled the data from 2017 and 2018 data collection to achieve a large sample size with relatively balanced proportions of males versus females and Guatemalans versus non-Guatemalans, the analysis is statistically robust and rejects the use of sagittal photography with the Iliac crest marked as an optimal form of body proportion measurement. The three body ratios of interest were trunk-to-leg ratio, trunk-to-height ratio, and leg-to-height ratio. All three displayed a weak correlation between the physical and photographic measurement, with Spearman Correlation Coefficients of 0.274, 0.305, and 0.272. All p-values indicated the correlation was significant, with p=4.11 e -6, 2.66 e -7, and 4.99 e -6 (significance at 0.05 level). The photographic measurement not only correlated weakly, but the ratio of the ratios produced by physical measurement to those of the photographic measurement was not near 1:1 as desired. Instead, it was 0.2529, 0.1907, and 0.1676, respectively.

Additionally, the data from physical measurements taken affirm previous studies' conclusions that stunting results in the loss of leg length rather than trunk length, leading to a higher trunk-to-height ratio in the Guatemalan populations which have long lineages of people affected by malnutrition and stunting, than in non-Guatemalan populations. Although inter- and intraobserver reliability was not measured in 2018 data collection, the 2017 results, which concluded high precision between observers and measurements, can be assumed to hold.

Altogether, the compiled 2017/2018 data indicates that creamy soups have the highest potential to serve as a vehicle for protein supplementation for Guatemalan women of the tested liquid dishes. Although 6-gram whey protein supplementation does create a noticeable difference when added to the liquid vehicle, it generally does not have a negative impact on the palatability of the soup, often even improving its perceived quality. Of the tested flavors across both years, chicken creamy soup appears to have a big comparative advantage for potential success as a vehicle for supplementation because the highest proportion of participants thought it was enhanced by the addition of protein, and it was among the most commonly reported flavors of consumption in the survey. One benefit, though, of creamy soup supplementation is that it has a high potential to reach a larger audience than other potential vehicles because it offers many flavors, several of which have already been demonstrated to be flavorally improved by the addition of whey protein. Thus women would have a variety of options within their home to prepare the soup and maintain a variety of flavors in the diet.

Milk-based smoothies rank second for potential success as a liquid vehicle for protein supplementation. They fail to meet the same criteria of existing consumption as creamy soups do because, while fruit smoothies do frequent the Guatemalan diet, the survey of Guatemalan women indicates that smoothies are commonly prepared with water rather than milk, barring proper supplementation with the creamy textured whey protein supplement. Although this appears an easy adaptation—swapping milk for water in smoothie preparation—many factors such as cost and access to milk would likely inhibit this solution. In light of this fact, milk-based smoothies are a weaker candidate for supplementation, despite the generally positive participants' reflection on milk-based smoothie taste and palatability with protein.

Lastly, both the study and sensory panel indicate very limited feasibility of cold soups as a vehicle for protein supplementation. Not only are they not part of the typical Guatemalan diet reported, the survey suggests that the Guatemalan population has very little knowledge about this liquid vehicle in general. Thus, it would be difficult to encourage use of this vehicle for whey protein supplement because there is a large implementation barrier, and it fails to conform to existing culture.

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Minor tweaks on data collection which could be made to enhance efficiency, such as the use of a tripod for the photography, but there is no factor that impinged on the accuracy of data collection to necessitate further study or data collection on the comparison of sagittal photography to physical measurement. One influence which could have lessened the correlation between the two forms of measurement was that physical measurement of sitting height varies with gluteal (buttocks) thickness, whereas the sagittal photograph's trunk height measurement is not affected by this. Further study could build on this work to analyze alternative methods of photographic measurement for the collection of body proportion data or other ways to effectively conduct large-scale, efficient yet unobtrusive data collection on the effects of stunting on body growth. To build on the second topic of interest, the differences in body proportions between non-Guatemalan and Guatemalan populations, further study could analyze the comparative rate of growth of each body portion (legs, trunk, arms, and head circumference) over the lifetime of individuals in communities with high rates of stunting (such as indigenous Guatemalan communities) to those unafflicted (such as foreign populations).

