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The Effects of Consuming Eggs on the Physical and Cognitive Development of Food-Insecure Haitian Children

Monica Elaine Stewart
University of Arkansas, Fayetteville

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The Effects of Consuming Eggs on the Physical and Cognitive Development of Food-Insecure
Haitian Children

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Agricultural and Extension Education

by

Monica Stewart
University of Arkansas
Bachelor of Science in Human Environmental Sciences, 2002

August 2018
University of Arkansas

This thesis is approved for recommendation to the Graduate Council.

Jeff Miller, Ph.D.
Thesis Director

Kate Shoulders, Ph.D.
Committee Member

Mechelle Bailey, M.S.
Committee Member

Karen Shank, M.S.
Ex-officio Member

Abstract

Within Latin America and the Caribbean, severe food insecurity is highest in Haiti. Fifty-five percent of the population lives below the poverty line with approximately 50% of the population undernourished. Given the typical diet in the developing world is primarily plant-based, the two studies presented in this thesis examine how eggs, a locally available animal protein, impact physical growth, cognitive development, and motor skills of food-insecure children from a single orphanage in Leogane, Haiti when added to the diet.

In the first study, growth parameters in children ages 3-8 years old were measured at baseline, six months, and one year. At the study mid-point, two eggs, five days per week (10 eggs per week) were supplemented weekly for six months. Dietary diversity and nutrient intakes were assessed throughout the study using a 24-hour recall. Growth parameters were evaluated using anthropometric data including: height, weight, mid-upper arm circumference, and tricep skinfold thickness, while body mass index was calculated. Significant differences in anthropometric outcomes showed a decrease in growth velocity after egg introduction. Key findings from the study included poor growth velocity over the course of the study, likely due to insufficient energy needs. In addition, an increase in dietary diversity was found but not reflective of increased caloric intake. These outcomes support the known relationship between child undernutrition and food insecurity.

In the second study, cognitive development and motor skills in children ages 3-6 years old were evaluated three times over the course of a year. At the study mid-point, two eggs, five days per week (10 eggs per week) were supplemented weekly for six months. Dietary diversity and nutrient intake was assessed using a 24-hour recall. Cognition and motor skill assessments

were conducted using Early Screening Profiles with no significant differences in outcomes found between the control period and the egg intervention period. Key learnings from the study included insight into cognitive and motor skills for this group of food-insecure children, estimated nutrient intakes among children in this single orphanage, and estimated nutrient intakes from the egg intervention, along with knowledge of research challenges in a food insecure developing country.

Acknowledgements

First, I would like to thank my amazing family for their incredible support over the last two years. To my husband, thank you for encouraging me, for setting the bar for hard work so high, and most of all for cheering me through to the end. To my daughter, thank you for understanding when I needed to put school first, for making me laugh when I needed it most, and helping me relax with your calming snuggles. Thank you to my in-laws for picking up the slack that is guaranteed to come from two working parents, for praying and cheering for me, and thank you to my sister and her family for traveling to me since I never had the time to come to you.

I am grateful for dear friends who loved on and gave extra attention to my precious daughter. From the movie trips, to sleep overs, to play dates, the support you have shown has been inspiring. It truly takes a village. Thank you most of all for girls' nights, group texts, and our weekend girl's trip; it pushed me through to the end!

Special thanks are extended to my graduate committee for investing their time and guidance to help me accomplish this goal. Mechelle Bailey, your knowledge and support during the project helped keep me sane. Karen Shank, in my personal dictionary, your picture is right next to the word support. You have a talent for recognizing strengths, providing the perfect amount of support, and I have you to thank for my professional growth over the past several years. Dr. Miller, thank you for your guidance on this project; your passion for OneEgg is inspiring. Dr. Shoulders, thank you for challenging me in class and providing your expertise on this project.

Lastly, I would like to extend a very special thanks to Tami Strickland, a coworker turned incredible friend, who's first words to me about returning to school were "You can help with OneEgg!". You are such a wise and wonderful friend. Your encouragement through this

process helped me more than you know. Thanks for bringing some “red” into my life, for all of the pep talks, and for initiating my involvement with this project.

Dedication

This thesis is dedicated to my late mother who taught me that I can do anything if I put my mind to it and who encouraged me to pursue higher education, and my late father who taught me that all things are possible with hard work. Thank you for working so hard to make sure Sis and I had it better than you did. My promise is to do the same for mine.

It is also dedicated to my daughter. My hope for you is to find your passion, pursue your dreams, and know that I hope to see your name on the Senior Walk one day too!

Table of Contents

CHAPTER I: INTRODUCTION	1
Need for the Study	1
Problem Statement.....	3
Purpose Statement	4
Egg Consumption and Physical Development of Food-Insecure Haitian Children...	4
Egg Consumption and Cognitive and Motor Development of Food-Insecure Haitian Children	5
Objectives	5
Egg Consumption and Physical Development of Food-Insecure Haitian Children...	5
Egg Consumption and Cognitive and Motor Development of Food-Insecure Haitian Children	5
Terms	6
Assumptions	7
Egg Consumption and Physical Development of Food-Insecure Haitian Children...	7
Egg Consumption and Cognitive and Motor Development of Food-Insecure Haitian Children	7
Limitations.....	7
Egg Consumption and Physical Development of Food-Insecure Haitian Children...	7
Egg Consumption and Cognitive and Motor Development of Food-Insecure Haitian Children	8
Institutional Review Board	8
References.....	9
Appendices.....	11
CHAPTER II: EGG CONSUMPTION AND PHYSICAL DEVELOPMENT OF FOOD-INSECURE HAITIAN CHILDREN	22
Abstract.....	22
Introduction.....	23
Conceptual Framework.....	25
Context of the Study	27
Purpose and Objectives.....	27

Methodology.....	27
General Design Approach	27
Intervention	28
Anthropometry	29
Dietary Diversity and Nutrient Intake	30
Statistical Analysis.....	31
Anthropometry	31
Dietary Diversity and Nutrient Intake	31
Results.....	32
Anthropometry	32
Dietary Diversity and Nutrient Intake	36
Discussion.....	37
Acknowledgements and Disclosures	41
References.....	42
Appendices.....	45
CHAPTER III: EGG CONSUMPTION AND COGNITIVE AND MOTOR	
DEVELOPMENT OF FOOD-INSECURE HAITIAN CHILDREN.....	54
Abstract.....	54
Introduction.....	55
Conceptual Framework – Cumulative Risks	58
Context of the Study	58
Methodology.....	59
General Design Approach	59
Intervention	59
Cognition and Motor Skills.....	60
Dietary Diversity and Nutrient Intakes	61
Statistical Analysis.....	62
Cognition and Motor Skills.....	62
Dietary Diversity and Nutrient Intakes	63
Results.....	63
Cognition and Motor Skills.....	64

Dietary Diversity and Nutrient Intakes	67
Discussion.....	69
Acknowledgements and Disclosures	72
References.....	72
Appendices.....	75
CHAPTER IV: CONCLUSION	84
References.....	87

CHAPTER I: INTRODUCTION

Need for the Study

According to the Sustainable Development Goals (SDG), one in eight people lived in extreme poverty in 2012, nearly 800 million worldwide do not have adequate access to food, and one in four children under the age of five had stunted growth in 2014 (United Nations, 2016). The second SDG seeks to “end hunger, achieve food security and improved nutrition and promote sustainable agriculture” (p. 4) by 2030 (United Nations, 2016). Worldwide challenges specific to poverty, food insecurity, and malnutrition are significant. Global malnutrition affects one in three people, with the term malnutrition including over and undernutrition (International Food Policy Research Institute [IFPRI], 2016). Undernutrition is linked more specifically to child stunting, child wasting, child and adult underweight, and micronutrient deficiencies (IFPRI, 2016).

Undernutrition is widespread in low-income countries, with poverty playing a large role (Black et al., 2008). The poorest country in the Western Hemisphere is Haiti, with 25% of the population living on less than \$1.90 a day, and 59% live below the national poverty line, equivalent to \$2.41 a day (United States Agency for International Development [USAID], 2018). While progress toward meeting the Sustainable Development Goals is being made, Haiti ranks 152nd out of 157 countries making progress (USAID, 2018). Smith, Kassa, and Winters (2017) found that in Latin America and the Caribbean, severe food insecurity was the highest in Haiti. Food security in the country was impacted in January 2010 by a major earthquake causing the average number of meals per day to decrease from 2.48 to 1.58 (United States Agency for International Development [USAID], 2011). According to *The State of Food Insecurity in the World 2015* report, 5.7 million people in Haiti are undernourished (Food and Agriculture

Organization of the United Nations [FAO], 2015). Young children in Haiti are at risk of undernutrition and micronutrient deficiencies from poverty and food insecurity, with one in five Haitian children currently stunted (USAID, 2018).

Nutrition research, current and future, has the potential to influence the health of global populations (American Society for Nutrition [ASN], n.d.a). The American Society for Nutrition (ASN) has identified six priority areas to lead innovative global nutrition research (ASN, n.d.a; n.d.b). Two of those priority areas include “The Impact of Nutrition on Healthy Growth, Development and Reproduction” and “Food Supply/Environment” (ASN, n.d.a). The first area in regard to childhood nutrition is a continued area of interest. Growth and development in children, from conception through adolescence, is impacted by diet and continued research is essential for further understanding of eating patterns, as well as individual food components on growth and development (ASN, n.d.b). ASN (n.d.b) identified this area as an area in need of continual assessment due to the essential role of nutrition and health. Next, “Food Supply/Environment” relates to food environment and food choice, novel foods and food ingredients, and public and private partnerships (ASN n.d.c). A safe, available, affordable, and nourishing food supply will play a huge role in a population’s food intake and lifestyle (ASN, n.d.c). Collaborating efforts between public and private organizations could have the power to advance nutrition research and improve the global state of malnutrition to achieve necessary improvements and promote a more food secure environment (ASN, n.d.c).

Improving the health of Haitian children will be necessary in long-term efforts to reduce poverty and food insecurity and promote a healthy population. There is limited data on the intake of animal sourced foods in Haitian children’s diets and limited statistical data on the cognitive development of children in developing countries (Grantham-McGregor, Cheung,

Cueto, Glewwe, & Strupp, 2007). The need for additional research on specific types of animal proteins and their impact on health will be key in determining accessible and affordable options that offer health benefits.

OneEgg, with multiple chapters throughout the world, is an organization that provides animal protein to some of the world's most vulnerable children (OneEgg.org, 2018). The OneEgg chapters are committed to supporting and investing in sustainable suppliers of eggs (OneEgg.org, 2018). The OneEgg Haiti Chapter began in 2013 to provide one egg a day to impoverished children in Haiti (OneEgg.org, 2018). OneEgg Haiti has been purchasing eggs from a local Haitian company that operates a poultry farm outside Port au Prince but in 2016, grant funding became available to build a sustainable poultry farm in Haiti for additional egg production (OneEgg.org, 2018). In 2018, over 1,800 children were receiving one egg a day (OneEgg.org, 2018). As the program continues to expand, current research is needed to understand the benefits of egg protein on physical growth and cognitive effects in early childhood.

Problem Statement

Nutrition is essential to any progress towards ending malnutrition, with changes specific to child nutrition crucial to improvement (IFPRI, 2016). Outcomes of undernutrition in children, specific to growth, can include growth stunting, wasting, and being underweight, with strong evidence of potential long-term effects of malnutrition in early life being delayed cognitive, motor, and socio-emotional development (Grantham-McGregor et al., 2007). Protein intake is necessary for the rapid growth and development of children, and eggs are considered a high-quality protein that contain several vitamins and minerals important to growth and development in young children (Mayurasakorn, Sitpahul, & Hongto, 2010; Sizer & Whitney, 1997).

A pilot study conducted in Uganda assessed the effect of egg intake on physical development of students in a school feeding program (Baum, Miller, & Gaines, 2017). School children, ages 6 to 9 were assigned to one of three dietary intervention groups: control, one egg or two eggs per school day, while height, weight, mid-upper-arm circumference (MUAC), and Tricep skinfold thickness (TSF) were measured monthly over a six-month period. Those given two eggs per school day had significantly higher growth and weight gain compared to the one egg and no egg group. TSF and MUAC significantly increased for both one and two egg groups as well. Conclusions from the study noted further research is needed to determine effects of egg supplementation on cognitive development (Baum et al., 2017).

A growing body of research suggests that all aspects of childhood development are impacted by nutrition (Neumann, Harris, & Rogers, 2002). With limited statistical data on the cognitive development of children in developing countries, this study will focus on the data gap specific to animal protein, more specifically, egg protein (Grantham-McGregor, et al., 2007). This thesis is comprised of two individual studies that will contribute to data concerning the role of egg protein in the diet of food-insecure Haitian children in Leogane, Haiti and any impacts on growth, cognition, and motor development.

Purpose Statement

Egg Consumption and Physical Development of Food-Insecure Haitian Children

The purpose of this study is to assess the impact of egg supplementation (10 eggs per week) on growth parameters in Haitian children ages 3 to 8 years old over a six-month period.

Egg Consumption and Cognitive and Motor Development of Food-Insecure Haitian Children

The purpose of this study is to assess the impact of egg supplementation (10 eggs per week) on cognition and motor skills in Haitian children ages 3 to 6 years old over a six-month period.

Objectives

Egg Consumption and Physical Development of Food-Insecure Haitian Children

1. Describe baseline anthropometric data in Haitian children ages 3 to 8 years old.
2. Describe rate of growth over a six-month period with no diet intervention in Haitian children ages 3 to 8 years old.
3. Describe rate of growth after six months of egg supplementation (10 eggs per week) in Haitian children ages 3 to 8 years old.
4. Describe any changes in growth between six months of no intervention and six months of egg supplementation and differences between time periods.
5. Describe the impact of egg supplementation on dietary diversity and nutrient intake of Haitian children ages 3 to 8 years old in Leogane, Haiti.

