2022

A Two-Day Virtual Workshop on the Micronutrient-Directed Nutrition-Focused Physical Exam for Ghanaian Nutrition Professionals: Examining Perceived Self-Efficacy and Innovation

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A Two-Day Virtual Workshop on the Micronutrient-Directed Nutrition-Focused Physical Exam for Ghanaian Nutrition Professionals: Examining Perceived Self-Efficacy and Innovation

by

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Doctoral Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctorate of Clinical Nutrition

University of North Florida
May 2022

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Dedication

I dedicate my dissertation to the driven, passionate community of nutrition professionals in Ghana who guided me in planning and conducting this project. I feel honored to be a part of the University of Ghana/University of North Florida collaboration. Thank you for welcoming me into this ongoing, remarkable collaboration.

Acknowledgements

First and foremost, I would like to acknowledge the mentorship of my relentlessly committed dissertation committee. Dr. Wright, thank you for welcoming me into the University of Ghana/University of North Florida collaboration in 2019. Our time in Accra paved the way for me to conduct this project, and I am so grateful for this opportunity. I think the collaboration between these two institutions that you have fostered is remarkable. I respect your ability to not lose sight of the "big picture" when conducting a project. This is a strength I aspire to, and I have grown in this way because of your mentorship.

Dr. Arikawa, I so appreciate you mentoring me throughout the doctorate and throughout this project. I have great respect for your knowledge of nutrition biochemistry, statistics, and your attention to detail; throughout this project I learned a tremendous amount from you in these disciplines. I also appreciate you pushing me beyond what I thought I was capable of, in the most respectful of ways. Thank you.

Dr. Intiful, thank you for your guidance throughout this project; your insight about the Ghanaian dietetics community and Ghanaian culture was incredibly valuable. I respect your research acumen, and your commitment to fostering the University of Ghana/University of North Florida collaboration. The project withstood several setbacks due to the pandemic, and due to my health issues. I so appreciated your continued support, understanding, and grace despite these challenges. I really enjoyed working with you. Thank you.

I would also like to thank additional members of the dietetics faculty at the University of Ghana. Dr. Laurene Boateng and Dr. Matilda Asante, thank you so much for your guidance and support throughout the planning and execution of this project.

Thank you to Dr. Leslie Van Horn who graciously offered to be the second coder for the qualitative data. Your expertise was extremely valuable and I really appreciated your willingness to be part of this project.

Thank you to the focus group leaders who generously donated their time and energy to this project: Erinn Neuburger, Barbara Goldman, Dr. Kristi Chipman, Dr. Su-Nui Escobar, Dr. Sherri Lewis, Alessandra Sparks, Heidi Druehl, Lizeth Cano Molina, Vicky Rojas, Seha Altinalan, Patricia Echeverria, Dr. Lauri Wright and Dr. Andrea Arikawa. You did a great job providing a platform on which focus group participants could express their thoughts and feelings. Your ability to promote constructive discussion in a zoom breakout room was impressive. Thank you for your devotion to the field, and your involvement in this project. Your contribution was greatly appreciated.

Thank you to Dr. Sarah Zeola for your guidance and friendship throughout this project. Your dissertation work in Ghana inspired me, and I was honored to be a part of it. I appreciated your valuable input on my project, especially in the most nascent stages.

I had to give myself a lot of grace throughout this project, and had to be self-aware about my abilities and limitations. My mom has instilled the value of emotional intelligence in me throughout my life, and I know I owe my self-awareness and ability to give myself grace to my mom. Thank you, mom. At the same time, when I think about the amount of hard work and mental focus that went into this project, I know I couldn't have done it without the influence of my dad over the course of my life. Your commitment to medicine, and your persistence in the face of adversity are values you instilled in me, and values that were integral to completing this doctorate. Thank you.

To my husband William, thank you for supporting me throughout my professional endeavors. You have been patient, kind, and understanding, even when my professional obligations have been especially demanding of my time and energy. I have always felt unwavering support from you when working towards my academic goals, even when that has involved international travel. Your emotional support has helped me foster my love for my profession. You inspire me to be my best self.

Thank you to my siblings Karl, Claire and Lauren. Your support, kindness and understanding throughout my dissertation gave me great comfort. You have all gladly provided a listening ear during the most exciting and frustrating moments of my dissertation. Thank you. And thank you for all of the fun times along the way that allowed me to reset, refocus, and remember why this is all worth it.

To my mother-in-law Samia, thank you for your teaching me "man masha aladarbi wasal," meaning, "the person who walks on the right path will arrive at the right destination." You not only taught me the phrase, but embodied that concept. I have carried this concept with me throughout my academic pursuits, and have derived much motivation and encouragement from it. Thank you.

To my Doctorate of Clinical Nutrition cohort, thank you for your support throughout the program. You are an amazing group of women, and you inspire me to be an intentional, strong nutrition professional. Thank you for checking in with me along the way, and for genuinely caring about my well-being. Knowing we were all in this together had a profoundly positive impact on me throughout the program.

I also want to thank my incredibly sweet little dog Morgan. Doctoral work can be solitary, and even isolating, at times. Morgan sat at my feet while I wrote every single word of

this manuscript. He provided me with an immense amount of emotional support along the way, and made sure I was never alone during this academic journey.

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Abstract

Micronutrients are key components of various physiological processes. Therefore, in the setting of deficiency, poor health outcomes ensue. In Ghana, micronutrient deficiencies are common and medical resources are limited. The Ghanaian dietetics profession is growing, and this growth is propitiously timed to address micronutrient deficiencies. Biochemical markers of nutrition status are considered the gold standard to detect micronutrient deficiencies, but are costly and require specialized medical equipment. In the absence of available biochemical markers of nutrition status, the micronutrient-directed nutrition-focused physical exam is a viable tool. Nutrition professionals such as Registered Dietitians are qualified to conduct this exam, but feel relatively ill-equipped to do so. This mixed-methods research was conducted to determine whether a two-day virtual workshop for Ghanaian nutrition professionals (n=131) improved perceptions that using the micronutrient-directed nutrition-focused physical exam is an innovative strategy to assess patients/clients for micronutrient deficiencies, and to assess whether the workshop significantly improved feelings of self-efficacy in regards to conducting this exam. Quantitative data was collected via a virtual pretest (immediately prior to the workshop) and a virtual posttest (immediately following the workshop). Qualitative data was gathered via focus groups, which were conducted in virtual breakout rooms on the second day of the workshop. Total posttest scores were significantly higher (M=70.15, SE= .703), t(130)= -7.357, p= <.001 than total pretest scores (M= 64.85, SE= .165), t(130)= -7.357, p= <.001. The qualitative data mirrored and complemented the quantitative data. Specifically, participants stated that micronutrient deficiencies are common in their workplace, that cost and/or insufficient medical infrastructure are often barriers to assessing micronutrient status, and for these reasons the physical exam is an incredibly useful tool in their workplaces. Participants improved their

feelings of self-efficacy in performing a complex clinical skill; a clinical skill that they perceive to be an advantageous and useful method of treating their patient population. Virtual platforms offer a safe and effective method by which to deliver nutrition-focused physical exam training during a global pandemic.

Chapter I: Introduction and Literature Review

Introduction

Adequate intake of the micronutrients is necessary for normal physiological processes to occur. Therefore, in the setting of deficiency, poor health outcomes ensue. The nutrition-focused physical exam (NFPE) is an effective method of identifying micronutrient deficiencies (MNDs), and is an acceptable alternative in the absence of other forms of MND assessment. However, nutrition professionals may feel unprepared to perform the NFPE due to a lack of training. The Ghanaian dietetics community is currently growing, and Registered Dietitians (RDs) are well-respected members of the medical community in Ghana. As MNDs and the associated poor clinical outcomes are prevalent in Ghana, providing training for Ghanaian nutrition professionals on the MND-directed NFPE might be an incredibly relevant and impactful continuing education opportunity.

Micronutrient deficiencies

The word "micronutrient" is an umbrella term for a variety of exogenous compounds that humans must obtain from the diet.[1] Micronutrients are essential for normal physiological processes to occur, and these processes are often impaired in the setting of even mild deficiency.[1] In the setting of severe deficiency, poor clinical outcomes can ensue.[1] If these poor clinical outcomes and their micronutrient-based etiologies are not addressed, MNDs can eventually lead to death.[1] Therefore, ensuring adequate micronutrient intake at all stages of life is integral to supporting optimal physiological functioning and preventing poor clinical outcomes.[1]

Micronutrients can be divided into two main categories: inorganic and organic compounds.[1] Dietary minerals are inorganic micronutrients while water- and fat-soluble vitamins are organic compounds.[1] The water-soluble vitamins include: thiamin (B_1), riboflavin (B_2),

niacin (B_3), biotin, pantothenic acid, pyridoxine (B_6), folate, cobalamin (B_{12}), and vitamin C.[2] The fat-soluble vitamins are vitamins A, D, E and K.[2] Minerals are divided into 2 classes (major and trace) based on the amount of the mineral present in the body.[2] The amount of each mineral that is present in the body is correlated with the amount of each that is required in the diet.[2] The major minerals are: sodium, chloride, potassium, calcium, phosphorus, magnesium, and sulfate.[2] The minor minerals are: iron, zinc, iodine, selenium, copper, manganese, fluoride, chromium and molybdenum.[2]

These physiologically-necessary compounds play several integral roles. Micronutrients act as cofactors and coenzymes in various metabolic processes, act as antioxidants to reduce systemic oxidative stress, and also provide structural support for the body.[1] Based on these roles, recommended intake levels have been set by the Institute of Medicine (IOM) and are referred to as the Dietary Reference Intakes (DRIs).[3] According to the Academy of Nutrition and Dietetics, the DRIs are the "best available evidence-based nutrient standards for estimating optimal intakes.[3]" The DRIs include the Recommended Dietary Allowances (RDAs), Adequate Intakes (AIs), Estimated Average Requirements (EARs) and the Tolerable Upper Intake Levels (ULs).[3]

Each DRI has a unique IOM definition. The EAR, RDA and AI all outline the minimum amounts of a nutrient an individual should consume in a day; these terms differ based on available empirical support.[4] Of note, each DRI refers to nutrient needs for healthy individuals.[4] The EAR is defined by the IOM as "the average daily nutrient intake level estimated to meet the requirements of half of the healthy individuals in a group.[4]" The RDA is defined as the "average daily dietary intake level sufficient to meet the nutrient requirements of nearly all (97–98%) healthy individuals in a group.[4]" If insufficient empirical support exists to set an EAR or RDA, and AI is set instead.[4] AIs for healthy breast-fed infants is the mean intake of the nutrient among

this population.[4] For other life stages, the AI is thought to meet the needs of healthy individuals, but relatively minimal empirical support does not allow for specificity about the percentage of the population for which the AI is appropriate.[4] Finally, the UL is defined as the "the highest level of daily nutrient intake that is likely to pose no risk of adverse health effects to almost all individuals in the general population.[4]" The amount of a given micronutrient in the body and the corresponding impact on the physiological function of the nutrient[1,5] is shown in Figure 1.

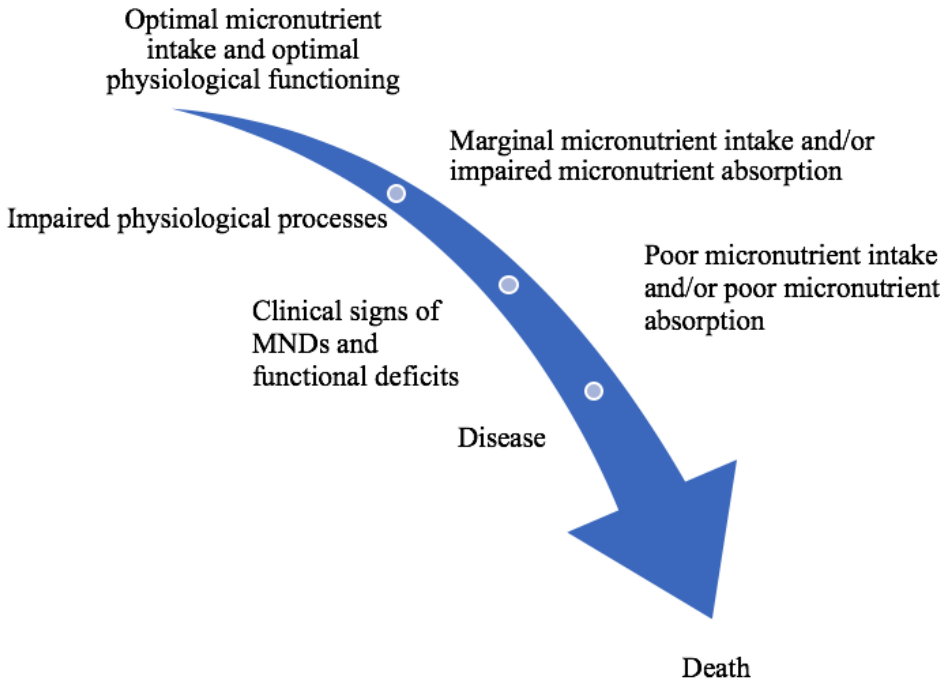

Figure 1. Progression of a Micronutrient Deficiency

The DRI terminology outlines the optimal intake levels of the micronutrients. Using these intake guidelines to consume a micronutrient-comprehensive diet reduces the risk of chronic disease and promotes optimal clinical outcomes.[3] The optimal way to obtain all necessary micronutrients is through diet alone, according to the Academy of Nutrition and Dietetics.[3]

However, socioeconomic, environmental, and/or health barriers exist which may prohibit optimal intake or absorption of one or more micronutrients; in these cases, supplementation is recommended to avoid MND.[6] In addition to inadequate intake of the nutrient, MNDs can be caused by inadequate absorption of the nutrient.[5] Nutrient absorption can be impaired by a variety of factors such as infection, disease, or inflammation.[5] The most common causes of MNDs worldwide are food insecurity, inadequate care or feeding practices, and inadequate access to health care.[5]

According to the Centers for Disease Control and Prevention, more than two billion people worldwide have at least one MND.[7] Among children six months to five years of age globally, half have at least one MND.[7] The most common MND worldwide is iron deficiency.[8] In fact, over 30% of the world's population is anemic,[8] and iron deficiency is the etiology for an estimated 50% of global anemia cases.[9] Anemia disproportionately affects woman and children—43% of children age five and under, and 38% of pregnant women globally are anemic.[7] The other most globally-prevalent MNDs are iodine, vitamin A, zinc, and folate.[8] An estimated two billion individuals consume inadequate iodine, with the greatest incidence of iodine deficiency occurring in South Asia and Sub-Saharan Africa (SSA).[10] An estimated 19 million pregnant women and 190 million preschool-age children are deficient in vitamin A, with regions of Africa and South-East Asia having the highest prevalence.[11] SSA and South Asia are also the regions of the world where individuals are at the greatest risk for inadequate zinc intake.[12] An estimated 17.3% of the global population is at risk for zinc deficiency. [12] Global prevalence of folate deficiency is unknown,[13,5] however, it is thought to be among the most common MNDs worldwide according to the World Health Organization (WHO) and the National Institutes of Health.[8,5]

MNDs cause a plethora of physical ailments at all stages of the life cycle.[5] However, these ailments may be more pronounced in infancy and childhood due to the increased demand for micronutrients during times of rapid growth and development.[5] In infancy, MNDs may contribute to a higher mortality rate, low birth weight, and mental development may be impaired.[5] Stunting during childhood can be caused my MNDs, and MNDs during childhood can contribute to impaired cognitive functioning and increased risk for infections.[5] Childhood MND symptoms can progress into adolescence if not treated, and can ultimately affect the individual in adulthood.[5] Adulthood implications of MNDs include reduced productivity and increased mortality.[5] If left untreated, MNDs can have lifelong and even intergenerational effects,[5] as depicted by Figure 2. The ailments caused by MNDs are micronutrient-specific, and will be discussed in-depth.

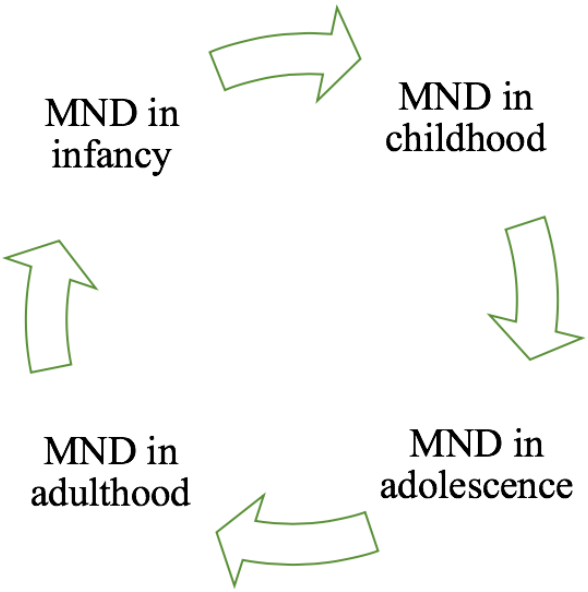

Figure 2. Lifelong and Intergenerational Nature of Untreated Micronutrient Deficiency

Ghana

As above-mentioned, SSA is a region of the world where MND prevalence is high. Ghana is located in this region, and MNDs affect many of the Ghanaian children under age five, as well as Ghanaian women.[14] Ghana is a fairly small Western African country, just slightly smaller than the U.S. state of Oregon.[15] Ghana borders the Gulf of Guinea, and is located between Cote d'Ivoir and Togo.[15] Ghana's location in Africa is shown in Figure 3, as represented by the Central Intelligence Agency. [15]

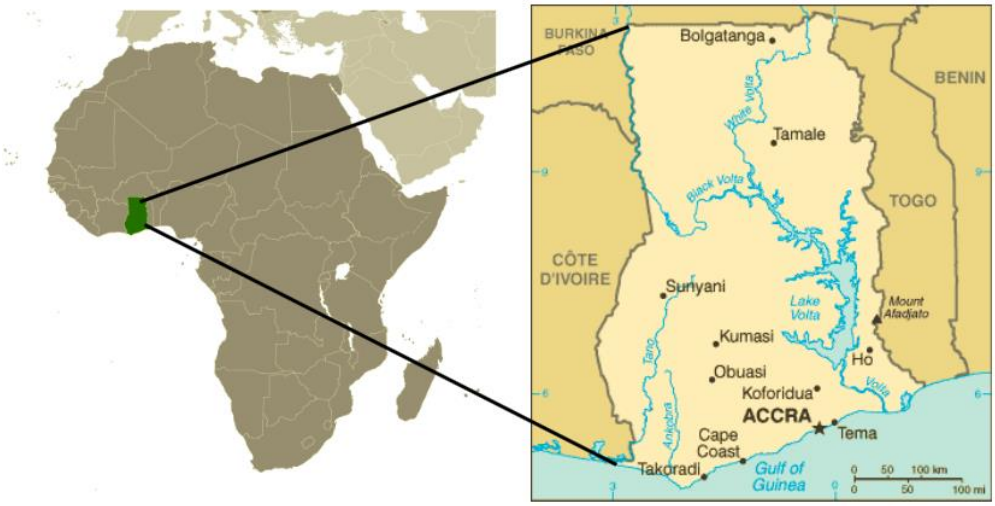

Figure 3. A Map of Ghana

According to July, 2018 data, Ghana has a population of 28,102,471.[15] The Ghanaian population is concentrated in the southern half of the country, with the largest number of people residing near the Atlantic coast.[15] As shown above in Figure 3, the capital, Accra, is located on the Atlantic coast. The greater Accra region is the most populous region of Ghana with a population of 4.943 million people based on 2019 data.[16] The second-largest urban area in Ghana is Kumasi which is home to just over 3 million Ghanaians, and is located just Northwest of Accra (also shown in Figure 3).[15] The University of Ghana is located in the capital, Accra, and is considered the leading university in Ghana.[17] Although English is the official language of Ghana, several languages are represented in this country.[15] For example, 16% speak Asante, 14% speak

Ewe, 11.6% speak Fante, and 4.9% speak Brong.[15] According to the World Bank Group, Ghana is considered a middle-income country.[18]

The chronic health problems that plague the U.S. such as obesity and obesity-related illnesses are not as prevalent in Ghana[15]; the young age structure of Ghana may play a part in this difference. Adult obesity prevalence in the year 2017-2018 was estimated to be 42.4% in the U.S. [19], and only 10.9% in Ghana in the year 2016.[15] Therefore, obesity-related diseases such as type II diabetes and cardiovascular disease are less prevalent in Ghana than they are in the U.S.[20] The age structure is quite young in Ghana; 57% of the population is under the age of 25.[15] However, Ghana's population of individuals older than 60 years old has grown in recent years due to improvements in healthcare, nutrition, and hygiene.[15] According to the Central Intelligence Agency, Ghana has the largest over-60 demographic (in terms of percentage of the overall population) among SSA countries.[15] Despite these improvements, female life expectancy in Ghana is only 65 years based on 2018 data; pregnancy-related complications are thought to be the reason for the relatively young life expectancy for Ghanaian women.[21] MNDs play a large role in the incidence of pregnancy-related complications, and this will be discussed in further detail.

Some of the most prominent medical problems in Ghana include infection, trauma, and reproductive health issues.[20] Medical practice in Ghana faces limited resources, and this limitation is more pronounced in rural areas.[20] The primary reason for hospital admission is infection, with malaria, typhus, tuberculosis, and HIV among the most common infections.[20] According to year 2018 data, 330,000 individuals currently have HIV in Ghana, and 110,000 of these individuals are on antiretroviral therapy.[22] Motor vehicle accidents account for many of the trauma-related hospital admissions followed by home/work accidents and violence.[20] Patients

with prenatal, postnatal and pregnancy-related health problems represent a large percentage of the critically ill patient population in Ghana.[20] Ghana has established high quality medical care, with the majority of the medical infrastructure located in Accra and Kumasi.[20] Areas of rural Ghana continue to have limited medical infrastructure.[20]

Malnutrition is considered one of the primary mortality risk factors in Ghana.[23] Additional risk factors include inadequate access to health care and clean water, as well as the high incidence of malaria.[23] Even in the setting of adequate economic resources, physical access to food, water, and health care is sometimes the barrier.[21] When United Nations Children's Fund (UNICEF) personnel assessed the nutrition status of children in Ghana, a 14-year-old girl reported "meat is not available. We have money to buy meat, but the place is too far away.[21]" However, over the course of the past 20 years, along with profound economic development, nutrition in Ghana has improved significantly. Year 2018 data from UNICEF showed the mortality rate (number of deaths per 1000 live births) is 48 for children under age five in Ghana, compared to 127 in 1990 and 99 in 2000.[21] To provide some perspective on this statistic, the under-five mortality rate is 25 in the United States.[21] Infant mortality has also improved greatly in Ghana over the past three decades; between 1990 and 2018, the infant mortality rate dropped from 80 to 35.[21] AIDS-related mortality per 100,000 in the year 2018 was 24.53 for children age 0-14, and 14.97 for adolescents age 10-19.[21] Incidence of exclusive breastfeeding for at least six months of life was estimated to be 52% in 2018 in Ghana.[21] As MNDs are a morbidity and mortality risk factor, and are vital for normal development, the high prevalence of MNDs among the Ghanaian pediatric population may be a contributing factor to relatively high mortality rates. Moreover, recent efforts to improve the nutrition status of the Ghanaian pediatric population may have contributed to recent mortality rate improvements.

As mentioned above, maternal MNDs can cause infants to be of low birthweight.[5] Among Ghanaian infants, 14% were of low birthweight in 2015.[21] Of note, this statistic may not paint a comprehensive picture because 40% of infants born between 2010 and 2018 in Ghana were not weighed at birth.[21] As aforementioned, MNDs among children can cause growth stunting.[5] Among Ghanaian children age 0-4 years of age, 19% had moderate or severe stunting, according to year 2018 data.[21] Moreover, 1% of children in this age group had severe nutritional wasting, while 5% had moderate to severe nutritional wasting.[21]

The aforementioned most globally-prevalent MNDs are also prevalent in Ghana,[14] and each of these micronutrients will be discussed in-depth. Iron, copper, vitamin A, zinc and vitamin D were found to be the most common MNDs among women of childbearing age in Asesewa, Ghana (located just north of Accra) in a 2019 study.[24] When 98 women in this demographic were assessed, 27% had at least one MND and 4% had two or more MNDs.[24] Moreover, 58% of these women had an insufficiency of at least one micronutrient, while 18% had two or more insufficiencies.[24] A recent, large study involving 1165 Ghanaian children and 973 Ghanaian women found that both anemia and MNDs were more prevalent in the Northern region of Ghana.[25] Stunting among children was found to be more common in rural areas, and in more socioeconomically disadvantaged households.[25] This data is concerning, as 90% of the dietitians who practice in Ghana are located in Accra, which is located in southern Ghana.[26] Moreover, much of the medical infrastructure is located in Accra, and medical infrastructure in rural Ghana is lacking.[20] Therefore, dietitian-led interventions which require minimal medical equipment, and which aim to ameliorate MNDs among the rural, northern Ghanaian communities might be incredibly effective.

Key micronutrients

Iron

Iron is fairly ubiquitous in the environment. [27] However, gastrointestinal absorption of the nutrient is dependent on several factors.[27] Iron exists in two dietary forms: heme and non-heme iron.[28] Heme iron is found in animal-derived foods such as red meat, poultry and fish.[28] About 15-35% of ingested heme iron is absorbed.[27] Meat fish and poultry also contain MFP factor, a peptide that promotes the absorption of nonheme iron.[28] Additional factors that enhance non-heme iron absorption include vitamin C, citric and lactic acid, as well as fructose. Nonheme iron is found in both plant and animal-derived foods.[28] About 2-20% of ingested nonheme iron is absorbed.[27] Plant foods contain tannic acid, phytates, and vegetable proteins which all inhibit absorption of the non-heme iron in plant foods.[27,28] Due to the limited bioavailability of iron in plant sources, vegetarians require about 1.8 times as much iron intake as omnivores.[28] Absorption efficiency of both iron forms can become more or less efficient depending on iron stores.[27,28]

Iron absorption occurs in the duodenum and upper jejunum.[27] Dietary iron exists in both the ferrous (Fe^{+2}) and ferric state (Fe^{+3}), and is largely absorbed in the ferric state (Fe^{+3}).[27] Oxidation of ferrous to ferric iron is facilitated by an acidic physiological environment, by ferric reductases in the intestinal lumen, and by exogenous vitamin C.[27] In fact, vitamin C negates the inhibiting effect of phytates, polyphenols and calcium when consumed concomitantly with non-heme iron, making it a great bioavailability-enhancing option for vegetarians.[27] Duodenal absorption is facilitated by the relatively low pH of the duodenum.[27] Therefore, medications which increase the pH of the stomach (and, consequently the duodenum), such as proton pump inhibitors inhibit iron oxidation and ultimately inhibit iron absorption.[27] Therefore, individuals on medications which increase the stomach pH are at increased risk of iron deficiency.[27]

Iron is integral to several physiological processes including oxygen transport, deoxyribonucleic acid (DNA) synthesis and electron transport.[27] Additionally, iron acts as a cofactor to various enzymes involved in making amino acids, collagen, hormones and neurotransmitters.[28] Iron is present in hemoglobin in erythrocytes and myoglobin in muscle cells; in both situations, iron helps accept, carry and release oxygen.[28] Due to iron's role as an oxygen transporter in muscle myoglobin and erythrocyte hemoglobin, iron deficiency appears to decrease the work capacity of skeletal muscle.[29] Decreasing an individual's work capacity may negatively impact earning potential and socioeconomic status. Iron deficiency has also been shown to contribute to increased mortality among individuals with heart failure, independent of other factors.[30]

The nature of iron's roles in the body creates an increased iron demand among populations undergoing rapid growth and development such as infants, children, adolescents, and pregnant women.[27,28] Moreover, menstruating women have high iron needs do to blood loss during menstruation.[27,28] Due to the high iron needs of pregnant women and menstruating women, the RDA for women age 19-50 is set at 18 milligrams(mg)/day, while the RDA for men is only 8 mg/day.[27]

Iron deficiency is a concern in Ghana.[14] When 98 women who were expected to become pregnant within six months were assessed in the Asesewa, Ghana, 33% were found to be anemic, and 18% were found to have iron-deficiency anemia.[24] These statistics are hugely problematic, as iron deficiency anemia during pregnancy accounts for 115,000 deaths per year globally.[6] In the year 2017, 2,700 maternal deaths occurred in Ghana.[21] During pregnancy, iron deficiency anemia can cause breathing difficulties, fainting, fatigue, palpitations, sleep difficulties, increased perinatal infection risk, pre-eclampsia and bleeding.[31] A 2017 survey involving 1165

children and 973 women found 21.5% of children age six to 59 months have iron deficiency in Ghana.[14] Moreover, a year 2020 publication showed 13.7% of non-pregnant Ghanaian women have iron deficiency.[25] Thankfully, global iron supplementation efforts have reduced maternal mortality by 20%.[6] According to Wegmüller et al[25] the incidence of iron deficiency and anemia are higher in the Norther region of Ghana.