The procedure used was effective and thus would be recommended for future research on this topic. One minor change to the survey used for both background information and the sensory panel is recommended: adding more details and specificity to the questions to gain clarity and a better understanding of the liquid vehicle's potential for successful supplementation in communities. To do this, asking questions specifically targeting this question, such as, in the sensory panel portion: "Would you serve this at home if the materials were available to you", and, in the survey portion: "Which of the following ingredients do you have regular access to at home?" followed by a list of many ingredients, including, but not limited to, those used in conducting the sensory panel. Further research could enhance this study with the further exploration of other liquid vehicles, such as the commonly consumed rice milk drink Horchata, and study among more geographically diverse groups (i.e. conduct sensory panels and surveys amidst communities in several different regions of Guatemala).

#### THE INTERNSHIP EXPERIENCE

Reflecting on my eight week experience has been an incredibly hard task. Of course, I am in a period of constant reflection, but to actually summarize my experience in concrete words, sentences, and grammar is virtually impossible. This internship has completely changed me and my future. I would do it again in a heartbeat. I cannot keep the little kids that I worked with out of my mind. The memory of them brings about a torrent of emotions, from deep love, caring, and compassion to guilt, sadness, and more. Outside of my projects, I got the opportunity in Guatemala to volunteer at Nuestros Ahijados organization and to go on the Project Spammy engagement trip, both of which opened my eyes to the true realities of poverty and taught me so much..