Egg Consumption and Cognitive and Motor Development of Food-Insecure Haitian Children

1. Describe baseline cognitive and motor skills in Haitian children ages 3 to 6 years old.
2. Describe changes in cognition and motor skills over a six-month period with no intervention in Haitian children ages 3 to 6 years old.

3. Describe changes in cognition and motor skills after 6 months of egg supplementation (10 eggs per week) in Haitian children ages 3 to 6 years old.
4. Describe any differences in cognition and motor skills between six months of no intervention and six months of eggs supplementation.
5. Describe the impact of egg supplementation on dietary diversity and nutrient intake of Haitian children ages 3 to 6 years old in Leogane, Haiti.

Terms

Poverty - most commonly defined as insufficient income to buy a minimum basket of goods and services but can be interpreted more broadly as lack of basic capabilities to live in dignity (United Nations Children's Fund [UNICEF], 2000).

Stunted – having a height (or length)-for-age more than 2 standard deviations below the median reference population (United Nations Children's Fund [UNICEF], n.d.).

Food Security – exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutrition food that meet their dietary needs and food preferences for an active and health life (Smith et al., 2017).

Malnutrition (undernutrition) – an imbalance between nutrient requirement and intake, resulting in cumulative deficits of energy, protein, or micronutrients that may negatively affect growth, development, and other relevant outcomes (Becker et al., 2014).

Wasting – having weight-for-height more than 2 standard deviations below the median value of the reference population (UNICEF, n.d.).

Underweight – moderate underweight is having weight-for-age more than 2 standard deviations below the median reference population, while severe underweight is having a weight-for-age more than 3 standard deviations below the median reference population (UNICEF, n.d.).

Assumptions

Egg Consumption and Physical Development of Food-Insecure Haitian Children

It is assumed the orphanage staff served the eggs five days per week and all subjects consumed both eggs, along with the assumed consumption of daily meals. In addition, it is assumed the birth dates provided by the orphanage director were correct.

Egg Consumption and Cognitive and Motor Development of Food-Insecure Haitian Children

It is assumed the translators assisting with exam facilitation were translating exactly what was scripted by the researchers. In addition, it is assumed the orphanage staff served the eggs five days per week and all subjects consumed both eggs, along with assumed consumption of daily meals. It is also assumed the birth dates provided by the orphanage director were correct.

Limitations

Egg Consumption and Physical Development of Food-Insecure Haitian Children

This study was limited by several factors directly related to working in a food-insecure, developing country including a lack of researcher control over the oversight of daily egg preparation and consumption. Specific to working with an orphanage, one limitation was the inability to validate birth dates and ages of participants. Incorrect birth dates would impact growth assessment. Birth dates used in this study were provided by the orphanage director but birth certificates on participants were unavailable. Another limitation was the lack of ability to

collect biomarker data, including biochemical markers for protein malnutrition or other micronutrient deficiencies. In addition, it is known that multiple factors beyond diet can impact growth and development in children, and that food availability and access to food can be seasonal. Finally, with a small sample size and the ratio of males to females in the study, gender indicators for statistical analysis could not be completed.

Egg Consumption and Cognitive and Motor Development of Food-Insecure Haitian Children

This study was limited by factors directly related to working in a food-insecure developing country including a lack of researcher control over the oversight of daily egg preparation and consumption. Specific to working with an orphanage, one limitation was the inability to validate birth dates and ages of participants. Incorrect birth dates would impact scoring. Birth dates used in this study were provided by the orphanage director but birth certificates on participants were unavailable. In addition, the language barrier was identified as an issue on multiple levels. The use of a translator could be a limitation to the instrumentation of the study, while the Early Screening Profile exams used in the study were benchmarked against American children (Harrison et al., 1990). It is also important to note that food availability and access to food can be seasonal (Smith et al., 2017). Finally, with a small sample size and the ratio of males to females in the study, gender indicators for statistical analysis could not be completed.

Institutional Review Board

In compliance with the policies of the University of Arkansas and federal regulations, human subject research is required to be submitted, reviewed, and approved prior to research completion. Following this policy, this study was approved by the University of Arkansas Institutional Review Board (IRB) office and granted permission to proceed with data collection.

The approval number provided for the research is 17-02-432 (Appendix A). An amendment was completed, along with an extension (Appendix B and C). A consent form was provided to the orphanage director and interpreted by a translator (Appendix D). Verbal consent was completed by the orphanage director, allowing participation of all children in the study.

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Appendices

Appendix A

The Effects of Consuming Eggs on the Physical and Cognitive Development of Food-Insecure Haitian Children IRB Approval

March 10, 2017

MEMORANDUM

TO: Jefferson D. Miller
Mechelle Bailey
Monica Stewart

FROM: Ro Windwalker,
IRB Coordinator

RE: New Protocol Approval

IRB Protocol #: 17-02-432

Protocol Title: *The Effects of Consuming Eggs on the Physical and Cognitive Development of Food-Insecure Haitian Children*

Review Type: EXEMPT EXPEDITED FULL IRB

Approved Project Period: Start Date: 03/03/2017 Expiration Date: 03/02/2018

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (<https://vpred.uark.edu/units/rscp/index.php>). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 59 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior* to implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 109 MLKG Building, 5-2208, or irb@uark.edu.

Appendix B

The Effects of Consuming Eggs on the Physical and Cognitive Development of Food-Insecure Haitian Children IRB Approval Amendment

To: Monica Elaine Stewart
From: Douglas James Adams, Chair
IRB Committee
Date: 02/12/2018
Action: **Expedited Approval**
Action Date: 02/09/2018
Protocol #: 1708011538R001
Study Title: The Effects of Consuming Eggs on the Physical and Cognitive Development of Food-Insecure Haitian Children
Expiration Date: 03/02/2019
Last Approval Date: 03/03/2018

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

cc: Jefferson Davis Miller, Investigator
Mechelle Bailey, Investigator

Appendix C

The Effects of Consuming Eggs on the Physical and Cognitive Development of Food-Insecure Haitian Children IRB Approval Extension

To: Monica Elaine Stewart
From: Douglas James Adams, Chair
IRB Committee
Date: 02/23/2018
Action: **Expedited Approval**
Action Date: 02/23/2018
Protocol #: 1708011538A002
Study Title: The Effects of Consuming Eggs on the Physical and Cognitive Development of Food-Insecure Haitian Children
Expiration Date: 03/02/2019
Last Approval Date: 03/03/2018

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

cc: Jefferson Davis Miller, Investigator
Mechelle Bailey, Investigator

Appendix D

The Effects of Consuming Eggs on the Physical and Cognitive Development of Food-Insecure Haitian Children IRB Consent Form

The effects of consuming eggs on the physical and cognitive development of food-insecure Haitian children

Consent to Participate in a Research Study

Principal Researchers: Jefferson Miller, Mechelle Bailey, Monica Stewart

INVITATION TO PARTICIPATE

As a part of the egg nutrition research project currently being conducted at your orphanage/school, staff and students are invited to participate in a study. These measurements, tests, and interviews will help researchers learn more about how feeding the children eggs has affected their physical and mental growth.

WHAT YOU SHOULD KNOW ABOUT THE RESEARCH STUDY

Who is the Principal Researcher?

Dr. Jefferson Miller, jdmiller@uark.edu
Ms. Mechelle Bailey, mlb13@uark.edu
Ms. Monica Stewart, mmerrell@email.uark.edu

What is the purpose of this research study?

The purpose of this study is to examine the physical and cognitive effects of incorporating eggs into the diets of 3-8 year old children in Haiti.

Who will participate in this study?

Approximately 35 children, ages 3-8, at a single orphanage near Leogane, Haiti and selected orphanage care givers.

What am I being asked to do?

Your participation will require the following:

- Children will eat their normal diet every day for the first six months of the study. The next 6 months, children will eat 2 boiled eggs per day, Monday through Friday for six months.
- Children will allow researchers to measure their height, weight, arm circumference, head circumference and upper-arm skin thickness approximately every three months.
- Children will participate in a 20-minute oral exam at the beginning, middle, and of the project.
- Children will participate in a 5-minute motor skills exam (stringing beads, walking on a straight line, balancing on one foot, and jumping)
- Caregivers will be interviewed about each child's diet and eating patterns.
- Video and still photography of children and caregivers will be used in a video documentary, which will be viewed by researchers and the general public. If you agree to participate, you will also be agreeing to allow researchers at the University of Arkansas to use video and still images of you and the children at your orphanage in the video and related educational and promotional materials.

What are the possible risks or discomforts?

There are no risks associated with your participation in this study.

What are the possible benefits of this study?

Children receiving eggs may benefit physically from consuming more protein. Orphanage staff may benefit from learning about the cognitive development of their children.

How long will the study last?

The study will last 1 year, from March 2017 through March 2018. Each child's exam will take about 40 minutes, and each caregiver interview will take about 20 minutes.

Will I receive compensation for my time and inconvenience if I choose to participate in this study?

Study participants will not be paid for their participation, but the eggs will be delivered every two weeks at no cost. OneEgg staff member and/or research team members will visit occasionally to inspect the egg deliveries and to ensure that children are consuming eggs during the week.

Will I have to pay for anything?

There will be no cost associated with participating.

What are the options if I do not want to be in the study?

If any children or orphanage staff do not want to be in this study, they may refuse to participate. Also, you may refuse to participate at any time during the study. Their position in the orphanage, and (for caregivers) their job and their relationship with their employer and with the University of Arkansas will not be affected in any way if they refuse to participate.

How will my confidentiality be protected?

All information will be kept confidential to the extent allowed by applicable State and Federal law. Test results will be stored in secure locations in hard copy and electronic form. Interview recordings will be transcribed, and both the recordings and transcriptions will be stored on a password-protected computer until they are destroyed at the conclusion of the data analysis. The names of any children or caregivers involved in the study will not be reported to protect their privacy, and the names of the orphanages/schools participating will also not be reported.

Will I know the results of the study?

At the conclusion of the study, orphanage directors who are the legal guardians of the children will have the right to request feedback about the test and measurement results for their children. Directors may contact the researchers, Jefferson Miller (jdmiller@uark.edu), Mechelle Bailey (mlb13@uark.edu), or Monica Stewart (mmerrell@email.uark.), to receive copies of the results.

What do I do if I have questions about the research study?

Participants have the right to contact the Principal Researchers as listed above about any concerns that you may have.

You may also contact the University of Arkansas Research Compliance office if you have questions about your rights as a participant, or to discuss any concerns about, or problems with the research:

Ro Windwalker, CIP
Institutional Review Board Coordinator
Research Compliance
University of Arkansas
109 MLKG Building
Fayetteville, AR 72701-1201
479-575-2208
irb@uark.edu

I have read the above statement and have been able to ask questions and express concerns, which have been satisfactorily responded to by the investigator. I understand the purpose of the study as well as the potential benefits and risks that are involved. I understand that participation is voluntary. I understand that significant new findings developed during this research will be shared with the participant. I understand that no rights have been waived by signing the consent form. I have been given a copy of the consent form.

- Orphanage director agrees to participate and to allow children to participate
- Orphanage staff member agrees to participate

Director/staff member name (entered by OneEgg team member)

OneEgg team member signature

CHAPTER II: EGG CONSUMPTION AND PHYSICAL DEVELOPMENT OF FOOD-INSECURE HAITIAN CHILDREN

Abstract

Within Latin America and the Caribbean, severe food insecurity is highest in Haiti with half of the population considered undernourished. While diets in the developing world are primarily plant-based, the addition of eggs, as a locally available source of nutrients, provides high-quality protein necessary for growth and development in children. The impact of egg supplementation on growth parameters in Haitian children ages 3-8 years old was assessed in this study. Children from a single orphanage were recruited and growth parameters were evaluated at baseline, six months, and one year. At the mid-point of the study, two eggs, five days per week (10 eggs per week) were provided to each child weekly for six months. All 11 participants received the same dietary intervention. Dietary diversity and nutrient intake were assessed throughout the study using a 24-hour recall. Growth parameters were evaluated using anthropometric data converted to Z-scores to identify stunting, wasting, and underweight, and to compare growth velocity in the control period to the intervention period during the study. Significant differences in anthropometric outcomes did not support previous research, with a decrease in growth velocity after egg intervention. A balance of energy and protein is needed for sufficient growth in children, and while dietary diversity is highly correlated with calorie and protein adequacy, findings from this study reflected an increase in dietary diversity was not reflective of increased energy intakes. While eggs delivered key nutrients to the diet, without adequate caloric intake, poor growth velocity was observed. The outcomes of the study support the known relationship between child undernutrition and food insecurity.

Introduction

With high rates of food insecurity prevalent among developing countries, the topic of food security continues to gain global attention and is a key focus of the Sustainable Development Goals (SDG) set by the United Nations (United Nations, 2016). Goal Two is specific to ending hunger, improving nutrition, and achieving food security by 2030 (United Nations, 2016). The results of global undernutrition are overwhelming with an estimate that 45% of deaths of children under age 5 are linked to malnutrition (Becker et al., 2014). Pediatric malnutrition (undernutrition) is defined as “an imbalance between nutrient requirements and intake, resulting in cumulative deficits of energy, protein or micronutrients that may negatively affect growth, development, and other relevant outcomes” (Becker et al., 2014, p.1989). Outcomes of undernutrition in children, specific to growth, can include growth stunting, wasting, and underweight with the risk of death increasing as Z scores fall (Black et al., 2008; Grantham-McGregor, Cheung, Cueto, Glewwe, & Strupp, 2007). The primary contributors to micronutrient deficiencies include a lack of diversity in the diet and incidence of diseases and infection (Nordin, Boyle, & Kemmer, 2013).