Physical signs and symptoms of iron deficiency are directly related to iron's physiological role and include pallor, fatigue, apathy, fainting and breathlessness.[31] The role of iron in hormone and neurotransmitter synthesis can contribute to an apathetic demeanor in iron-deficient individuals.[31] Iron's integral role in erythrocytes causes pallor, fainting and breathlessness.[31] Individuals with iron deficiency may also experience headaches, palpitations, hair loss and tinnitus.[31] In addition to these signs and symptoms, iron deficiency increases susceptibility to infection.[31]

Malaria is endemic in Ghana.[24] The connection between malaria and iron deficiency is controversial, with some sources suggesting that iron deficiency may provide some protection against malaria.[32,33] The results of such studies prompted the WHO and UNICEF to release a joint statement in 2006 recommending that iron supplementation only be given to children who have anemia and are believed to be at risk for iron deficiency.[34] As a response to this statement, several programs to fight anemia in Ghana were stopped.[35] In response to the cessation of these programs, a large, double-blind, cluster, randomized trial of Ghanaian children was conducted—the results of which were published in the Journal of the American Medical Association in 2013.[35] A total of 1958 Ghanaian children were included in the study living in 1552 clusters.[35] Of note, a cluster was defined as an area including one or more households. The clusters in this study represented two districts (Tain and Wenchi) and 99 villages.[35] The geographical location

of the districts represented in this study are shown in Figure 4, as depicted by Google Maps.[36] When considering iron deficiency incidence is most prevalent in the northernmost region of Ghana,[25] and comparing that to the location of the districts in Figure 4, the study conducted by Zlotkin et al[35] was not conducted in the areas of Ghana with the highest incidence of iron deficiency. However, the study by Zlotkin et al[35] was conducted in a fairly rural area, far from the well-established medical infrastructure in Accra.

Figure 4. Geographical Location of the Zlotkin et al[35] Study Site as Represented by GoogleMaps

The children in the study by Zlotkin et al[35] were age six to 35 months. Over the course of a five-month intervention, one group of children (the control group) received a micronutrient powder (MNP) containing iron, while the other group received a non-iron-containing MNP. [35] The MNP was given on a daily basis, and the group receiving iron received 12.5 mg of iron per day. [35] Of note, the RDA for iron for children 7-12 months is 11 mg/day, and is 7 mg/day for children 1-3 years of age.[37] No significant differences were noted in malaria incidence between

the two groups, suggesting that restoring adequate iron status among children is not a malaria risk factor.[35] Of note, every study participant had an insecticide-treated bed net.[35]

In addition to the aforementioned implications of iron deficiency, iron deficiency poses great risks to the pediatric population due to the high rate of growth and development that occurs during infancy, childhood, and adolescence. According to Chen et al,[38] iron deficiency increases the risk of unipolar depressive disorder, bipolar disorder, anxiety disorder, autism spectrum disorder, attention deficit hyperactivity disorder, delayed development, and mental retardation among children and adolescents. This is concerning, as iron deficiency is often missed in the clinical setting.[39] According to Yager and Hartflield,[39] iron deficiency can induce developmental delay, stroke, breath-holding episodes, pseudotumor cerebri, and cranial nerve palsies in the pediatric population.

Iron deficiency in infancy may also increase behavioral problems in childhood. When iron-deficient infants received zero, one, or two milligrams (mg) per kilogram per day of iron from six weeks to six months of age, those who received less iron exhibited significantly more behavioral problems at three and a half years of age.[40] The results of a trial by Algarin et al[41] suggests iron deficiency in infancy may also result in irreversible neurological damage in childhood. When 10-year old children were assessed, those who had iron deficiency in infancy had poorer inhibitory control and slower reaction times than 10-year old children who did not have iron deficiency in infancy.[41] Moreover, a study of three severely iron-deficient children suggests that correction of iron deficiency acutely improves cognitive function.[42] These three children were age 14 months, 3 years, and 12 years, and were all exhibiting developmental problems.[42] All children exhibited improvements in cognitive function after iron stores were replenished aggressively.[42] The results of this study showed that when children with iron

deficiency and no remarkable neuroimaging were supplemented with iron, their cognitive function improved.[42]

Health care providers in malaria-endemic areas may be hesitant to supplement iron-deficient children for fear of increasing malaria risk. Recognizing the discrepancy between the former and current recommendations on this topic is extremely important, as iron is integral to normal growth, development, and cognitive functioning in the pediatric population. Moreover, iron deficiency increases the risk of serious psychological and developmental disorders for children and adolescents. Training nutrition professionals on current empirical evidence, as well as providing training on how to recognize the signs and symptoms of iron deficiency is important. Increased nutrition professional knowledge on these topics likely has great potential to improve the iron deficiency problem in Ghana, and to also improve the myriad of negative health outcomes associated with iron deficiency.

Iodine

Iodine deficiency is the most prevalent, preventable cause of brain damage worldwide, and is among the leading causes of impaired cognitive development in children.[43] Iodine deficiency during pregnancy can cause stillbirth, spontaneous abortion, and irreversible mental retardation known as cretinism.[43] These negative health outcomes occur due to the role of iodine in the endocrine system; iodine is a vital component of the hormones produced by the thyroid gland.[10] Thyroid-related issues resulting from iodine deficiency are collectively referred to as iodine-deficiency disorders.[44] As aforementioned, an estimated two billion individuals consume inadequate iodine, with the greatest incidence of iodine deficiency occurring in South Asia and SSA.[10] Because of the high prevalence and the devastating effects of iodine deficiency, salt iodization has become a widespread practice.[43]

Iodine exists in many forms in the environment, and iodate is the form of iodine widely used in salt iodization.[10] Whatever form is ingested, it is reduced or oxidized to iodide prior to absorption in the stomach and duodenum.[10] The bioavailability of iodide is high, at an estimated 90% among healthy individuals.[10] However, several dietary compounds exist that are competitively absorbed with iodide; these compounds are referred to as goitrogens.[10] Cruciferous vegetables such as cabbage, kale, cauliflower, broccoli, turnips, and rapeseed contain glucosinolates.[10] Glucosinolate metabolites competitively absorb with iodide.[10] Additionally, cyanogenic glucosides found in cassava, lima beans, linseed, sorghum, and sweet potato metabolize to thiocyanates that compete with iodide for absorption.[10] Cassava is the key ingredient in two staple Ghanaian dishes.[45] Adequately soaking and/or cooking cassava removes the thiocyanate precursors that inhibit iodide absorption.[10] Ensuring that Ghanaian nutrition health professionals are educated on this potential iodine absorption inhibitor therefore has the potential to improve the iodine status of individuals in Ghana.

In the setting of iodine deficiency, the pituitary gland increases secretion of thyroid stimulating hormone, which allows the thyroid gland to adapt to inadequate iodine intake.[10] This change allows the thyroid gland to increase iodide uptake, and also reduces renal excretion of iodide.[10] In the setting of chronic iodine deficiency, the thyroid gland eventually increases in size in an attempt to overcome the insufficient thyroid hormone production caused by inadequate iodine intake.[37] An enlarged thyroid gland is referred to as a goiter, and is typically the first clinical feature of iodine deficiency.[37] Initially, goiters are diffuse, and over time become nodular.[37] Eventually, goiter can result in esophageal compression and damage to the larynx causing hoarsness.[10]

In 1995, Ghana passed legislation which made mass fortification of food grade salt mandatory.[46] The cost of salt iodization is estimated to be about five cents per person per year,[6] making mass salt iodization an attainable goal for a middle-income country. From the year 2013 to 2018, 64% of the households in Ghana consumed iodized salt.[21] However, iodized salt quality differs from brand to brand,[46] and a 2015 survey suggests only 29.3% of Ghanaian households were using salt that was adequately iodized.[47] However, while hypothyroidism made up 20.4% of thyroid-related hospital admissions in Ghana between 1982 and 1989, this diagnosis only made up 2.1% of hospital admissions between 2010 and 2014, suggesting salt iodization has supported improvements in thyroid function among Ghanaian individuals.[48] Moreover, Asibey-Berko et al[49] assessed the efficacy of a salt fortified with both iron and iodine, or with iodine only, on anemia and iodine status in women and children in the Sekyere West District of Ghana. Both the dual fortified salt and the salt fortified with iodine only reduced iodine deficiency in both women and children, suggesting a dual fortified salt is also an effective supplementation strategy among these populations.[49] Of note, the dual fortified salt was shown to prevent anemia in women and both salts prevented and treated anemia in children.[49]

The RDA for iodine for adults is 150 μg/day.[28] Most foods provide 3-75 μg per serving.[28] Excellent food sources include seafood (not from freshwater sources- only from the ocean), seaweed, iodized salt, and foods farmed on soils high in iodine.[28] High iodine soils include those which were at one time under the ocean and are not flood-prone (flood waters leach iodine from the soil).[28] Based on the WHO salt iodization standards, one gram of salt provides 60 μg of iodine per gram of salt.[28] Therefore, ½ teaspoon of iodized salt provides the adult RDA for iodine.[28]

Year 2015 data suggests 82% of Ghanaians have heard of iodized salt, while only 40.2% have heard of iodine deficiency.[47] Mean urinary iodine of <100 μg/L (micrograms per Liter) is typically used to define iodine deficiency among women of child-bearing age and school age children, however, recent research suggests the optimal range might be 100-299.9 μg/L.[47] Year 2015 data suggests only 5.2% of the Ghanaian population has severe iodine deficiency, with a urinary iodine level of <50 μg/L.[47] Average urinary iodine was 169 μg/L among women of childbearing age in rural areas of Ghana and 220.8 μg/L in urban areas of Ghana.[47] Based on these data, Ghanaian public health officials estimate that about 50% of non-pregnant women in Ghana are iodine deficient.[14] Iodine indicators were not included on the most recent 2017 micronutrient survey in Ghana.[14] It should also be noted that deficiencies of selenium, iron, and vitamin A worsen the effects of iodine deficiency.[10]

Hypothyroidism can be diagnosed using urinary iodine,[50] ultrasound,[51] and palpation of the thyroid gland for the detection of goiter.[50,51] Urinary iodine is considered and objective, accurate biomarker of iodine status,[50] however, this measure may not be always be available due to limited medical infrastructure or financial limitations. Ultrasound has also been used to determine thyroid size and goiter prevalence, however, palpation is thought to be an acceptable alternative to ultrasound in the absence of adequate medical equipment.[51]

Vitamin A

Vitamin A is an umbrella term for several fat-soluble compounds such as retinol, retinyl palmitate, and beta-carotene.[52] These compounds represent a nutrient integral to normal vision, growth, cell division, reproduction and immunity.[53] Specifically, vitamin A participates in cellular differentiation, epithelial barrier function, and immune function.[52] Vitamin A also acts as an antioxidant in some physiological contexts.[53] As described above, an estimated 19 million

pregnant women and 190 million preschool-age children are deficient in vitamin A globally, with regions of Africa and South-East Asia having the highest prevalence.[11] In low and middle-income countries, appropriate vitamin A supplementation among children reduces all-cause mortality.[54]

In the setting of vitamin A deficiency, the normal epithelium is disrupted and the resulting epithelium is stratified and keratinized.[52] Keratinization is most pronounced in the eyes, periocular glands, respiratory tract, gastrointestinal tract, and genitourinary tract.[52] Keratinization of the eye secondary to vitamin A deficiency contributes to several ocular symptoms which have the potential to negatively impact vision; xeropthalmia refers to this group of symptoms.[55] Xerophthalmia represents nyctalopia (night blindness) conjunctival xerosis (dryness of the tissue surrounding the eye) Bitot's spots (opaque white deposits on the sclera conjunctiva), corneal xerosis (dryness of the eye surface), and keratomalacia (liquification of part of all of the cornea).[55]

Ross et al[56] conducted two double-blind, randomized, placebo-controlled trials on the impact of vitamin A supplementation on the morbidity and mortality of Ghanaian children. These trials were conducted in the Kassena Nankana District of Ghana, which is located in the northern region of Ghana. The location of this district is demarcated by the red symbol on the map of Ghana in figure 5, as represented by Google Maps.[57] As shown in Figure 5, this district is far from both Accra and Kumasi, where the majority of the medical infrastructure and dietetics training programs are located.

Figure 5. Geographical Location of the Ross et al[56] Study Site, as Represented by GoogleMaps

The study by Ross et al[56] was published in 1995, and at the time of the study, an estimated 57% and 73% (respectively, in the location of each trial) of children had moderate to severe vitamin A deficiency in this district of Ghana. The age of the study participants ranged from six months to seven and a half years of age. Children age six to 11 months received an oral dose of 30 mg, or 100,000 IU (international units) retinol equivalent of vitamin A, and children older than 11 months of age received double that amount. Vitamin A supplementation was given at four-month intervals for a duration of two years. One clinical trial included 21,906 children, and the other included 1,455 children. Vitamin A supplementation significantly reduced incidence of severe illnesses, clinic visits, hospital admissions, and mortality when compared to the placebo group. The data presented by Ross et al[56] suggests that ensuring children consume adequate vitamin A improves the quality of life of these children, and reduces health care costs.

As vitamin A is heavily involved in cell differentiation, preschool-age children and pregnant women are at the greatest risk for vitamin A deficiency and xeropthalmia due to increased vitamin A needs during growth and development.[55] Vitamin A capsules cost two cents each.[6] The financial obtainability of vitamin A supplements has allowed vitamin A supplementation to reach 83% of young children (age 6-59 months) in West and Central Africa.[58] In Ghana, 50% of the population is estimated to have access to full coverage vitamin A supplementation, based on year 2017 data.[21] Despite these efforts, year 2017 data suggests 20.8% of Ghanaian children and 1.5% of non-pregnant Ghanaian women are deficient in vitamin A.[25] Another year 2017 source suggests 30% of preschool aged children are vitamin A deficient in Ghana.[14]

If vitamin A deficiency-induced xeropthalmia is promptly treated with vitamin A supplementation, symptoms generally resolve in one to two days.[55] However, chronic, untreated vitamin A deficiency-induced xeropthalmia can result in corneal ulceration, and eventual irreversible blindness.[55] Therefore, ensuring Ghanaian nutrition professionals are well-equipped to recognize the clinical signs of vitamin A deficiency has the potential to prevent blindness among Ghanaian individuals, as well as other complications of vitamin A deficiency.

Zinc

According to Solomons,[59] after vitamin A, iron, and iodine, zinc is likely the next most relevant nutrient to global public health. As aforementioned, SSA and South Asia are the regions of the world where individuals are at the greatest risk for inadequate zinc intake, and an estimated 17.3% of the global population is at risk for zinc deficiency.[12] According to Gernand et al,[24] zinc is one of the main nutrients of concern among women of child-bearing age in Ghana.

Zinc deficiency among this population is especially concerning, as zinc has integral roles to growth and development. An estimated 6% of the Ghanaian population is zinc deficient.[25]

Zinc plays a wide variety of physiological roles.[59] The role of zinc in growth and development includes supporting a key transcription factor that regulates gene expression,[60] assisting in sperm production, fetal development, and childhood growth and development.[28,61] Moreover, inadequate zinc intake may negatively impact cognitive and motor functioning among children.[62] Zinc supports the work of hundreds of proteins which participate in metabolic processes, such as insulin,[63] and proteins that support thyroid function.[10,28] Specifically, zinc participates in the synthesis, storage and release of insulin within pancreatic β-cells.[63] Zinc is also needed to produce retinal (the biologically active form of vitamin A) and retinol-binding protein (the primary vitamin A transport protein).[29] Taste perception is thought to be dependent on adequate zinc intake as well.[64,65] Zinc also supports the immune system by assisting in wound healing; zinc is heavily involved in several stages of the wound healing process such as the initial injury, the inflammatory process, and tissue remodeling.[66] The roles of zinc in these processes include platelet activation, bacterial clearance, tissue debris removal, re-epithelialization, angiogenesis, and scar formation.[66]

Due to the fact that malaria is endemic in Ghana,[24] and that zinc plays such a vital role in immune function, Owusu-Agyei et al[67] analyzed the role of zinc supplementation on malaria morbidity in Ghanaian children. This study was published in 2013 and analyzed the impact of vitamin A or vitamin A with zinc supplementation on malaria morbidity among 200 Ghanaian children age six to 24 months.[67] Study participants were chosen from 12 randomly-selected communities in rural, northern Ghana.[67] Children were randomized into either the control group, which received either 100,000 IU of vitamin A or 200,000 IU of vitamin A, depending on age, or

to the intervention group, which received the aforementioned vitamin A supplementation in addition to 10 mg of zinc. Vitamin supplementation was given daily for six months. Malaria incidence was 27% lower in the group that received additional zinc supplementation, suggesting zinc may be protective against malaria in the pediatric Ghanaian population.[67]

As aforementioned, among Ghanaian children age 0-4 years of age, 19% had moderate or severe stunting, according to year 2018 data.[21] Zinc deficiency may play a role in growth stunting among children. A meta-analysis of 33 randomized, controlled, intervention trials showed that zinc supplementation supports normal growth responses in children with low initial weight-for-age and height-for-age z scores (among children greater than six months of age).[61] Corresponding improvements in serum zinc concentrations were associated with these growth improvements.[61] Moreover, in middle and low-income countries, zinc supplementation decreased diarrhea incidence among children.[54] Therefore, ensuring that Ghanaian nutrition professionals feel well-equipped to assess patients for clinical signs and symptoms of zinc deficiency has the potential to reduce the negative health complications of zinc deficiency among the Ghanaian population, including malaria and growth stunting among the pediatric population.

Folate

The primary coenzyme form of folate is tetrahydrofolate (THF).[68] THF is part of an enzyme that transfers one-carbon compounds that arise during metabolism.[68] This action is involved in various reactions such as the conversion of vitamin B12 into one of its coenzyme forms, synthesizing DNA, and deriving methionine from homocysteine.[68] Note, to activate folate, a methyl group must be removed from it by an enzyme that requires the help of B12.[68] Without vitamin B12, folate is unable to support DNA synthesis and cell growth.[68] Since cell division, protein synthesis and tissue growth are dependent on folate, these processes are

impaired during folate deficiency.[68] In the setting of folate deficiency, DNA damage destroys erythrocytes as they attempt to divide and mature; the result is fewer, large, immature, erythrocytes, which is referred to as macrocytic or megaloblastic anemia.[68] This presents on a CBC (complete blood count) as a high mean corpuscular volume (MCV) and a low Hemoglobin (Hb).[69] The resulting erythrocytes cannot carry oxygen as efficiently as healthy erythrocytes.[69]

In addition to inhibiting the abovementioned physiological processes, maternal folate deficiency prior to and during pregnancy greatly increases the risk of birth defects in the developing fetus. Periconceptional folic acid-containing multivitamin supplementation prevents about 90% of neural-tube defects and about 40% of congenital heart defects, where periconception is defined as two to three months prior to and until three months after conception.[70] The brain and spinal cord develop from the neural tube.[70] After the 15th post-conception day, dorsal folding of the neural plate occurs and forms the brain and spinal cord.[70] Therefore, defects in neural tube formation during the first few weeks of pregnancy can result in various central nervous system disorders such as spina bifida and even death.[70]

After birth, if folate deficiency continues into infancy, this can lead to a condition referred to as cerebral folate deficiency (CFD).[71] Cerebral folate deficiency occurs when there are low levels of THF in the cerebrospinal fluid, despite normal levels in the plasma and erythrocytes.[71] The onset of symptoms occur at four to six months of age and typically begin with agitation and insomnia before progressing to deceleration of head growth, psychomotor retardation, hypotonia, spasticity, ataxia, dyskinesia, gait disturbances, speech disturbances and epilepsy.[71] Treatment for CFD includes prolonged treatment with folinic acid, a more biologically active form of folate than folic acid.[71] CFD results from decrease folate transport across the blood-brain barrier, which can have several etiologies.[71] Therefore, CFD can occur

independent of folate intake, but may be exacerbated by inadequate folate intake, stressing the importance of promoting adequate folate status among infants.[71]

Folate deficiency has been seen in infants who drink goat milk since it is very low in folate.[72] While infants younger than six months of age require 65 μg/day of folate, goat's milk only contains about 6 μg/liter.[72] Breast milk is high in folate, containing about 45-50 μg/liter.[72] The RDA for folate for adults is 400 μg/day. Due to the increased demand for folate during periods of rapid growth and development the RDA increases to 600 μg/day for pregnant individuals.[28] Of note, because high folate intake can mask vitamin B12 deficiency,[68] adult folate intake should not exceed 1 mg/day, which is the UL for adults.[28]

The serious negative impacts of maternal folate deficiency on fetal and infant development make the high rates of folate deficiency among women of childbearing age a topic of great concern. Year 2017 data suggests 53.8% of non-pregnant Ghanaian women of child-bearing age are deficient in folate.[25] Luckily, folate is somewhat unique in the way that synthetic supplemental folic acid is about 85% bioavailable, while food folate is only about 50% bioavailable.[68] The high bioavailability of supplemental folate suggests supplementation efforts among this population might be highly effective. However, supplementation compliance may be low among adolescent Ghanaian women. When 424 adolescent girls age 13-16 were assessed in the Tamale Metropolis of Ghana in 2019, compliance with an iron-folic acid supplementation program was only about 26%.[73] Identified compliance barriers included the adolescent girl perception that the supplement was "family planning medicine" and the unavailability of water in classrooms.[73] Supplementation compliance among infants and young children may be better. Combination iron-folic acid supplementation has been found to reduce the risk of anemia

significantly among children under age five in several clinical trials conducted in low and middle-income countries.[54]

Other relevant micronutrients

Although iodine, vitamin A, iron, zinc and folate have been the focus nutrients of worldwide supplementation efforts, they are not the only micronutrients of concern in Ghana. As mentioned previously, MNDs may increase the risk of chronic disease development and prevent optimal physiological functioning.[1] In addition to facilitating growth and development and preventing disease, micronutrient status is also highly relevant in the setting of certain acute illnesses. For example, the status of several micronutrients are thought to be strongly and positively correlated with positive clinical outcomes in the setting of heart failure.[74] Not only does micronutrient status serve as a predictive factor in the setting of heart failure, but it is highly relevant to heart failure pathophysiology as well.[74] Heart failure affects an estimated 26 million individuals worldwide.[75] Moreover, in 2012, heart failure alone incurred worldwide health care costs of an estimated $31 billion.[75] Improving clinical outcomes in the setting of heart failure is a great example of the importance of adequate micronutrient status in the setting of critical illness.

Recent literature suggests the role of micronutrients as antioxidants, cofactors and coenzymes may also be highly relevant in the setting of critical illness. Among critically ill patients, timely identification of nutrition risk and implementation of appropriate interventions improves clinical outcomes.[76] Trauma is one of the primary reasons for hospital admission in Ghana, with motor vehicle accidents accounting for many of the trauma cases.[20] Individuals with major physical trauma and/or burns have increased selenium, zinc, vitamin C and vitamin E needs; individuals with burns also have increased copper needs.[77] Patients with severe trauma and burns develop an acute-phase response to the injury, and many have a systemic

inflammatory response.[77] Selenium, zinc, vitamin C and vitamin E are micronutrients with antioxidant properties that support the immune response to injury, and protect cells from the reactive oxygen species produced by the immune response.[77] Supplementation with thiamin has also been associated with positive clinical outcomes in the setting of trauma and burns.[77]

Other forms of critical illness are thought to be strongly correlated to micronutrient status as well. Vitamins A, C, and E act as antioxidants, meaning they have the potential to reduce systemic oxidative stress.[78] Selenium and zinc also participate in reducing systemic oxidative stress through their roles as cofactor trace elements.[78] Combination therapy with these antioxidant micronutrients may provide benefit in the setting of acute respiratory distress syndrome, ischemia-perfusion injury, and multiorgan dysfunction in sepsis.[78]

Selenium

Selenium may be an especially relevant micronutrient for illnesses common in Ghana such as HIV, kwashiorkor, and pediatric glucose-6-phosphate dehydrogenase deficiency (G6PD). To adequately elaborate on the physiological roles of selenium, an overview on the topic is warranted. Selenium is a trace mineral responsible for several physiological processes in healthy individuals.[79] Selenium acts as an antioxidant (in the presence of adequate vitamin E), has anti-inflammatory properties, and is also involved in immunological activities.[79] Adequate selenium intake is required for the protein glutathione peroxidase (GP) to function normally; this protein plays a pivotal role in protecting cell membranes from lipid hydroperoxides and hydrogen peroxide, and also decreases systemic oxidative stress.[79] Selenium's role in reducing systemic oxidative stress might be related to its ability to inhibit nuclear transcription factor kappaB.[79] Thyroid hormone metabolism is also heavily selenium-dependent.[79] The RDA for selenium is 55

μg/day for adults; this RDA was set based on the intake levels required to support normal GP function.[28]

Selenium's involvement in these physiological processes becomes increasingly relevant as systemic inflammation increases. Plasma levels of selenium decrease in the setting of thermal injury, trauma, systemic inflammatory response syndrome, and among patients who have just undergone surgery.[79] It should be noted that selenium is an acute phase reactant; C-reactive protein is negatively correlated with serum selenium levels.[79] However, when serum selenium levels are cross-referenced with C-reactive protein levels, serum selenium continues to be low among the aforementioned patient populations.[79] Also of note, other non-acute phase reactant biochemical markers of selenium status including plasma GP levels are available in some health care settings.[79]

Due to its important physiologic roles, selenium deficiency has profound implications. Individuals with selenium deficiency may experience acute signs and symptoms of oxidative stress such as increased susceptibility to opportunistic infections and increased recovery time from any infection.[79,80] Over time, selenium deficiency can increase the risk of certain cancers (colon, rectum, lung, bladder, skin, esophagus, stomach), can increase cardiovascular disease risk, can promote cognitive decline, and can contribute to thyroid disease.[81] Selenium toxicity is also possible, but typically occurs only when supplemental doses of the micronutrient are given.[82] Selenium toxicity symptoms include hair brittleness, nail brittleness, skin rash, garlic-like breath odor, fatigue, irritability, nausea/vomiting, metallic taste in the mouth, discolored teeth, and nervous system problems.[81] According to a recent study by Agarwal et al,[83] in regards to selenium toxicity, nail and hair involvement often present first, with skin involvement occurring subsequently.

According to the National Center for Biotechnology Information, among otherwise healthy individuals, "intakes of selenium less than 900 μg/day (for adults) are unlikely to cause adverse reactions. Prolonged intakes of selenium of doses of 1,000 μg/day (or 1 mg) or greater daily may cause adverse reactions.[81]" Moreover, pregnant women and nursing mothers shouldn't consume more than the RDA for selenium.[82]

The increased demand for selenium that occurs in the setting of systemic inflammation often requires supplementation to prevent both deficiency and the negative health outcomes associated with selenium deficiency in the acute care setting.[79] For example, Uzzan et al[79] evaluated serum selenium status among individuals on home parenteral nutrition, and found that low serum selenium was associated with a higher risk of serious infection, independent of other factors. Preventing serious infections should be a goal of all hospital systems, but might be an especially important goal among hospital systems with limited resources.

The benefit of supplementing selenium among critically ill patients extends beyond infection prevention. According to a year 2018 study by Heidari et al,[80] selenium supplementation improved clinical outcomes among critically ill patients. In this study, 105 patients who had critical illness of varying etiologies were represented; etiologies included pulmonary diseases, sepsis, central nervous system disorders, and other conditions.[80] Of note, critical illness was determined with the Acute Physiology and Chronic Health Evaluation (APACHE) II scoring system.[80] In this study, the placebo group was given no selenium supplementation, while the treatment group was given selenium daily for 13 days in a dose of one mg (1000 μg) for the first day and 500 μg for each subsequent day.[80] The treatment group experienced statistically significant improvements in overall mortality and decreased ICU length of stay.[80] The improvements in patient welfare observed in the treatment groups were thought to

be related to selenium's role in the GP system which diminishes reactive oxygen species propagation and protects endothelial cells from oxidative damage.[80]

The results of a prospective, randomized, placebo-controlled, multicenter study also suggest selenium supplementation has profound protective effects among individuals who have systemic inflammatory response syndrome, sepsis, and septic shock.[84] Study participants included individuals hospitalized in the intensive care unit, and who had systemic inflammatory response syndrome, sepsis, and septic shock, as well as an APACHE III score of >70.[84] The primary outcome measure of interest in this study was 28-day mortality, however serum selenium and GP levels were also outcome measures of interest.[84] Of note, the type of selenium supplemented in this study was sodium selenite, given intravenously.[84] A total of 92 patients were in the intervention group, and 97 patients were in the placebo group.[84] The intervention group received 1000 μg of sodium-selenite intravenously over the course of 30 minutes on the first day, and received daily infusions (given continuously over the course of 24 hours) of 1000 μg/day of sodium selenite for 14 subsequent days.[84] The placebo group received 0.9% sodium chloride on the same schedule.[84] Of note, patients on parenteral nutrition received 100 μg/day of selenium selenite regardless of group status.[84] The 28-day mortality rate among the intervention group was significantly lower than that of the placebo group; the mortality rate was 42.4% in the intervention group and 56.7% in the placebo group.[84] Serum concentrations of selenium and GP were at the upper end of normal in the intervention group, and were low in the placebo group.[84] Of note, no adverse reactions related to the selenium supplementation were observed.[84]

Selenium supplementation may also be relevant in the setting of COVID-19 infection. Cytokines are immune cells, and a "cytokine storm" refers to an immune response in which many cytokines are involved.[85,86] A cytokine storm produces a myriad of reactive oxygen species

resulting in severe oxidative stress, and is cited as a "crucial cause of death from COVID-19.[85]" Moghaddam et al[87] found that patients (n=166) with lower levels of selenium were more likely to die from a COVID-19 infection than those with higher levels of selenium. Again, improving ICU length of stay, mortality rates, and the incidence of serious infections should be a goal for all hospital systems. However, among hospital systems with limited resources, improvements in these categories have great potential to improve health care resource allocation efforts in low-resource settings.