- 1. "One life, live it up, 'cause you don't get it twice": While here in Guatemala, I have watched almost every game of the World Cup (I have had to miss some for work). Not only am I a soccer fan myself, it is really fun to sit with my host family and watch the games—it unites us across cultures and can lead to some friendly competition if we are divided in which team we support. This line—"One life, live it up, 'cause you don't get it twice"—is featured in Nicki Jam's song "Live It Up", the theme song of the 2018 FIFA Men's world cup, and I have found that there is nothing more true, both on small and large scales. Take advantage of opportunities that you get even if they terrify you. Going to a foreign, third world country by yourself for eight weeks as a 17 year old is certainly intimidating, but it has been incredibly worthwhile and live changing. You get one life, so say yes while you can. It doesn't matter if it is a little opportunity, like playing a game with your family, or a much bigger one, like this internship in Guatemala— saying yes is the first step to stumbling upon meaningful experiences. If it turns out poorly, which it sometimes will, time still keeps on going, an unfortunate circumstance will pass, and a new day will begin, offering new opportunities. So one life, live it up, 'cause you don't get it twice... and that starts today—live it up, 'cause you don't get it twice.
- 1. Don't forget to leave time to be in the moment: When I first got to Guatemala, I expected to be constantly on the go, excited, and experiencing new, amazing things. There was plenty of that in the mix, but, just like at home, there was also a lot of downtime. As it turns out, this time taught me just as much as anything else here in Guatemala. I have learned to be content with waiting; to absorb everything around me— sights, sounds, smells; and to find peace with not having an activity or a game or constant stimulation. Instead, I breathe. I breathe in the smells of street food which drift in through the car window. I breathe in the cool fresh air and try to absorb every detail of the intricate patterns of the Indigenous dress. I breathe and try to imagine what it would be like in their shoes— what it would be like if I had to get up early and go to bed late, on my feet all day, hassling tourists to buy the beautiful clothes in my giant bag strung over my back or the fruit from the basket on my head or one of the necklaces hanging from my arm; what it would be like to count on this lifestyle to keep the clothes on my back, the food in my children's stomach, and the haphazard tin roof and clay walls I call home. I have learned that when you step back from your phone and constant buzz of activity, you notice things that you never would have otherwise and sometimes those are the most beautiful things. For me, I will hold in my heart the man I saw sitting on a doorstep bent over his sombero, just resting; the little girl whose big black eyes peeked out from behind her mother's colorful huipil and her little hand waving hi to me; and all the other beautiful things I have observed in the times when I had nothing else to do.
- 1. A loving community is much more important than material wealth: Although I cannot deny that things are important to have—they feed us, clothes us, and give us a sense of identity, I have learned that the relationships that can be formed with people are what truly make life valuable. When you have a person with you, no matter how long you have known them, you have an infinite source of entertainment. Everyone has a story; in fact, everyone has millions of stories, and most people love to share. Taking the time to get to know the stories of my host parents, the maid, my coworkers, the participants in my study, and everybody else I have met here in Guatemala has been one of my favorite parts. Some are very short and others very long, but they tell the tales of people working hard to get to where they are in life and never giving up on their dreams. My host mom works as a lawyer and advocate for women and children, particularly focused on reducing sexual abuse. My host dad works in risk management, something that is particularly interesting and relevant in the face of the recent cruption of Volcan Fuego. Doña Marie, the maid, has family over four hours away, but she stays here to work and returns to them on her breaks (for about four or five days every two or three weeks it would appear). She has worked here since before the kids were born (over thirteen years!), cooking, cleaning, and making the house run smoothly. Each of them have told me fascinating stories of how they got where they are today and have inspired me to consider many different paths for my career and life. Furthermore, when I have to do something I do not particularly love, I have found that people can make all the difference. Afterall, washing dishes is a lot more fun when you can giggle about the patterns that the stream of water makes as it hits a spoon with your little host sister and recruiting strangers to participate in a scientific study is made a lot better when it comes with the opportunity to learn little snippets of their life and t
- 1. Happiness is making the most of what you have: This is everywhere in Guatemala. There are so many little anecdotes to this effect in my experience. Kids are perfectly content playing soccer with anything remotely-ball shaped on fields of cement, dirt, grass, hills, or anything where they can mark out a goal. Nobody complains when they have to wait an hour for their turn to participate in a taste test of soup in return for soup, salad, and a canvas bag. Nor do the little kids who can't afford school seem to mind running from foreigner to foreigner to ask to shine their shoes or make them a bracelet. Doña Marie smiles and laughs constantly, despite working long hours, far from her family. In fact, this culture is full of life and smiles, despite the poverty ingrained in the livelihood of so many of the people. These people have showed me that you don't have to have everything to be happy—you don't need the newest things or the best job or a high level of education. Instead, happiness is a matter of recognizing the blessings in what you do have, whether that be the opportunity to spend the day with your friends, experience something new, or eat a meal with your family.
- Ask questions: Before this experience, I was pretty naturally introverted. There would be times when I would step out of my comfort zone to ask a question or get directions from somebody I didn't know well, but, for the most part, I stayed well within my shell of familiarity. After being surrounded for eight weeks by nothing but unfamiliarity and having work which requires asking people in a market to participate in a study, that has changed. I have learned that there is no harm in a question. In fact, if you are curious about something, it will generally form a connection between you and whoever you are asking. People love sharing stories, experiences, and knowledge, so don't be scared to ask!
- The world is beautiful, and we don't take enough time to appreciate the global community— every place and culture has something to offer: I have been blessed with the opportunity of meeting the people of Guatemala and witnessing fractions of their life, both in happiness and hardship. At the same time, the United States has been in political uproar over immigration over the Mexican border. Many of these refugees come from Guatemala and neighboring countries, escaping violence, threats, and poverty there, and to degrade them with blanket accusations as rapists and criminals is a devastating misunderstanding. Being here and surrounded by these people has showed me nothing but good intentions, hard work, and unfortunate circumstances. I was lucky to be born with a secure home, family, and enough money to go around, but these people did not get so lucky in the birth lottery. They are dedicated, hard workers and deserve respect for their beautiful culture and what it has to offer. The hardship they have faced do not define their character, so they merit proper treatment as fellow human beings and a chance to show all that they have to offer.
- "When the whole world is silent, even one voice becomes powerful." Malala Yousafzai: It breaks my heart to leave behind all the people in desperate need of help to go back to my comfortable first world life. It feels wrong. My mind can't escape the image of beautiful baby Natalia at Casa Jackson just one of the many relevant stories. I went back another day to volunteer, and I found something out: she is not 7 months old... she is 1 year and 7 months old. Yet she looks five months old and can't crawl, let alone walk or talk. Like so many facing devastating poverty, she is incredibly happy, but that does not make it fair. It is not fair. We owe it to her and all the other kids & families trapped in a cycle of poverty and hunger to do something. We need to stop talking about border walls and spending significant money on senseless debate and political gestures and start to make real changes to help real people. Right now, there are nowhere near enough voices. Each and every person who speaks out makes a difference. Travel, see the world, lend a hand, and become a voice. I am incredibly thankful for the opportunity I have had to see first hand the effects of global poverty and to put faces and names to what I already knew was a very real issue. For me, the adventure with tackling the issue of food insecurity started small. It started several years ago, packing food into backpacks in my church basement for kids in need to take home from school so they could have a meal at dinner time. It grew a little into research projects for C-SPAN StudentCam on the minimum wage and for the World Food Prize Global Youth Institute on improving animal agriculture in Uganda. It became more real as I grew to love the kids that my family hosted as part of a private foster care system and now it has become an integral part of who I am with my my past two months of experience as a Borlaug-Ruan intern. Although it feels a bit like my arms and legs are tied down while I am forced to watch something horrible happen in front of me whil

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