In Haiti, one of the poorest countries in the world, 55% of the population lives below the poverty line with about 50% of the population undernourished (Food and Agriculture Organization of the United Nations [FAO], 2015; United States Agency for International Development [USAID], 2017). One in five Haitian children are stunted, while two-thirds of children under age 5 are anemic and one-third of children under 5 are Vitamin A deficient (United States Agency for International Development [USAID] 2011; 2018). Repeated occurrences of natural disasters in the country are directly linked to food insecurity, with 3.6 million people reportedly food insecure in 2017 (United States Agency for International

Development [USAID], 2018). Using the Food and Agricultural Organization's (FAO's) Food Insecurity Experience Scale (FIES), Haiti has the highest rate of severe food insecurity in Latin America and the Caribbean (Smith, Kassa, & Winters, 2017).

Dietary diversity, assessed by the number of food groups consumed over a reference period, is highly correlated with calorie and protein adequacy (Swindale & Bilinsky, 2006). Protein intake is vital in infancy and childhood to provide a continuous supply of amino acids which support rapid growth and build new tissue (Sizer & Whitney, 1997). Improving diet quality is one approach to improving nutrition status (Neumann, Harris, & Rogers, 2002). Children eating a primarily plant-based diet, common in the developing world, may fail to meet micronutrient needs (Pachon et al., 2007). While animal protein provides all essential amino acids and is considered the highest quality protein, some sources including eggs also provide important micronutrients (Watson & DeMeester, 2015). Eggs are a locally available source of animal protein that provide essential vitamins and minerals including micronutrients such as iron, iodine, Vitamin A and zinc making them an excellent option for animal protein supplementation (Genesis R&D Product Development and Labeling Software, 2017).

Research shows that the negative effects of undernutrition can be offset by the positive effects of nutrition interventions in relation to growth. Several studies have shown supplementing dietary intake with animal protein improves growth (Baum, Miller, & Gaines, 2017; Grantham-McGregor et al., 2007; Neumann, Murphy, Gewa, Grillenberger, & Bwibo, 2007). Specific to eggs, one study of children ages 6-9 years old in Africa found that school children provided with two eggs per day in a school feeding program gained significantly more height and weight compared to children receiving one egg or no eggs per day (Baum et al., 2017).

Because eggs are a complete protein, contain a variety of micronutrients, and are generally available, eggs are of interest in malnutrition research (Mayurasakorn, Sitphahul, & Hongto, 2010). With limited data on the intake of animal sourced foods in Haitian children's diets and known nutrition related public health concerns in Haiti, additional research is needed (Pachon et al., 2007). More specifically, research on types of animal proteins and their impact on health will be key in determining accessible and affordable options that offer nutritional benefits.

Conceptual Framework

Underlying causes of child undernutrition are understood to be directly related to a variety of factors outlined in the United Nation's Children Fund (UNICEF) framework in Figure 1, with poverty playing a fundamental role. (Black et al., 2008). Poverty directly impacts household food insecurity and inadequate dietary intake, with adverse outcomes including undernutrition. These challenges, common in developing nations, are linked to both short-term and long-term consequences including inadequate growth and development, increased morbidity, mortality, disability, and decreases in adult stature, economic productivity, and intellectual ability (Black et al., 2008). Improving the health of Haitian children will be necessary in long-term efforts to reduce poverty and food insecurity and help promote a healthy population.

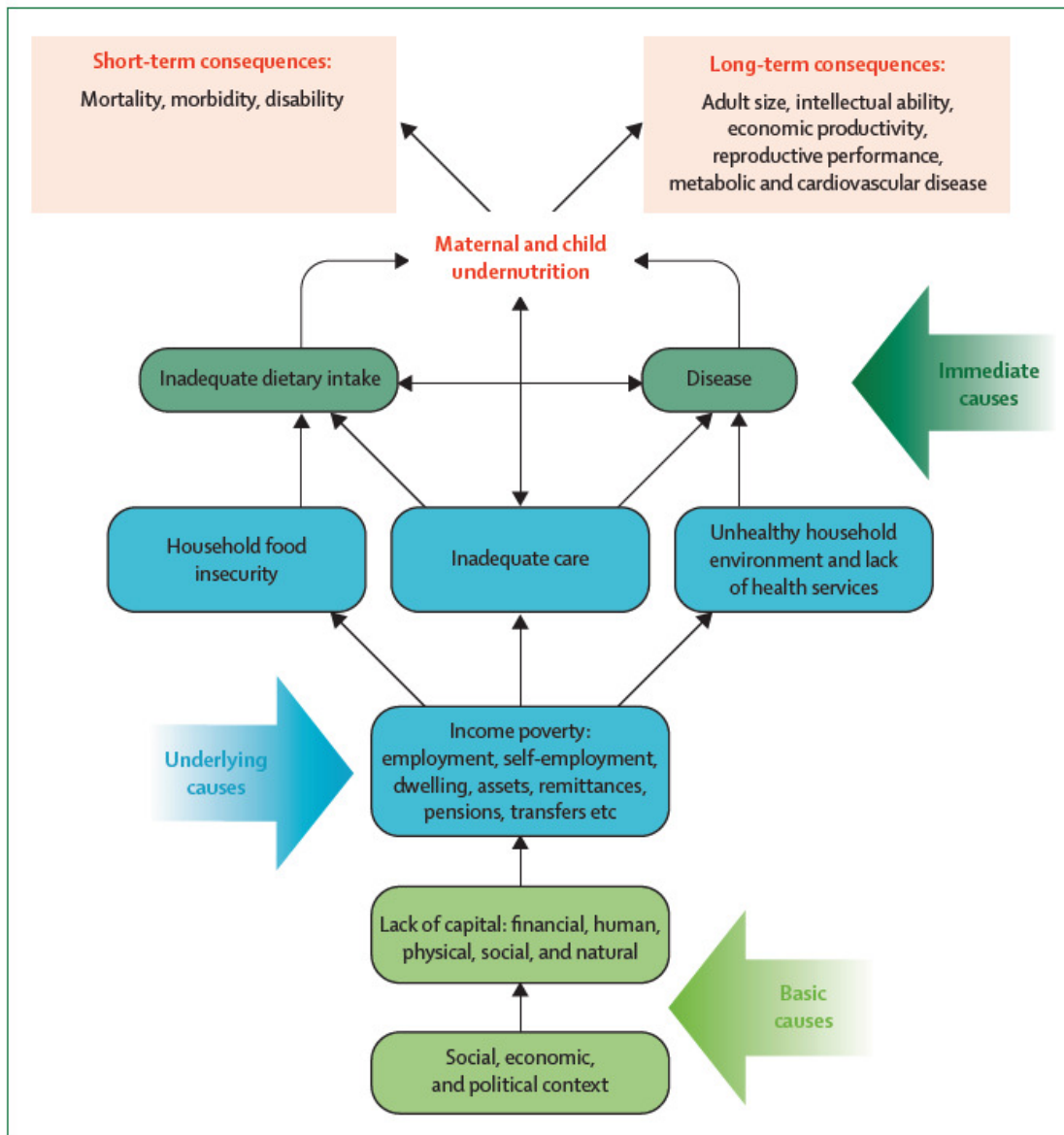


Figure 1. The UNICEF framework for basic, underlying, and immediate causes of child undernutrition identifies three elements that impact child nutrition status directly: household food insecurity, inadequate care, and health status. Adapted from “Maternal and child undernutrition: global and regional exposures and health consequences,” by R. E. Black, L. H. Allen, Z. A. Bhutta, L. E. Caulfield, M. de Onis, M. Ezzati, C. Mathers, J. Rivera, for the Maternal and Child Undernutrition Study Group, 2008, *The Lancet*, 371, p.244.

Context of the Study

OneEgg, with multiple chapters throughout the world, is an organization that provides animal protein to some of the world's most vulnerable children (OneEgg.org, 2018). The OneEgg Haiti Chapter began in 2013 to provide eggs to impoverished children and through grant funding has expanded their presence in Haiti with a sustainable poultry farm, providing eggs to over 1,800 children a day (OneEgg.org, 2018). As the program continues to expand, current research is needed to understand the benefits of egg protein on physical growth in early childhood when added to the diet. OneEgg staff has been instrumental in the development of this project.

Purpose and Objectives

This article presents the results of a quasi-experimental study aimed to assess the impact of egg supplementation (10 eggs per week) on growth parameters and dietary diversity in Haitian children ages 3 to 8 years old over a six-month period. Baseline anthropometric measurements, rate of growth without intervention and with intervention, changes in growth and the impact of egg supplementation on nutrient intake and dietary diversity of Haitian children will be described. The hypothesis was that the supplementation of eggs would improve child growth and increase dietary diversity.

Methodology

General Design Approach

A quasi-experimental design examining the impact of egg supplementation on growth parameters, along with dietary diversity and nutrient intake was conducted over a one-year period in Leogane, Haiti. A single orphanage, identified by OneEgg staff through site visitation,

was identified to serve as their own control group for the study for one year. Inclusion criteria included children under the age of 8 years old. Anthropometric measurements captured were determined based on current literature used to identify and define pediatric undernutrition. Z-scores were calculated for weight-for-height, height-for-age, and weight-for-age, while growth velocity, was evaluated as well. Dietary diversity and nutrient intake was evaluated with a 24-hour recall. Ethical approval for the study was obtained from the University of Arkansas Institutional Review Board, approval number 17-02-432. Informed consent for study participation was obtained from the orphanage director, through the use of a translator, as legal guardian of the children, before data collection was initiated.

Intervention

Growth parameters, dietary diversity and estimated nutrient intakes were assessed for six months with no egg supplementation, allowing the group to serve as their own control. Eggs were then introduced at the mid-point of the study and provided for six months. Egg supplementation consisted of two medium-sized eggs a day (~50 grams each), five days a week (10 eggs per week) for each child in the orphanage. There were no children with any reported egg allergy or egg related intolerances. Eggs were procured from local poultry farms and delivered bi-monthly to the orphanage by poultry farm staff. The orphanage director and staff were instructed to serve the eggs hard boiled as a supplement to the diet five days per week. Cooking instructions, along with serving instructions, were provided via an interpreter and translated in writing to Haitian Creole for the orphanage staff.

Anthropometry

Anthropometric measures were collected according to World Health Organization (WHO) and United Nations Children's Fund (UNICEF) protocols (World Health Organization [WHO], 2008; United Nations Children's Fund [UNICEF], n.d.b) Before the study began, the registered dietitian researcher participated in a training workshop by the Academy of Nutrition and Dietetics for a hands-on Pediatric Nutrition Focused Physical Examination. Height, body weight, mid-upper-arm circumference (MUAC), and tricep skinfold thickness (TSF) were measured for each child at baseline, six months, and one year for a total of three sets of data points for each child. Shoes and any items from pockets were removed for measurements. Height was measured using a self-standing stadiometer to the nearest 0.1 centimeter (cm) in duplicate; the average of the two measurements was used. Body weight was measured with a standing scale to the nearest 0.1 kilogram (kg), and a minimum of two readings were taken. The average of the two measurements for body weight was used. Height and body weight measurements were used to calculate body mass index (BMI). MUAC was measured to the nearest 0.1 cm on each child's right arm using a paper measuring tape in triplicate; the average of the three measurements was used (UNICEF, n.d.b). TSF was measured on the right arm using Lange skinfold calipers to the nearest 0.1 millimeter (mm) in triplicate; the average of the three measurements was used.

The anthropometric measurements and Z-scores were used to identify stunting, wasting, and underweight, all commonly used to identify child undernutrition (Black et al., 2008).

Anthropometric measures were converted to Z-scores for height-for-age and weight-for-age for all children referencing with standards (World Health Organization [WHO], 2006). Weight-for-height was converted to z-scores on children under the age of 5 to identify wasting, as WHO Z-

score references are unavailable past age 5 for weight-for-height. Stunting was defined as height-for-age less than 2 standard deviations (SD) below the median using WHO growth charts, while underweight was defined as a weight-for-age less than 2 SD below the median, and wasting defined as less than 2 SD below median weight-for-height (United Nations Children's Fund [UNICEF], n.d.a).

Dietary Diversity and Nutrient Intake

Via an interpreter, the orphanage staff was interviewed throughout the study by a registered dietitian to describe the typical diet for the children within the study. The data on number of meals eaten daily, along with household dietary diversity scores (HDDS) were collected using a 24-hour dietary recall questionnaire adapted by the Food and Nutrition Technical Assistance Project (FANTA) (Appendix A) (Swindale & Bilinsky, 2006). Orphanage staff was asked to report all food and beverages consumed by the children on the previous day, including ingredients in dishes and estimated portions consumed by the children. The 24-hour dietary recall was translated into Haitian Creole by Haitian translators, and the questionnaire was revised to include local foods popular in the Haitian culture (Appendix B). Once the interviews were completed, the researcher assigned a HDDS following the tabulation guidelines provided by FANTA (Swindale & Bilinsky, 2006). Interviews were completed at baseline, six months and one year, for a total of three scores.

Using Genesis[®], a nutrition analysis software program, the data taken from the 24-hour recall was evaluated by the registered dietitian researcher and used for calculation of nutrient composition to compare against estimated nutrient requirements for children ages 3-8 (Genesis R&D Product Development and Labeling Software, 2017; Institute of Medicine [IOM], 2006). Calculated nutrient composition, specific to calories, protein, fat, carbohydrate, iron, Vitamin A,

zinc, and iodine was then compared to the Dietary Reference Intakes (DRI) by age group for each nutrient (IOM, 2006).

Statistical Analysis

Anthropometry

The difference in baseline and midpoint data (control period) was calculated for height, weight, MUAC, TSF, and BMI. Next, the difference between midpoint and endpoint data (egg intervention period) was also calculated to compare growth differences between time periods. Paired sample *t*-tests were then used to assess the differences between both groups of data for height, weight, MUAC, TSF, and BMI, while descriptive statistics were used to describe nutrition status including pediatric undernutrition indicators for stunting, wasting, and undernutrition. All analyses were conducted using SAS Software 9.3 (SAS for Windows, 2017). Male and female data were combined for analysis.