The positive physiological potential of selenium in the setting of illness is great. Selenium status is highly relevant to illnesses that commonly affect Ghanaian individuals such as HIV, kwashiorkor, and G6PD deficiency. As aforementioned, 330,000 individuals currently have HIV in Ghana, and 110,000 of these individuals are on antiretroviral therapy.[22] Selenium levels are diminished in HIV seropositive individuals.[88] This is problematic, as GP is dependent on selenium, and plays in integral role in cellular defense against HIV.[89] GP is one of three main intracellular enzymatic antioxidants highly involved in reducing the great reactive oxygen species load implicated in HIV replication.[89] In the setting of diminished selenium status, GP function is compromised.[79] Therefore, restoring normal selenium status, and consequently restoring normal GP function, has the potential to improve clinical outcomes among Ghanaian individuals with HIV.

Adu et al[90] assessed G6PD incidence among 200 blood donors in the Brong-Ahafo Region of Ghana, which is located in central Ghana. The incidence of G6PD deficiency among study participants was 19.5%.[90] The most common medical problem that occurs in the setting of G6PD deficiency is hemolysis-induced hemolytic anemia.[91] Hafez et al[92] supplemented 36 male children with G6PD with either vitamin E alone (800 IU/day) or with vitamin E (800 IU/day) in

combination with selenium (25 μg/day) for 60 days. In the single supplement group, the erythrocyte half-life improved from 16.9 to 22.8 days. In the combination supplement group, erythrocyte half-life improved from 15.6 to 24.3 days. The data gathered by Hafez et al[92] suggests that vitamin E and selenium have protective effects for erythrocytes in the context of pediatric G6PD.

As aforementioned, malnutrition is considered one of the primary mortality risk factors in Ghana.[23] Kwashiorkor is a type of malnutrition, and the term was actually developed in Ghana in 1933 by physician Cicely Williams, who worked with the pediatric population in Ghana at that time.[93] When Manary et al assessed 66 children with kwashiorkor, those who developed congestive heart failure had lower serum selenium concentrations than those who did not develop congestive heart failure.[94] Becker et al treated children with severe kwashiorkor with three different treatment regimens. Reduced glutathione supplementation positively impacted survival among the study participants. Although selenium itself wasn't supplemented, the investigators recognize that selenium is a reduced glutathione cofactor, and may therefore enhance the therapeutic properties of reduced glutathione in this context in future clinical trials.[95]

Ghanaian food staples and micronutrient sources

As selenium appears to be so relevant to illnesses common in Ghana, assessing the selenium content of traditional Ghanaian foods seems appropriate. Adotey et al[96] highlight the selenium content of several traditional Ghanaian dishes in a recent study. The study by Adotey et al[96] was conducted to examine the dietary selenium content of adolescent diets in three residential care orphanages in Southern Ghana. These orphanages were located in Osu, Tutu-Akwapim and Teshie.[96] Over the course of seven days, Adotey et al[96] recorded all food served at the orphanages, and proceeded to assess the selenium content of all food consumed within a 24-

hour period. Selenium content was determined by radiochemical neutron activation analysis. According to Adotey et al, "the mean dietary supply of selenium were, 57.6±17.3, 82.0± 30.7 and 91.7± 44.2 μg day−1 for Osu, Tutu-Akwapim and Teshie orphanages respectively.[96]" Therefore, the average dietary selenium content met the RDA of 55 μg/day for these individuals. The 24-hour periods which yielded the highest dietary supplies of selenium occurred at the Tutu-Akwapim orphanage on day seven of the trial, and at the Teshie orphanage on day four. The estimated selenium content of the diet on day seven at the Tutu-Akwapim orphanage and was 133 μg. The estimated selenium content of the diet on day four at the Teshie orphanage was 148.8 μg. The high amount of selenium provided by the diet on these days necessitates an examination of the foods provided on these days, in these locations.

At the Teshie orphanage on day four the following foods were provided: milo beverage and bread, banku and okra stew, and boiled rice with tomato stew.[96] Of note, the banku served on this day contained fish and meat (both good sources of selenium) and the stew also contained fish. At the Tutu-Akwapim orphanage on day seven of the trial, the following foods were served: wheat porridge and koose, banku and palmnut soup, and boiled rice and palaver sauce mixed with soya beans. Of note, koose is made of milled beans. The high selenium content of the diet on this day was likely related to the palmnut and fish served in the banku and palmnut soup. Therefore, fish and meat-containing banku, as well as palmnut soup might be appropriate selenium-containing, food-based supplements for individuals who are critically ill in Ghana.

The foods in the study by Adotey et al[96] are representative of the traditional Ghanaian diet. Traditional Ghanaian dishes include fufu, banku, and rice.[45] These foods are commonly made in the home, and are also sold by street food vendors.[45] There are an estimated 60,000 street food vendors in Accra alone, with a combined annual turnover of $100 million.[45] Fufu is a

staple starchy dish, typically made from coco-yam, cassava or oatmeal, which are kneaded together to form a mash.[45] Banku is made from fermented corn and cassava dough, both of which are mixed with hot water to form a smooth paste.[45] Both fufu and banku are commonly served with other foods such as soup or fish and rice.[45]

Food mineral content is partially dependent on the mineral content of the soil in which it is grown. An article published in 2020 by Kihara et al[97] reviewed the soil mineral content in SSA, and how the soil mineral content affects food mineral content. Per Kihara et al, [97] one-third of arable soils worldwide are deficient in micronutrients, and SSA soils are particularly prone to deficiency. Zinc appears to be the most prominently deficient nutrient in SSA soils followed by boron, iron, molybdenum and copper.[97] The mineral content of the crops grown in these soils reflects the soil mineral content.[97] Therefore, if Ghanaian individuals are consuming locally-grown crops, they may be at increased risk for deficiency of these minerals. When conducting a patient interview in Ghana, nutrition professionals may benefit from inquiring about locally-grown crop consumption, and focusing a physical exam on signs and symptoms of mineral deficiencies that may result from consuming only local crops. Applying micronutrient-containing fertilizers appears to improve the micronutrient quality of the plants in 60-80% of cases, and may be a viable option to improve mineral deficiencies among the Ghanaian population.[97]

As food mineral content is greatly impacted by the soil in which it is grown, local food mineral assessment is warranted. A comprehensive outline of the macronutrient and micronutrient content of several foods native to West Africa is outlined in "Composition of selected Foods from West Africa" by Stadlymayr et al.[98] Of note, according to Stadlymayr et al,[98] a 100-gram edible portion of a raw coconut grown in West Africa contains 810 µg of selenium. Therefore, coconut may be an appropriate supplemental selenium source in this region.

Moreover, a study conducted in Nigeria assessed the mineral content of a locally-sourced bambaranut—tigernut—coconut milk beverage.[99] Per 100 grams, this beverage contained 8.34-18.2 mg calcium, 1.82-4.24 mg potassium, 0.86-2.24 mg iron, 1.02-3.38 mg zinc, 1.15-2.97 mg phosphorus and 0.87-1.24 mg magnesium,[99] suggesting the bamabaranut, tigernut and coconut are rich, local dietary sources of minerals in West Africa.

Poor local crop mineral content may be one reason that many households in Ghana do not meet the food-based dietary guidelines (FBDGs). The FBDGs were developed in Ghana to guide policy makers to assess the nutrient intake of vulnerable populations.[100] Ghanaian FBDGs reflect actual dietary patterns, available foods, and traditional dishes. When Jager el al[100] assessed 329 Ghanaian households, 40% of rural Northern Ghanaian infants only met about 50% of their nutrient intakes, and their growth was stunted as a result. Nutrients of particular concern were calcium, vitamin A, iron, vitamin B12 and vitamin C.[100] At the national level, grains were sufficiently available to Ghanaian households, however legumes and vegetables were not.[100]

Inadequate access to certain foods and the micronutrients they contain has led to widespread food fortification efforts in Ghana. Available multivitamin/mineral supplements include sprinkles (SP), a powder developed by Ped Med Inc., Canada, a crushable Nutritab (NT), developed by UNICEF, and a fortified peanut butter (NB) developed by Nutriset SA, Malaunay, France.[101] SP contains iron, zinc, vitamin A, and vitamin C. NT contains these micronutrients, but also contains several additional micronutrients, making it a somewhat comprehensive micronutrient supplement.[101] NB is a comprehensive micronutrient supplement with added energy and fat.[101] These three supplements all contain vitamins and minerals integral to growth and development among infants.[101] When 313 Ghanaian infants age six to 12 months were given one of these three supplements daily until they reached 12 months of age, positive outcomes

were seen. Of note, these infants were breast-fed throughout the intervention, and the supplements were used as complimentary foods. All three supplements positively impacted motor development at 12 months of age, suggesting the micronutrients in SP (iron, zinc, vitamin A, and vitamin C) might be primary nutrients of concern among Ghanaian infants six to 12 months of age.[101] The NB supplement was the only one to positively impact growth, suggesting these infants may not be meeting their kcalorie and/or fat needs as well.[101]

Weanimix is a cereal-legume blend developed by UNICEF and the Ghanaian government that is available as a complementary food in Ghana.[102] Weanimix is made up of 10-15% soybeans or cowpeas, 10% groundnuts and 75-80% corn.[102] In a study published in 1999, Weanimix was studied alongside Koko, a fermented maize porridge commonly used as an infant food in Ghana.[102] Ghanaian infants age six to 12 months of age were fed Koko with fish powder, Weanimix, Weanimix with additional vitamins and minerals, or Weanimix plus fish powder. Of note, the 208 infants included in this study were breast-fed, and the interventions were used as complimentary foods. The anthropometric measurements of the study participants were compared to infants not included in the intervention. All four complimentary foods improved growth when compared to infants not included in the intervention groups.[102] Moreover, infants in the groups fed Weanimix had better stores of iron and vitamin A than infants in the other groups, suggesting soybeans/cowpeas, groundnuts, and corn support infant growth when used in complementary foods.[102] Of note, utilizing nutrition education has been identified as a facilitator to in child feeding programs in rural Ghana.[103] Early identification of MNDs among the pediatric population in Ghana can provide guidance to Ghanaian nutrition professionals working to identify infants and children who would benefit from nutrient-dense complimentary foods.

The nutrition-focused physical exam for identification of MNDs

The NFPE is an effective tool for identifying MNDs.[104–106] Moreover, the NFPE does not require any specialized equipment.[106] RDs are qualified to conduct the NFPE to assess nutritional status.[107] When conducting a general NFPE, the RD will assess muscle or grip strength, scalp, hair, mouth, skin and nail health, the general appearance of several body parts including the arms, legs chest, back and face, as well as signs of fluid retention or dehydration.[107] The NFPE focused on identifying MNDs hones in on the skin, nails, head/hear, eyes, extra/intraoral cavity, neck/chest, the musculoskeletal system, as well as the lower extremities.[106] Each of these body regions, and the diagnostic purposes of assessment in this context will be discussed in-depth.

The NFPE for the pediatric population might be especially critical, as early identification of malnutrition among this population can prevent negative outcomes related to growth and development.[108] Identification of diseases states that may predispose children to certain MNDs can help to guide the NFPE.[108] For example, inflammatory bowel disease may be associated with deficiencies in iron, folate, selenium, zinc, calcium and vitamin D. [108] Likewise, chronic diarrhea may be associated with zinc deficiency. [108]

Biochemical markers of nutrition status are considered the gold standard to assessing micronutrient status, because they are more objective than other forms of nutrition assessment (such as a physical exam).[109,110] However, biochemical markers of nutrition status have limitations. For example, biochemical markers are not available in certain settings, such as settings in which medical infrastructure is lacking.[5] Financial restraints may also limit availability, even when infrastructure is sufficient. Furthermore, biochemical markers of nutrition status are heavily influenced by inflammation, infection, hydration status, age and kidney function.[5,111] For example, in the setting of inflammation, serum levels of calcium, zinc, iron, vitamin A, and α-tocopherol decrease, independent of micronutrient status.[112] Within a few

hours of infection, serum levels of retinol binding protein (sometimes used to assess vitamin A status), and transferrin (sometimes used to assess iron status) are decreased.[112] Proteins that decrease in the setting of inflammation are referred to as negative acute phase reactants, and those that increase in the setting of inflammation are referred to as positive acute phase reactants.[112] Ceruloplasmin, a copper storage protein, is a positive acute phase reactant, and increases by about 50% in the setting of acute inflammation.[112]

As aforementioned, iron deficiency is the most common MND worldwide.[8] Independent of disease status, serum iron fluctuates throughout the day, and therefore is not considered a sensitive measure of iron status.[113] Ferritin is the primary iron storage protein, and serum ferritin accurately reflects total body iron stores.[113] Therefore, ferritin is often used as a biochemical marker of iron status in the clinical setting, and is considered a sensitive measure of iron status.[113] However, ferritin is a positive acute phase reactant, and therefore may falsely reflect normal iron stores in the setting of inflammation.[111] Therefore, although they may be more objective than the NFPE, biochemical markers of nutrition status have several limitations, which may render them impractical in many situations in Ghana.

Although awareness about utilizing the NFPE for diagnostic purposes is currently growing among nutrition professionals, relying on a physical exam for diagnosis is hardly a new concept. Sir William Osler was a prominent internal medicine physician who lived from 1849 to 1918, and is considered by many as a seminal figure in the field of medicine.[114] Osler was one of four physicians who founded John's Hopkins.[115] In the late 19th and early 20th century, Osler was a Professor of Medicine at both Johns Hopkins and Oxford.[115] While at Johns Hopkins, he brought clinical care from the classroom to the bedside, and relied heavily on the physical exam

to diagnose patients.[116] He has been quoted as saying "he who studies medicine without books sails an uncharted sea, but he who studies medicine without patients does not go to sea at all.[114]"

Now, over a century later, Johns Hopkins residents spend a mere eight minutes with each patient per day.[117] Limited reliance on the physical exam and patient interview has led to weakened diagnostic skills among Johns Hopkins residents.[118] A bedside training program at Johns Hopkins Hospital aimed to improve cardiopulmonary diagnostic skills effectively enhanced resident physicians' confidence and skill when conducting a physical exam.[118] Dr. Brian Garibaldi, a Johns Hopkins residency director, recognizes the negative impact that limited patient interaction is having on overall patient care, and emphasizes the importance of the physical exam and patient interview throughout medical residents' training.[116] Garibaldi says "with incredible institutional support, we're going to lead how we do the physical exam in the 21st century.[116]" As the head of the medical team, the time a physician spends conducting a physical exam and conversing with patients might heavily influence the way nutrition professionals spend their time as well. Therefore, it is paramount that nutrition professionals feel well-equipped to conduct a physical exam.

One century ago, Osler realized how integral the physical exam was to patient care. Since that time, Western medicine has gradually fallen away from using the physical exam, and has relied more heavily on specialized medical technology for diagnostic purposes. Now, key members of Western medicine training programs are recognizing this issue, and are working to resolve it. Nutrition professionals have the potential to take part of this innovative shift in Western medicine, and should be adequately trained to do so.

Skin

When focusing on the skin throughout the NFPE, the nutrition professional should assess the skin for altered color, texture, temperature, moisture, lesions, mobility and turgor.[106] Pallor, a paleness of the skin when compared to its normal color, can be most easily detected on the conjunctiva (lower eyelid), nail beds, tongue, the overall appearance of the individual,[106] and the palms of dark-skinned individuals.[119] Pallor is often associated with deficiencies in the micronutrients involved in erythropoiesis, such as iron, folate and vitamin B12.[106] Biotin deficiency can present similarly, but is most commonly seen among patients receiving non-biotin containing parenteral nutrition, or in the setting of chronic raw egg consumption.[106]

Depigmentation of the skin that presents as a whitish, gray coloring on the face, hands/fingers, chest, legs, and feet can result from copper deficiency.[106] Copper deficiency is also associated with progressive generalized weakness, lower extremity numbness, tingling and abnormal balance.[120] It should be noted that copper and zinc are competitively absorbed.[121] Due to the high prevalence of global zinc deficiency, zinc supplementation may be commonly encountered in the clinical setting, and long-term zinc supplementation can lead to copper deficiency.[121] In a case report of a 35-year old individual who received 440-660 mg of zinc sulfate per day (110-165 mg of elemental zinc) for 10 months, cessation of zinc supplementation and aggressive copper supplementation were required to restore normal copper status.[121] Therefore, if copper deficiency is suspected, determining if the patient is consuming a zinc supplement is an important consideration.

The presence of perifollicular hemorrhages (hemorrhages around the hair follicle) is another clinical finding relevant to MNDs.[106] Perifollicular hemorrhages often appear with petechiae and purpura (reddish-purple spots).[106] Perifollicular hemorrhages and petechiae and purpura can result from vitamin C deficiency because of this nutrient's integral role in collagen

synthesis; reduced collaged synthesis weakens capillary walls.[106] These clinical manifestations of vitamin C deficiency occur most commonly on the arms and legs, and do not change color when pressure is applied.[106]

Vitamin K is integral to blot clotting due to its role in clotting factor support.[106] Unusual ecchymosis, or bruising, is therefore a sign a notable sign of vitamin K deficiency.[106] As aforementioned, vitamin A is integral to cell differentiation and maturation, and these roles are impaired in the setting of deficiency.[52] Therefore, the epidermis can appear dry, rough and hard in the setting of vitamin A deficiency.[106] Moreover, increased keratinization in the epithelium can produce a hard, inflexible build-up around the hair follicle, and often indicates vitamin A deficiency.[106]

Seborrheic dermatitis (red, inflamed areas on the surface of the skin) is another clinical finding relevant to MNDs.[106] When one or more of the B vitamins are deficient, seborrheic dermatitis can ensue.[106] Pellagra is another cutaneous manifestation of B-vitamin complex deficiencies, however, is typically representative of niacin deficiency specifically.[106] Pellagra dermatitis with a niacin-deficiency etiology typically presents on the arms and legs.[106] Due to the various aforementioned physiological roles of zinc, zinc deficiency also has cutaneous implications. Physical findings of zinc deficiency tend to occur relatively shortly after serum zinc levels decrease.[106] A reddish, scaly rash on the face, neck, and/or hands,[106] as well as slow wound healing[66] can represent zinc deficiency.

Nails

Zinc deficiency can also present on the nails as Beau's lines, which can be described as transverse ridges and horizontal grooves on the nail.[122] Of note, Beau's lines can also be caused by poorly controlled diabetes, peripheral vascular disease, measles, mumps, and pneumonia. [123]

As aforementioned, blood vessel integrity is heavily dependent on vitamin C.[106] Therefore, splinter hemorrhages under the nail can reflect vitamin C deficiency.[122] Koilonychias is a condition in which nails are spoon-shaped, concave,[122] thin, brittle and rigid.[106] Koilonychias can result from both iron and protein deficiency.[122, 106] Iron deficiency is also sometimes associated with central nail ridges; central nail ridges can reflect both iron and folate deficiency.[122] Nails that are excessively brittle and split easily can indicate magnesium deficiency.[106] Lastly, vitamin B12 deficiency can present as dry, darkened nails with rounded or curved ends.[106]

Head/hair

Alopecia can reflect biotin, zinc, and/or iron deficiency. [108] Biotin is heavily involved in hair growth, and the aforementioned varied physiological roles of zinc and iron can also cause alopecia in the setting of deficiency.[106,122] As aforementioned, vitamin C is heavily involved in capillary integrity.[106] Therefore, vitamin C deficiency can cause small hemorrhages in the hair shaft, causing the hair to have a corkscrew appearance.[106,122] Color changes of the hair, a lackluster shine or depigmentation can be caused by deficiencies in manganese, selenium, and copper.[122] During the formation of hair through the process of keratinization, hair selenium uptake occurs; selenium incorporates into the hair matrix and provides structure and integrity.[124] Therefore, in the setting of selenium deficiency, hair loss and pseudo albinism of the hair can occur.[124]

Eyes

As aforementioned, a pale conjunctiva can reflect deficiency of the micronutrients involved in erythropoiesis such as iron, folate and vitamin B12.[106] Vitamin B6 and copper deficiency have also been associated with a pale conjunctiva. Copper is involved in hemoglobin synthesis,[125] and the role of vitamin B6 in key metabolic cofactors can also contribute to anemia

in the setting of vitamin B6 deficiency.[126] Of note, pregnant individuals may be at increased risk for vitamin B6-induced anemia due to the role of vitamin B6-dependent cofactors in placental support.[126]

The ophthalmologic findings of vitamin A deficiency are abovementioned and include xeropthalmia.[55] Ophthalmoplegia is another clinical manifestation of MNDs, and can occur in the setting of thiamin and/or phosphorus deficiency. Ophthalmoplegia is characterized by paralysis of the muscles surrounding the eye, and in the setting of thiamin deficiency is likely related to Wernicke's encephalopathy.[127] The phosphorus deficiency-related ophthalmoplegia etiology is not well-understood, but is thought to be related to phosphorus' role in oxidative phosphorylation, particularly as this relates to mitochondrial damage.[128,129]

As aforementioned, a deficiency in one of more of the B vitamins can cause dermatitis of the face. Deficiencies of niacin, riboflavin, vitamin B6 and/or iron deficiency can cause inflammation of the skin of the eyelid corners, otherwise known as angular palpebritis.[122] Riboflavin, biotin, vitamin B6, and zinc deficiency can also cause a similar condition, angular blepharitis, which refers more broadly to inflammation of the eyelid.[130]

Extra/intraoral cavity

Assessment of the extra and intraoral cavity is an especially useful tool when conducting a NFPE to assess for MNDs, as symptoms appear quickly in this area of the body.[131,132] Oral mucosal cells have a three to seven-day turnover rate, and the B vitamins are heavily involved in cell function and integrity. Cheilosis of the lips, or a dry, swollen, ulcerated appearance, as well as angular cheilosis, or fissures at the corners of the mouth, are common clinical findings of MNDs.[131] MNDs associated with cheilosis or cheilitis of the lips are vitamin B6, folate, riboflavin, niacin, vitamin B12, and iron.[131]

Xerostomia, or dry mouth, is another oral clinical manifestation of MNDs, and can be caused by zinc deficiency.[131] As aforementioned, zinc deficiency is associated with changes in taste perceptions, [64,65] so taste perception changes and xerostomia may occur together in the setting of zinc deficiency. Aphthous stomatitis, or canker sores, may occur in the setting of vitamin B12 and folate deficiency, and the risk of contracting oral candidiasis, or thrush, increases in the setting of vitamin C and iron deficiency.[131] The association between a pale conjunctiva and iron deficiency was discussed above; iron deficiency is also associated with paleness of the oral tissues as well.[131] In addition to causing paleness of the oral tissues, iron deficiency can cause stomatopyrosis, or pain and inflammation in the mouth, and dysesthesia, otherwise known as burning mouth syndrome.[131] Other MNDs associated with stomatopyrosis and dysethesia are vitamin B12, folate, and magnesium.[131]

Scurvy is a well-known clinical finding of vitamin C deficiency, and symptoms include bleeding gums, tooth loss and dental caries.[131] These symptoms can be associated with vitamin B12 deficiency as well.[131] Glossitis, or a sore, inflamed, red tongue can be caused by riboflavin, niacin, vitamin B6, vitamin B12, folate, and severe iron deficiency.[131] Glossitis is often associated with atrophic filiform papillae, or flattened protrusions on the tongue resulting in a smooth texture, and can be caused by the same MNDs.[131] Intra and extra oral clinical signs are extremely relevant to MND identification.[131]

The musculoskeletal system

Thiamin deficiency can occur in the setting of chronic alcohol consumption.[106] Wernicke-Korsakoff is a syndrome that affects chronic alcohol users, and which results in disorientation, loss of memory, and a staggering gait; these symptoms occur due to thiamin deficiency.[106] Thiamin deficiency can also contribute to absent deep tendon reflexes and eventual foot and

wrist drop as well as calf tenderness.[122] Bone demineralization and the associated illnesses such as epiphyseal enlargement of the wrists, legs and knees, bowed legs, Rickets, osteomalacia, fontal bossing (prominent forehead), bone/joint tenderness can all result from Vitamin D, phosphorus, and/or calcium deficiency, due to the role of these micronutrients in bone mineralization.[106,122] Generalized weakness is associated with deficiencies in phosphorus, potassium, vitamin C, vitamin D, and vitamin B6.[122] The electrolyte micronutrients (sodium, potassium, magnesium, chloride, and calcium) all facilitate muscle flexion.[133] Therefore, deficiencies of these micronutrients can cause muscle cramps, and this clinical finding may be exacerbated in the setting of intense physical activity.[133]

Neuropathy is a general term referring to the dysfunction of one or more peripheral nerves.[134] Neuropathy has several possible micronutrient-related etiologies, and can result in pain and tingling in the extremities.[134] Deficiencies in thiamine, vitamin B12, vitamin E, vitamin B6, niacin, and copper all have the potential to cause neuropathy, however, the presentation varies based on the deficient nutrient.[134] Thiamine is involved in several physiological processes such as cellular respiration, ATP production, and maintenance of the myelin sheath surrounding nerve fibers.[134] In the setting of early thiamine deficiency (days to weeks), the patient may feel fatigued, irritable, and have muscle cramps.[134] Symptoms then progresses to distal sensory loss, burning pain, a burning/pricking sensation, or muscle weakness of the feet and toes.[134] Severe deficiency can eventually lead to ascending weakness in the legs and sensorimotor neuropathy in the hands.[134]

Vitamin B12 is also involved in the maintenance of the myelin sheath; vitamin B12 facilitates the conversion of L-methylmalonyl coenzyme A into succinyl coenzyme A—a compound integral to the myelin sheath.[134] The neurologic symptoms of vitamin B12 deficiency

are unique among the other micronutrients mentioned here, because feet and hand symptoms typically present together.[134] Decreased sensation of the feet may present concomitantly with numbness in the hands; this presentation is similar to that of copper deficiency.[134] Decreased loss of vibratory sense in the feet is a hallmark sign of vitamin B12 deficiency.[134]

Vitamin E is a potent antioxidant, and the neurologic clinical findings of vitamin E deficiency are related to decreased antioxidant potential.[134] Specifically, swelling and degeneration occurs around the large myelinated axons within the peripheral nerves.[134] Vitamin E deficiency-related neuropathy is typically slow and progressive.[134] Symptoms include ataxia, hyporeflexia and loss of vibratory sense in the feet.[134] A neurological exam may also reveal dysarthria, nystagmus, ophthalmoparesis, retinopathy, head titubation, decreased sensation, and proximal muscle weakness.[134]

Peripheral neuropathy in the setting of vitamin B6 deficiency is rare, but can occur.[134] In infants, deficiency can cause seizures. In adults, clinical findings include numbness, pain, tingling, burning, and pain in the feet.[134] If left untreated, these symptoms can ascend to the legs and hands. Burning sensations in the extremities may be a more common finding in the setting of vitamin B6 deficiency than deficiency of the other neurologically-relevant micronutrients.[134] Niacin deficiency can cause peripheral neuropathy, however, treatment with niacin alone typically will not treat the neuropathy, as niacin deficiency typically occurs in the setting of other B vitamin deficiencies as well.[134] Neurologic symptoms of niacin deficiency are typically more relevant to the central nervous system and include apathy, inattention, irritability and depression.[134] In the setting of copper deficiency, gait disturbances are a hallmark sign, and this is often accompanied by lower limb paresthesia (burning/pricking sensation).[134]

Benefits of using the NFPE include the fact that specialized medical equipment is not required, it can be conducted in areas with little to no medical infrastructure, and the cost of conducting the NFPE is very low. Moreover, the NFPE is not subject to the aforementioned limitations of using biochemical markers of nutrition status to screen for MNDs. Also, the NFPE allows for early detection of malnutrition, which might be especially relevant to the devastating effects of MNDs among children.[108] However, the NFPE is a clinical skill, and nutrition professionals must be adequately trained to accurately utilize this screening tool.

Ghanaian Dietetics Profession

Ghanaian RDs receive similar training to those in the U.S.[135] In the U.S. obtaining an RD requires an undergraduate bachelor's degree in dietetics, one year of practical experience, and successful completion of the licensure exam.[136] In 2024 in the U.S., a master's degree will also be required to take the licensure exam to become an RD.[136] In Ghana, either a undergraduate bachelor's degree or a master's degree is required, as well as one year of practice experience and successful completion of the licensure exam.[135] Limited literature exists on training programs for Registered Nutritionists in Ghana. Dr. Intiful, PhD, MPhil, BSc, RD is a lecturer and researcher at the University of Ghana Department of Nutrition and Dietetics and was a valuable resource for the present study. Dr. Intiful reports that training programs for Registered Nutritionists are similar to that for Registered Dietitians. Dr. Intiful also reports that Registered Nutritionists more commonly work in the community setting than in the clinical setting.