Dietary Diversity and Nutrient Intake

Descriptive statistics, including raw data from the 24-hour recall, were used to discuss differences between DRI and calculated intakes for calories, protein, fat, carbohydrate, iron, Vitamin A, zinc, and iodine to describe the typical diet and nutrient intake of food insecure children in a single orphanage in Leogane, Haiti.

Results

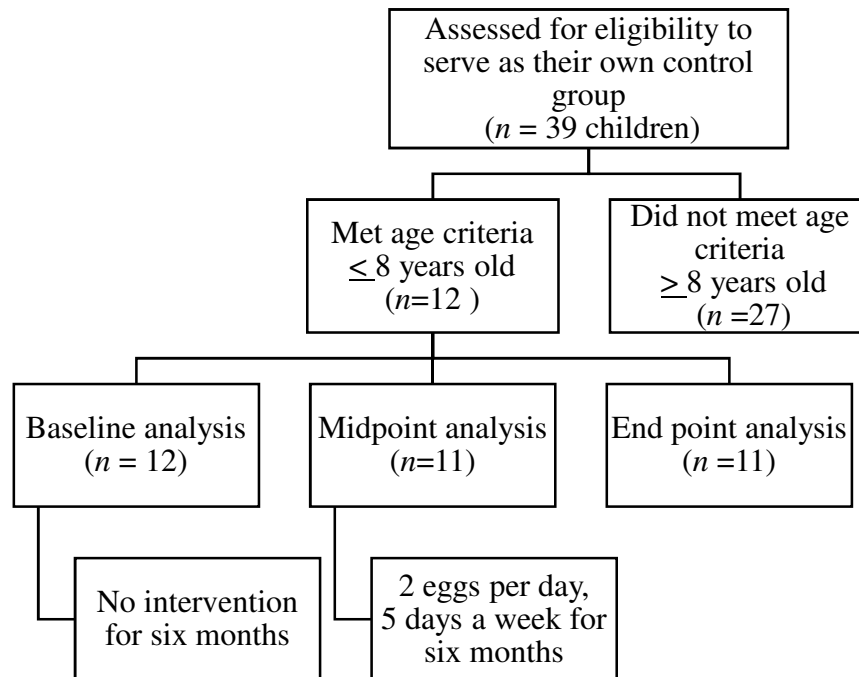


Figure 2. Participant enrollment and retention flow diagram.

Anthropometry

At baseline, 39 children at a single orphanage in Leogane, Haiti were assessed for study eligibility. Of those, 12 children met the age requirement of less than 8 years of age, see Figure 2. At the end of the study, one year later, 11 of the 12 children completed the study. One child did not complete due to migration from the orphanage, yielding an 8% attrition rate. The baseline characteristics of the children are shown in Table 1, along with six-month mid-point and one-year final assessment data. Nutritional status was identified for those that met criteria for stunting, wasting, and undernutrition. No allergic reactions or intolerances were reported after consuming the eggs at any point in the study.

Table 1

Demographics and Health Characteristics of Food-Insecure Haitian children			
Characteristics	Baseline	Mid-point	End
	<i>n</i> = 11	<i>n</i> = 11	<i>n</i> = 11
	Mean (SD)	Mean (SD)	Mean (SD)
Age, mo	61 (10.7)	67 (10.58)	73 (10.58)
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Female	2 (18)	2 (18)	2 (18)
Male	9 (82)	9 (82)	9 (82)
Nutritional Status			
Stunted (HAZ < -2 SD)	1 (9)	1 (9)	2 (18.2)
Underweight (WAZ < -2 SD)	2 (18.2)	2 (18.2)	5 (27.3)
Wasted (WHZ < -2 SD) ^a	2 (18.2)		1 (9)

Note. Egg intervention was introduced after midpoint measurements were taken. SD = standard deviation; mo = months; HAZ = height-for-age z score; WAZ = weight-for-age z score; WHZ = weight-for-height z score

^aData only available for children under 5 years old.

At the beginning of the study, the children ranged in age from 3 years, 4 months to 7 years, 2 months, with a median age of 5 years 3 months. The majority of the children in the study were male, including one set of male twins. Twenty-seven percent of the children, three in total, met criteria for either stunted, underweight, or wasted at baseline. The child that was stunted, was also underweight. The other underweight child was also classified as wasted. At the midpoint evaluation, prior to egg intervention, 18% of the children met criteria for malnutrition, a slight improvement from baseline. Of the two children that met criteria for underweight, one was also stunted. The same children classified as underweight at the beginning of the study, still met criteria for underweight at the study midpoint. Initially, of the two children that met criteria for wasted at baseline, one was over age five at midpoint and both were over age 5 at the endpoint in the study. Z-score data on weight-for-height is not available by the WHO for children over the age of 5. At the final evaluation, the youngest child in the study met criteria for wasted. Final measurements showed 54.5% of the children, six in total, met some form of

undernutrition by study completion. The majority, five children (45.5%), met criteria for underweight. The child who met criteria for stunting at baseline still met stunting criteria at the end of the study.

Table 2

Mean Changes in Growth Parameters Among Food-Insecure Haitian Children Receiving Two Eggs Per Day for Six Months

Anthropometric Data	Control Period	Egg Intervention	<i>p</i>
	Difference	Period Difference	
	Mean (SD)	Mean (SD)	
Height, cm	2.33 (0.15) ^a	0.67 (0.51) ^b	<.001
Weight, kg	0.54 (0.68) ^a	- 0.75 (0.27) ^b	<.001
TSF, mm	0.36 (0.82) ^a	- 1.08 (0.71) ^b	.001
MUAC, cm	-0.06 (0.49) ^a	- 0.75 (0.29) ^b	.001
BMI	-0.15 (0.42) ^a	- 0.79 (0.21) ^b	.001

Note. From midpoint to endpoint, two eggs per day, five days per week were initiated and provided until study completion at one year. SD = standard deviation; cm = centimeter; kg = kilogram; mm = millimeter; BMI = body mass index

Means not sharing the same letter are significantly different within a row.

The results of the paired sample *t*-tests are presented in Table 2, showing the mean differences in anthropometric data from both baseline to midpoint (control period), and then midpoint to study completion (egg intervention period). Data shows the children had a greater mean increase in linear growth, gained more weight on average, and had an increase in mean TSF during the control period. TSF, a measurement of fat, showed greater fat loss after intervention. While MUAC and BMI decreased on average during the control period, the decrease was significantly greater after the intervention. MUAC, which measures fat, bone, and muscle, decreased more after the intervention. Mean BMI decreased with a height increase and weight loss. Overall, growth outcomes were not improved with the intervention of two eggs per day, five days per week (10 eggs per week).

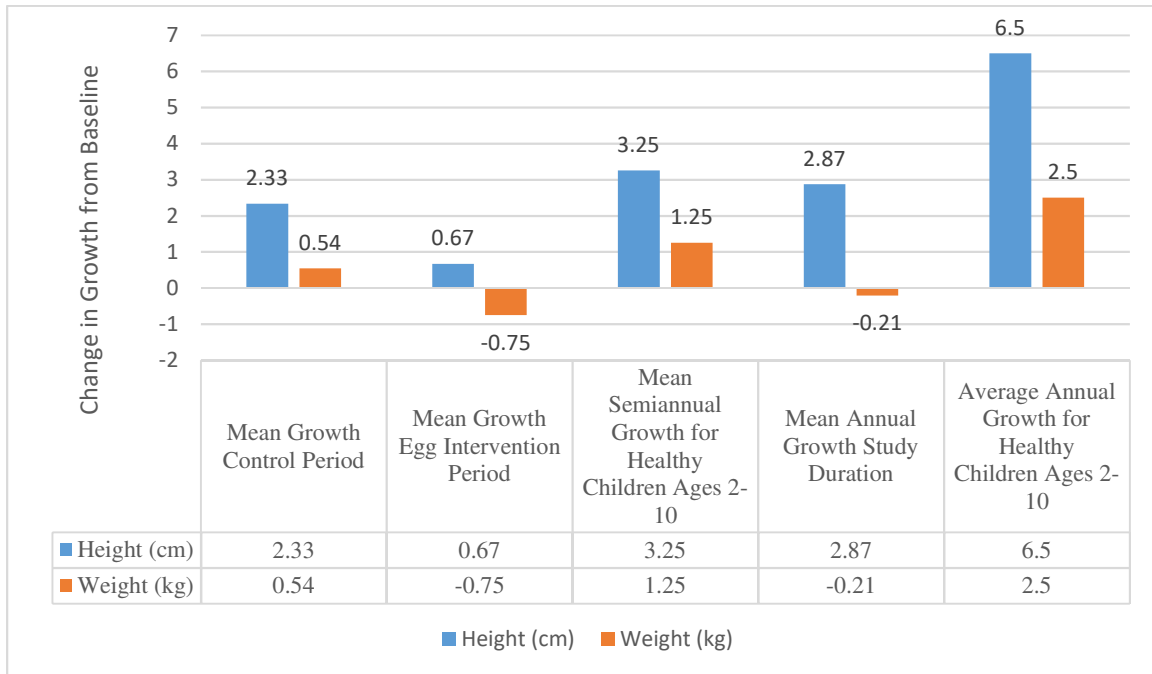


Figure 3. Mean growth velocity is below the average growth benchmarks for healthy children in this same age group during control and egg intervention period. American Academy of Pediatrics Committee on Nutrition. (2014). Chapter 14 Energy. In R. E. Kleinman & F. R. Greer (Eds.) *Pediatric Nutrition Handbook 7th Edition* (p. 143). Elk Grove Village, IL: American Academy of Pediatrics.

Looking specifically at height and weight, during the control period, prior to the intervention, the mean linear growth and mean weight gain were below that of average semiannual growth for this age group, as seen in Figure 3. While the growth trajectory was already below average, the growth velocity continued to decline as the study progressed, even after the egg intervention. Mean growth velocity during the egg intervention of two eggs per day was overall less than the period before intervention. Throughout the study, all children increased in height (100%), five children gained weight (45%), one child maintained weight (9%), and five lost weight (45%). Additionally, mean growth velocity total for one year for both height and weight was lower when compared to the average annual growth for adequately nourished children in the same age group (American Academy of Pediatrics Committee on Nutrition, 2014).

Dietary Diversity and Nutrient Intake

Egg intervention and the impact on dietary diversity and nutrient composition was examined during the study by using a 24-hour recall, along with the Household Dietary Diversity Score (HDDS). Dietary diversity, calculated via HDDS, and estimated nutrient intake results were the same for each child, as they were all served the same portion sizes and meals daily. Results are shown in Table 3. Possible scores for the HDDS ranged from 0-12 representing the following 12 food groups: cereals, root and tubers, vegetables, fruits, meat and poultry, eggs, fish and seafood, pulses/legumes/nuts, milk and milk products, oils/fats, sugar/honey, and a miscellaneous category for condiments and drinks (Swindale & Bilinsky, 2006). Each food group represented is equal to one point on the HDDS.

During the study, the number of meals per day decreased, while the dietary diversity score increased. Reported food groups at baseline were cereals, beans, and oils. At midpoint, reported food groups included cereals, beans, oils, vegetables and poultry, while final food groups included cereals, beans, oils, vegetables, poultry, sugars, and eggs. Eggs were reportedly consumed *as* the breakfast meal, rather than supplemented according to the study protocol.

As seen in Table 3, estimated total energy, carbohydrate, and iron all decreased from baseline to the end of the study. Protein, fat, Vitamin A, zinc and iodine increased with the addition of two eggs per day. The percent of energy from protein and fat increased throughout the study, while the percent of energy from carbohydrates decreased.

Table 3

Calculated Dietary Diversity and Estimated Nutrient Intakes of Children Ages 3-8 Years at a Single Orphanage in Leogane, Haiti

Variable			Baseline	Midpoint	End
No. of meals consumed per day			3	2	2
HDDS (0-12)			3	5	7
	DRI ^a				
Nutrient	1-3 yrs	4-8 yrs			
Energy Intake (kcal)	1230 ^b	1715 ^b	933.67	848.42	789.13
Protein intake (g/d)	13	19	26.53	34.23	43.87
Fat intake (g/d)	ND	ND	7.91	13.62	22.69
Carbohydrate intake (g/d)	130	130	189.09	147.23	102.36
Iron (mg/d)	7	10	7.56	7.23	7.02
Vitamin A (µg/d)	300	400	0.00	29.32	166.43
Zinc, (mg/d)	3	5	3.09	3.91	4.74
Iodine, (µg/d)	90	90	15.80	11.85	67.38
% total energy from protein	5-20%	10-30%	11.4%	16.2%	22.2%
% total energy from fat	30-40%	25-35%	7.6%	14.4%	25.9%
% total energy from carbohydrate	45-65%	45-65%	81.0%	69.4%	51.9%

Note. Eggs were introduced after midpoint data was taken; endpoint data includes eggs. Nutrient reference values are for both boys and girls. HDDS = Household Dietary Diversity Score; DRI = dietary reference intakes; ND = not determined.

^a Adapted from “Dietary Reference Intakes: The Essential Guide to Nutrient Requirements,” by J. J. Otten, J. P. Helwig, & L. D. Meyers, 2006, Institute of Medicine, Washington DC: National Academy of Sciences.

^b Reflects recommended intakes for energy in calories per day for boys since boys have highest caloric needs. Adapted from “Feeding and Nutrition of Infants and Young Children” by K. F. Michaelsen L. Weaver, F. Branca & A. Robertson, 2000, World Health Organization (WHO) Regional Publications.

Discussion

This study examined the impact of egg supplementation on physical growth in food insecure Haitian children. The primary objectives were to describe baseline anthropometric data, rates of growth, overall changes in growth, and to describe the impact of egg supplementation on nutrient intake and dietary diversity. Key findings that emerged from the research included the following:

1. insufficient energy intakes and poor growth outcomes were observed over the course of the study, with additional protein likely used for energy rather than growth,
2. increases in dietary diversity were not reflective of adequate nutrient intakes,
3. the addition of eggs to the diet increased protein, vitamin A, zinc, and iodine,
4. food insecurity is a well-known challenge in Haiti that likely played a role in study outcomes.

These outcomes support the known relationship between child undernutrition and food insecurity (Black et al., 2008).

With reported increased rates of food insecurity during the last three months of the study, a decline in the number of meals served per day, and reports of using the eggs as a meal replacement to extend food supplies, the results of the study did not support the hypothesis. This hypothesis was based on previous research that suggests this simple food based intervention of two eggs per day can positively impact growth parameters in food insecure children (Baum, et al., 2017). Growth measurements during the control period indicated below average growth before the intervention when compared to normal growth patterns for children in this age range. A decrease in growth velocity continued throughout the study, with calculated estimates from the 24-hour recalls supporting insufficient energy intake as a possible cause. A balance of energy and protein is needed for sufficient growth, particularly in relation to undernutrition, and undernutrition outcomes would include growth failure and nutrient deficiencies (American Academy of Pediatrics Committee on Nutrition, 2014; Grantham-McGregor et al., 2007). While six of the children met criteria for underweight at the study completion, stunting was also

identified in two children. Growth deficits, including a decrease in height velocity or stunting, are indicative of chronic malnutrition (Mehta et al., 2013).

Estimated energy needs for this age group ranged from 1230-1715 calories per day. Between 54-75% of estimated calorie needs were being met prior to the intervention and 46-64% were met during the egg intervention and reported food shortages, with the majority of the children falling into the higher energy needs based on their age. While protein intake is necessary for the rapid growth and development of children, if calorie needs are not sufficient, supplementary protein is not available for growth utilization and is instead utilized for maintenance energy needs (Arsenault & Brown, 2017; Sizer & Whitney, 1997). The consequences of consuming 46-64% of estimated needs is clearly illustrated. While the literature includes several studies on animal protein that show supplementing dietary intake with protein can improve growth in children, there are also country specific case studies where large-scale nutrition programs have failed with reports of food sharing and insignificant or worsening growth patterns (FAO, 2015; Grantham et al., 2007; Neumann et al., 2002; 2007; Watanabe, Flores, Fujiwara, & Tran, 2005; World Health Organization [WHO], 2013).

Baseline anthropometric data, including the control period, showed faster rates of growth than during the egg intervention period. The study was designed for the eggs to supplement the diet, but when food supplies became scarce, the eggs were instead used as a meal replacement. The typically higher carbohydrate based meal was replaced, which caused a subsequent reduction in total energy intake and increased protein intake. Dietary diversity increased throughout the study, despite a calculated decrease in caloric intake. The increase in HDDS was not reflective of increased quantity of energy. The addition of eggs to the diet provided an increase in dietary protein, Vitamin A, zinc, and iodine. While increasing diet quality with

animal sources of foods can be beneficial in the prevention of common micronutrient deficiencies in Haitian children, like anemia and Vitamin A, these deficiencies were not tested in our study (Sizer & Whitney, 1997).

When calorie intake is adequate to meet daily energy needs, eggs, as a locally available, complete protein source, could be an ideal choice to help improve nutrition status in pediatric undernutrition. In this study, the eggs unintentionally became a replacement for carbohydrate (and energy and iron), replacing some of the daily carbohydrate at breakfast, which was typically corn or enriched pasta. The addition of eggs delivered additional dietary protein, Vitamin A, zinc, and iodine to the typical diet of the children in this study. These key findings may be helpful in future research specific to common micronutrient deficiencies in Haitian children.

Limitations in this study should be recognized. Specific to the study design, the researchers had no control over food access, other than a consistent supply of eggs, therefore any impact to food supply was an impact to every child in the study. In addition, on-site supervision of meals and feeding practices were not feasible for this study. An additional limitation that would be expected when working with an orphanage was the inability to validate birth dates. Birth dates used in this study were provided by the orphanage director but birth certificates for date validation were unavailable. Incorrect birthdates would impact pediatric growth assessment. Another limitation was the inability to collect blood samples for micronutrient analysis or to analyze biochemical markers for protein malnutrition. In addition, with the high ratio of males to females in the study, and a small sample size, gender indicators for statistical analysis could not be measured. Finally, it is known that multiple factors beyond diet can impact physical growth in children; no medical assessments of the children were completed to assess overall health status.

While every food insecure community has unique challenges, the underlying causes of undernutrition identified by Black et al. (2008) were not unique to this study. Food insecurity, identified as a direct cause of malnutrition will continue to be a challenge for countries, until goal two of the SDG is met (United Nations, 2016). Considerations for future research could include an allocation of resources for daily oversight of meals and feeding practices, an education component highlighting the importance of egg supplementation to the diet (not replacement in the diet), and incorporating education on basic nutrition. Investigating nutrient intake, specific to energy and protein, before research begins will help identify and verify that supplemental protein will likely be used for growth, rather than used for energy (Arsenault & Brown, 2017). Involving the local community to identify gaps in nutrition or feeding practices could be beneficial in research geared towards infants and young children. The need for additional research on specific types of animal proteins and their impact on growth will be key in determining accessible and affordable options that offer nutritional benefits. To further explore whether additional animal protein may improve growth in at risk children, future research is needed in a younger population, when growth is beginning to falter, for instance during the first 1,000 days of life (Arsenault & Brown, 2017). In addition, research that includes a marker of protein status or micronutrient deficiencies that could be monitored while utilizing larger samples sizes could potentially help identify the most critical time to provide nutrition interventions.

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Appendices

Appendix A

FANTA Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access

24 Hour Recall

Please describe the foods (meals and snacks) that the children ate or drank yesterday during the day and night, whether at home or outside the home. Start with the "first food or drink of the morning.

Write down all foods and drinks mentioned. When composite dishes are mentioned, ask for the list of ingredients.

When the respondent has "finished, probe for meals and snacks not mentioned.

BREAKFAST	SNACK	LUNCH	SNACK	DINNER	SNACK

[Households: include foods eaten by any member of the household, and exclude foods purchased and eaten outside the home]

When the respondent recall is complete, "ll in the food groups based on the information recorded above. For any food groups not mentioned, ask the respondent if a food item from this group was consumed.

When completed, fill in Questionnaire Format below with Respondent.

III. Questionnaire Format for Haiti

In order to collect household dietary diversity data, the following questions should be added to the baseline and final surveys. As appropriate, locally available foods should be added into the food groups.

QUESTIONS AND FILTERS

CODING CATEGORIES

- 1 Now I would like to ask you about the types of foods that you or anyone else in your household ate yesterday during the day and at night.

READ THE LIST OF FOODS. PLACE A *ONE* IN THE BOX IF ANYONE IN THE HOUSEHOLD ATE THE FOOD IN QUESTION, PLACE A *ZERO* IN THE BOX IF NO ONE IN THE HOUSEHOLD ATE THE FOOD.

- | | | |
|---|--|------------|
| A | Any [INSERT ANY LOCAL FOODS, E.G. UGALI, NSHIMA], bread, rice noodles, biscuits, cookies, or any other foods made from millet, sorghum, maize, rice, wheat, or [INSERT ANY OTHER LOCALLY AVAILABLE GRAIN]? | A __ |
| B | Any pumpkin, carrots, squash (chou) or sweet potatoes that are yellow or orange inside? | B __ |
| C | Any white potatoes, white yams, manioc, cassava or any other foods made from roots or tubers? | C __ |
| D | Any dark, green, leafy vegetables such as cassava leaves, bean leaves, kale, spinach, pepper leaves, taro leaves, and amaranth leaves? | D __ |
| E | Any other vegetables? | E __ |
| F | Any ripe mangoes, ripe papayas or [INSERT ANY OTHER LOCALLY AVAILABLE VITAMIN A-RICH FRUIT]? | F __ |
| G | Any other fruits? | G __ |
| H | Any beef, pork, lamb, goat, rabbit wild game, chicken, duck, or other birds, liver, kidney, heart, or other organ meats? | H __ |

- | | | |
|---|--|------------|
| I | Any eggs? | I..... __ |
| J | Any fresh or dried fish or shellfish, shrimp, red snapper? | J __ |
| K | Any foods made from beans, peas, or lentils? | K __ |
| L | Any cheese, yogurt, milk or other milk products? | L __ |
| M | Any foods made with oil, fat, or butter? | M __ |
| N | Any sugar or honey? | N __ |
| O | Any other foods, such as condiments, coffee, tea? | O __ |

Appendix B

FANTA Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access (translated into Haitian Creole)

24 Lè Rapèl

Tanpri eksplike manje yo ak ti goute yo pou tout timoun ki te manje oswa bwè yè pandan lajounen ak lannwit, kit se lakay ou oswa andeyò kay la. Kòmanse ak "premye manje a oswa bwè nan maten an.

Dejene	Casse-Croûte (Ti Goute)	Manje Mindi	Casse-Croûte (Ti Goute)	Dine	SNACK

[Lakay: Se manje nan kay la, men se pa manje ki te achte ak manje deyò kay la

Lè ou fini ak fòm sa, ranpli sa ki anba. Fini sa avan.

III. Questionnaire Format for Haiti

In order to collect household dietary diversity data, the following questions should be added to the baseline and final surveys. As appropriate, locally available foods should be added into the food groups.

QUESTIONS AND FILTERS

CODING CATEGORIES

- 1 Now I would like to ask you about the types of foods that you or anyone else in your household ate yesterday during the day and at night.

READ THE LIST OF FOODS. PLACE A *ONE (1)* IN THE BOX IF ANYONE IN THE HOUSEHOLD ATE THE FOOD IN QUESTION, PLACE A *ZERO (0)* IN THE BOX IF NO ONE IN THE HOUSEHOLD ATE THE FOOD.

- | | | |
|---|--|------------|
| A | Any bread, rice noodles, biscuits, or any other foods made from millet, sorghum, maize, white or brown rice, wheat, corn or corn meal, spaghetti noodles, and cereals – corn flakes? | A __ |
| B | Any pumpkin, carrots, squash (chou) or sweet potatoes that are yellow or orange inside? | B __ |
| C | Any white potatoes, white yams, manioc, cassava or any other foods made from roots or tubers? | C __ |
| D | Any dark, green, leafy vegetables such as cassava leaves, bean leaves, kale, spinach, pepper leaves, taro leaves, militon (gords), leaves, papaya leaves and amaranth leaves? | D __ |
| E | Any other vegetables – tomato, garlic, onion, avocado? | E __ |
| F | Any ripe mangoes, ripe papayas, cherries, oranges, or passion fruit (Vitamin A)? | F __ |
| G | Any other fruits – pineapple, bananas, lemons, lime or coconuts (coconut milk)? | G __ |
| H | Any beef, pork, lamb, goat, rabbit wild game, chicken, duck, or other birds, liver, kidney, heart, or other organ meats? | H __ |

- | | | |
|---|---|------------|
| I | Any eggs? | I..... __ |
| J | Any fresh or dried fish or shellfish, shrimp, red snapper? | J __ |
| K | Any foods made from beans, peas, or lentils (black beans, red beans, brown beans)? | K __ |
| L | Any cheese, yogurt, milk or other milk products? | L __ |
| M | Any foods made with oil (palm), fat, or butter (timalice – Haitian butter)? | M __ |
| N | Any sugar or honey or other sweets (cookies, candy, Tampico juices (3% juice), hot chocolate? | N __ |
| O | Any other foods, such as condiments (ketchup, salt), coffee, tea? | O __ |

CHAPTER III: EGG CONSUMPTION AND COGNITIVE AND MOTOR DEVELOPMENT OF FOOD-INSECURE HAITIAN CHILDREN

Abstract

It is estimated that at least 200 million children in developing countries never reach their full development potential due to a number of risk factors including inadequate nutrition and micronutrient deficiencies. Haiti, as one of the poorest countries in the world, faces frequent obstacles, including food insecurity, that increase the risk of malnutrition. A primarily plant-based diet, typical of most developing countries, plays a role in common nutrient deficiencies. Eggs, as a good source of nutrients necessary for development, including high-quality protein, were supplemented in the diet of Haitian children ages 3 to 6 years old, from a single orphanage in Leogane, Haiti to determine any impact on child development. Objectives were to describe the impact of egg supplementation on cognition and motor skills during a control period and an egg intervention period, and describe dietary diversity and nutrient intake of food insecure Haitian children. Cognition and motor skills were assessed at study initiation, a midpoint reference, and study conclusion. After the reference point, two eggs per day, 5 days a week (10 eggs per week) were introduced until study completion. All participants received the same dietary intervention. Dietary diversity was assessed using 24-hour recalls. Cognition and motor skills were evaluated using the Early Screening Profiles assessment tool. Although no significant results were found between groups, key findings included below average scores in logical discrimination testing and above average motor skills in this group of children. In addition, dietary diversity increased throughout the study, with nutrients related to cognitive development, including protein, iodine, and zinc, increasing with the addition of eggs to the diet.

Poor child development is directly related to risks seen in this study, including poverty and a lack of nutrients needed for adequate development.

Introduction

The United Nations Sustainable Development Goals (SDG) offer targets to address global challenges, including poverty, food security, and quality education for all (United Nations, 2016). It is estimated that at least 200 million children in developing countries never reach their full development potential due to a number of risk factors including inadequate nutrition and more specifically growth stunting and iron and iodine deficiencies (Walker et al., 2007). Poverty increases several of these risk factors linked to poor child development (Walker et al., 2007). Adequate nutrition is a key component of the foundation of cognitive function, and research on child undernutrition and links to cognitive development, school attendance, and school performance continue to grow (Cusick & Georgieff, 2016; Neumann, Harris, & Rogers, 2002).