The dietetics field in Ghana has grown significantly since the early 1960s.[26] The University of Ghana initiated a graduate program in dietetics in 2004, and an undergraduate program in 2009.[26] The University of Health and Allied Sciences, as well as the Kwame Nkrumah University of Science and Technology now offer dietetics programs as well.[26] The

University of Health and Allied Sciences is located in the Volta Region of Ghana, which is just outside of Accra,[137] and the Kwame Nkrumah University is located in Kumasi.[138] A year 2014 study showed there were 100 RDs practicing in Ghana at the time,[135] and that 90% of the RDs in Ghana practice in Accra.[26] Due to the availability of RD training programs in Ghana, and the growing Ghanaian dietetics field, this number has surely grown in recent years.

Ghanaian dietitians are considered important members of the health care team. When 114 Ghanaian physicians were surveyed, 85% reported making referrals to dietitians in their setting of medical practice.[139] The physicians surveyed largely felt as though nutrition is a key component to preventing and managing chronic diseases.[139] Eighty-one percent of physicians believed their patients needed more nutrition information, and 84% felt that their patients will adopt healthier lifestyles if they were counseled to do so by a dietitian.[139] Perceived barriers for physicians to offer nutrition guidance to patients included lack of time, inadequate knowledge about nutrition, and a lack of confidence regarding counseling skills.[139] As Ghanaian dietitians are well-equipped to receive referrals from physicians for nutritionally-relevant health ailments, an intervention to enhance dietitian presence in the medical team may be incredibly effective in increasing patient access to dietitians.

NFPE training

According to the Accreditation Council for Education in Nutrition and Dietetics (ACEND), conducting the NFPE is a skill practicing RDs should possess.[140] In fact, one of the 2017 ACEND competencies for entry-level RDs is "conduct nutrition focused physical exams.[140]" However, when 367 RDs were surveyed, only 34.6% reported they had received training in the NFPE.[141] NFPE skills RDs reported using most frequently were measuring weight, height, waist circumference, and skin assessment.[141] Therefore, RDs might be missing

key diagnostic body regions, especially when conducting a micronutrient-focused NFPE. Limiting factors to using the NFPE identified by RDs include a lack of education and training on the NFPE.[141] A lack of training on the NFPE is reflected in RD comfort-level in conducting the NFPE. RDs report barriers to conducting the NFPE include a lack of training, limited time, and discomfort touching patients.[142]

In another recent study on this matter, 96 RDs actively working in clinical dietetics were surveyed about their use of the NFPE in practice.[143] Prior NFPE education, training, and recognition of the value of conducting the NFPE as part of patient assessment, having confidence to conduct the NFPE, and NFPE experience were reported by practicing RDs as the foremost reasons the NFPE was utilized in practice.[143] RD-reported barriers and facilitators to utilizing the NFPE in practice suggest bolstering education for RDs on the NFPE might be incredibly effective.

When a NFPE simulation was incorporated into a graduate-level medical nutrition therapy course, positive outcomes were seen.[142] Graduate students showed improvements in preforming the NFPE, and reported they were more confident when conducting the NFPE.[142] Continuing education opportunities for practicing RDs have shown to be effective as well. The Academy of Nutrition and Dietetics offers a hands-on training workshop to strengthen practicing RDs' clinical skills in this area.[104] RDs who have completed this workshop experience increased feelings of comfort and confidence in performing the NFPE, and this workshop has been shown to increase RD proficiency in this area as well.[104]

The RD training program at the University of Ghana in Accra is similar to those in the U.S.,[144] suggesting Ghanaian RDs may be experiencing some of the same feelings about NFPE training. Therefore, similar interventions to enhance confidence and proficiency in this area

might be equally effective. A one-day workshop on nutrition support was held in Accra in 2019 for nutrition professionals.[145] This workshop increased participants' confidence in their nutrition support skills, satisfaction with their nutrition support knowledge, nutrition support knowledge accuracy, and ability to apply knowledge gains using the nutrition care process. [145]

Although hands-on training may be the most effective manner in which to deliver training on the MND-directed NFPE to nutrition professionals, this modality may not always be feasible during the COVID-19 pandemic. The COVID-19 pandemic poses a unique challenge during an international collaboration. In fact, the COVID-19 pandemic has dramatically impacted medical training worldwide.[146] However, during the COVID-19 pandemic, medical students had positive responses to virtual training on conducting a physical exam.[147] Moreover, virtual training among medical students allowed medical students to continue their coursework during the COVID-19 pandemic, and resulted in positive training outcomes pertaining to the bedside exam.[148] Furthermore, online learning may be a useful tool when providing education for community-based nutrition professionals, particularly in the areas of knowledge and self-efficacy pertaining to clinical skills.[149]

Chapter II: Theoretical framework

When designing and implementing a global health intervention, using a framework or theory to inform the intervention has great potential to improve intervention efficacy.[150,151] The diffusion of innovations theory (DOI) lends helpful global health intervention guidance, as it encompasses the cross-cultural component of global health interventions.[151] For example, how the culture of interest perceives intervention attributes, and consideration of the social system in which the intervention will be implemented are key components of the DOI. [151] These are just two of the reasons, according to Dearing,[152] that the DOI theory is especially useful when developing an international health care intervention.

The DOI theory was developed by E.M. Rogers in 1962, and has since been used to inform a plethora of interventions in fields such as communication, agriculture, public health, criminal justice, social work, and marketing.[153] According to Rogers, "diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system…it is a kind of social change.[154]" The DOI theory is centered around the notion that a new idea or behavior permeates (or diffuses) a certain population or system when the idea is seen as innovative.[153] The end result of this permeation is that the people, or individuals within the population or system of interest, adopt the new idea or behavior.[153] The adoption of the new behavior hinges on the individuals' perception of the idea; perception that the idea is new or innovative is a strong intervention efficacy predictor.[153] Essentially, the belief that the new idea is innovative drives the diffusion.[153]

Five main factors or constructs have been identified that influence the adoption of an innovative idea; the first is relative advantage.[153] The construct of relative advantage is the "degree to which an innovation is seen as better than the idea, program, or product it replaces.[153]" In the setting of incorporating use of the NFPE into routine clinical practice for nutrition professionals in Ghana, illustrating to nutrition professionals (the population of interest) that such an intervention has the potential to decrease the incidence of MNDs through enhanced detection of MNDs would likely illustrate the innovative nature of this intervention. Moreover, illustrating that incorporating the NFPE into routine clinical care could ultimately decrease serious infection risk, overall mortality, stunting incidence, and cognitive impairments among children, and decrease the risk of pregnancy-related complications, would likely also illustrate the fact that this intervention is superior to not routinely using the NFPE in clinical practice.

Moreover, RDs currently using the NFPE report that recognizing the value of conducting the NFPE as part of patient assessment is a facilitator to incorporating the NFPE into practice.[143]

The next construct of the DOI is compatibility, or "how consistent the innovation is with the values, experiences, and needs of the potential adopters.[153]" E.M. Rogers echoes this definition, stating "compatibility, in the context of the diffusion of innovations theory, is a measure of how well an innovation is consistent with existing social and cultural practices, if it is likeable, and if it meets the needs of potential adopters.[154]" As mentioned above, Ghana is a middle-income country with limited medical infrastructure in rural settings. Moreover, the incidence of MNDs is highest in rural areas of Ghana. The NFPE does not require medical infrastructure or specialized medical equipment, and the cost of conducting the NFPE is very low. The NFPE may provide a low-cost, alternative to biochemical markers of micronutrient status in situations in which laboratory tests are out of financial reach. In situations in which medical infrastructure is lacking and a MND is suspected, the NFPE offers a way to detect MNDs without the need for medical infrastructure. As above-mentioned, most of the RDs practicing in Ghana practice in Accra.[26] Therefore, an intervention that could be employed remotely may allow nutrition professionals to screen for MNDs in more rural areas that might be far from their place of work. In these ways, incorporating the NFPE into routine clinical practice for Ghanaian nutrition professionals would likely closely align with the values, experiences, and needs of the potential adopters.

The next construct is complexity, or "how difficult the innovation is to understand and/or use.[153]" Again, using the NFPE to assess a patient for MNDs requires little to no medical equipment, which speaks to the ease of using this intervention. RDs practicing in Ghana are well-versed in medical nutrition therapy, as evidenced by the rigor of Ghanaian RD training

programs.[144] A sound understanding of medical nutrition therapy is the foundational knowledge required to conduct the NFPE. Several RDs currently practicing do not feel well-trained in the NFPE, [141,142] and one-day workshops have been shown to adequately enhance the knowledge of RDs in this area.[104] Therefore, in the setting of the COVID-19 pandemic, implementing a two-day virtual workshop on the NFPE has great potential to enhance the proficiency of nutrition professionals in conducting the NFPE, and consequently make this intervention easy to understand and use in the clinical setting.

The next construct of the DOI is trialability, or, "the extent to which the innovation can be tested or experimented with before a commitment to adopt is made.[153]" Incorporating use of the NFPE into routine clinical practice can certainly be done on a case-by-case basis. This practice does not need to be adopted on a large scale until the Ghanaian dietetics community unanimously support this intervention, and thus unanimously perceive the efficacy and innovation of this intervention. Moreover, the NFPE is somewhat unique among nutrition interventions in that conducting the NFPE has no negative side effects. Use of a physical exam to assess a patient for MNDs also does not require the clinician to withhold standardized treatment. Very low-risk interventions have high trialability in the clinical setting.

The last construct of the DOI theory is observability, or "the extent to which the innovation provides tangible results.[153]" The myriad of health benefits associated with identifying and treating MNDs is supported by a large body of empirical support. Moreover, the plethora of interventions to decrease MND incidence among the Ghanaian population that have already been implemented suggests this is a goal of the dietetics community in Ghana. Therefore, the Ghanaian dietetics community in Ghana is likely to see tangible results, in the form of improved clinical outcomes, when incorporating the NFPE into routine clinical practice.

Thurber and Fahey[154] conducted a study to investigate the efficacy of the DOI theory when encouraging consumption of a nutritious local plant to promote adequate nutrition status among malnourished individuals in low-resource areas of the world. The plant of interest in this study was Moringa oleifera, a plant which grew in the areas of interest, and was already being used by some local healers in the settings of interest (suggesting appropriate compatibility and complexity).[154] M. Oleifera is a good source of thiamine, riboflavin and niacin, which substantiates use and lends support to the DOI theory construct of relative advantage.[154] Strong anecdotal evidence in the cultures of interest supported the therapeutic properties of M. oleifera in the setting of malnutrition, which allowed individuals to "observe" intervention efficacy (observability).[154] Lastly, several individuals in the social systems of interest in this study had experimented with M. oleifera, supporting the DOI theory construct of trialability.[154] However, the investigators underscore the fact that a lack of empirical support of M. oleifera use for malnutrition compromised the trialability to a certain degree.[154] The cross-cultural success of the DOI theory in the study by Thurber and Fahey[154] suggests efficacy in other cross-cultural settings, such as a University of North Florida Doctor/University of Ghana collaboration.

Combining empirical support, a theoretical framework, and information regarding practical application has great capacity to enhance the efficacy of a nutrition-related intervention.[155] As outlined above, the empirical support for the positive outcomes associated with early identification and treatment of MNDs, and the efficacy of the NFPE in identifying MNDs in the absence of other methods of assessment is more than sufficient. Outlining this empirical support as part of a one-day workshop on routine incorporation of the NFPE into nutrition professionals' clinical practice has the potential to increase the efficacy of such an intervention. As aforementioned, practicing RDs identify several barriers to incorporating the

NFPE into practice; such barriers include a lack of training, limited time, and discomfort touching patients.[142] Designing a two-day virtual workshop which provides nutrition professionals with training on conducting the NFPE has the potential to lessen the severity of/remove these barriers for practicing nutrition professionals.

One of the facilitators to utilizing the NFPE reported by practicing RDs is having confidence to conduct the NFPE.[143] The DOI theory accounts for several reasons a workshop of this nature might be effective, but does not necessarily address RD confidence. The social cognitive theory (SCT) is among the most commonly used theoretical frameworks for medical education interventions.[156] The SCT has several constructs; the construct most relevant to nutrition professional confidence in conducting the NFPE is the construct of self-efficacy. The construct of self-efficacy suggests that an individual will more likely adopt a certain behavior if they feel confident in their ability to perform the behavior.[157]

Lu and Dollahite[158] conducted a large study to assess RD-perceived self-efficacy of their counseling abilities. When 612 RDs provided input in the form of a survey, 486 reported they counselled patients for more than 50% of their work week.[158] RDs who reported high levels of confidence in counseling patients also reported using this skill frequently.[158] The results of the data collected by Lu and Dollahite[158] suggest that RD self-confidence with a patient-related task positively correlates with frequent implementation of this task into practice. Chen and Allman-Farinelli[159] conducted a study published in 2019 to assess RDs' self-efficacy using a mobile health phone application to facilitate patient care. Chen and Allman-Farinelli[159] implemented an intervention that included a one-day workshop; this workshop included informational lectures and skill-building activities.[159] Skill building activities were designed to illustrate the practical application of the information presented in the lectures.[159] The intervention implemented by

Chen and Allman-Farinelli significantly improved RDs' self-efficacy towards using the health application of interest in this study.

Several theory-based considerations should be made when implementing a two-day virtual workshop for Ghanaian nutrition professionals on using the NFPE to detect MNDs. First, the workshop should accurately communicate the incidence of MNDs in Ghana, the severity of MND-related complications, and the efficacy of the NFPE in identifying MNDs. This information can be communicated via lectures. The workshop will be advertised by a leader in the Ghanaian dietetics community. Therefore, this information has the potential to illustrate the innovative nature of using the NFPE to identify MNDs to key members of the Ghanaian dietetics community. According to the DOI theory, if this practice is seen as innovative by key members of the Ghanaian dietetics community, it will more likely become a widely adopted practice.

Next, the workshop should consider Ghanaian nutrition professionals' self-efficacy in integrating a micronutrient-focused NFPE into routine clinical practice. Following the aforementioned lectures, focus groups will be conducted during which participants will have the opportunity to discuss barriers and facilitators to utilizing the MND-directed NFPE in their workplace. The focus groups may provide a more individualized platform on which to address concerns, and brainstorm solutions to these concerns with colleagues. The focus groups discussions have the potential to illustrate the practical application of the information provided. The methodical specifics of such a workshop will be discussed further in the next section. A conceptual model of the theoretical framework for the project is outlined in Figure 6.

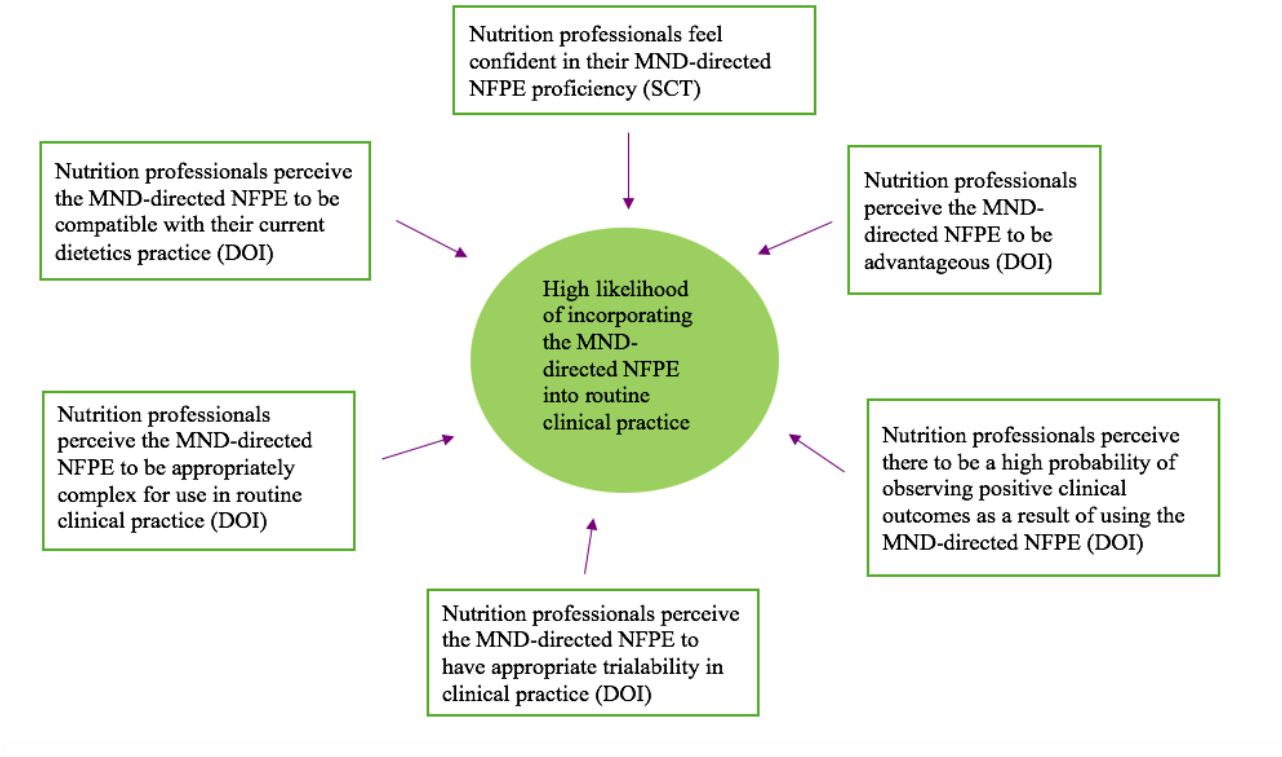

Figure 6. A Conceptual Model of the Theoretical Framework for the Present Study

Chapter III: Research Methods

Statement of the problem

MNDs are prevalent in Ghana, especially in rural areas where medical infrastructure is lacking. The high prevalence of MNDs in Ghana is having profound negative impacts on the health of the Ghanaian population. The NFPE may be an effective tool to help Ghanaian nutrition professionals identify and treat MNDs. However, nutrition professionals feel relatively unprepared to conduct the NFPE due to lack of training, and, consequently, a lack of confidence in conducting the NFPE. More effective MND identification has the potential to improve the quality of life of Ghanaian individuals with MNDs, and the burden of MND-related health problems on the Ghanaian medical system. Therefore, ensuring Ghanaian nutrition professionals feel adequately trained to conduct the NFPE could positively impact the health of the Ghanaian

population in a myriad of ways. As the NFPE does not require medical infrastructure or specialized medical equipment, nutrition professionals who work in the south of Ghana have the option to travel to the northern regions of Ghana, where MNDs are more prevalent, and conduct the NFPE. Training in the form of a two-day virtual workshop has the potential to improve nutrition professional confidence and proficiency when conducting the NFPE.

Research aims

The aims of this project were to significantly improve Ghanaian nutrition professionals' perceptions that using the MND-directed NFPE is an innovative strategy to assess patients/clients for MNDs, and to significantly improve nutrition professionals' feelings of self-efficacy in conducting the NFPE to identify MNDs. The means by which these aims were achieved included conducting a two-day virtual workshop for Ghanaian nutrition professionals, which provided information on the prevalence of MNDs (globally, and, in Ghana), physiological implications of MNDs common in Ghana, and on how to conduct the NFPE with an emphasis on MNDs. The workshop also provided time for small-group and large-group discussions about barriers and facilitators to using the NFPE in the workplace. In an effort to remove the risk of COVID-19 transmission associated with a large gathering, a physical workshop was not held. Therefore, each participant was encouraged to participate individually, and from a location deemed most safe and convenient for them.

Research questions

1. Will a two-day virtual workshop for Ghanaian nutrition professionals improve perceptions that using the micronutrient-directed NFPE is an innovative strategy (i.e. appropriately complex, trialable, advantageous, compatible, and yields positive observable outcomes) to assess patients/clients for MNDs?

2. Will a two-day virtual workshop for Ghanaian nutrition professionals significantly improve RDs' feelings of self-efficacy in regards to conducting the NFPE to identify MNDs?

Hypotheses

1. A two-day virtual workshop for Ghanaian nutrition professionals will significantly improve perceptions that using the micronutrient-focused NFPE is an innovative strategy to assess patients/clients for MNDs.
2. A two-day virtual workshop for Ghanaian nutrition professionals will significantly improve feelings of self-efficacy in conducting the NFPE to identify MNDs.

Study design

A mixed-methods study design was employed to test the aforementioned hypotheses and answer the aforementioned research questions. Both qualitative and quantitative methods were employed to assess nutrition professional perceptions of utilizing the NFPE to identify MNDs. Quantitative methods included use of a pre-test (immediately prior to the workshop) and a post-test (immediately following the workshop) for all workshop participants. Qualitative methods included conducting focus groups on the second day of the workshop.

Quantitative and qualitative research designs have complementary strengths.[160,161] One reason these two, distinct research designs complement each other, is that they are based on opposing assumptions.[160,161] For example, when using a qualitative research design, the investigator is the primary instrument for data collection and analyses, making both processes somewhat subjective.[160] In this way, qualitative research is highly inductive, allowing the investigator to make hypotheses and theoretical assumptions based on the data gathered.[160] Therefore, a strength of the qualitative study design is the ability to capture the context in which

the data is collected.[160] Key conceptual aspects for the present study may include how the MND-focused NFPE might fit into the current day-to-day work life of nutrition professionals; this information could represent how compatible, trialable, and complex integrating the new behavior might be, which represents three constructs of the DOI. In the same way, a limitation of the qualitative study design is that the data collected can be somewhat ambiguous, and is subject to the interpretation of the investigator.[160]

Strengths of the quantitative research design include the ability to objectively interpret data, making it quite complementary to the qualitative research design.[160] Moreover, standardized instruments are typically used in quantitative research. Therefore, both the data gathering and interpretation are more objective in quantitative studies than qualitative studies, which is why quantitative research is seen by some as more empirically sound.[160] While qualitative studies may yield results which help form hypotheses, quantitative studies may yield results which prove or disprove a hypotheses. [161] In the setting of assessing whether a two-day virtual workshop effectively improves nutrition professional perceptions that integrating a MND-focused NFPE into clinical practice is innovative, a quantitative research design has the potential to effectively determine exactly the degree to which perceptions on this topic changed after attending a workshop. Utilizing both of these research designs removes the limitations of each to a certain degree and has the potential to add depth and breadth to the study results.

Study participants

The workshop was open to all Ghanaian nutrition professionals. Strengthening clinical skills related to the NFPE focused on identification of MNDs might be especially relevant to Ghanaian nutrition professionals due to the well-established dietetics community in Ghana, and the relatively high prevalence of MNDs in Ghana. Dr. Freda Intiful, a University of Ghana

faculty member and member of the doctoral project committee for the present project was instrumental in the study design. Specifically, Dr. Intiful facilitated participant recruitment, provided extremely valuable insight on the wording of the data collection instruments, and clarified culturally-specific vernacular during interpretation of the qualitative results.

To ensure the workshop was maximally beneficial for the study participants, the principal investigator worked with Dr. Intiful to approve the workshop for continuing education credit. The Allied Health Professions Council, the credentialing agency for nutrition professionals in Ghana, awarded four continuing professional development credits to all workshop participants. Moreover, to ensure that live-streaming the five-hour virtual workshop would not financially strain the workshop participants, the investigators of the present study worked to secure funding through the University of North Florida for data cards that would cover the data costs associated with virtual workshop participation.

To recruit study participants, the target population was sent an email and a flyer by Dr. Intiful, who has access to a Listserv of Ghanaian nutrition professionals. The email read as follows:

> "Greetings,
> Please join the University of Ghana and the University of North Florida for a two-day zoom webinar on using the nutrition-focused physical exam to identify micronutrient deficiencies on January 21st and 22nd at 3pm GMT each day. Details are provided here: Webinar flyer
>
> After registering here: Webinar Informed Consent and Pretest, you will receive an email containing a zoom link for each day. Please note the registration deadline of January 8th. We look forward to seeing you at the webinar!
>
> **Follow this link to the Survey:**
> Take the Survey
> Or copy and paste the URL below into your internet browser:
> http://unf.co1.qualtrics.com/jfe/form/SV_0839fLjMmxpPvh3?Q_

DL=wtmLEU9bnu9lvHZ_0839fLjMmxpPvh3_MLRP_bvb3qVirZCTQ7Fr&Q_CHL=email
Follow the link to opt out of future emails:
Click here to unsubscribe"

The email contained a link to the webinar flyer (shown in Appendix A), and a link to register for the webinar. When clicking on this link, participants were directed to an informed consent document within Qualtrics software. Here, participants could choose whether or not to agree to the consent document prior to proceeding with registration. The informed consent document also provided information on the structure of the webinar, and informed the participants that the workshop would be recorded and would be made available in an asynchronous format after the webinar.

Upon registering for the webinar, participants were then directed to two questions about their data carrier, so the appropriate data card could be provided. Next, six demographic questions were asked, followed by the 18-question pretest. Each of the aforementioned questions were asked synchronously within Qualtrics software. Registered participants were sent two zoom links (one for each virtual workshop day). At this time, the participants were also emailed a data card to cover the cost of data usage for five hours of zoom meeting participation. The following email was sent to each study participant prior to the first day of the virtual workshop.

"Greetings everyone,
Thank you for your interest in the two-day zoom webinar on using the nutrition-focused physical exam to identify micronutrient deficiencies tomorrow and Friday at 3 pm GMT. The zoom link for tomorrow is listed below. Attached to this email are two articles that complement the material that will be covered in the webinar. We encourage you to review these articles in the next few days as a supplement to the webinar material.

If you have technical difficulties signing in tomorrow, please contact Dr. Andrea Arikawa or Dr. Lauri Wright.

Data Cards

When you registered, if you listed Vodafone, Tigo/Airtel, or GLO as your preferred network, you will receive a code for data from me within the next few hours. If you listed MTN as your preferred network, and have not yet sent me your telephone number, please do so to receive data.

We look forward to seeing you tomorrow!

Regards,
Leah Qubty, RDN, MS
Doctoral Candidate

Leah Qubty is inviting you to a scheduled Zoom meeting.

Topic: Webinar Day 1
Time: Jan 21, 2021 03:00 PM Greenwich Mean Time

Join Zoom Meeting
https://unf.zoom.us/j/92044124622"

The two articles[106,131] referenced in the aforementioned email were identified by the investigators as relevant, comprehensive review articles. The inclusion of supplemental reading materials was intended to bolster the educational capacity of the workshop as well as add variety to the teaching style. The first day of the webinar was conducted using the zoom meeting function. About 190 individuals participated in day one of the virtual workshop. Some individuals had an inconsistent internet connection, and some were unable to stay for the entire three hours due to other obligations. Therefore, participant numbers varied from about 180 to about 200 participants throughout the three hours.

The principal investigator presented one, one-hour lecture, and two, 45-minute lectures which were each followed by a 10-minute question and answer portion. The first lecture focused on MNDs. Specifically, topics included the physiological implications of MNDs, global MND incidence, Ghanaian MND incidence, current supplementation efforts, and Ghanaian food sources of key micronutrients. The focus of the second lecture was key micronutrients. Topics

included the physiological roles of iron, vitamins A, C, E, iodine, zinc, folate, and selenium, including an introduction to clinical signs of deficiencies of these micronutrients. The third lecture focused on the MND-directed NFPE. This lecture focused on best practices for conducting the NFPE to identify MNDs, and included pictorial representation of several MND presentations.

The virtual workshop started with an ice-breaker polling question to engage the audience and increase audience familiarity with the zoom meeting polling feature. Throughout the three lectures, polling questions were asked throughout to add an interactive component to the lectures. Five polling questions were asked in the first lecture, and three were asked in each of the two subsequent lectures. A majority of the workshop attendees participated in the polling questions. Between the two virtual workshop days, the following email was sent to all participants:

> "Greetings everyone,
> Thank you for your interest in the two-day zoom webinar on using the nutrition-focused physical exam to identify micronutrient deficiencies. Thank you for your participation today, and we look forward to seeing you tomorrow for day 2 of the webinar at 3 pm GMT. Please see the zoom link below. Attached to this email are two articles that complement the material we are covering in the webinar. I attached these articles to the email I sent out yesterday as well. We encourage you to review these articles in the next few days as a supplement to the webinar material.
>
> We look forward to seeing you tomorrow!
>
> Regards,
> Leah Qubty, RDN, MS
> Doctoral Candidate
>
> Leah Qubty is inviting you to a scheduled Zoom meeting.
>
> Topic: Webinar Day 2
> Time: Jan 22, 2021 03:00 PM Greenwich Mean Time

Join Zoom Meeting
https://unf.zoom.us/j/92336114035”

The second day of the virtual workshop took place using the zoom meeting function for a duration of two hours. About 170 individuals participated in day two of the webinar, however, some individuals had an inconsistent internet connection, and some were unable to stay for the entire two hours due to other obligations. Therefore, participant numbers varied from about 150 to about 180 participants throughout the two hours. Of note, zoom allows participants to decide whether to enable their video, and also allows participants to change their viewable name to the host and other participants; these options were outlined in the informed consent document, and some participants chose to maintain their anonymity throughout the study. The first day of the virtual workshop was recorded and was made available for participants not able to participate synchronously to participate asynchronously. The lectures presented during day one of the virtual workshop were uploaded to YouTube, and the YouTube link was sent to individuals who expressed interest in participating asynchronously. Eight individuals contacted the principal investigator for access to the YouTube links. The asynchronous registration process was identical to the synchronous registration process.