Haiti is considered one of the poorest countries in the world (United States Agency of International Development [USAID], 2018). With a population of 10.8 million, roughly 6 million live below the national poverty level, which is equivalent to \$2.41 per day (USAID, 2018). Common obstacles for the population include food insecurity, natural disasters, poor sanitation practices, and limited access to treated water sources, increasing the risk of malnutrition (USAID, 2018). In 2017, 3.6 million Haitians were considered food insecure (USAID, 2018). Specific to children under the age of 5, 22% are stunted and common micronutrient deficiencies include iron and iodine (USAID, 2011; USAID, 2018).

Micronutrient deficiencies are often a direct result of diet quality (Best et al., 2011). A primarily plant-based diet, typical of most developing countries, can be deficient in micronutrients like iron and zinc unless fortified foods or animal sourced foods are incorporated

(Pachon et al., 2007). The three most common micronutrient deficiencies that impact early brain development are iron, zinc, and iodine; if these three deficiencies were eradicated, the world IQ could increase by 10 points (Cusick & Georgieff, 2016). The delivery of crucial micronutrients is needed at very specific periods in brain development and deficiencies can lead to lasting effects on development (Schwarzenberg, Georgieff, & American Academy of Pediatrics [AAP] Committee on Nutrition, 2018).

Overall health is impacted by diet, with a balance of nutrients important to diet quality (Watson & DeMeester, 2015a). Eggs, as a high-quality protein source with known health benefits are one of the least expensive sources of animal protein in the diet (Watson & DeMeester, 2015b). Rich in vitamins and minerals, eggs contain several nutrients that play a role in cognitive development including protein, iodine, and zinc (Genesis R&D Product Development and Labeling Software, 2017; Schwarzenberg et al., 2018). As a locally available source of nutrients, eggs are a nutrient dense food that contains essential amino acids needed throughout the lifecycle, particularly to support growth and development in children (Watson & DeMeester, 2015b). An improvement in diet quality, even in modest amounts, provides potential opportunities to improve cognitive development in children (Neumann et al., 2002).

A balance of calories and macronutrients, including protein, is also important in brain development. Landmark studies from Guatemala in the 1970s and 1980s showed the importance of macronutrients, especially protein, during the prenatal period and early childhood in achieving full developmental potential (Cusick & Georgieff, 2016). Pregnant women, breastfeeding mothers, and children up to age 7 from two villages in Guatemala were provided with either a high-calorie, high-protein supplement or a low-calorie supplement without protein. After following the children for over 10 years, those children who received high-calorie, high-protein

supplementation before age 2 scored higher on tests and had faster reaction times (Schwarzenberg et al., 2018).

In Kenya, a controlled school feeding intervention was designed to determine the effects of animal sourced foods on the rate of growth and development and micronutrient status using milk and meat (Neumann, Murphy, Gewa, Grillenberger, & Bwibo, 2007). The four-condition design included the following groups for children ages 6 to 14: control, meat group, milk group, and oil (energy) group, with a positive relationship seen between meat and milk intake and functional outcomes in children including improved cognitive performance, increased high levels of physical activity and increased initiative and leadership behaviors (Neumann et al., 2007).

Poor development is a direct outcome of specific risks, including poverty and undernutrition (Walker et al., 2007). Evidence suggests that early interventions can help prevent the loss of development potential in affected children (Grantham-McGregor, Cheung, Cueto, Glewwe, & Strupp, 2007; Watanabe, Flores, & Tran, 2005). However, statistics around child development are generally not available for most developing countries (Grantham-McGregor et al., 2007). Further research is needed to look specifically at different types of animal proteins to determine how they can contribute to the role in cognitive development and the overall diet in young children in developing countries.

The purpose of this study was to examine how egg consumption impacts children's cognitive abilities. Objectives included describing cognitive abilities in this group of Haitian children, changes in cognition and motor skills after six-months of egg intervention (10 eggs per week), and differences in skills between no intervention and egg intervention, and also describing the impact of egg supplementation on dietary diversity and nutrient intake of food insecure Haitian children ages 3 to 6 years old in Leogane, Haiti. The hypothesis was that the

supplementation of eggs would improve cognition and motor skills and increase dietary diversity while improving estimated nutrient intake.

Conceptual Framework – Cumulative Risks

Adverse outcomes for children in developing countries are typically attributable to an accumulation of risks, as shown in Figure 1 (Walker et al., 2007). Child development encompasses three interrelated areas, including cognitive-language, sensori-motor, and social-emotional with poverty increasing exposure to several types of risks (Walker et al., 2007). Biological risk factors, like undernutrition and nutrient deficiencies, can be detrimental to development but can be addressed with interventions (Walker et al., 2007).

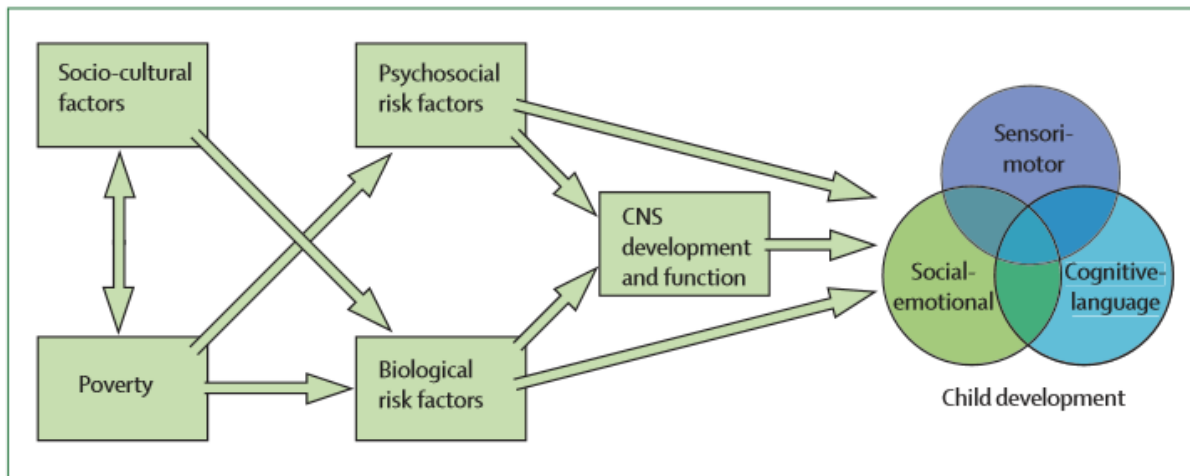


Figure 1. Cumulative risks to a child in the developing world over time may include poverty, along with biological risk factors like child undernutrition which can influence child development outcomes. Taken from “Child development: risk factors for adverse outcomes in developing countries,” by S. P. Walker, T. D. Wachs, J. M. Gardner, B. Lozoff, G. A. Wasserman, E. Pollitt, J. A. Carter, and the International Child Development Steering Group, 2007, *The Lancet*, 369, p.146.

Context of the Study

OneEgg, with multiple chapters throughout the world, is an organization that partners with schools and orphanages to deliver eggs to some of the world’s most vulnerable children

(OneEgg.org, 2018). The OneEgg Haiti Chapter began in 2013 and through grant funding has grown its reach by building a sustainable poultry farm allowing over 1,800 children a day to receive eggs (OneEgg.org, 2018). As the program continues to expand, current research is needed to understand any benefits of egg protein on cognitive effects in early childhood when added to the diet. OneEgg staff has been instrumental in the development of this project.

Methodology

General Design Approach

A quasi-experimental design examining the impact of egg supplementation on cognition and motor skills was conducted over a one-year period in Leogane, Haiti. A single orphanage, identified by OneEgg staff through site visitation, was identified to serve as its own control group. Inclusion criteria included children under the age of 6 years, 11 months who were recruited in Leogane, Haiti. The orphanage, with a total of 39 children, had 10 children that met age criteria. Cognitive and motor skill testing was completed at study initiation, reference midpoint, and final assessment over a one-year period. Ethical approval for the study was obtained from the University of Arkansas Institutional Review Board, 17-02-432. Informed consent for study participation was obtained from the orphanage director, through the use of a translator, as legal guardian of the children, before data collection was initiated.

Intervention

The study was divided into six months without intervention (control period) and six months of egg intervention (egg intervention period), to allow the children to serve as their own control group. Eggs were introduced and provided for six months midway through the study. Egg supplementation consisted of two medium-sized eggs a day (~50 grams each), five days a

week (10 eggs per week) for each child in the orphanage. There were no children with any reported egg allergy or egg related intolerances. Eggs were procured from local poultry farms and delivered bi-monthly to the orphanage by poultry farm staff. The orphanage director and staff were instructed to serve the eggs hard boiled as a supplement to the diet five days per week. Cooking instructions, along with serving instructions, were provided via an interpreter and translated in writing to Haitian Creole for the orphanage staff.

Cognition and Motor Skills

The Early Screening Profiles (ESP) assessment tool was chosen to screen motor and cognitive skills in children aged 2 years, 0 months through 6 years, 11 months and consisted of seven components or profiles that can be used independently or in any combination on children in this age range (Harrison et al., 1990). The ESP tool was tested for reliability and validity with children in the United States in 26 states and the District of Columbia and standardized on a sample of 1,149 children (Harrison et al., 1990). Due to the language barrier, the two cognitive subtests, Visual Discrimination and Logical Relations, which are used to measure nonverbal cognitive reasoning abilities were chosen for the focus of this study to assess cognition. The Visual Discrimination test allows the child to select from several pictures to identify every image that duplicate the stimulus, while the Logical Relations allows the child to point to pictures that correspond to stimulus pictures and solves visual analogies (Harrison et al., 1990). Sample items were provided as the first question for example purposes and were not scored (Harrison et al., 1990). On the test record, items were scored using 1 for correct and 0 for incorrect (Harrison et al., 1990). In addition, the Motor Profile was chosen to measure physical development by assessing gross and fine motor skills (Harrison et al., 1990). Specific motor skill assessment information is found in Table 1 (Harrison et al., 1990). All profiles were scored on a test record

completed by the same researcher according to scoring guidelines provided by ESP (Harrison et al., 1990).

Table 1

Motor Profile Subtest Measures from Early Screening Profiles

Gross Motor Subtest	Fine Motor Subtest
Imitating movements	Stringing beads (timed 30 seconds)
Walking forward on the walking line	Drawing lines and shapes
Standing on one foot on the walking line	Completing pencil mazes
Walking forward heel-to-toe, on the walking line	
Performing a standing broad jump	

Note. The gross motor subtest was administered for two trials, using the best score for each trial, while the fine motor subset was administered only once per testing instructions.

This screening tool was used on each child at study initiation, at the reference six-month midpoint of the study, and at the final evaluation of one year via face to face interview with an interpreter. The assessments were done at the same time each day. A training video, provided by ESP, along with instruction manual was completed by the researchers prior to the study. The ESP manual provided in depth details on administration, scoring, and interpretation of the results, allowing several options for determining the total screening score, including percentile rank, standard score, and age equivalent scores (Harrison et al., 1990).

Dietary Diversity and Nutrient Intakes

A 24-hour dietary recall questionnaire adapted by the Food and Nutrition Technical Assistance Project (FANTA) (Appendix A) was used to collect data on the number of meals consumed daily, and household dietary diversity scores (HDDS) from orphanage staff via an interpreter, by the registered dietitian researcher (Swindale & Bilinsky, 2006). Orphanage staff were asked to report all food and beverages eaten by the children on the day prior to the interview, including specific ingredients in dishes and asked to estimate portions served to the children. The 24-hour dietary recall was translated into Haitian Creole by four Haitian

translators, and the questionnaire was revised to include local foods popular in the Haitian culture (Appendix B). Once the interviews were completed, the researcher assigned a HDDS following the tabulation guidelines provided by FANTA (Swindale & Bilinsky, 2006). Interviews were completed at initial screening, at the reference screening six months later, and at one year, for a final screening and a total of three scores.

Using Genesis[®], a nutrition analysis software program, the data taken from the 24-hour recall was evaluated by the registered dietitian researcher for nutrient composition and compared against estimated requirements for children ages 3-6, based on the Daily Reference Intakes (DRI) for calories, protein, iron, zinc, and iodine (Genesis R&D Product Development and Labeling Software, 2017).

Statistical Analysis

Cognition and Motor Skills

Descriptive statistics were used to describe initial testing, reference testing before eggs, and final testing after intervention. The difference between study initiation scores and reference data scores was calculated for each screening profile as the control portion of the study, then the difference between reference data scores and final testing scores were calculated as the intervention portion of the study in order to compare the differences between both groups. Paired sample *t*-tests were then used to assess the differences between groups for each subscale or profile, while descriptive statistics and were used to describe percentile ranks and age equivalent information. All analyses were conducted using SAS Software 9.3 (SAS for Windows, 2017). Male and female data were combined for analysis.

Dietary Diversity and Nutrient Intakes

Descriptive statistics, including raw data were used to discuss differences between DRI and calculated intakes for calories, protein, iron, zinc, and iodine to help describe the typical diet of food insecure children in a single orphanage in Leogane, Haiti and how the nutrients found in eggs can contribute to the overall diet.

Results

At initial screening, 39 children at a single orphanage in Leogane, Haiti were assessed for study eligibility. Of those, 10 children met the age requirement of less than 6 years, 11 months of age, see Figure 2. All children completed the study over a one-year period. No allergic reactions or intolerances were reported after consuming the eggs at any point in the study.