Quantitative Data Collection

Quantitative data was collected in the form of a pretest and posttest, developed by the principal investigator, with valuable input from the dissertation committee members. The test was comprised of 18 questions; three questions represented each of the six theoretical constructs used to inform the present study. Therefore, the pre/post-test was the instrument used to collect quantitative data. As aforementioned, the principal investigator developed the pre/post-test for this purpose, the reliability and validity of the instrument was not confirmed for this population.

As part of the pre/posttest development, a pilot test was conducted. The intention of the pilot test was three-fold. First, as the pre/posttest is an unvalidated tool, the pilot test was conducted in an effort to correct for errors associated with utilization of an unvalidated tool. The second intention of the pilot study was to determine if asking construct-specific questions together resulted in different results than asking construct-specific questions apart. The third intention was to determine average test scores, and determine an appropriate effect size to use when conducting the a priori power calculation. One of the committee members at the University of North Florida incorporated the pre/posttest into the coursework of one of their ongoing nutrition courses. Qualtrics software was used to administer the pilot test.

While 22 individuals completed the version of the test in which construct-specific questions were asked in sequence, 20 individuals completed the second version of the test in which construct-specific questions were asked out of sequence. Pilot test data was exported from Qualtrics to IBM SPSS statistics 26 software. Within SPSS, descriptive statistics were determined to assess for differences among responses to the two versions of the test. Subtle differences were noted among the descriptive statistics. Therefore, it was determined that the second version of the test would most effectively reduce errors associated with asking construct-specific questions in sequence. Based on the descriptive statistics, and pilot test participant report, questions appeared to be interpreted accurately, and without confusion. Lastly, based on mean test scores, an effect size of 25% was estimated to be appropriate for the a priori power calculation.

Each of the 18 knowledge-based test questions were answered on a five-point Likert scale. Therefore, the quantitative portion of the project elicited data measured at the interval level of measurement. Data is considered to be measured at the interval level of measurement due to

the fact that the data will have no true zero, the distance between categories is well-defined, and categories are mutually exclusive.[162] Due to the fact that the data was measured at the interval level of measurement, parametric assumptions were not violated and parametric statistical tests were to assess variable relationships.[162] Normal distribution was confirmed for each variable prior to analysis.

The inferential statistical test most appropriate for the present study is the dependent sample t-test. A dependent sample t-test is used when the subjects within the sample are the same, but are being measured or sampled more than once. [162] When using a dependent sample mean, the participants in one group (representing one comparative mean) are also the same participants in the other group (representing the other comparative mean).[162] Therefore, dependent t tests were used to assess the relationship between pretest and posttest answers.

An a priori power test was conducted to effectively diminish the chance of committing a type II error to 20%. To calculate the number of participants needed to conduct dependent t tests, a confidence interval of 95% and a corresponding z score of 1.96 was used, as well as an effect size of 25%. The a priori power test showed that a minimum of 128 nutrition professionals were needed.

The knowledge-based pretest and posttest questions were identical. The pretest questions aimed to collect informed consent, demographic information, and cellular data information were not present on the posttest. The pretest and posttest can be found in Appendix B and C, respectively. Moreover, the knowledge-based questions of the pre/posttest are outlined in Appendix D; Appendix D also outlines which theoretical construct informed each question.

As aforementioned, the pretest was provided for participants prior to the virtual workshop, and the posttest was sent to participants immediately after the workshop. The posttest

was sent with the information that the posttest would be available for one week. The following email was sent to participants immediately following the two-day workshop:

> "Greetings everyone,
> Thank you so much for taking the pretest, and for participating in the webinar. I feel honored to be part of this University of Ghana and University of North Florida collaboration. It was a joy to work with all of you.
> This webinar is part of my doctoral research project, and filling out this posttest will help me to complete my research. I would really appreciate it if you would follow the "take the survey" link below to take the brief posttest.
> The posttest will be available for 1 week. **The last day to complete the posttest is January 29th.** Thank you!
> Regards,
> Leah Qubty, RDN, MS
> Doctorate of Clinical Nutrition Candidate
> **Follow this link to the Survey:**
> Take the Survey"

Quantitative data analysis

The pretest had 211 responses, while the posttest had 149 responses. Pretest and posttest data were exported from Qualtrics to Excel in the "text" format. The columns containing the participant's email addresses (one column from the pretest data set and one column from the posttest data set) were then copied and pasted into a new excel file. These two, email address-containing columns were then alphabetized so they could be compared. Email addresses which did not have a pretest or posttest counterpart were excluded. Three email addresses appeared twice in the pretest column, meaning they were associated with two pretests. Two email addresses appeared twice in the posttest column, meaning they were associated with two posttests. One of the duplicate pre/posttests was associated with the same email address. In each of these scenarios, the participant did not complete the pretest or posttest on the first attempt. The participant then emailed the principal investigator for a new link to the pretest or posttest and

completed the test. Therefore, in these situations, the more complete of the two pretests or posttests, respectively, were included in the analysis while the less complete test was excluded.

After email addresses associated with both a matching pretest and posttest were identified, the data associated with these email addresses were moved to a new excel file. To do this, two new excel files were created: pretests with posttest counterparts and posttests with pretest counterparts. Using these two new excel files, the missing data was addressed. Among the pretest data, eight pretests were missing one question, and one pretest was missing two questions. As a reminder, the total number of questions in the pretest is 18. In these scenarios, the missing data was replaced with the corresponding posttest answer to neutralize the response. Ten pretests were omitted due to large amounts of missing data. The amount of missing data in each of the omitted pretests is further described in Table 1. For each omitted pretest, the corresponding posttest was also omitted. Among the posttest data, three posttests were missing one question. In these scenarios, the missing data was replaced with the corresponding pretest answer to neutralize the response. Five posttests were omitted due to large amounts of missing data. The amount of missing data in each of the omitted posttest is further described in Table 1. For each omitted posttest, the corresponding pretest was also omitted. The total number of complete pretests and posttests was 131. (Note, the power analysis indicated that 128 matching tests were needed to conduct dependent t tests). Figure 7 outlines the pretest and posttest omission process, and Table 1 outlines the number of missing questions in pretests and posttests omitted due to missing data.

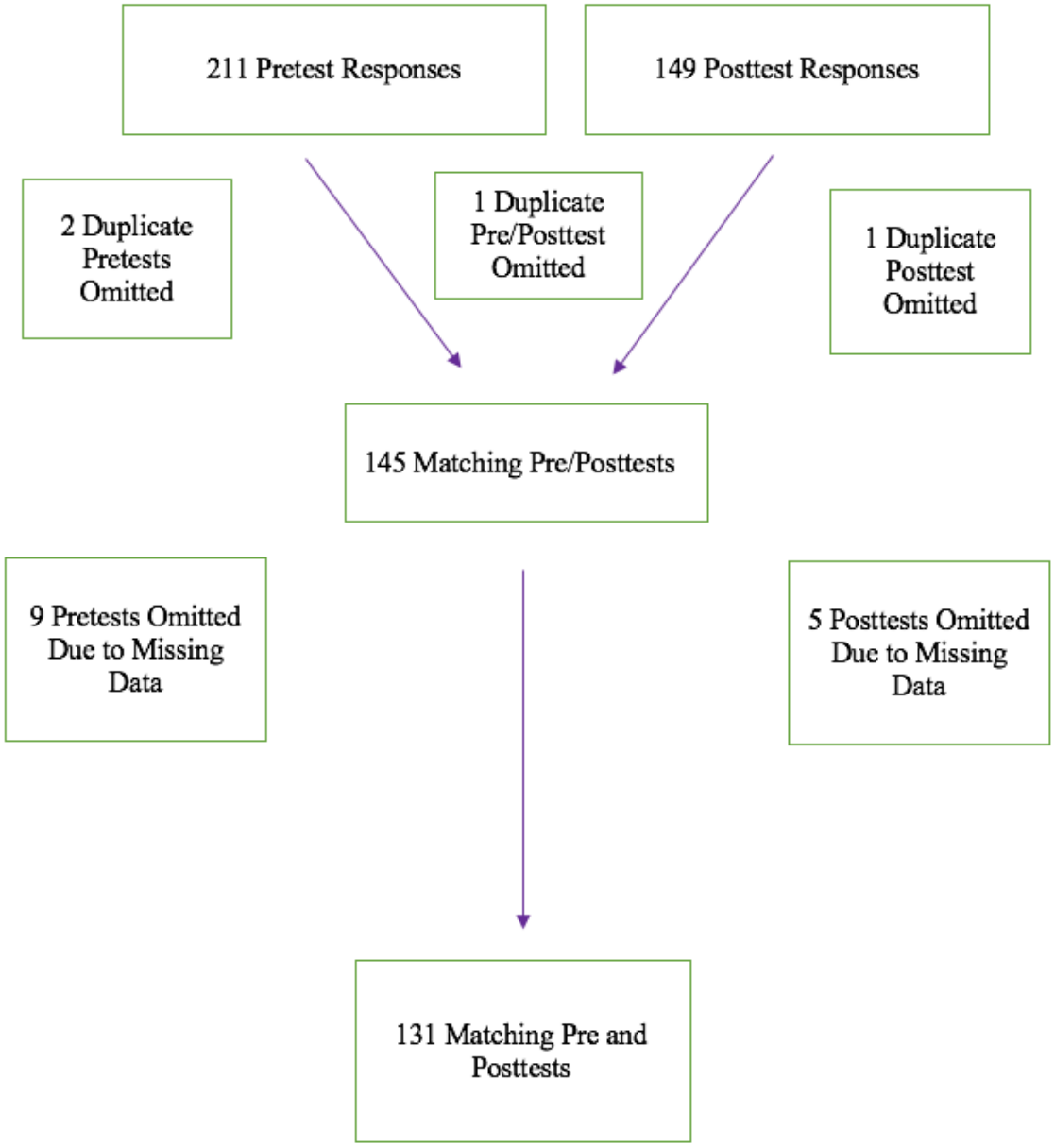

Figure 7. Pretest and Posttest Omission Process

Test Type	Pre	Pre	Pre	Pre	Pre	Pre	Pre	Pre	Pre	Post	Post	Post	Post	Post
Missing Questions	17	18	18	13	6	6	13	16	18	12	5	18	15	4

Table 1. Omitted Pre and Posttest Details

After missing data was addressed, demographic information about the study participants was quantified. The survey questions used to identify demographic information are pretest questions four through nine outlined in Appendix B. The principal investigator used Microsoft excel to quantify demographic information, and to create pie charts to communicate this data. Next, the complete pretest and posttest data was coded. To begin coding the data, two new excel files were created: coded pretest data, and coded posttest data. The same strategy was used to code both files and will be described here. To create the coded data file, the email address column and 18 pretest answer columns were copied and pasted into the coded test data file. Of note, these 18 questions correspond to the knowledge-based questions asked on the test. Questions eliciting demographic and informed consent information were excluded. As a reminder, the pretest and posttest were identical. The pretest and posttest contained five questions in need of coding due to the nature of the question asked. For example, among 13 of the 18 questions, a more positive answer (i.e. strongly agree) indicated a more positive response. For 5 of the 18 questions, a more positive answer indicated a more negative response. Therefore, for these 5 columns of data, the answers were reversed. More specifically, the response of "strongly agree" was changed to "strongly disagree" and vice versa, "agree" was changed to "disagree" and vice versa. No change was made to the "neutral" response. After the questions were coded, the textual data was changed to numerical data. More specifically, "strongly agree" was given a score of "5", "agree" was given a score of "4", "neutral" was given a score of "3", "disagree" was given a score of "2", and "strongly disagree" was given a score of "1."

After the data was coded and changed to numeric form, total sums were calculated for each test. The coded pretest data and the coded posttest data continued to be in two separate

Microsoft excel files, and the summation and organization methods employed were the same for each file. These methods will be further described here. First, an additional column was added to indicate the total score for each test. Each test was represented by one Microsoft excel row. The "autosum" feature in Microsoft excel was used to calculate a total test score for each row. The "autosum" result was listed in the new "total sum" column.

The data was then organized by the theoretical construct used to inform each test question. Six theoretical constructs were used to inform the test questions and three questions were informed by each construct for a total of 18 test questions. A new row was added to the top of the Microsoft excel file to label each question. Each question was represented by a column. Questions were labeled "obs 1," "obs 2," and "obs 3" to indicate the three questions informed by the "observability" theoretical construct. The labels "compat 1," "compat 2," and "compat 3," were used to indicate the three questions informed by compatibility theoretical construct. The labels "complex 1," "complex 2," and "complex 3" were used to indicate the three questions informed by the complexity construct. The labels "trial 1," "trial 2" and "trial 3" were used to indicate the three questions informed by the trialability construct. The labels "self 1," self 2" and "self 3" were used to indicate the three questions informed by the self-efficacy theoretical construct. The labels "relad 1," "relad 2" and "relad 3" were used to indicate the questions informed by the relative advantage theoretical construct.

Columns were then rearranged so each set of three columns representing each theoretical construct were next to each other. Six new columns were then created to represent the total score of each group of three questions: "obs total," "compat total," "complex total," "self total," and "relad total." The total score for each three-question set was then calculated. Using IBM SPSS statistics 26 software, one dependent t-test was used to examine the difference the total score of

the pretest to the total score of the posttest. Next, the total scores for each construct-specific, three-question set were compared. One dependent t-test was used to compare pretest and posttest answers for the three-question set representing each theoretical construct used to inform the present study.

Qualitative Data Collection

Qualitative data was collected via focus groups on the second day of the virtual workshop. According to Rosenthal,[163] focus groups can provide valuable information about the participants' "experiences and perceptions." To determine the ideal number of study participants in qualitative research, data saturation is determined.[164] Data saturation refers to the sample size at which qualitative data begins to repeat itself.[164] Sample size estimation to achieve data saturation when conducting qualitative research is a subjective process, and one that varies based on the characteristics and confines of each individual study.[165] The number of study participants in qualitative research is generally between 5 and 50.[166] Studies that use more than one method of data collection are thought to require fewer study participants.[166] It is estimated that roughly 100 participants actively participated in the focus groups, so data saturation in the present study is highly likely. Focus group participant participation will be further described below.

The principal investigator recruited focus group leaders to lead each group. Focus group leaders included two investigators of the present study who are Registered Dietitians and have terminal degrees in the field of nutrition and dietetics, practicing Registered Dietitians, Doctorate of Clinical Nutrition students, and dietetic interns training to become Registered Dietitians. All 13 focus group leaders were currently practicing, teaching, or training in the United States. The principal investigator conducted a training for all focus group leaders. The one-hour training occurred over zoom. Prior to the training, the principal investigator provided the focus group

leaders with the focus group guide, which can be found in Appendix D. During the training, the principal investigator explained the background of the study and the research questions. Next, the focus group guide was reviewed, including the intention of each question, and focus group leader questions were addressed. The zoom meeting was recorded, and the recording was sent to the focus group leaders who could not attend the training synchronously.

The focus group guide was developed by the principal investigator with valuable input from the dissertation committee members. The goal of the focus group guide was to aid the focus group leaders in promoting constructive conversation within the focus group. Moreover, the focus group guide aimed to elicit responses from participants about barriers and facilitators to using the MND-directed NFPE in clinical practice. Open-ended questions are an important aspect of focus groups, as they allow participants to provide a response unique to their own experience.[163] Open-ended questions were therefore used to elicit genuine responses from focus group participants. Focus group questions should also hone in on one concept each.[163] By narrowing the focus of the question to one topic, the focus group leader helps avoid confusion among focus group participants.[163] Therefore, each focus group guide question focused on one topic only.

The second day of the workshop consisted of a two-hour zoom meeting. About 170 individuals participated in day two of the webinar, however, some individuals had an inconsistent internet connection, and some were unable to stay for the entire two hours due to other obligations. Therefore, participant numbers varied from about 150 to about 180 participants throughout the two hours. At the beginning of the zoom meeting, an introduction was given regarding the structure of the zoom meeting. This introduction included an explanation that individuals would be divided into breakout rooms, each breakout room would be led by a focus

group leader who had undergone a training with the principal investigator, and also included a time outline for the various zoom meeting components.

As there were 13 focus group leaders, study participants were divided into 13 breakout rooms within the zoom meeting. Each focus group contained 10-15 participants. Based on feedback from the focus group leaders, many individuals were not able to actively participate in the discussion due to being in public or work settings at the time. Focus group leaders also reported that some participants within the breakout rooms chose to maintain their anonymity and therefore were passively involved in the group. Therefore, actively participating member numbers were less than 10-15 in most groups.

The focus groups were 45 minutes in duration. Each focus group was encouraged to select a spokesperson during the breakout session that would provide a summary of the focus group discussion after the breakout session was complete. During the time in the breakout rooms, the focus group engaged in a discussion on the application of the information provided during the first day of the workshop. Specifically, the discussion focused on barriers and facilitators to using the MND-directed NFPE to identify micronutrient deficiencies in the workplace. After the 45-minute breakout sessions were complete, the entire group engaged in discussion. Each focus group spokesperson provided about a five-minute summary about their focus group discussion for the large group.

Qualitative Data Analysis

Two of the investigators recorded their individual focus group discussions, and the large group discussion was also recorded. Based on the recordings, the principal investigator created three transcripts: one for each individual focus group discussion and one for the large group discussion. AlSense Otter.ai version 2.1.65 transcription software was initially used to transcribe

the recordings; however, the resulting transcript contained a myriad of errors. The large amount of errors may have been related to large amounts of background noise during the discussion, and a wide variety of accents represented within the discussions. Due to these variables, the principal investigator largely transcribed the focus group recordings. AlSense Otter.ai version 2.1.65 transcription software was used during few, select sections of the transcription that appeared to have fewer extraneous variables impacting the software efficacy. The principal investigator reviewed these sections thoroughly and corrected any errors.

Once the transcripts were developed, the principal investigator identified themes throughout the transcripts. Based on these themes, codes were developed. Codes were then organized into a codebook. The codebook can be found in Appendix F. A total of 14 codes were developed. Of these codes, 11 were deemed to be deductive codes (prompted by the interviewer) and three were deemed inductive (broached independent by a study participant). Six codes were directly related to the theoretical constructs used to inform the study as a whole, and the focus group guide. The remaining eight codes, although not directly reflective of these theoretical constructs, all provided insightful information related to the theoretical constructs.

After the codebook was developed, the principal investigator coded each transcript. As coding qualitative data is a subjective process,[167] the principal investigator analyzed the qualitative data before analyzing the quantitative data in an effort to avoid bias associated with knowledge of the quantitative results. To further acknowledge and account for the subjective nature of the coding process, a second coder was included. Collaboration with a second coder is thought to enhance the reliability of the process.[167] By incorporating the input of a second coder, the process becomes more systematic and transparent.[167]

The principal investigator reached out to a Post Doctorate Fellow and recent Doctorate of Clinical Nutrition graduate at the University of North Florida to assist as a second coder. The principal investigator provided the second coder with the transcripts and the codebook, and the second coder coded the transcripts independently. The two, independently coded transcript sets were coded much the same way. However, some discrepancies did exist. To reconcile these discrepancies, the principal investigator and second coder discussed all discrepancies in a zoom meeting. For each discrepancy, the principal investigator and second coder provided a rationale for the coding, and the two parties decided on how to code the data together.

Limitations associated with the qualitative and quantitative data collection methods and instruments reflect the strengths and weaknesses of quantitative versus qualitative study designs. While the pre/post-test might fail to capture key contextual cues, the focus groups have great potential to capture these nuances. Moreover, while the test may fail to show relevant work-culture nuances, it has the potential to objectively assess the efficacy of the workshop, where the focus groups only have the potential to subjectively inform in this way.

Chapter IV: Results

In response to the question: “Are you a Registered Dietitian?” 85, or 64.9% of study participants responded “yes.” In response to the question: “Are you a Registered Nutritionist?” 34, or 26.0% of participants responded “yes.” One participant (0.9%) omitted the answer to this question after responding “no” to the question about being a Registered Dietitian. Seven study participants (5.3%) responded “yes” to both “Are you a Registered Dietitian?” and “Are you a Registered Nutritionist?” 18 study participants (13.7%) responded “no” to both “Are you a Registered Dietitian?” and “Are you a Registered Nutritionist?” Of these 18 participants, eight (6.1%) reported having a graduate degree and 10 (7.6%) reported having an undergraduate degree. This information is further described in Figure 8.

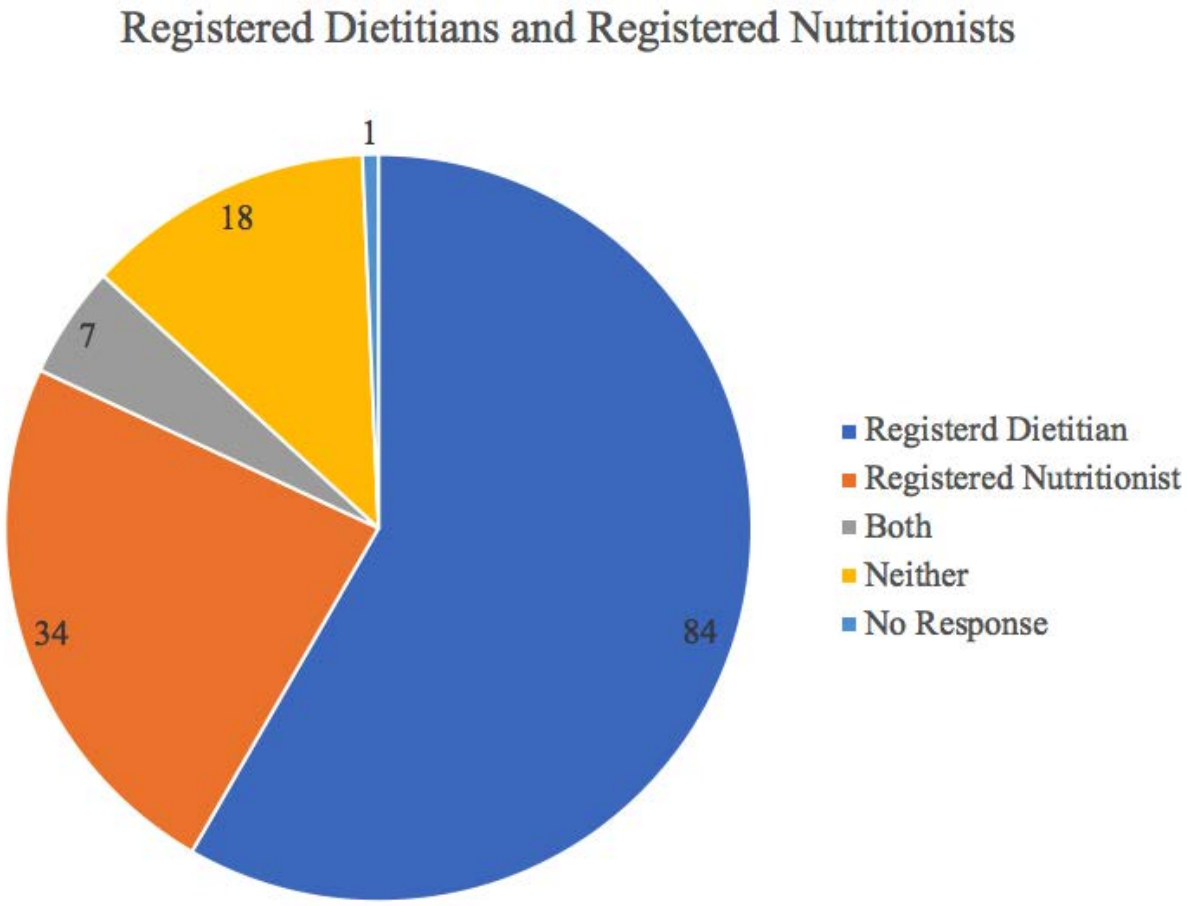

Figure 8. Study Participant Demographics

The next demographic question inquired about years of experience. The question is as follows: "If you answered yes to the previous question, how many years have you been practicing as a Registered Dietitian?" Of the 85 participants who responded "yes" to the first question, one (0.9%) indicated they were a dietetic intern, and was therefore not yet technically a Registered Dietitian, and one (0.9%) did not answer the second question. Therefore, the total number of responses to the second question was 83. Of these 83 responses, one (0.9%) reported working less than 1 year, 47 participants (35.8%) reported working 0-3 years, 18 participants

(13.7%) reported working 4-6 years, 14 individuals (10.7%) reported working 7-9 years and 4 participants (3.1%) reported working 10 years or more. This information is further described in Figure 9 below.

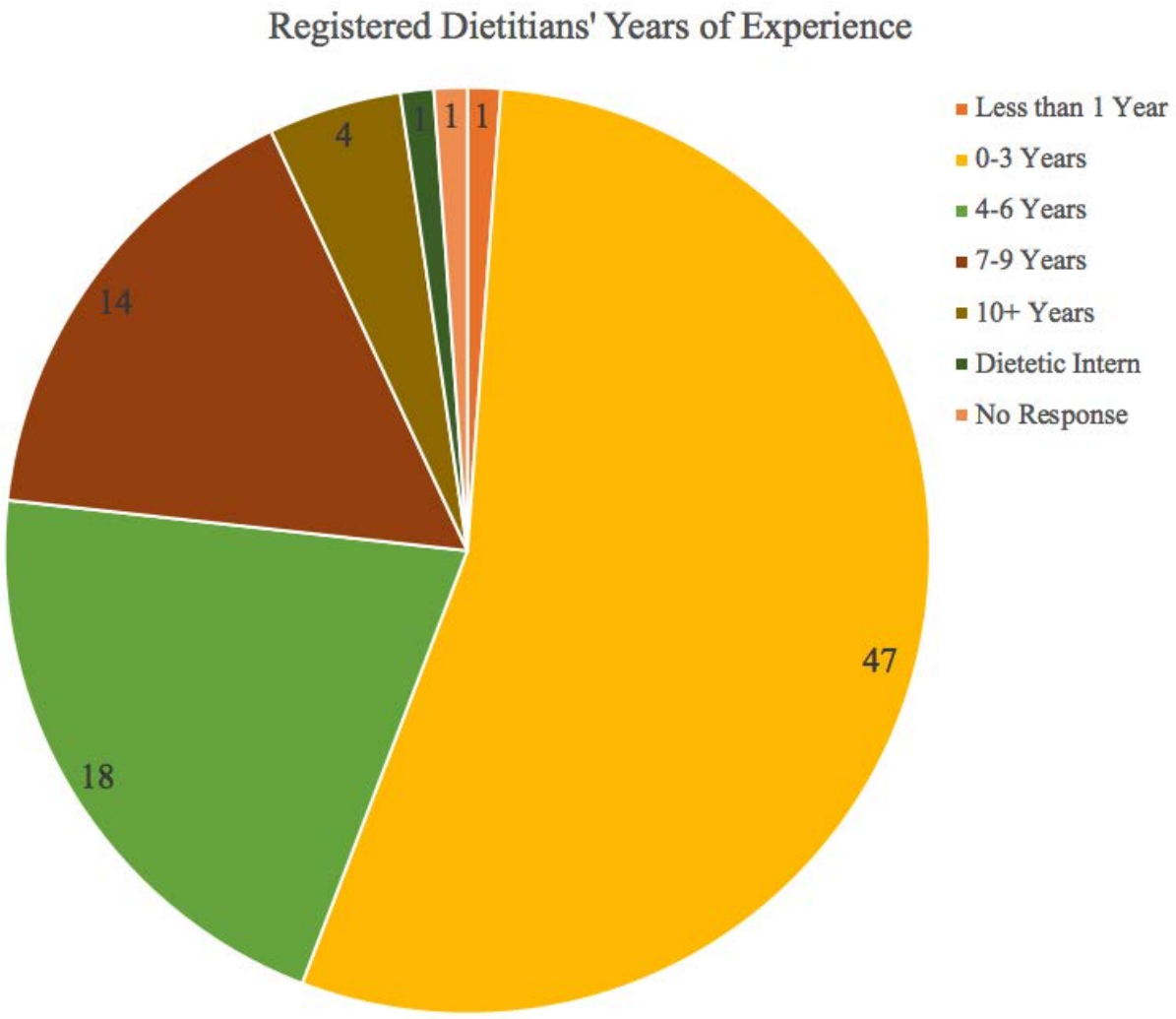

Figure 9. Registered Dietitians' Years of Experience

The next demographic question is as follows: "If you answered yes to the previous question, how many years have you been practicing as a Registered Nutritionist?" Of the 34 participants (26%) who responded "yes" to the first question, two (1.5%) did not answer the second question. Therefore, the total number of responses to the second question was 32. Of

these 32 responses, one (0.9%) reported working less than 1 year, 12 participants (9.2%) reported working 0-3 years, 6 participants (4.6%) reported working 4-6 years, 4 individuals (3.1%) reported working 7-9 years and 9 participants (6.9%) reported working 10 years or more. This information is further described in Figure 10 below.

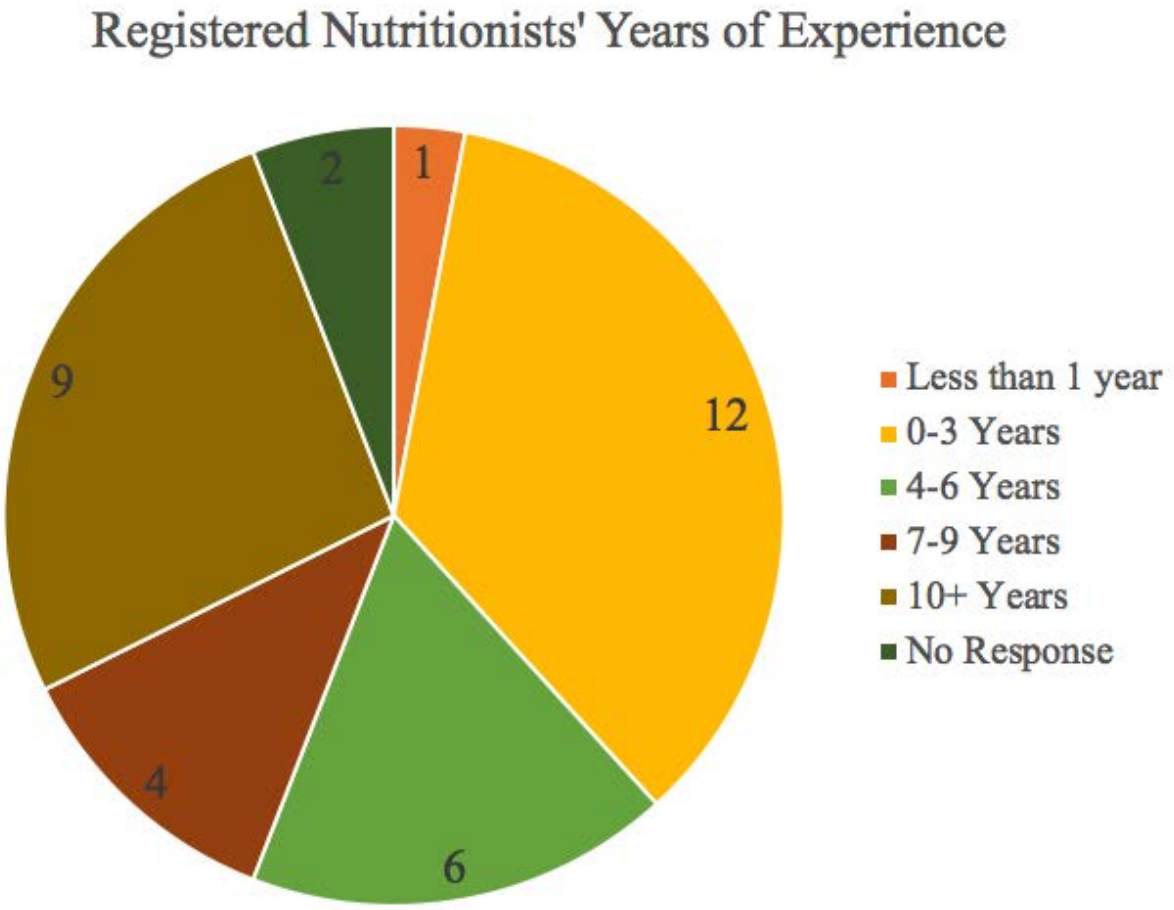

Figure 10. Registered Nutritionists' Years of Experience

The next demographic inquired about level of education, and was as follows: "What is your highest level of dietetic/nutrition education: Undergraduate, or Postgraduate?" Every study participant responded to this question. Fifty-five individuals (42%) responded that they had a

postgraduate education, and 76 individuals (58%) reported that they had an undergraduate education. This information is further depicted in Figure 11 below.

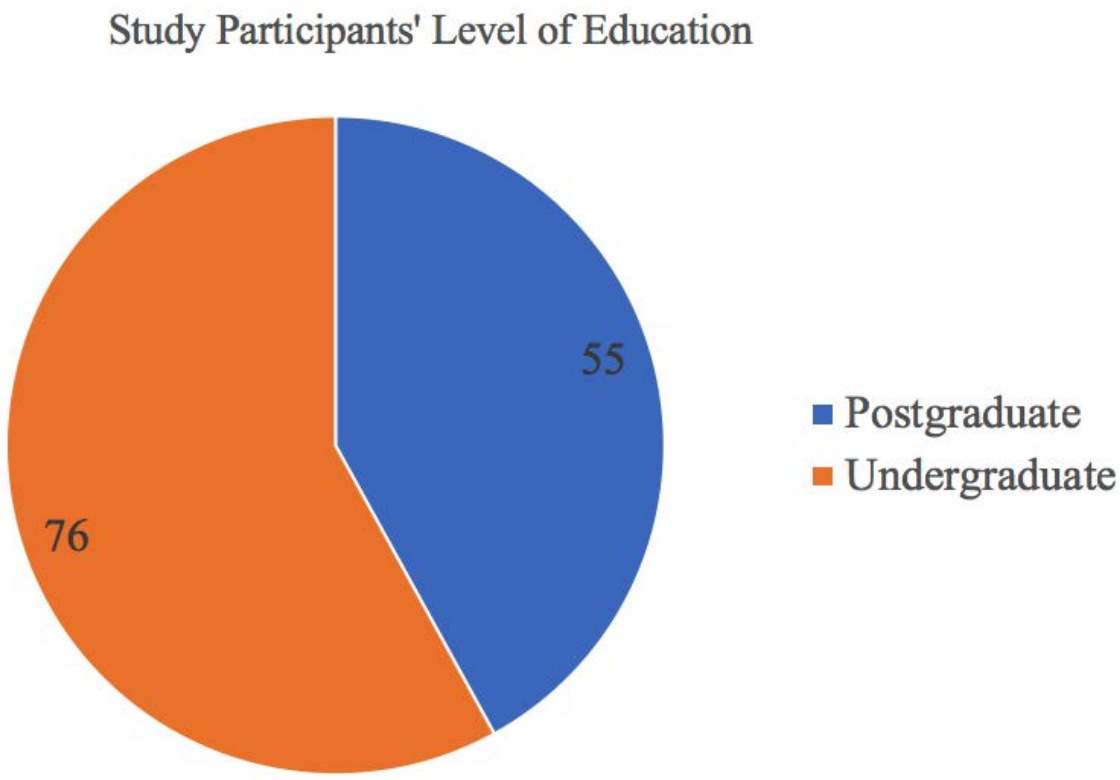

Figure 11. Study Participants' Level of Education

The next demographic question was "Which term best describes your place of practice: private, public/government, or freelance?" Four study participants (3.1%) did not respond to this question, 21 (16.0%) responded "private," 83 participants (63.4%) responded "public/government," and 23 participants (17.6%) responded "freelance." This information is further described in Figure 12 below.

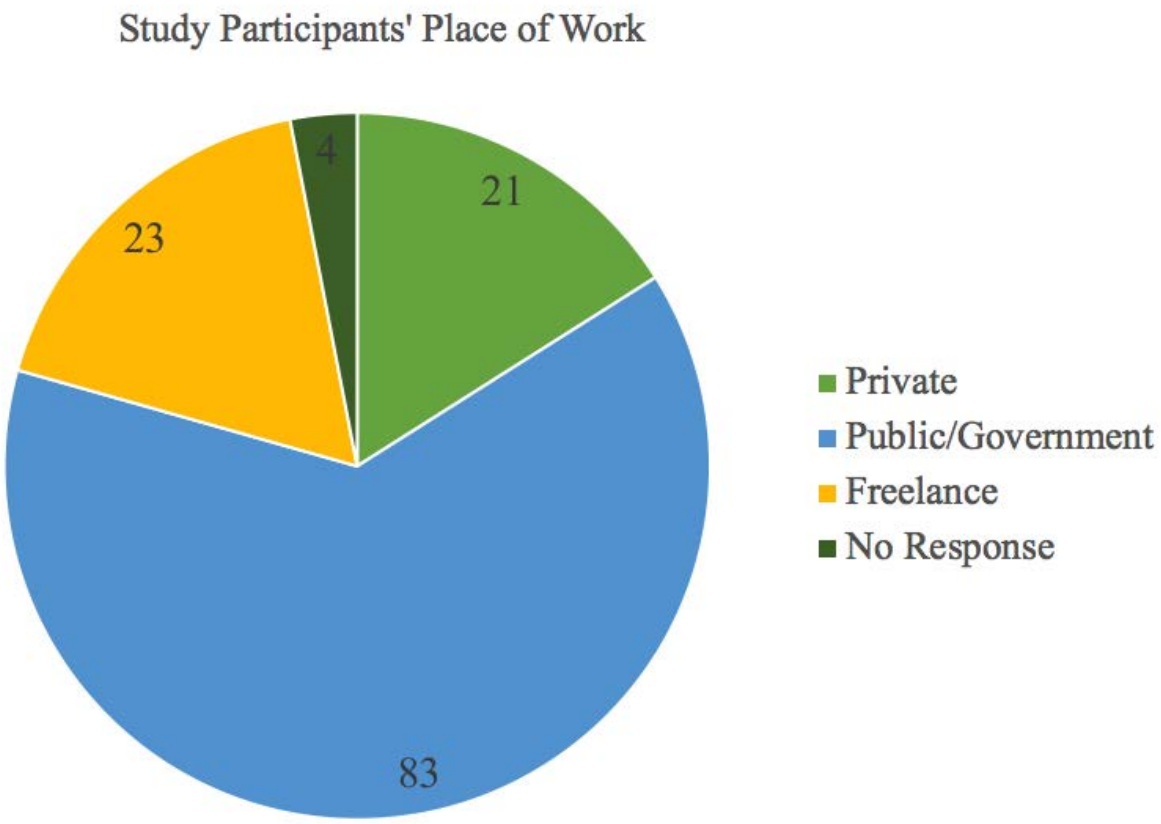

Figure 12. Study Participants' Place of Work

A summary of the demographic information can be found in Table 2 below.

Demographic Question	Frequency (%) *n* = 131
Are you a Registered Dietitian? ◯ Yes ◯ No	Yes: 85 (64.9%) No: 18 (13.7%) No response: 1 (0.9%)
If you answered yes to the previous question, how many years have you been practicing as a Registered Dietitian? _____	Less than 1 year: 1 (0.9%) 0-3 years: 47 (35.8%) 4-6 years: 18 (13.7%) 7-9 years: 14 10.7%) 10+ years: 4 (3.1%) Dietetic intern: 1 (0.9%) No response: 1 (0.9%)
Are you a Registered Nutritionist?	Yes: 34 (26.0%) No: 18 (13.7%)

Demographic Question	Frequency (%) *n* = 131
◯ Yes ◯ No	
If you answered yes to the previous question, how many years have you been practicing as a Registered Nutritionist? _____	Less than 1 year: 1 (0.9%) 0-3 years: 12 (9.2%) 4-6 years: 6 (4.6%) 7-9 years: 4 (3.1%) 10+ years: 9 (6.9%) No response: 2 (1.5%)
What is your highest level of nutrition education: ◯ Undergraduate (BsC) ◯ Postgraduate (MSc/MPhil/PhD)	Undergraduate: 76 (58.0%) Postgraduate: 55 (42.0%)
Which term best describes your place of practice: ◯ Private ◯ Public/Government ◯ Freelance	Private: 21 (16.0%) Public/Government: 83 (63.4%) Freelance: 23 (17.6%) No response: 4 (3.1%)

Table 2. Demographic Information Summary

Inferential Statistics and Corresponding Qualitative Data

Total posttest scores were significantly higher (M=70.15, SE= .703), $t(130)$= -7.357, p= <.001 than total pretest scores (M= 64.85, SE= .165), $t(130)$= -7.357, p= <.001. This quantitative data correlates with the qualitative data analyzed in several ways. “Cultural leader influence” and “dietetic leader influence” were two inductive codes identified in the qualitative data. The “Cultural leader influence” code was identified twice in the data. Study participants discussed that physical exams are, in some ways, part of the Ghanaian culture. One study participant elaborated on this cultural component, stating:

> “So my group, we had a very nice discussion about the use of the NFPE in determining micronutrient deficiencies. And we realized that it’s been used. In our setting, mostly our grandmothers—when a lady is pregnant—they will look around the eyes and the eyelids in order to check if she’s pregnant. The main use is in order to detect pregnancy—that’s according to our grandmothers. But mostly

> that shows if the lady is pregnant or not. So, in a way, it's being used by our grandmothers and other people."

In addition to cultural leaders, leaders of the dietetics community are also influential figures for Ghanaian nutrition professionals, according to the qualitative data. On 23 occasions, study participants discussed how dietetic leaders shape their dietetics practice. One participant, when referring to using the NFPE to identify micronutrient deficiencies, stated: "there could be a call to make that part of the standard of care." Incorporating a "standard of care" component to using the NFPE in clinical practice was brought up on three separate occasions by three study participants.

When discussing facilitators to incorporating the MND-directed NFPE into clinical practice, additional MND-directed NFPE training within the didactic curriculum was emphasized. Specifically, participants mentioned it may be especially instructive for preceptors to showcase use of the MND-directed NFPE within clinical rotations for dietetics students. The discussion around facilitating the use of the exam in clinical practices circled closely around practical application. In fact, the word "practical" was used six times in the text that fell into the "dietetic leader influence" code. Additional continuing education opportunities were also cited as opportunities to bolster use of the exam among Ghanaian nutrition professionals. One study participant spoke to the impact clinical preceptors have on students adopting this practice, stating:

> "I think that having more opportunities like this to, not just refresh on the theory but also talk about the need for more practical application is helpful. I think most certainly they do work hand in hand in hand, especially for those who have already gone through the training like we can't really go back too much, we can only rely on continuously getting educated, and if we find ourselves in maybe preceptor roles, or you know whatever roles in which we are mentoring others we can also draw younger people's attention—and I'm using younger just like people younger to the field, not necessarily younger than us—to draw their attention to the fact that they can use this assessment methods in their practice, I think."

Another code noted in the qualitative data analysis was "knowledge." "Knowledge" was deemed a deductive code, due to the fact that the focus group leader broached the topic. Throughout the qualitative transcripts, the topic of knowledge associated with conducting the MND-directed NFPE was addressed 18 times, all in a positive manner. Of note, total focus group recordings totaled about three hours in duration. One study participant mentioned "we have learned a lot and we are grateful to you" while another stated "even if it was something you were using and you were not using it so much now, we now have more things to look out for. And then for those in academia, some shared that it's also given them the opportunity to refresh what they know."

Posttest scores for questions pertaining to the observability construct were significantly higher (M=13.47, SE=.165), $t(130)$= -3.423, p= <.001 than pretest questions pertaining to the observability construct (M=12.77, SE= .155), $t(130)$= -3.423, p= <.001. The "observability" code identified in the qualitative data reflects the results of this inferential statistical result. "Observability" was considered a deductive code. Study participants eluded to the fact that using the MND-directed physical exam would likely yield observable, and desirable, patient outcomes on 21 occasions. One such statement is as follows:

> "And then the NFPEs are very important to our practice because it makes us more proactive, in the sense that we are able to identify certain things and quickly put an intervention which will probably have delayed hospital stay, would have increased hospital health care cost, and then also we get to tackle the root cause of the problem, like some of the skin conditions where a lot of the people go to the dermatologist and then they just solve the rash or whatever presentation they see on the skin. Meanwhile the root cause of the problem hasn't been tackled."

Often, when "observability" was addressed, it was in the context of a larger discussion about the incidence of micronutrient deficiencies in the participants' workplace. "Micronutrient

deficiencies" was another deductive code identified in the qualitative data. Within about three hours of focus group recordings, micronutrient deficiencies were discussed on 22 occasions. Of note, the mention of a specific micronutrient deficiency was recorded separately from mentions that using the MND-directed NPFE would yield observable results in the clinical setting. Iron was the most commonly-addressed micronutrient deficiency. Iron deficiency specifically was discussed on 15 occasions. This may be especially noteworthy, as the focus group leaders did not inquire about iron specifically. One participant mentioned "I think the most of the micronutrient deficiencies will be iron." Certain medical conditions were discussed in the context of iron deficiency including burns and pregnancy.

Other vitamin deficiencies that were brought up by the study participants as commonly-encountered issues in the clinical setting were vitamin A, iodine, B vitamins, magnesium, vitamin D, phosphorus, and vitamin C. Vitamin A, iodine, and B vitamins were addressed twice, while the other aforementioned micronutrients were only addressed once. One study participant stated "vitamin A deficiency, if I recall, was also a problem." Iodine deficiency was discussed in terms of decreasing prevalence, but still notable. One example of iodine deficiency discussion is as follows: "the common one is iron deficiency. That is the most common MND in our country. But sometimes we will have goiter. It is a little common. I think, for some time now, it is reduced." Focus group leaders did not mention the names of any specific micronutrients. Therefore, the micronutrients addressed by the study participants may be especially significant.

Posttest scores for questions pertaining to the compatibility construct were not significantly different (M= 10.86, SE= .201), $t(130)= -2.246$, $p= <.026$ than pretest scores for questions pertaining to the compatibility construct ($M= 10.38$, $SE= .171$) $t(130)= -2.246$, $p= <.026$. Qualitative data pertaining to the deductive "compatibility" code were varied. For

example, while one participant mentioned “I think it could be very feasible in my workplace” another mentioned “Some of the barriers we heard were time constraints—too many patients.” Overall, whether the MND-directed NFPE was compatible in the workplace was addressed on 27 occasions.

Of these 27 occasions, in three situations, participants were encouraged about incorporating the exam into their practice, one comment was neutral, and 23 occurred in the context of barriers to conducting the exam. Of those who were encouraged about incorporating the exam into practice, one mentioned that organization and time management were important considerations, and one mentioned that it may be especially feasible to incorporate in the pediatric setting. The remaining 23 instances could be described as the study participant explaining ways in which conducting the MND-directed NFPE may not be compatible with their workplace.

Study participants mentioned several specific barriers to conducting the MND-directed NFPE in the context of whether this practice was compatible with their work life. Barriers mentioned were inadequate lighting to physically assess the patient, communication issues among the health care team, and a lack of awareness about the MND-directed NFPE. Time was mentioned as a barrier on four separate occasions, and macronutrient deficiencies being prioritized over micronutrient deficiencies was mentioned twice. Moreover, other medical conditions being prioritized over micronutrient deficiencies was mentioned on three occasions. Twice it was mentioned that conducting the MND-directed NFPE is not currently considered the standard of care, and lack of motivation was also cited as a reason why this practice is not more widely incorporated. Lastly, one participant stated a lack of space to conduct the exam was a barrier, and insufficient privacy was mentioned as a barrier on five separate occasions.

"Religious or cultural barriers" was identified as an inductive code in the qualitative data. Religious or cultural barriers were cited on four occasions in the context of being barriers to conducting the MND-directed NFPE. For example, one participant mentioned: "He couldn't even touch some of his clients, due to religious reasons because they came in gowned from head to toe, you can't even see the skin." "COVID-19" was also a code established in the qualitative data that spoke to barriers. COVID-19, a deductive code, was addressed on six occasions. Specifically, a desire to socially distance from the patient and a lack of personal protective equipment were listed as reasons COVID-19 infection among patients was a barrier to nutrition professionals conducting the MND-directed NFPE. One study participant stated:

> "Then we were able to identify the barriers that will cause a challenge in using the tool. One was mainly the COVID era, when there's social distancing and staying away from people by direct contact. We're going to have a challenge, because we need to, at one point actually touch your patient so how are we going to factor that in."

Posttest scores for questions pertaining to the complexity construct were significantly higher (M= 9.99, SE= .202), $t(130) = -5.174$, p= <.001 than pretest scores for questions pertaining to the complexity construct (M= 8.88, SE= .173), $t(130) = -5.174$, p= <.001. Several participants referred to how complex they perceived the MND-directed NFPE to be. "Complexity" was identified as a deductive code, and was identified in the qualitative data on 28 occasions. The complexity of the MND-directed NFPE appeared to be the most-discussed topic. One theme identified within the "complexity" code was the fact that utilizing the MND-directed NFPE was somewhat outside of the participants' comfort zone. Participants also mentioned that certain aspects of the MND-directed NFPE were intimidating. Approaching the patient, touching the patient, and being comfortable recognizing the myriad of signs and symptoms of MNDs were all cited as reasons for this discomfort. For example, one participant stated:

> "The NFPEs can be very subjective in determining deficiencies. Can be very subjective, can be very tricky. Depending on your expertise and your experience it's going to be a little tricky. So we also want to use other tests to confirm our findings."

When discussing the complexity of this exam, participants mentioned that further education about the exam and quickly accessible reference materials may make the exam seem less complex.

Posttest scores for questions pertaining to the self-efficacy construct were significantly higher (M= 11.51, SE= .156), t(130)= -7.781, p= <.001 than pretest scores for questions pertaining to the self-efficacy construct (M= 9.96, SE= .195), t(130)= -7.781, p= <.001. Within the qualitative data, "self-efficacy" was identified as a deductive code. Feelings of self-efficacy were discussed among participants on 17 occasions. The overarching message from participants closely mirrors the quantitative results. One participant mentioned that "this webinar will help embolden me to look out for MNDs anytime I assess a patient." Another participant summarized a focus group discussion, and provided some insight on enhanced confidence levels among study participants in the following statement:

> "And then we also talked about the impact of the webinar on our practice. And we said it had a very positive impact, it had boosted our confidence, which used to be a limitation, but as we keep hitting on it and visiting it, it is encouraging us to use it more, and it has also encouraged us to go beyond what – what I would say our comfort zone—the biomedical findings—to include the nutrition-focused physical examination in our assessment—as part of our assessment"

In all 17 instances that participants mentioned feelings of self-efficacy, participants discussed enhanced feelings of self-efficacy after attending the virtual workshop.

Posttest scores for questions pertaining to the trialability construct were not significantly different (M= 11.05, SE= .192), t(130)= -1.269, p=.207 than pretest scores for questions

pertaining to the trialability construct (M= 10.83, SE= .159) $t(130)$= -1.269, p=.207. "Trialability" was identified as a deductive code in the qualitative data. The topic of whether participants felt the MND-directed NPFE was a trailable clinical skill was mentioned 25 times. Study participants largely reported they felt as though the MND-directed NFPE had high trialability in their workplace. Therefore, the qualitative data does not appear to directly reflect the qualitative results in the realm of trialability. This may be due to the fact that many participants also reported that they currently use the MND-directed NFPE in their practice. Participants that incorporated this exam into their practice prior to the virtual workshop likely would not have different pretest and posttest scores on questions pertaining to trialability.

One study participant summarized a focus group discussion, saying "what we heard is that there are a lot of clinicians using NFPE- almost using it as a screen- that clinical assessment as a screen" while another summarized "are we using it already? Yes, to a lesser extent, because it's not a conscious effort. We do look out for micronutrient deficiencies but we need to do more work in using it as we should." Therefore, it seems as though some participants already utilize the MND-directed NFPE to a certain extent. Participants also report a desire to incorporate this exam more comprehensively into their practice.

Use of the MND-directed NFPE in the community setting was often discussed alongside the trialability of this exam. "Community application" was deemed a deductive code in the qualitative data. Application of the MND-directed NFPE in the community setting was broached on 8 occasions by study participants. The rationale provided by participants for why the exam may be especially useful in the communities was that in more rural settings, MNDs may be more common, and that medical infrastructure may be lacking. For example, one participant stated

> "Maybe for people who are working with communities and doing like some kind of nutrition education for people at a community level, they might be able to

> utilize this to catch some of these deficiencies early, especially if we think about the fact that, in the rural communities, people might not even have access to like proper hospitals. So, if, if you work in that setting that might be helpful."

Of note, when discussing the trialability of the MND-directed NFPE in the community setting, study participants also mentioned that inadequate space and privacy were concerns when conducting the exam in these settings.

Posttest scores for questions pertaining to the relative advantage construct were significantly higher (M= 13.26, SE= .148), $t(130)$= -7.608, p= <.001 than pretest scores for questions pertaining to the relative advantage construct (M= 12.05, SE= .159), $t(130)$= -7.608, p= <.001. When study participants were asked about how micronutrient deficiencies are identified in their workplace, laboratory tests were the subject of most ensuing discussion. For example, one participant stated "right now, in order to find these micronutrient deficiencies, they're really relying on lab work." Therefore, "laboratory tests" was deemed a deductive code, and appeared on 15 occasions. Participants described that biochemical markers of nutrition status are often ordered in the inpatient setting, and are used by the nutrition professional to develop a nutritional plan of care. One participant explained:

> "So normally, when someone comes to the hospital in Ghana, it's a baseline—they do a baseline test, they kind of like run tests. And through that, you are able to pick out what has fallen below the normal range, and all that. So, when a patient comes to, for example, myself for consultation I would look out for the labs first."

When discussing laboratory tests, however, participants also discussed situations in which obtaining biochemical markers of nutrition status is not feasible. In these instances, participants described that using the MND-directed NFPE may be a valuable diagnostic alternative; comments on this topic were coded as "relative advantage." "Relative advantage" was deemed a deductive code, and appeared 12 times in the qualitative data. On 10 occasions,

the cost associated with measuring biochemical markers of nutrition status was cited as a barrier to identifying MNDs, and was also cited as the reason why the MND-directed NFPE would be a useful alternative. For example, one patient stated "lab tests can be very expensive in our country so we can rely on the NFPEs in identifying MNDs."

Participants also discussed the fact that biochemical markers of nutrition status are sometimes unavailable due to inadequate medical infrastructure. One study participant summarized a focus group discussion, stating: "they also said that lab work is not always available so they rely on NFPE a lot. Someone said NFPE is faster in detecting patients with MND than the biochemical methods. Also it is cost efficient, like a lot of people said." One participant mentioned that the MND-directed NFPE may be less advantageous than laboratory values in detecting MNDs due to the fact that the exam can be time consuming. This comment was the only of the 12 comments in the "relative advantage" construct that involved describing the exam being less advantageous than other forms of detecting MNDs. Of the remaining 11 comments, all study participants expressed they perceived the MND-directed NFPE to be preferable than other forms of detecting MNDs, especially when barriers to other methods exist. Therefore, the qualitative data relating to the "relative advantage" theoretical construct mirrored the aforementioned quantitative results pertaining to this construct.

The aforementioned inferential statistical tests are further summarized in Table 3 below. Moreover, qualitative codes and associated quotes are summarized in Table 4.

Variable	Pretest Mean +/- SE	Posttest Mean +/- SE	P-value
Total	64.85	70.15	<0.001
Observability	12.77	13.47	<0.001
Compatibility	10.38	10.86	0.026
Complexity	8.88	9.99	<0.001
Self-Efficacy	9.96	11.51	<0.001
Trialability	10.83	11.05	0.207
Relative Advantage	12.05	13.26	<0.001

Table 3. Total and Construct-Specific Dependent T Test Results

Code	Code Type	Example Quotes
Cultural Leader Influence	Inductive	"So my group, we had a very nice discussion about the use of the NFPE in determining micronutrient deficiencies. And we realized that it's been used. In our setting, mostly our grandmothers—when a lady is pregnant—they will look around the eyes and the eyelids in order to check if she's pregnant. The main use is in order to detect pregnancy—that's according to our grandmothers. But mostly that shows if the lady is pregnant or not. So, in a way, it's being used by our grandmothers and other people."
Dietetic Leader Influence	Inductive	"I think that having more opportunities like this to, not just refresh on the theory but also talk about the need for more practical application is helpful. I think most certainly they do work hand in hand in hand, especially for those who have already gone through the training like we can't really go back too much, we can only rely on continuously getting educated, and if we find ourselves in maybe preceptor roles, or you know whatever roles in which we are mentoring others we can also draw younger people's attention—and I'm using younger just like people younger to the field, not necessarily younger than us—to draw their attention to the fact that they can use this assessment methods in their practice, I think." "There could be a call to make that [the MND-directed NFPE] part of the standard of care."
Knowledge	Deductive	"We have learned a lot and we are grateful to you"

Code	Code Type	Example Quotes
		"Even if it was something you were using and you were not using it so much now, we now have more things to look out for. And then for those in academia, some shared that it's also given them the opportunity to refresh what they know."
Observability	Deductive	"And then the NFPEs are very important to our practice because it makes us more proactive, in the sense that we are able to identify certain things and quickly put an intervention which will probably have delayed hospital stay, would have increased hospital health care cost, and then also we get to tackle the root cause of the problem, like some of the skin conditions where a lot of the people go to the dermatologist and then they just solve the rash or whatever presentation they see on the skin. Meanwhile the root cause of the problem hasn't been tackled."
Micronutrient Deficiencies	Deductive	"I think most of the micronutrient deficiencies will be iron." "Vitamin A deficiency, if I recall, was also a problem" "The common one is iron deficiency. That is the most common MND in our country. But sometimes we will have goiter. It is a little common. I think, for some time now, it is reduced."
Compatibility	Deductive	"I think it [the MND-directed NFPE] could be very feasible in my workplace" "Some of the barriers [to using the MND-directed NFPE] we heard were time constraints—too many patients."
Religious or Cultural Barriers	Inductive	"He couldn't even touch some of his clients, due to religious reasons because they came in gowned from head to toe, you can't even see the skin."
COVID-19	Deductive	"Then we were able to identify the barriers that will cause a challenge in using the tool. One was mainly the COVID era, when there's social distancing and staying away from people by direct contact. We're going to have a challenge, because we need to, at one point actually touch your patient so how are we going to factor that in."
Complexity	Deductive	"The NFPEs can be very subjective in determining deficiencies. Can be very subjective, can be very tricky.