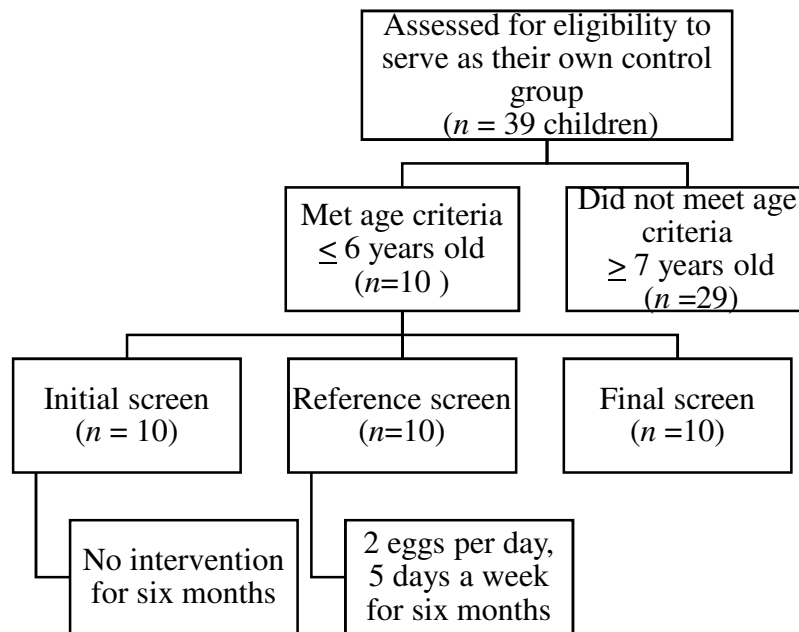


Figure 2. Participant enrollment and retention flow diagram.

Initial demographics of the children are shown in Table 2, along with six-month reference data and one-year final evaluation data. At the initiation of the study, the children ranged in age

from 3 years, 4 months to 5 years, 9 months, with the median age of 5 years, 1 month. The majority of the children in the study were male, including one set of male twins.

Table 2

Demographics of Haitian Children at a Single Orphanage in Leogane, Haiti			
Characteristics	Initial Screening <i>n</i> = 10	Reference Screening <i>n</i> = 10	Final Screening <i>n</i> = 10
	Mean (SD)	Mean (SD)	Mean (SD)
Age, mo	59 (7.7)	65 (7.9)	71 (7.9)
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Female	2 (20)	2 (20)	2 (20)
Male	8 (80)	8 (80)	8 (80)

Note. All screenings were completed six months apart.

Cognition and Motor Skills

Initial screening, reference screening, and final screening means, ranges, and standard deviations (SD) are presented in Table 3; for reference, the standardized mean for the exam was 100 with a SD of 15 (Harrison et al., 1990). Specific to cognition, the cognitive subscale means, which are a combination of visual and logical discrimination scores, were equivalent to a national percentile rank of 27th percentile, 30th percentile and 21st percentile at initial, reference, and final testing. Throughout the study, the children scored higher as a group on the visual discrimination than they did on the logical discrimination subscale, with logical subscale means ranking at 18th percentile, 19th percentile, and 8th percentile respectively.

Regarding motor skills, the mean motor profile was almost a full SD above the mean throughout the study with half of the children achieving above average or greater than 85th percentile ranks for motor skills and group means ranking 86th, 82nd, and 86th percentiles respectively. Throughout the study, combined cognition subscale and motor profile shows the overall testing mean averages to be slightly above the standardized mean while cognitive scores alone were below the standardized mean and motor scores were above.

Table 3

ESP Means, Ranges, and Standard Deviations for Food-Insecure Haitian Children in a Single Orphanage in Leogane, Haiti at Initial, Reference, and Final Screening

ESP Profiles	Initial (n = 10)			Reference (n = 10)			Final (n = 10)		
	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Cognitive Subscale	91.8	61-130	23.1	92.7	67-132	20.6	88.0	59-127	19.0
Visual Discrimination	98.2	63-128	21.9	99.0	77-130	19.2	98.0	53-137	21.6
Logical Discrimination	86.3	66-128	21.9	87.1	63-125	21.0	79.5	54-111	16.2
Motor Profile	116.9	86-159	23.5	114.6	84-155	21.7	116.7	94-141	14.2
Total Combined Cog + Motor Profile	106.7	74-160	27.6	106.1	76-160	25.4	103.7	80-142	18.5

Note. Eggs were introduced after reference screening completed. Final data is reflective of six months with egg intervention.

Age equivalent scores that had the largest gap between actual mean age and mean age equivalent were found in logical discrimination scores and motor skills scores. The actual mean age of the group at initial assessment was 59 months. Logical discrimination and motor skills mean age equivalents were associated with mean ages of 47 and 70 months at initial assessment. Six months later, at the reference point, mean actual age was 65 and mean age equivalent scores for logical and motor skills were 54 months and 75 months, with final assessments having a mean age equivalent of 52 months for logical and 79 months for motor. Mean actual age at study completion was 71 months.

The total combined cognitive subscale with motor profile standard scores are shown in Figure 3 for each child at all screenings. The standardized mean is shown in red, with one SD below the mean at the score of 85 and one SD above at the score of 115, shown in black. Clearly, one child scored above average consistently during the study, while the majority fell within one SD of the mean. Child E and Child F were the set of twins. Two of the children were

consistently below average for the duration of the study, while one child moved closer to the mean by the study completion. Final assessment screening shows 70% of the children had a total combined score within one SD of the mean, which is typical with normalized standard scores (Harrison et al., 1990).

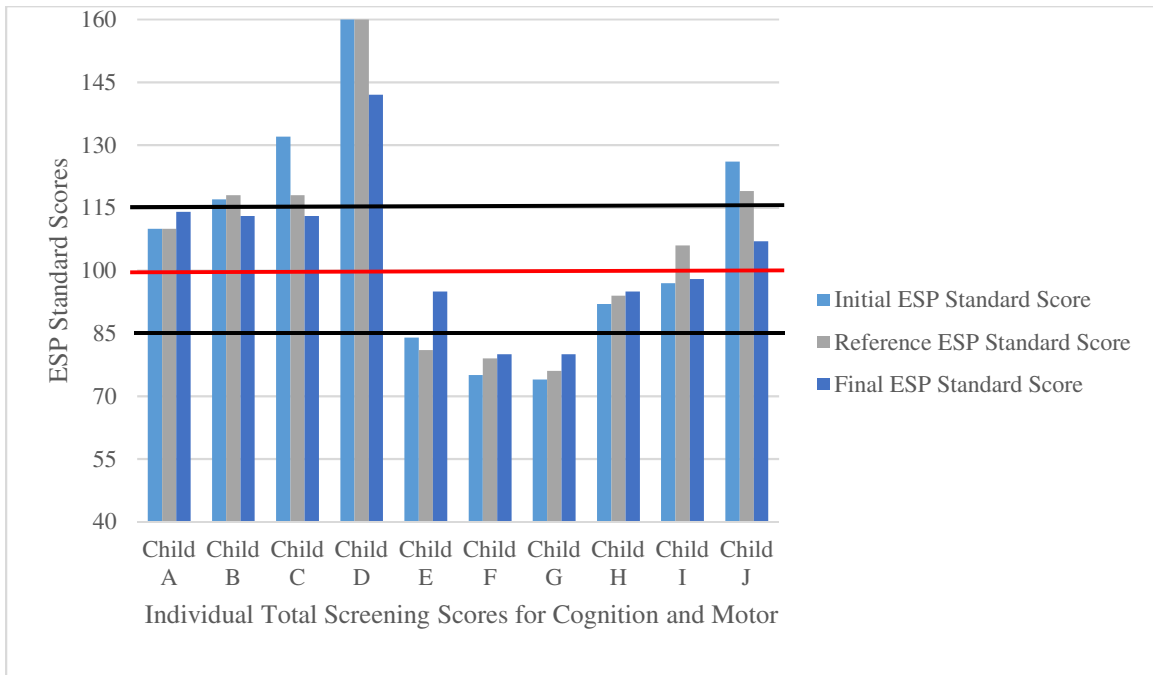


Figure 3. Combined ESP Cognitive Subscale and Motor Profile Standard Scores of Food-Insecure Haitian Children at a Single Orphanage in Leogane, Haiti. Final ESP scores are reflective of egg intervention.

The differences in standard score screening results from initial screening to reference screening (control period), and then from reference screening to final screening (egg intervention period) were compared. Results of the paired sample *t*-tests are shown in Table 4. No significant difference for any component of the screening profiles including visual discrimination, logical discrimination, cognitive subscale, motor subscale, and combined cognitive with motor subscales was seen between the control period and egg intervention.

Table 4

Mean Changes in Early Screening Profile Assessments Among Food-Insecure Haitian Children Receiving Two Eggs Per Day for Six Months

ESP Profiles	Initial to Reference	Reference to Final	<i>p</i>
	Difference	Difference	
	Mean (SD)	Mean (SD)	
Cognitive Subscale	0.9 (6.03)	- 4.7 (10.36)	0.16
Visual Discrimination	0.8 (7.63)	- 1.0 (11.98)	0.74
Logical Discrimination	0.8 (11.97)	- 7.6 (18.13)	0.31
Motor Profile	-2.3 (6.31)	2.1 (9.37)	0.29
Combined Cognitive + Motor Profile	-0.6 (6.29)	- 2.4 (9.16)	0.61

Dietary Diversity and Nutrient Intakes

Egg intervention and the impact on dietary diversity and nutrient composition was examined during the study using a 24-hour recall, as a part of the Household Dietary Diversity food questionnaire. Dietary diversity calculated via HDDS and estimated nutrient intake results are the same for each child, as they are all served the same portion sizes and meals daily within the orphanage. Results are shown in Table 5. Possible scores for HDDS ranged from 0-12 representing the following 12 food groups: cereals, root and tubers, vegetables, fruits, meat and poultry, eggs, fish and seafood, pulses/legumes/nuts, milk and milk products, oils/fats, sugar/honey, and a miscellaneous category for condiments and drinks (Swindale & Bilinsky, 2006). During the study, the number of meals per day decreased, while the dietary diversity score increased, as reported food groups increased. Eggs were reportedly incorporated into the breakfast meal, rather than supplemented to the diet according to the study design.

Table 5

Calculated Dietary Diversity of Children Ages 3-6 Years in Leogane, Haiti

Variable	Initial	Reference	Final
No. of meals consumed per day	3	2	2
HDDS	3	5	7
Food groups eaten	cereals, beans, oils	cereals, beans, oils, vegetables, poultry	Cereals, beans, oils, vegetables, poultry, eggs, sugars

Note. Eggs were introduced after reference data was evaluated. HDDS = household dietary diversity score.

The introduction of two boiled eggs per day, five days per week provided additional sources of nutrients to the diet including those found in Table 6. Looking at children ages 4 to 8 years, two eggs per day provided 66% of protein, 10% of iron, 20% of zinc, and 60% of iodine needs for this age group. Compared to estimated intakes prior to egg intervention, nutrients commonly linked to cognitive development all increased with the exception of iron and energy.

Table 6

Estimated Nutrient Intakes of Children Ages 3-6 Years at a Single Orphanage in Leogane, Haiti

Nutrient	DRI ^a		Calculated Intakes		Two, whole boiled eggs ~100g
	1-3 yrs	4-8 yrs	Without Eggs	With Eggs	
Energy, kcal ^b	1230	1715	891.05	789.13	155.00
Protein, g/d	13	19	30.38	43.87	12.58
Iron, mg/d	7	10	7.40	7.02	1.19
Zinc, mg/d	3	5	3.50	4.74	1.05
Iodine, µg/d	90	90	13.83	67.38	54.00

Note. Eggs were introduced after midpoint data was taken; initial and reference estimates were averaged and do not include eggs; endpoint data includes egg intervention. Nutrient reference values are for both boys and girls. DRI = dietary reference intakes.

^a Adapted from “Dietary Reference Intakes: The Essential Guide to Nutrient Requirements,” by J. J. Otten, J. P. Helwig, & L. D. Meyers, 2006, Institute of Medicine, Washington DC: National Academy of Sciences.

^b Reflects recommended intakes for energy in calories per day for boys since boys have highest caloric needs. Adapted from “Feeding and Nutrition of Infants and Young Children” by K. F. Michaelsen L. Weaver, F. Branca & A. Robertson, 2000, World Health Organization (WHO) Regional Publications.

Discussion

The purpose of this study was to examine how egg consumption impacted child development, specific to cognition and motor skills. While there were no significant differences found during the egg intervention period, key learnings from the study included insight into cognitive and motor skills for this group of food-insecure children, data on dietary diversity including estimated nutrients contributed with and without egg intervention among children in this single orphanage, and research challenges encountered in a food insecure developing country.

Food insecurity is a well-known challenge in Haiti, along with extreme poverty and undernutrition (USAID, 2018). The challenges faced within the study are a direct outcome of everyday challenges within this community, creating challenges for researchers. Reports from orphanage staff noted shortages in food the last three months of the study, using the egg intervention as a replacement for food, rather than a supplement. The study design was not followed and unpredicted outcomes showing no change in cognitive ability during the egg intervention were seen.

As expected, there were no significant differences between the first two tests (control period), however interesting findings from each screening point show scores well below the mean for logical discrimination and above average mean scores for motor skills in these children throughout the study. Both findings could be attributed to cultural and environmental influence, while internal validity of the research tool itself could be at fault regarding logical discrimination test questions. For instance, some test questions referenced items that may be unfamiliar to these children, including connecting a carrot to a rabbit. This analogy is typical of American culture and may not translate to the Haitian culture. Another example was connecting a train to train

tracks. There are currently no operating railways in Haiti, therefore Haitian children most likely do not understand that analogy. Specific to motor skills, mean above average scores within this skill set could be due to the active lifestyle of the children who typically run, jump rope, play games outside and have no access to sedentary activities such as television, video games, or screen based applications.

Null results of the study during the egg intervention period could be attributed to a number of factors including reports of limited food access during the study. The use of the 24-hour dietary recall helped describe estimated food intake. Contrary to the study design, the orphanage staff described replacing the morning meal, typically enriched pasta or corn, with the egg intervention. Previous research supports a positive impact on diet quality when animal sourced foods are added to the diet (Neumann et al., 2002). While dietary diversity increased throughout the study, diet quality did not with an estimated decline in calories and iron observed, which would be expected if the eggs were replacing fortified carbohydrates. Nutrient estimates from the dietary recall showed an increase in nutrients known to support cognitive development including protein, zinc, and iodine. While these nutrients increased, estimates also showed calorie needs were likely not met during the study.