Code	Code Type	Example Quotes
		Depending on your expertise and your experience it's going to be a little tricky. So we also want to use other tests to confirm our findings."
Self-efficacy	Deductive	"This webinar will help embolden me to look out for MNDs anytime I assess a patient." "And then we also talked about the impact of the webinar on our practice. And we said it had a very positive impact, it had boosted our confidence, which used to be a limitation, but as we keep hitting on it and visiting it, it is encouraging us to use it more, and it has also encouraged us to go beyond what – what I would say our comfort zone—the biomedical findings—to include the nutrition-focused physical examination in our assessment—as part of our assessment."
Trialability	Deductive	"What we heard is that there are a lot of clinicians using NFPE- almost using it as a screen- that clinical assessment as a screen" while another summarized "are we using it already? Yes, to a lesser extent, because it's not a conscious effort. We do look out for micronutrient deficiencies but we need to do more work in using it as we should."
Community Application	Deductive	"Maybe for people who are working with communities and doing like some kind of nutrition education for people at a community level, they might be able to utilize this to catch some of these deficiencies early, especially if we think about the fact that, in the rural communities, people might not even have access to like proper hospitals. So, if, if you work in that setting that might be helpful."
Laboratory Tests	Deductive	"Right now, in order to find these micronutrient deficiencies, they're really relying on lab work." "So normally, when someone comes to the hospital in Ghana, it's a baseline—they do a baseline test, they kind of like run tests. And through that, you are able to pick out what has fallen below the normal range, and all that. So, when a patient comes to, for example, myself for consultation I would look out for the labs first."
Relative Advantage	Deductive	"Lab tests can be very expensive in our country so we can rely on the NFPEs in identifying MNDs." "They also said that lab work is not always available so they rely on NFPE a lot. Someone said NFPE is faster in

Code	Code Type	Example Quotes
		detecting patients with MND than the biochemical methods. Also it is cost efficient, like a lot of people said."

Table 4. Qualitative Codes and Example Quotes

Chapter V: Discussion

Study participants were well-versed in micronutrient deficiency pathophysiology and Ghanaian micronutrient deficiency incidence. Micronutrients are essential for normal physiological processes to occur, and these processes are often impaired in the setting of even mild deficiency.[1] Study participants eloquently and fervently described that accurately identifying and treating micronutrient deficiencies would result in positive health outcomes among their patient population. Participants also described that the MND-directed NFPE may be a valuable tool in this effort. This qualitative data mirrored the quantitative data, which showed a significant difference in pretest and posttest scores among questions relating to the observability of positive outcomes when utilizing the MND-directed NFPE.

Iron is an especially relevant micronutrient deficiency in Ghana,[14] and this was the most-addressed micronutrient deficiency by study participants. Iodine deficiency prevalence continues to be somewhat of a concern in Ghana, but the incidence of iodine deficiency has decreased significantly as iodized salt becomes more widely utilized.[48] This phenomenon was touched on by study participants within the focus groups. Moreover, vitamin A deficiency may be impacting up to 73% of children in some regions of Ghana.[56] Vitamin A deficiency was addressed several times by study participants within the focus groups. Lastly, MNDs appear to be more common in rural areas of Ghana[25] and the issue of limited medical resources is more pronounced in the rural areas.[20] Study participants expressed perceptions of high community applicability of the MND-

focused NFPE for these reasons. Ghana is considered a middle-income country. [18] Cost was identified as a barrier to utilizing biochemical markers of nutrition status to identify micronutrient deficiencies, and was cited as a reason why using the MND-directed NFPE is a more appropriate tool in some situations. Study participants showed a sound understanding of key issues surrounding micronutrient deficiency in Ghana, and expressed their passionate commitment to ameliorating these issues in the best possible way for their patients.

Although nutrition professionals perceive the MND-directed NFPE to be a useful tool in many situations, incorporating this exam into routine clinical practice may not be compatible with the work life of all Ghanaian nutrition professionals. Specifically, privacy issues are a concern when conducting a physical exam, especially in the community setting. Moreover, COVID-19 related proximity concerns and religious reasons may be barriers to conducting the comprehensive MND-directed NFPE. Furthermore, time constraints in the clinical setting may prevent nutrition professionals from being able to effectively utilize this tool. Therefore, although participants felt as though using the MND-directed NFPE was trailable in theory, logistical issues may prevent participants from feeling as though using this exam is actually feasible due to the aforementioned barriers. Lastly, some participants may already be utilizing the MND-directed NPFE, which may account for the fact that no significant differences were found among pretest and posttest scores for questions pertaining to the "trialability" construct.

About 64% of study participants work for the government. The Ghanaian government is involved in nutrition supplementation efforts.[102] Therefore, enhanced skills pertaining to micronutrient deficiency screening may be especially relevant for nutrition professionals in government work. Furthermore, a greater number of Registered Nutritionists had ten or more years of work experience than Registered Dietitians. This may be related to the fact that training

programs in Ghana for Registered Dietitians are in the more nascent stages of development[26] than programs for Registered Nutritionists. Due to the fact that training programs for Registered Dietitians are currently growing in Ghana, it may be an ideal time to offer training opportunities for these professionals on conducting the MND-directed NFPE. Also, more than half of the study participants were Registered Dietitians, suggesting Ghanaian Registered Dietitians are eager to engage in continuing education opportunities.

Dietetic leader and cultural leader influence were identified as inductive codes within the qualitative data. It seems noteworthy that these topics were broached by the study participants, and also so closely align with the theoretical framework for the present study. Although physical exams are not necessarily being used by cultural leaders to detect micronutrient deficiencies, the fact that study participants discussed the correlation between the two suggests that using the MND-directed NFPE might feel culturally congruent for Ghanaian nutrition professionals. Based on the diffusion of innovations theory, cultural congruence, especially when demonstrated by cultural leaders, promotes the adoption of a new practice among members of that community.[154] Nutrition professionals are well-respected members of the medical community in Ghana,[139] and study participants expressed feelings that their preceptors and other educators are highly influential when it comes to incorporating a new practice into their standard of care. According to the diffusion of innovations theory,[154] these nutrition professional leaders have great potential to influence nutrition professionals.

Overall, the qualitative results mirrored the quantitative results. The qualitative data appeared to add breadth and depth to the qualitative data. For example, according to the qualitative data, many participants felt as though using the NFPE to identify MNDs was outside

of their comfort zone. However, according to the quantitative data, the same participants also felt the virtual workshop helped them feel more comfortable with the complexity of this exam.

Although the complex nature of using the MND-directed NPFE was widely discussed, improved feelings of self-efficacy after attending the virtual workshop were also discussed. Moreover, participants scored higher on posttests in the realms of self-efficacy and perceived complexity on the posttest than on the pretest. The fact that study participants improved in similar ways in both of these areas suggests participants perceived themselves to have improved their confidence in performing a complex clinical skill. Moreover, participants also felt that MNDs were relatively common in their workplace, and that the MND-directed NFPE would yield observably positive clinical outcomes among their patient population. Moreover, they found the NFPE to be a more advantageous method by which to assess for MNDs than other methods of MND assessment, especially in certain situations. Therefore, participants improved their feelings of self-efficacy in performing a complex clinical skill; a clinical skill that they perceive to be an advantageous and useful method of treating their patient population.

Study limitations

One limitation of the present study is the fact that qualitative data was transcribed and largely interpreted in a cross-cultural manner. The principal investigator is American, while the study participants were Ghanaian. One of the strengths of qualitative data is that it captures the nuances in the data.[160] Although the principal investigator attempted to diminish this limitation by discussing any unfamiliar vernacular with Dr. Intiful, the potential of missing nuances in the data was likely magnified by the cross-cultural qualitative data analysis.

Another study limitation is the fact that an unvalidated survey tool was utilized to collect the quantitative data. The pilot test was conducted in an effort to correct for errors associated

with use of an unvalidated tool, yet the tool remained unvalidated at the time of use during the study. Another component of this study that proved to be a limitation was inconsistent internet connection among study participants and webinar leaders alike. For example, one of the focus group leaders was disconnected from the internet for the entirety of the zoom meeting, and the principal investigator acted as a substitute focus group leader during that time. A lack of continuity of focus group leaders and focus group participants appeared to negatively impact the flow of discussion within the focus groups. Lastly, one study participant noted that although the starting time was listed on the virtual workshop flyer, the duration and/or end time was not listed. This was an unfortunate oversight by the principal investigator, and may have contributed to attrition as the virtual workshop progressed.

Nutritional Implications

Micronutrient deficiencies are prevalent globally,[7] and in Ghana.[14,24] When left unaddressed, MNDs can cause a plethora of ailments across the lifecycle that have the potential to dramatically diminish quality of life.[5] Biochemical markers of nutrition status are considered the gold standard of micronutrient assessment, [109,110] and study participants report lab values are often used in the clinical setting to identify MNDs in Ghana. However, study participants also report that cost is often a barrier to conducting laboratory tests to assess micronutrient status. Moreover, Ghanaian nutrition professionals state that insufficient access to medical facilities is also a barrier to obtaining biochemical markers of nutrition status. In these situations, study participants perceive the MND-directed NFPE to be a valuable tool in identifying MNDs. The virtual workshop enhanced nutrition professionals' feelings of self-efficacy in performing what they also perceive to be a relatively complex skill. Therefore, the virtual workshop may embolden nutrition professionals to identify MNDs in circumstances when MNDs could not

otherwise be identified. Identifying and treating MNDs can prevent devastating health outcomes such as blindness,[55] cognitive impairment,[42] and even death.[1] Moreover, many study participants are employed by government entities, and these entities are involved in nutrition supplementation efforts. Therefore, these professionals may be able to use the MND-directed NFPE to obtain useful data to inform their efforts.

The MND-directed NFPE may be a key method by which Ghanaian nutrition professionals identify MNDs. Ghanaian nutrition professionals often face financial and medical infrastructure barriers to assessing biochemical markers of nutrition status. In these frequently-encountered situations, the MND-directed NFPE offers a viable alternative to identify MNDs. Now that Ghanaian nutrition professionals feel confident and knowledgeable about using the MND-directed NFPE, they may be able to identify otherwise non-detectable MNDs.

Although enhancing nutrition professionals' clinical skills pertaining to the MND-directed NFPE may theoretically improve patient outcomes, logistical concerns exist. For example, in rural areas, where using the MND-directed NFPE might be especially relevant due to the fact that medical facilities are more challenging to access, privacy is a concern when conducting a physical exam. Study participants report that many community settings offer inadequate space, and inadequate privacy to perform the exam. Insufficient lighting, inadequate personal protective equipment, and religious barriers are also concerns that may limit the use of the MND-directed NFPE by Ghanaian nutrition professionals.

The MND-directed NFPE may be a crucial tool for Ghanaian nutrition professionals. Some logistical concerns do exist, however, when implementing this practice. Due to the high utility of the MND-directed NFPE in Ghana, identifying strategies to overcome the aforementioned barriers is a priority. Providing a platform on which Ghanaian nutrition

professionals can discuss these barriers may catalyze the development of strategies to overcome these barriers. A conversational space would allow Ghanaian nutrition professionals to collaborate and conceptualize solutions to logistical concerns of implementing the MND-directed NFPE into routine clinical practice. Continuing education opportunities in Ghana could focus on this topic, and could involve discussion on overcoming these barriers. Moreover, future research could focus on more systematically identifying barriers to use of the MND-directed NFPE. Qualitative research may be an especially effective tool when aiming to identify nuanced reasons for logistical concerns among Ghanaian nutrition professionals.

Future Research Considerations

While assessing the qualitative data, one theme recognized by the principal investigator, but that was somewhat outside the scope of the present research project, was discussion about clinical resources available to Ghanaian nutrition professionals. Specifically, study participants reported that if they had access to brief reference materials for use on the hospital floor and in the communities, this would support use of the MND-directed NFPE in their clinical practice. The Academy of Nutrition and Dietetics Nutrition Focused Physical Exam Pocket Guide by Mordarski and Wolff[122] was provided as an example of one such reference. Moreover, inadequate lighting was cited by study participants as a barrier to conducting the MND-directed physical exam. Lastly, a lack of personal protective equipment in the setting of the COVID-19 pandemic was recognized as a limitation to physically examining patients. Future research may benefit from assessing which materials may benefit the practice of Ghanaian nutrition professionals the most, and how best to facilitate nutrition professional access to such materials.

Another theme noted by the principal investigator while analyzing the qualitative data was the fact that study participants enjoyed the polling questions. In an individual focus group,

one participant stated “I really liked the polls that Leah gave in between her lectures. It made you pay attention. Because I was somehow scoring myself to see how well I am doing. And I think it's a good move that she did.” Study participants also felt as though the lectures may have been too long. One focus group spokesperson provided a summary for the focus group and mentioned the group “did think the webinar was very good but they thought that it was a little bit long. They did like the polls and felt that kind of kept their attention throughout it, and would have liked actually to have a few more polls throughout the webinar.” Future research on virtual workshops may therefore benefit from assessing the optimal ratio of instruction to polling questions to keep the audience engaged and interested in the material.

Lastly, study participants felt as though the virtual workshop enhanced their feelings of self-efficacy in utilizing a complex, relevant clinical skill. However, participants also reported that hands-on, in person, practical training may be even more beneficial. Participants expressed that they would benefit from in-person training, as this would make them feel more comfortable approaching the patient, and performing the physical exam. Therefore, future research should focus on providing in-person practical training to Ghanaian nutrition professionals on utilizing the MND-directed NFPE.

Chapter VI: Conclusion

MNDs are prevalent in Ghana, significantly diminish quality of life, and contribute to high health care costs in the setting of limited clinical resources. The MND-directed NFPE offers a viable option to detect MNDs when common barriers to using biochemical markers of nutrition status exist. Study participants felt as though the virtual workshop enhanced their knowledge and feelings of self-efficacy in utilizing a complex, relevant clinical skill. Therefore, virtual platforms offer a safe and effective method by which to deliver MND-directed NFPE training during a global pandemic. Future research should focus on more systematically identifying and

ameliorating the compatibility and trialability concerns of Ghanaian nutrition professionals in regards to seamlessly incorporating the MND-directed NFPE into routine clinical practice. The success of this virtual two-day workshop paves the way for other virtual clinical skills training programs. Health care educators may perceive it necessary to conduct clinical skills training in person. However, circumstances may arise, such as a global pandemic, which may hinder the ability of health care educators to deliver in-person training. In the absence of safe, in-person training options, virtual platforms provide an effective alternative. The results of this research offer insight into virtual options for exclusively in-person clinical skills training programs.

References

1. Shenkin A. Micronutrients in health and disease. *Postgrad Med J*. 2006;82(971):559-567. doi:10.1136/pgmj.2006.047670
2. Mahan K, Stump-Escott S, Raymond J. *Krause's Food and the Nutrition Care Process*. St Louis, Missouri: Elsevier Saunders; 2012.
3. Marra MV, Boyar AP. Position of the American Dietetic Association: nutrient supplementation. *J Am Diet Assoc*. 2009;109(12):2073-2085. doi:10.1016/j.jada.2009.10.020
4. Institute of Medicine. *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements (2006)*. Vol 55.; 2006. doi:10.1111/j.1753-4887.1997.tb01621.x
5. Bailey RL, West KP, Black RE. The epidemiology of global micronutrient deficiencies. *Ann Nutr Metab*. 2015;66(suppl 2):22-33. doi:10.1159/000371618
6. Berenjforoush U. *Investing in the Future Global Report 2009*. Vol 9.; 2014. doi:10.1109/MEI.2005.1437601
7. Centers for Disease Control and Prevention. Micronutrient Facts. https://www.cdc.gov/nutrition/micronutrient-malnutrition/micronutrients/index.html. Accessed February 8, 2020.
8. World Health Organization. Micronutrient Deficiencies. https://www.who.int/nutrition/topics/vad/en/. Accessed February 10, 2020.
9. Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non-pregnant women for 1995-2011: A systematic analysis of population-representative data. *Lancet Glob Heal*. 2013;1(1):16-25. doi:10.1016/S2214-109X(13)70001-9
10. Zimmermann MB. Iodine deficiency. *Endocr Rev*. 2009;30(4):376-408. doi:10.1210/er.2009-0011
11. WHO. Guideline : Vitamin A supplementation in infants and children 6 – 59 months of age. *World Heal Organ*. 2011.
12. Wessells KR, Brown KH. Estimating the Global Prevalence of Zinc Deficiency: Results Based on Zinc Availability in National Food Supplies and the Prevalence of Stunting. *PLoS One*. 2012;7(11). doi:10.1371/journal.pone.0050568
13. McLean E, de Benoist B, Allen LH. Review of the magnitude of folate and vitamin B12 deficiencies worldwide. *Food Nutr Bull*. 2008;29(2 SUPPL.):38-51. doi:10.1177/15648265080292s107
14. University of Ghana, GroundWork, University of Wisconsin-Madison, KEMRI-WellcomeTrust U. *Ghana Micronutrient Survey 2017.* Accra, Ghana; 2017.
15. Central Intelligence Agency. Africa:Ghana. https://www.cia.gov/library/publications/the-world-factbook/geos/gh.html. Accessed February 15, 2020.
16. Ghana Statistical Service. Greater Accra. https://www.statsghana.gov.gh/regionalpopulation.php?population=MTM0NTk2MjQzOS4yMDE1&&Greater Accra&regid=3#. Published 2019. Accessed April 10, 2020.
17. University of Ghana. https://www.ug.edu.gh/about/overview. Accessed February 15, 2020.
18. The World Bank Group. The World Bank in Ghana. https://www.worldbank.org/en/country/ghana/overview. Accessed March 1, 2020.

19. Centers for Disease Control and Prevention. Adult Obesity Facts. https://www.cdc.gov/obesity/index.html. Accessed February 28, 2020.
20. Drislane F, Akpalu A, Wegdam H. The Medical System in Ghana. *Yale J Biol Med*. 2014;(87):321-326.
21. UNICEF. *Children, Food and Nutrition. The State of the World Children 2019. Executive Summary.*; 2019.
22. UNAIDS. Country Factsheets. Ghana 2018. https://www.unaids.org/en/regionscountries/countries/ghana. Accessed February 28, 2020.
23. Agriculture and Consumer Protection Department. Ghana. http://www.fao.org/ag/agn/nutrition/gha_en.stm. Accessed February 17, 2020.
24. Gernand AD, Aguree S, Pobee R, Colecraft EK, Murray-Kolb LE. Concurrent Micronutrient Deficiencies Are Low and Micronutrient Status Is Not Related to Common Health Indicators in Ghanaian Women Expecting to Become Pregnant. *Curr Dev Nutr*. 2019;3(6):1-10. doi:10.1093/cdn/nzz053
25. Wegmüller R, Bentil H, Wirth JP, et al. Anemia, micronutrient deficiencies, malaria, hemoglobinopathies and malnutrition in young children and non-pregnant women in Ghana: Findings from a national survey. *PLoS One*. 2020;15(1):e0228258. doi:10.1371/journal.pone.0228258
26. Aryeetey RNO, Boateng L, Sackey D. State of dietetics practice in Ghana. *Ghana Med J*. 2014;48(4):219-224. doi:10.4314/gmj.v48i4.9
27. Abbaspour N, Hurrell R, Kelishadi R. Review on iron and its importance for human health. *J Res Med Sci*. 2014;19(2):164-174.
28. Whitney E, Rolfes S. *Understanding Nutrition*. 14th ed. Stamford, CT: Cengage Learning; 2007.
29. Haas JD, Brownlie T. Iron Deficiency and Reduced Work Capacity: A Critical Review of the Research to Determine a Causal Relationship. *J Nutr*. 2001;131(2):676S-690S. doi:10.1093/jn/131.2.676s
30. Mistry R, Hosoya H, Kohut A, Ford P. Iron deficiency in heart failure, an underdiagnosed and undertreated condition during hospitalization. *Ann Hematol*. 2019;98(10):2293-2297.
31. Abu-Ouf NM, Jan MM. The impact of maternal iron deficiency and iron deficiency anemia on child's health. *Saudi Med J*. 2015;36(2):146-149. doi:10.15537/smj.2015.2.10289
32. Nyakeriga AM, Troye-Blomberg M, Chemtai AK, Marsh K, Williams TN. Malaria and nutritional status in children living on the coast of Kenya. *Am J Clin Nutr*. 2004;80(6):1604-1610. doi:10.1111/j.0300-9475.2004.01423o.x
33. Sazawal S, Black R, Ramsan M, Chwaya H, Rebecca S, Dutta A. Effects of routine prophylactic supplementation with iron and folic acid on admission to hospital and mortality in preschool children in a high malaria transmission setting: community-based, randomised, placebo-controlled trial. *Lancet*. 2006;367(9505):133-143.
34. World Health Organization, (UNICEF) UNCF. *Iron Supplementation of Young Children in Regions Where Malaria Transmission Is Intense and Infectious Disease Highly Prevalent: Joint Statement.* Geneva, Switzerland; 2006.
35. Zlotkin S, Newton S, Aimone AM, et al. Effect of iron fortification on malaria incidence in infants and young children in Ghana: A randomized trial. *JAMA - J Am Med Assoc*. 2013;310(9):938-947. doi:10.1001/jama.2013.277129
36. Google Maps. Tain, Ghana to Wenchi, Ghana.

37. Institute of Medicine (U.S.). Panel on Micronutrients. *DRI : Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc : A Report of the Panel on Micronutrients ... and the Standing Committee on the Scientific*.; 2001.
38. Chen MH, Su TP, Chen YS, et al. Association between psychiatric disorders and iron deficiency anemia among children and adolescents: A nationwide population-based study. *BMC Psychiatry*. 2013;13(1):1. doi:10.1186/1471-244X-13-161
39. Yager J, Hartfield D. Neurologic manifestations of iron deficiency in childhood. *Pediatr Neurol*. 2002;27(2):85-92.
40. Berglund S, Westrup B, Hagglof B, Hernell O, Domellof M. Effects of Iron Supplementation of LBW Infants on Cognition and Behavior at 3 Years. *Pediatrics*. 2013;131(1):47-55.
41. Algarin C, Nelson C, Peirano P, Westerlund A, Reyes S, Lozoff B. Iron-deficiency anemia in infancy and poorer cognitive inhibitory control at age 10 years. *Dev Med Child Neurol*. 2013;55(5):453-458. doi:10.1038/jid.2014.371
42. Qubty W, Renaud D. Cognitive Impairment Associated With Low Ferritin Responsive to Iron Supplementation. *Pediatr Neurol*. 2014;51(6):831-833.
43. World Health Organization. Iodine deficiency disorders. https://www.who.int/nutrition/topics/idd/en/. Accessed March 2, 2020.
44. Zimmerman M, Jooste P, Pandav C. Iodine-deficiency disorders. *Lancet*. 2008;372(9645):1251-1262.
45. Afele M. Street food boom in Ghana spurs calls for better hygeine. *Bull World Health Organ*. 2006;84(10):765-840.
46. Doku GN, Bortey EA. Iodine levels in brands of salt on the markets of Accra, Ghana. *Ghana Med J*. 2018;52(3):163-167. doi:10.4314/gmj.v52i3.10
47. Nutrition Department-GHS, GAIN U. National Iodine Survey Report, Ghana 2015. 2017;(June):1-150.
48. Sarfo-Kantanka O, Kyei I, Sarfo FS, Ansah EO. Thyroid Disorders in Central Ghana: The Influence of 20 Years of Iodization. *J Thyroid Res*. 2017;2017. doi:10.1155/2017/7843972
49. Asibey-Berko E, Zlotkin SH, Yeung GS, et al. Dual Fortification of Salt with Iron and Iodine in Women and Children in Rural Ghana. *East Afr Med J*. 2007;84(10):473-480.
50. Zimmermann MB, Andersson M. Assessment of iodine nutrition in populations: Past, present, and future. *Nutr Rev*. 2012;70(10):553-570. doi:10.1111/j.1753-4887.2012.00528.x
51. Zimmermann M, Saad A, Hess S, Torresani T, Chaouki N. Thyroid ultrasound compared with World Health Organization 1960 and 1994 palpation criteria for determination of goiter prevalence in regions of mild and severe iodine deficiency. *Eur J Endocrinol*. 2000;143(6):727-731. doi:10.1530/eje.0.1430727
52. Chea E, Milstein H. Vitamin A. https://www.ncbi.nlm.nih.gov/books/NBK482362/. Accessed March 3, 2020.
53. Clinic M. Vitamin A. https://www.mayoclinic.org/drugs-supplements-vitamin-a/art-20365945. Accessed March 2, 2020.
54. Tam E, Keats E, Rind F, Das J, Bhutta A. Micronutrient Supplementation and Fortification among Children Under-Five in Low- and Middle-Income Countries: A Systematic Review and Meta-Analysis. *Nutrients*. 2020;12(2).
55. World Health Organization. Xerophthalmia and night blindness for the assessment of

clinical vitamin A deficiency in individuals and populations. *Unpublished*. 2014:1-6.
56. Ross DA, Kirkwood BR, Binka FN, et al. Child morbidity and mortality following vitamin A supplementation in Ghana: Time since dosing, number of doses, and time of year. *Am J Public Health*. 1995;85(9):1246-1251. doi:10.2105/AJPH.85.9.1246
57. Google Maps. Kassena Nankana, Ghana.
58. Winterfeld A. *Improving Child Nutrition.* Vol 18.; 2010.
59. Solomons NW. Editorial. *Ann Nutr Metab*. 2013;62(SUPPL.1):5-6. doi:10.1159/000348577
60. Tjian R. Gene regulation: An introduction. https://www.youtube.com/watch?v=ugMJrhQSfm8&feature=emb_title. Accessed February 21, 2020.
61. Brown KH, Peerson JM, Rivera J, Allen LH. Effect of supplemental zinc on the growth and serum zinc concentrations of prepubertal children: A meta-analysis of randomized controlled trials 1-3. *Am J Clin Nutr*. 2002;75(6):1062-1071. doi:10.1093/ajcn/75.6.1062
62. Black M. The Evidence Linking Zinc Deficiency with Children's Cognitive and Motor Functioning. 2003;133(5):1473S-1476S.
63. Li Y. Zinc and insulin in pancreatic beta-cells. *Endocrine*. 2014;(45):178-189.
64. Aliani M, Udenigwe C, Girgih A, Pownall T, Bugera J, Eskin M. Zinc Deficiency and Taste Perception in the Elderly. *Crit Rev Food Sci Nutr*. 2012;53(3):245-250.
65. Okayama T, Watanabe H. Association between taste perception, nutrient intake, and mental health in young japanese women. *Nutr Res Pract*. 2019;13(1):41-46. doi:10.4162/nrp.2019.13.1.41
66. Lin PH, Sermersheim M, Li H, Lee PHU, Steinberg SM, Ma J. Zinc in wound healing modulation. *Nutrients*. 2018;10(1):1-20. doi:10.3390/nu10010016
67. Owusu-Agyei S, Newton S, Mahama E, et al. Impact of vitamin A with zinc supplementation on malaria morbidity in Ghana. *Nutr J*. 2013;12(1):1. doi:10.1186/1475-2891-12-131
68. Ebara S. Nutritional role of folate. *Congenit Anom (Kyoto)*. 2017;57:138-141.
69. Nagao T, Hirokawa M. Diagnosis and treatment of macrocytic anemias in adults. *J Gen Fam Med*. 2017;18(5):200-204. doi:10.1002/jgf2.31
70. Czeizel AE, Dudás I, Vereczkey A, Bánhidy F. Folate deficiency and folic acid supplementation: The prevention of neural-tube defects and congenital heart defects. *Nutrients*. 2013;5(11):4760-4775. doi:10.3390/nu5114760
71. Gordon N. Cerebral folate deficiency. *Dev Med Child Neurol*. 2009;51:180-182.
72. Harrison M, Hillard R, Lavine E. Case 2: You look like you've seen a goat. *Paediatr Child Health (Oxford)*. 2007;12(5):389-391.
73. Dubik SD, Amegah KE, Alhassan A, Mornah LN, Fiagbe L. Compliance with Weekly Iron and Folic Acid Supplementation and Its Associated Factors among Adolescent Girls in Tamale Metropolis of Ghana. *J Nutr Metab*. 2019;2019. doi:10.1155/2019/8242896
74. Cvetinovic N, Loncar G, Isakovic AM, et al. Micronutrient depletion in heart failure: Common, clinically relevant and treatable. *Int J Mol Sci*. 2019;20(22):1-14. doi:10.3390/ijms20225627
75. Savarese G, Lund LH. Global Public Health Burden of Heart Failure. *Card Fail Rev*. 2017;3(1):7-11. doi:10.15420/cfr.2016
76. Jensen G, Compher C, Sullivan D, Mullin G. Recognizing Malnutrition in Adults: Definitions and Characteristics, Screening, Assessment, and Team Approach. *J Parenter*