In this group of children, the egg intervention provided additional nutrients known to support cognitive development, but challenges including poverty and food insecurity likely prevented caloric needs from being met. Food insecurity can negatively impact learning and development potential (Chilton, Chyatte, & Breaux, 2007). While nutrition plays a significant role in cognitive development, compounding risk factors compromise development, limiting education opportunities (Walker et al., 2007).

Limitations to the study should be recognized. Some are directly related to working in a food-insecure, developing country including lack of researcher control over the oversight of daily egg preparation and consumption. Others could be anticipated in working with an orphanage, such as the inability to validate birth dates and ages of participants. Birth dates used in this study were provided by the orphanage director, but birth certificates for participants were unavailable. Inaccurate birth dates would impact scores. In addition, language was identified as a barrier on multiple levels. The use of a translator could be a limitation to the instrumentation of the study, while the Early Screening Profile exams used in the study were benchmarked against American children (Harrison et al., 1990). It is also important to note that food availability and access to food can be seasonal (Smith et al., 2017). Finally, with a small sample size and the ratio of males to females in the study, gender indicators for statistical analysis were not able to be completed.

Future research regarding egg supplementation would benefit from including biomarkers to measure micronutrient deficiencies, specifically those associated with cognition and brain development. Children in developing countries encounter multiple threats, which can have lasting health effects, and early interventions can help prevent the loss of development potential in disadvantaged children (Grantham-McGregor et al., 2007). Scientific evidence linking inadequate growth and impaired brain development to nutritional deficiencies before the age of 2 has grown, creating a focus on nutrient impact during the complementary feeding period and early childhood development period, including time in utero, commonly referred to as the first 1,000 days (United Nations Children's Fund [UNICEF], 2013).

Poor child development is directly related to risks seen in this study, including poverty and a lack of nutrients needed for adequate development (Walker et al., 2007). Improving child

cognition while be instrumental in meeting Sustainable Development Goals with quality education leading to increases in fundamental skills like reading (United Nations, 2016). Education is key in poverty reduction for both individuals and nations (Walker et al., 2007). While cognitive brain development continues throughout life, research has identified the early years of life, before the age of 3, as the most sensitive time to promote brain development (Cusick & Georgieff, 2016). As a nutrient dense source of essential amino acids and micronutrients important to cognition and brain development, eggs can improve diet quality and may play a role in supporting growth and development in children (Watson & DeMeester, 2015b). An improvement in diet quality, even in modest amounts, provides potential opportunities to improve cognitive development in children (Neumann et al., 2002). With known risk factors including inadequate nutrition, iron deficiency, and iodine deficiencies linked to poor child development, eggs in combination with adequate calories could play a role in improving maternal and child nutrition during the first 1,000 days as a potential intervention, to help end the cycle of poverty.

Acknowledgements & Disclosures

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Appendices

Appendix A

FANTA Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access

24 Hour Recall

Please describe the foods (meals and snacks) that the children ate or drank yesterday during the day and night, whether at home or outside the home. Start with the "first food or drink of the morning.

Write down all foods and drinks mentioned. When composite dishes are mentioned, ask for the list of ingredients.

When the respondent has "finished, probe for meals and snacks not mentioned.

BREAKFAST	SNACK	LUNCH	SNACK	DINNER	SNACK

[Households: include foods eaten by any member of the household, and exclude foods purchased and eaten outside the home]

When the respondent recall is complete, "ll in the food groups based on the information recorded above. For any food groups not mentioned, ask the respondent if a food item from this group was consumed.

When completed, fill in Questionnaire Format below with Respondent.

III. Questionnaire Format for Haiti

In order to collect household dietary diversity data, the following questions should be added to the baseline and final surveys. As appropriate, locally available foods should be added into the food groups.

QUESTIONS AND FILTERS

CODING CATEGORIES

- 1 Now I would like to ask you about the types of foods that you or anyone else in your household ate yesterday during the day and at night.

READ THE LIST OF FOODS. PLACE A *ONE* IN THE BOX IF ANYONE IN THE HOUSEHOLD ATE THE FOOD IN QUESTION, PLACE A *ZERO* IN THE BOX IF NO ONE IN THE HOUSEHOLD ATE THE FOOD.

- | | | |
|---|--|------------|
| A | Any [INSERT ANY LOCAL FOODS, E.G. UGALI, NSHIMA], bread, rice noodles, biscuits, cookies, or any other foods made from millet, sorghum, maize, rice, wheat, or [INSERT ANY OTHER LOCALLY AVAILABLE GRAIN]? | A __ |
| B | Any pumpkin, carrots, squash (chou) or sweet potatoes that are yellow or orange inside? | B __ |
| C | Any white potatoes, white yams, manioc, cassava or any other foods made from roots or tubers? | C __ |
| D | Any dark, green, leafy vegetables such as cassava leaves, bean leaves, kale, spinach, pepper leaves, taro leaves, and amaranth leaves? | D __ |
| E | Any other vegetables? | E __ |
| F | Any ripe mangoes, ripe papayas or [INSERT ANY OTHER LOCALLY AVAILABLE VITAMIN A-RICH FRUIT]? | F __ |
| G | Any other fruits? | G __ |
| H | Any beef, pork, lamb, goat, rabbit wild game, chicken, duck, or other birds, liver, kidney, heart, or other organ meats? | H __ |

- | | | |
|---|--|------------|
| I | Any eggs? | I..... __ |
| J | Any fresh or dried fish or shellfish, shrimp, red snapper? | J __ |
| K | Any foods made from beans, peas, or lentils? | K __ |
| L | Any cheese, yogurt, milk or other milk products? | L __ |
| M | Any foods made with oil, fat, or butter? | M __ |
| N | Any sugar or honey? | N __ |
| O | Any other foods, such as condiments, coffee, tea? | O __ |

Appendix B

FANTA Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access (translated into Haitian Creole)

24 Lè Rapèl

Tanpri eksplike manje yo ak ti goute yo pou tout timoun ki te manje oswa bwè yè pandan lajounen ak lannwit, kit se lakay ou oswa andeyò kay la. Kòmanse ak "premye manje a oswa bwè nan maten an.

Dejene	Casse-Croûte (Ti Goute)	Manje Mindi	Casse-Croûte (Ti Goute)	Dine	SNACK

[Lakay: Se manje nan kay la, men se pa manje ki te achte ak manje deyò kay la

Lè ou fini ak fòm sa, ranpli sa ki anba. Fini sa avan.

III. Questionnaire Format for Haiti

In order to collect household dietary diversity data, the following questions should be added to the baseline and final surveys. As appropriate, locally available foods should be added into the food groups.

QUESTIONS AND FILTERS

CODING CATEGORIES

1 Now I would like to ask you about the types of foods that you or anyone else in your household ate yesterday during the day and at night.

READ THE LIST OF FOODS. PLACE A *ONE (1)* IN THE BOX IF ANYONE IN THE HOUSEHOLD ATE THE FOOD IN QUESTION, PLACE A *ZERO (0)* IN THE BOX IF NO ONE IN THE HOUSEHOLD ATE THE FOOD.

- | | | |
|---|--|------------|
| A | Any bread, rice noodles, biscuits, or any other foods made from millet, sorghum, maize, white or brown rice, wheat, corn or corn meal, spaghetti noodles, and cereals – corn flakes? | A __ |
| B | Any pumpkin, carrots, squash (chou) or sweet potatoes that are yellow or orange inside? | B __ |
| C | Any white potatoes, white yams, manioc, cassava or any other foods made from roots or tubers? | C __ |
| D | Any dark, green, leafy vegetables such as cassava leaves, bean leaves, kale, spinach, pepper leaves, taro leaves, militon (gords), leaves, papaya leaves and amaranth leaves? | D __ |
| E | Any other vegetables – tomato, garlic, onion, avocado? | E __ |
| F | Any ripe mangoes, ripe papayas, cherries, oranges, or passion fruit (Vitamin A)? | F __ |
| G | Any other fruits – pineapple, bananas, lemons, lime or coconuts (coconut milk)? | G __ |
| H | Any beef, pork, lamb, goat, rabbit wild game, chicken, duck, or other birds, liver, kidney, heart, or other organ meats? | H __ |

- | | | |
|---|---|------------|
| I | Any eggs? | I..... __ |
| J | Any fresh or dried fish or shellfish, shrimp, red snapper? | J __ |
| K | Any foods made from beans, peas, or lentils (black beans, red beans, brown beans)? | K __ |
| L | Any cheese, yogurt, milk or other milk products? | L __ |
| M | Any foods made with oil (palm), fat, or butter (timalice – Haitian butter)? | M __ |
| N | Any sugar or honey or other sweets (cookies, candy, Tampico juices (3% juice), hot chocolate? | N __ |
| O | Any other foods, such as condiments (ketchup, salt), coffee, tea? | O __ |

CHAPTER IV: CONCLUSION

The United Nations Sustainable Development Goals encompass 17 unified goals to address global challenges facing our planet (United Nations, 2016). Goals one, two and four relate to poverty reduction, food security, and quality education for all with an understanding that improvements are interrelated (United Nations, 2016). Specific areas of nutrition research have been identified to have the greatest influence on the health of global populations, including the impact of nutrition on healthy growth and development (American Society for Nutrition [ASN], n.d.a). A growing body of research suggests that all aspects of childhood development are impacted by nutrition with continued research essential for further understanding of eating patterns, as well as individual food components on growth and development (American Society for Nutrition [ASN], n.d.b.; Neumann, Harris, & Rogers, 2002). Decreased cognition and ability to learn impacts not only individuals, but societies and nations (Neumann et al., 2002).

The two articles presented in this thesis explored the impact of egg supplementation on physical growth and cognitive and motor skill development of food-insecure Haitian children living in a single orphanage in Leogane, Haiti. The same children are referenced in both articles, with the exception of one child that did not meet age criteria for the ESP assessment tool. Therefore, 11 children were included in the data for Chapter II related to growth and 10 children were included in the data for Chapter III, related to cognition and motor skills development.

While results from both studies do not support current literature related to the impact of animal protein on growth and child development, the study design was not followed and numerous challenges related to international research were encountered. Findings from both articles demonstrate challenges related to human nutrition research in places where an absence of adequate calories exist. Specific challenges included reports of food insecurity, lack of

researcher control over daily food preparation and intake, inability to validate birthdates, and a lack of available tools necessary to evaluate malnutrition criteria in children over the age of 6. All of these challenges had considerable impacts on study results and discussion.

In the first article, growth parameters, along with a calculated assessment of food groups and nutrient intakes were evaluated. Baseline data on height and weight, when compared to children within this age group, showed below average growth before the egg intervention. With reports of increased rates of food insecurity during the last three months of the study, the eggs were used as a meal replacement in order to extend the orphanage's food supplies, rather than supplement the diet as the study was designed. The percentage of children that met criteria for stunting and underweight increased throughout the study. With the criteria for wasting only available for children under the age of five, this characteristic was unavailable for 90% of the children at the study completion who were over the age of five. The single child that was under 5, did classify as wasted. The food recall tool validated the decrease in growth velocity by showing an estimated decrease in energy as the study progressed and a decrease in the number of meals served per day. While the dietary diversity score improved as the study progressed, portion sizes were not taken into account with this tool and calculated caloric intakes decreased throughout the study. A balance of energy and protein is needed to support growth in children and estimates from this study showed a probable lack of energy to meet estimated daily needs. While protein intake is necessary for the rapid growth and development of children, if calorie needs are not sufficient, supplementary protein is not available for growth utilization and is instead utilized for maintenance energy needs (Arsenault & Brown, 2017; Sizer & Whitney, 1997). Though the literature contains numerous studies showing the positive impact of animal protein on growth and development in children, this article does not support those same

conclusions. With a lack of adequate calculated calories to support growth, a reported shortage in food intakes during the intervention portion of the study, a decrease in number of meals per day, and failure to comply with the study design, mean growth velocity declined. The data supports the known link between food insecurity and child undernutrition. The full results of *Egg Consumption and Physical Development of Food-Insecure Haitian Children* can be further examined in Chapter II of this thesis.

Poverty, household food insecurity, and inadequate dietary intake are common challenges faced by developing nations with known links to short-term and long-term consequences including inadequate growth and development, increased morbidity, mortality, disability, and decreases in adult stature, economic productivity, and intellectual ability (Black et al., 2008). In the second article, cognition and motor skills were evaluated, along with a calculated assessment of dietary diversity and nutrient intakes. There were no significant differences in any sections of the screening assessment between the control period and the egg intervention period with reports from the orphanage staff of lack of adequate food supplies during the final three months of the study. The study design was not followed, as eggs were being used to replace the morning meal, rather than supplement the diet. While no significant differences were found, scores related to logical discrimination and motor skills were of great interest. Questions relating to logical relationships were the lowest among the group. With the ESP tool benchmarked against American children, it contained some questions geared toward American culture, potentially skewing results for this portion of the test. Motor skill scores were above average in this group of children, presumably related to their active lifestyle, with little access to sedentary activities. While calculated estimates from the 24-hour recall showed the eggs provided additional nutrients during the intervention period, the children were likely not receiving adequate calories to meet

their nutrient needs. Poor child development is directly related to risks seen in this study, including poverty and a lack of nutrients needed for adequate development (Walker et al., 2007). The full results of *Egg Consumption and Cognitive and Motor Development of Food-Insecure Haitian Children* can be further examined in Chapter III of this thesis.

Given the body of knowledge related to growth and cognition during the first 1,000 days, future research for OneEgg would be beneficial with expecting mothers, breastfeeding mothers, and children in the complementary feeding period when growth is beginning to falter (Horton, 2008). In addition, a nutrition education component may be beneficial to go along with egg supplementation and provide a better understanding of the value of animal protein and the importance of egg supplementation, not replacement of foods in the diet.

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