Enter Nutr. 2013;37(6):802-807.
77. Berger M. Antioxidant Micronutrients in Major Trauma and Burns: Evidence and Practice. *Nutr Clin Pract*. 2006;12:438-449.
78. Koekkoek WAC, Van Zanten ARH. Antioxidant Vitamins and Trace Elements in Critical Illness. *Nutr Clin Pract*. 2016;31(4):457-474. doi:10.1177/0884533616653832
79. Jin J, Mulesa L, Carrilero Rouillet M. Trace Elements in Parenteral Nutrition: Considerations for the Prescribing Clinician. *Nutrients*. 2017;9(5):440.
80. Heidari K, Goharani R, Lakestani M, Hajeismaeilli M. The Effects of Selenium Supplementation on Clinical Outcomes in Mechanically Ventilated, Non-Surgical/Traumatic Critically Ill Patients. *J Cell Mol Anesth*. 2018;3(2):54-59.
81. Institute of Medicine (U.S.). Panel on Dietary Antioxidants and Related Compounds. *Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium, and Carotenoids*. Washington (DC): National Academies Press (US); 2000. https://www.ncbi.nlm.nih.gov/books/NBK225470/. Accessed March 5, 2020.
82. National Center for Biotechnology Information. Selenomethionine, CID=15103. https://pubchem.ncbi.nlm.nih.gov/compound/Selenomethionine. Accessed March 3, 2020.
83. Agarwal P, Sharma S, US A. Selenium toxicity: A rare diagnosis. *Indian J Dermatology, Venerol Leprol*. 2016;82(3):690.
84. Angstwurm M, Engelmann L, Zimmermann T. Selenium in intensive care (SIC): Results of a prospective randomized, placebo-controlled, multiple-center study in patients with severe systemic inflammatory response syndrome, sepsis, and septic shock. *Crit Care Med*. 2007;35(1):118-126.
85. Hu B, Huang S, Yin L. The cytokine storm and COVID-19. *J Med Virol*. 2:0-2. doi:10.1002/jmv.26232
86. Cecchini R, Cecchini AL. SARS-CoV-2 infection pathogenesis is related to oxidative stress as a response to aggression. *Med Hypotheses*. 2020;143:110102. doi:10.1016/j.mehy.2020.110102
87. Moghaddam A, Heller RA, Sun Q, et al. Selenium Deficiency Is Associated with Mortality Risk from COVID-19. *Nutrients*. 2020;12(7):2098. Published 2020 Jul 16. doi:10.3390/nu12072098
88. Dworkin B, Rosenthal W, Wormser G, Weiss L. Selenium Deficiency in the Acquired Immunodeficiency Syndrome. *J Parenter Enter Nutr*. 1986;10(4):405-407.
89. Kuleape JA. University of Ghana http://ugspace.ug.edu.gh UNIVERSITY OF GHANA COLLEGE OF BASIC AND APPLIED SCIENCES GLUTATHIONE S-TRANSFERASE GENE POLYMORPHISM AND ANTIOXIDANT ENZYMES ACTIVITY IN HIV / AIDS PROGRESSION IN GHANAIAN PATIENTS BY A THESIS SUBMITTED TO THE. 2016;(July).
90. Adu P, Simpong DL, Takyi G, Ephraim RKD. Glucose-6-Phosphate Dehydrogenase Deficiency and Sickle Cell Trait among Prospective Blood Donors: A Cross-Sectional Study in Berekum, Ghana. *Adv Hematol*. 2016;2016. doi:10.1155/2016/7302912
91. Medicine USNL of. Glucose-6-phosphate dehydrogenase deficiency. https://ghr.nlm.nih.gov/condition/glucose-6-phosphate-dehydrogenase-deficiency#diagnosis. Accessed March 4, 2020.
92. Hafez M, Amar ES, Zedan M, et al. Improved erythrocyte survival with combined vitamin E and selenium therapy in children with glucose-6-phosphate dehydrogenase deficiency and mild chronic hemolysis. *J Pediatr*. 1986;108(4):558-561. doi:10.1016/S0022-

3476(86)80833-2
93. ScienceDirect. Kwashiorkor. https://www.sciencedirect.com/topics/medicine-and-dentistry/kwashiorkor. Accessed March 5, 2020.
94. Manary M, MacPherson G, McArdle F, Jackson M, Hart C. Selenium status, kwashiorkor an d congestive hear t failure. *Acta Paediatr*. 2001;90(8):950-952.
95. Becker K, Pons-Kühnemann J, Fechner A, et al. Effects of antioxidants on glutathione levels and clinical recovery from the malnutrition syndrome kwashiorkor - A pilot study. *Redox Rep*. 2005;10(4):215-226. doi:10.1179/135100005X70161
96. Dietary supply of selenium for adolescents in three residential care orphanages in southern ghana. *Sci Total Environ*. 2011;410-411:72-79.
97. Kihara J, Bolo P, Kinyua M, Rurinda J, Piikki K. Micronutrient deficiencies in African soils and the human nutritional nexus: opportunities with staple crops. *Environ Geochem Health*. 2020;0123456789. doi:10.1007/s10653-019-00499-w
98. Stadlmayr B, Charrondiere UR, Addy P, et al. *Composition of Selected Foods from West Africa*.; 2010. http://www.bioversityinternational.org/nc/publications/publication/issue/composition_of_selected_foods_from_west_africa-1.html.
99. Udeze OS. Mineral Composition of Bambaranut – Tigernut – Coconut Mil Beverage Blends. *J Food Nutr Sci*. 2014;2(5):231. doi:10.11648/j.jfns.20140205.15
100. De Jager I, Giller KE, Brouwer ID. Food and nutrient gaps in rural Northern Ghana: Does production of smallholder farming households support adoption of food-based dietary guidelines? *PLoS One*. 2018;13(9):1-26. doi:10.1371/journal.pone.0204014
101. Adu-Afarwuah S, Lartey A, Brown KH, Zlotkin S, Briend A, Dewey KG. Randomized comparison of 3 types of micronutrient supplements for home fortification of complementary foods in Ghana: Effects on growth and motor development. *Am J Clin Nutr*. 2007;86(2):412-420. doi:10.1093/ajcn/86.2.412
102. Lartey A, Manu A, Brown KH, Peerson JM, Dewey KG. A randomized, community-based trial of the effects of improved, centrally processed complementary foods on growth and micronutrient status of Ghanaian infants from 6 to 12 mo of age. *Am J Clin Nutr*. 1999;70(3):391-404. doi:10.1093/ajcn/70.3.391
103. Armar-Klemesu M, Osei-Menya S, Zakariah-Akoto S, Tumilowicz A, Lee J, Hotz C. Using Ethnography to Identify Barriers and Facilitators to Optimal Infant and Young Child Feeding in Rural Ghana: Implications for Programs. *Food Nutr Bull*. 2018;39(2):231-245. doi:10.1177/0379572117742298
104. Mordarski B. Nutrition-Focused Physical Exam Hands-On Training Workshop. *J Acad Nutr Diet*. 2016;116(5):868-869. doi:10.1016/j.jand.2016.03.004
105. Academy of Nutrition and Dietetics. Nutrition Focused Physical Exam Hands-on Training Workshop. https://www.eatrightpro.org/practice/professional-development/face-to-face-learning/nfpe-workshop. Accessed February 28, 2020.
106. Esper DH. Utilization of nutrition-focused physical assessment in identifying micronutrient deficiencies. *Nutr Clin Pract*. 2015;30(2):194-202. doi:10.1177/0884533615573054
107. Gordon B. What is the Nutrition Focused Physical Exam. https://www.eatright.org/food/nutrition/healthy-eating/what-is-the-nutrition-focused-physical-exam. Accessed March 1, 2020.
108. Green Corkins K. Nutrition-focused physical examination in pediatric patients. *Nutr Clin*

Pract. 2015;30(2):203-209. doi:10.1177/0884533615572654
109. Hedrick VE, Dietrich AM, Estabrooks PA, Savla J, Serrano E, Davy BM. Dietary biomarkers: advances, limitations and future directions. *Nutr J*. 2012;11(1):1. doi:10.1186/1475-2891-11-109
110. Picó C, Serra F, Rodríguez AM, Keijer J, Palou A. Biomarkers of nutrition and health: New tools for new approaches. *Nutrients*. 2019;11(5):1-30. doi:10.3390/nu11051092
111. Tomkins A. Assessing Micronutrient Status in the Presence of Inflammation. *J Nutr*. 2003;133(5):1649S-1655S. doi:10.1093/jn/133.5.1649s
112. Gruys E, Toussaint MJM, Niewold TA, Koopmans SJ. Acute phase reaction and acute phase proteins. *J Zhejiang Univ Sci*. 2005;6 B(11):1045-1056. doi:10.1631/jzus.2005.B1045
113. Centers for Disease Control and Prevention. *Iron-Status Indicators*.; 2004.
114. American College of Physicians. Sir William Osler and Internal Medicine. https://www.acponline.org/about-acp/about-internal-medicine/sir-william-osler-and-internal-medicine. Accessed March 1, 2020.
115. Stanford Medicine. 11 Facts About Sir William Osler. https://stanfordmedicine25.stanford.edu/blog/archive/2013/11-Facts-About-Sir-William-Osler.html. Accessed March 1, 2020.
116. Johns Hopkins Medical. A Mission to Reinvigorate Bedside Medicine. https://www.hopkinsmedicine.org/news/articles/a-mission-to-reinvigorate-bedside-medicine. Published 2018. Accessed March 1, 2020.
117. Block L, Habicht R, Wu AW, et al. In the wake of the 2003 and 2011 duty hours regulations, how do internal medicine interns spend their time? *J Gen Intern Med*. 2013;28(8):1042-1047. doi:10.1007/s11606-013-2376-6
118. Garibaldi BT, Niessen T, Gelber AC, et al. A novel bedside cardiopulmonary physical diagnosis curriculum for internal medicine postgraduate training. *BMC Med Educ*. 2017;17(1):1-11. doi:10.1186/s12909-017-1020-2
119. Rai A, Vaishali V, Naikmasur VG, Kumar A, Sattur A. Aplastic anemia presenting as bleeding of gingiva: Case report and dental considerations. *Saudi J Dent Res*. 2016;7(1):69-72. doi:10.1016/j.sjdr.2015.04.004
120. Wazir SM, Ghobrial I. Copper deficiency, a new triad: anemia, leucopenia, and myeloneuropathy. *J Community Hosp Intern Med Perspect*. 2017;7(4):265-268. doi:10.1080/20009666.2017.1351289
121. Hoffman H, Phyliky R, Fleming R. Zinc-Induced Copper Deficiency. *Gastroenterology*. 1988;94(508):12.
122. Academy of Nutrition and Dietetics. *Nutrition Focused Physical Exam Pocket Guide*.; 2017.
123. Mayo Clinic. Fingernails: Possible Problems. https://www.mayoclinic.org/healthy-lifestyle/adult-health/multimedia/nails/sls-20076131?s=5. Accessed March 5, 2020.
124. Goluch-Koniuszy ZS. Nutrition of women with hair loss problem during the period of menopause. *Prz Menopauzalny*. 2016;15(1):56-61. doi:10.5114/pm.2016.58776
125. Myint Z, Oo T, Thein K, Tun A, Saeed H. Copper deficiency anemia: review article. *Ann Hematol*. 2018;97:1527-1534.
126. Hisano M, Suzuki R, Sago H, Murashima A, Yamaguchi K. Vitamin B6 deficiency and anemia in pregnancy. *Eur J Clin Nutr*. 2010;64(2):221-223. doi:10.1038/ejcn.2009.125
127. Hershkowitz E, Reshef A, Munich O, Yosefi B, Markel A. Thiamine deficiency in self-

induced refeeding syndrome, an undetected and potentially lethal condition. *Case Rep Med*. 2014;2014. doi:10.1155/2014/605707
128. Barbiroli B, Medori R, Tritschler H, et al. Lipoic (thioctic) acid increases brain energy availability and skeletal muscle performance as shown by in vivo 31P-MRS in a patient with mitochondrial cytopathy. *J Neurol*. 1995;242(7):472-477.
129. McClelland C, Manousakis G, Lee MS. Progressive External Ophthalmoplegia. *Curr Neurol Neurosci Rep*. 2016;16(6). doi:10.1007/s11910-016-0652-7
130. American Academy of Opthalmology. Angular blepharitis. https://www.aao.org/image/angular-blepharitis-2. Accessed March 6, 2020.
131. Radler DR, Lister T. Nutrient deficiencies associated with nutrition-focused physical findings of the oral cavity. *Nutr Clin Pract*. 2013;28(6):710-721. doi:10.1177/0884533613507284
132. Touger-Decker R, Mobley C. Position of the Academy of Nutrition and Dietetics: Oral Health and Nutrition. *J Acad Nutr Diet*. 2013;113(5):693-701. doi:10.1016/j.jand.2013.03.001
133. Jung AP, Bishop PA, Al-Nawwas A, Dale RB. Influence of hydration and electrolyte supplementation on incidence and time to onset of exercise-associated muscle cramps. *J Athl Train*. 2005;40(2):71-75.
134. Hammond N, Wang Y, Dimachkie MM, Barohn RJ. Nutritional neuropathies. *Neurol Clin*. 2013;31(2):477-489. doi:10.1016/j.ncl.2013.02.002
135. Dorfman L. International Affiliate of the Academy of Nutrition and Dietetics. https://eatrightinternational.org/2018/01/09/interview-with-laurene-boateng-ghana-country-representative-copy/. Accessed February 28, 2020.
136. Academy of Nutrition and Dietetics. 5 Steps to Become a Registered Deititian Nutritionist. https://www.eatrightpro.org/about-us/become-an-rdn-or-dtr/high-school-students/5-steps-to-become-a-registered-dietitian-nutritionist. Accessed April 23, 2022.
137. University of Health and Allied Sciences. https://www.uhas.edu.gh/en/. Published 2020. Accessed February 27, 2020.
138. Kwame Nkrumah University of Science and Technology. https://www.knust.edu.gh/. Published 2019. Accessed February 27, 2020.
139. Mogre V, Stevens FCJ, Aryee PA, Matorwmasen-Akkermans FL, Abubakari B, Scherpbier AJJA. Nutrition Care Practices, Barriers, Competencies and Education in Nutrition: a Survey Among Ghanaian Medical Doctors. *Med Sci Educ*. 2018;28(4):815-824. doi:10.1007/s40670-018-0591-9
140. ACEND. ACEND accreditation standards for nutrition and dietetics coordinated programs (CP). 2017:1-18. www.eatright.org/ACEND.
141. Stankorb S, Rigassio-Radler D, Hafiz K, Touger-Decker R. The Professional Practices of Nutrition Focused Physical Examination among Registered Dietitians. *J Am Diet Assoc*. 2009;109(9):A9.
142. Tyler C. *Incorporating Simulations of the Nutrition-Focused Physical Exam into Graduate-Level Dietetics Curriculum*.
143. Desjardins S, Brody R, Tougher-Decker R. Nutrition-Focused Physical Examination Practices of Registered Dietitian Nutritionists Who Have Completed an In-Person NFPE Course. *Top Clin Nutr*. 2018;33(2):95-105.
144. University of Ghana. Department of Nutrition and Dietetics. https://www.ug.edu.gh/nutrition-dietetics/courses. Accessed March 8, 2020.

145. Zeola S. Exploring the Impact of a Nutrition Support Workshop for Ghanaian Nutrition Professionals. 2020.
146. Alsoufi A, Alsuyihili A, Id AM, et al. Impact of the COVID-19 pandemic on medical education : Medical students ' knowledge , attitudes , and practices regarding electronic learning. 2020:1-20. doi:10.1371/journal.pone.0242905
147. Ponti R De, Marazzato J, Maresca AM, Rovera F, Carcano G, Ferrario MM. Pre-graduation medical training including virtual reality during COVID-19 pandemic : a report on students ' perception. 2020:1-7.
148. Kovács E, Kállai A, Fritúz G, et al. The efficacy of virtual distance training of intensive therapy and anaesthesiology among fifth-year medical students during the COVID-19 pandemic : a cross-sectional study. 2021:1-10.
149. Stark CM, Graham-kiefer ML, Devine CM, Dollahite JS, Olson CM. Online Course Increases Nutrition Professionals ' Knowledge , Skills , and Self-Efficacy in Using an Ecological Approach to Prevent Childhood Obesity. 2011;43(5):316-322. doi:10.1016/j.jneb.2011.01.010
150. Yamey G. Scaling up Global Health Interventions: A Proposed Framework for Success. *PLoS One*. 2011;8(6):1-5.
151. Peters D, Tran D, Adam T. *Implementation Research in Health: A Practical Guide*.; 2013.
152. Dearing J. Applying Diffusion of Innovation Theory to Intervention Development. *Res Soc Work Pract*. 2009;19(5):503-518.
153. LaMorte W. Diffusion of Innovation Theory. Boston University School of Public Health. http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories4.html. Accessed February 20, 2020.
154. Thurber M, Fahey J. Adoption of Moringa oleifera to combat under-nutrition viewed through the lens of the "Diffusion of innovations" theory. *Ecol Food Nutr*. 2009;48(3):212-225.
155. Contento I. Nutrition education : Linking research, theory, and practice. *Asia Pac J Clin Nutr*. 2008;17(Suppl 1):176-179.
156. Torre DM, Daley BJ, Sebastian JL, Elnicki DM. Overview of Current Learning Theories for Medical Educators. *Am J Med*. 2006;119(10):903-907. doi:10.1016/j.amjmed.2006.06.037
157. Bandura A. Social Cognitive Theory: An Agentic Perspective. *Annu Rev Psychol*. 2001;52:1-26.
158. Lu AH, Dollahite J. Assessment of dietitians' nutrition counselling self-efficacy and its positive relationship with reported skill usage. *J Hum Nutr Diet*. 2010;23(2):144-153. doi:10.1111/j.1365-277X.2009.01024.x
159. Chen J, Allman-Farinelli M. Impact of Training and Integration of Apps Into Dietetic Practice on Dietitians' Self-Efficacy With Using Mobile Health Apps and Patient Satisfaction. *J Med Internet Res*. 2019;7(3):e12349.
160. Ochieng PA. an Analysis of the Strengths and Limitation of Qualitative and Quantitative Research Paradigms. *Probl Educ 21st Century*. 2009;13:1-18. http://www.scientiasocialis.lt/pec/node/files/pdf/Atieno_Vol.13.pdf.
161. Choy LT. The Strengths and Weaknesses of Research Methodology: Comparison and Complimentary between Qualitative and Quantitative Approaches. *IOSR J Humanit Soc Sci*. 2014;19(4):99-104. doi:10.9790/0837-194399104

162. Kim M, Mallory C. *Statistics for Evidence-Based Practice in Nursing*. Second edi. Burlington, MA: Jones & Bartlett Learning, LLC; 2017.
163. Rosenthal M. Qualitative research methods : Why , when , and how to conduct interviews and focus groups in pharmacy research. *Curr Pharm Teach Learn*. 2016;8(4):509-516. doi:10.1016/j.cptl.2016.03.021
164. Saunders B, Sim J, Kingstone T, et al. Saturation in qualitative research: exploring its conceptualization and operationalization. *Qual Quant*. 2018;52(4):1893-1907. doi:10.1007/s11135-017-0574-8
165. Vasileiou K, Barnett J, Thorpe S, Young T. Characterising and justifying sample size sufficiency in interview-based studies: Systematic analysis of qualitative health research over a 15-year period. *BMC Med Res Methodol*. 2018;18(1):1-18. doi:10.1186/s12874-018-0594-7
166. Mason M. Sample Size and Saturation in PhD Studies Using Qualitative Interviews. *Forum Qual Soc Res*. 2010;11(3).
167. Connor CO, Joffe H. Intercoder Reliability in Qualitative Research : Debates and Practical Guidelines. 2020;19:1-13. doi:10.1177/1609406919899220

Appendix A: Workshop Flyer

University of Ghana in Conjunction with the University of North Florida presents
Continuous Professional Development for Dietetic and Nutrition Professionals

Date: 21-22th January, 2021
Time: 3pm GMT each day
Venue: Via Zoom

Leah Qubty, RDN, MS
Doctorate of Clinical Nutrition Student
University of North Florida

Dr. Andrea Arikawa, PhD, MPH, RDN, LDN, FAND
Associate Professor
University of North Florida

Dr. Freda Intiful, PhD, RD
Senior Lecturer
University of Ghana

Dr. Lauri Wright, PhD, RDN, LDN, FAND
Associate Professor
University of North Florida

Registration Information:

- The registration deadline is January 8th, 2021
- The course is accredited by the Allied Health Professions Council
- Registration by the registration deadline will allow us to provide you with a data card that will cover the data cost of webinar participation
- Participation in the webinar is free of charge

Appendix B: Pretest

Pretest

1. Project Title: A Two-Day Webinar on the Micronutrient-Directed Nutrition-Focused Physical Exam for Ghanaian Dietitians: Examining Dietitian-Perceived Self-Efficacy and Innovation

You are invited to take part in a research project being conducted by Leah Qubty, a doctorate of clinical nutrition student at the University of North Florida. Participation in the research project involves taking a pretest, participating in a webinar, participating in an online focus group, and taking a posttest. You are not required to fill out the informed consent form if you are not interested in earning continuing professional development credits. Therefore, participation in the study is not required to participate in the webinar. The information in this form is provided to help you decide whether or not to take part. If you decide to take part in the project, you will be asked to agree to this consent form. Participation is voluntary and if you decide you do not want to participate, there will be no penalty to you. You may choose to withdraw from the program at any time without penalty.

In order to participate in this program, you must be 18 years of age or older.

Leah Qubty, principal investigator, leahqubty@gmail.com or +1218-428-4090.

Why is this project being done?
In conjunction with the University of Ghana, we are conducting a two-day webinar on utilizing the nutrition-focused physical exam (NFPE) to identify micronutrient deficiencies. As part of the webinar, we will be assessing nutrition professionals' perceptions of using the NFPE to identify micronutrient deficiencies in Ghana. The information you share with me will be used to design training programs on this topic in the future.

What is the format of the webinar?
You have the option to participate in this webinar synchronously (occurring in real-time) and asynchronously (available at any time). The format for each is outlined below:

<u>Synchronous (real-time)</u>
Day 1: 2.5-hour zoom webinar with 30 minutes for interactive questions
Day 2: 2-hour focus group discussion on the zoom meeting platform

<u>Asynchronous (available at any time)</u>
2.5-hour pre-recorded zoom webinar

Why am I being asked to participate in this project?
You are being asked to participate in this project because you are a nutrition professional in Ghana.

How many people will be asked to be in this project?

200-250 Ghanaian nutrition professionals.

What will I be asked to do in this project?
You will first be asked to take a pretest. Then, you will be asked to participate in a 3-hour webinar. Next, you will be asked to participate in a 2-hour online focus group. Lastly, you will be asked to take a post test. If you participate in the asynchronous version of the webinar, you will not be asked to participate in the focus group portion of the research project. The focus groups will be further outlined below.

Are there any risks to me?
There are no foreseeable risks associated with study participation. If you take part in this project, you will be asked questions about your comfort level using the NFPE to identify micronutrient deficiencies, NFPE practices in your workplace, and perceived barriers and facilitators to using the NFPE to identify micronutrient deficiencies in your workplace. You do not have to answer anything you do not want to. We expect that it will take about 30 minutes of your time to complete the pre-test and post-test, and about two hours to participate in the focus group. Your responses will be anonymous. Only authorized personnel will have access to your responses.

Are there any benefits to me?
Although there are no direct benefits to or compensation for taking part in this study, others may benefit from the information we learn from the results of this study.

Will there be any costs to me?
Aside from your time, and the internet data used to participate, there are no costs for taking part in the project.

Will I be paid to take part in this project?
You will not be paid for participating in this project.

Will information from this project be kept private?
We will not be gathering any information that will identify you or link your name to anything. We are only asking for your electronic agreement and you are not asked to sign this form so that your name will not be linked and therefore maintain your confidentiality.

The webinar will take place over zoom. To send you the zoom link, we need your email address. To protect your privacy, you are welcome to create an email address to only be used in this project. Both the webinar (day 1) and focus groups (day 2) will take place on the zoom meeting platform. On both days, you are encouraged to change your name to a pseudonym to protect your privacy. You also have the option to turn off your video. You are able change your name to a pseudonym and turn off your video before joining the webinar. Day 1 of the synchronous version of the webinar will be recorded for use for those participating in the asynchronous version.

On day two of the webinar, you will be asked to participate in a focus group during which you will be asked about your perceptions of using the NFPE to identify micronutrient deficiencies. Although you have the option to use a pseudonym and turn off your video, confidentiality cannot be guaranteed in a focus group. We ask that you respect the privacy of other focus group

members by not sharing participants' identities or responses with others outside of the focus group to maintain anonymity.

The records of this program will be kept private. No identifiers linking you to this program will be included in any sort of report that might be published, unless with your consent. Research records will be stored securely and only research personnel will have access to the records. This consent form will be stored online and password protected. People who have access to your information include the Principal Investigator and research program personnel.

Who may I contact for more information?
You may contact the Principal Investigator, Leah Qubty, to tell her about a concern or complaint about this research at leahqubty@gmail.com or +1218-428-4090.

For questions about your rights as a research participant, to provide input regarding research, or if you have questions, complaints, or concerns about the research, you may call the UNF IRB by phone at +1904-620-2455 or by email at IRB@unf.edu.

What if I change my mind about participating?
Your participation in this project is voluntary, and you have the choice of whether or not to participate in this project. You may decide to not begin or to stop participating at any time. If you choose not to participate in this project, or stop participating in this project, there will be no effect.

The PI of this program can terminate the program under certain circumstances. If there are reported issues from participants that are harmful, the program will be terminated immediately. Any other concerns will be reviewed prior to decide if the program shall continue or terminate.

STATEMENT OF CONSENT
I agree to participate in this project and know that I am not giving up any legal rights by agreeing to this form. The procedures, risks, and benefits have been explained to me, and my questions have been answered. I can ask more questions if I want. I have read the agreement to the above consent and I acknowledge that I have read this document. By clicking "continue" below, I am agreeing to participate or in this study.

◯ Checking this box will be considered your electronic agreement to participate

2. What is your preferred network for data bundle?

This information will be used to provide you with a data card to cover the cost of participation in the webinar.

◯ MTN
◯ TIGO/AIRTEL
◯ VODAFONE
◯ GLO
◯ OTHER

3. If you chose “other” above, please list your data bundle below:

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4. Are you a Registered Dietitian?

◯ Yes
◯ No

5. If you answered yes to the previous question, how many years have you been practicing as a Registered Dietitian?

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6. Are you a Registered Nutritionist?

◯ Yes
◯ No

7. If you answered yes to the previous question, how many years have you been practicing as a Registered Nutritionist?

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8. What is your highest level of nutrition education:

◯ Undergraduate (BsC)
◯ Postgraduate (MSc/MPhil/PhD)

9. Which term best describes your place of practice:

◯ Private
◯ Public/Government
◯ Freelance

Please choose one response to each statement below

10. The nutrition focused physical exam (NFPE) can be used to detect signs and symptoms of micronutrient deficiencies (MNDs).

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

11. I have adequate time during my work day to incorporate the NFPE into practice.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

12. MNDs that are common in the U.S. can be detected by using the NFPE.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

13. I have adequate resources at work to incorporate the NFPE into practice.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

14. Using the NFPE to detect signs and symptoms of MNDs is challenging.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

15. Identification of MNDs using the NFPE and subsequent treatment of MNDs promotes positive clinical outcomes.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

16. The complexity of the NFPE will limit my use of the NFPE to detect MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

17. MNDs are common in my workplace, and utilizing the NFPE will help me better identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

18. Certain components of the NFPE seem too complex for routine use in my work setting to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

19. Using the NFPE to identify MNDs is safe, and is associated with few risks.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

20. I feel adequately trained to conduct the NFPE to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

21. Using the NFPE to detect signs and symptoms of MNDs is especially relevant in settings where medical infrastructure is lacking.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

22. I predict that using the NFPE to identify MNDs will be associated with risks in my workplace.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

23. I feel confident in my ability to conduct the NFPE to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

24. Using the NFPE to detect signs and symptoms of MNDs is especially relevant in the setting of inflammation when the accuracy of biochemical markers of nutrition status may be compromised.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

25. Potential risks associated with use of the NFPE in my workplace will limit my use of the NFPE to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

26. I feel comfortable with the aspects of the NFPE that require me to touch the patient.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

27. Using the NFPE to detect signs and symptoms of MNDs is especially relevant when cost prohibits the use of biochemical markers of nutrition status.

1. Strongly disagree

2. Disagree
3. Neutral
4. Agree
5. Strongly agree

Appendix C: Posttest

Posttest

Please choose one response to each statement below

1. The nutrition focused physical exam (NFPE) can be used to detect signs and symptoms of micronutrient deficiencies (MNDs).

    1. Strongly disagree
    2. Disagree
    3. Neutral
    4. Agree
    5. Strongly agree

2. I have adequate time during my work day to incorporate the NFPE into practice.

    1. Strongly disagree
    2. Disagree
    3. Neutral
    4. Agree
    5. Strongly agree

3. MNDs that are common in the U.S. can be detected by using the NFPE.

    1. Strongly disagree
    2. Disagree
    3. Neutral
    4. Agree
    5. Strongly agree

4. I have adequate resources at work to incorporate the NFPE into practice.

    1. Strongly disagree
    2. Disagree
    3. Neutral
    4. Agree
    5. Strongly agree

5. Using the NFPE to detect signs and symptoms of MNDs is challenging.

    1. Strongly disagree
    2. Disagree
    3. Neutral
    4. Agree
    5. Strongly agree

6. Identification of MNDs using the NFPE and subsequent treatment of MNDs promotes positive clinical outcomes.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

7. The complexity of the NFPE will limit my use of the NFPE to detect MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

8. MNDs are common in my workplace, and utilizing the NFPE will help me better identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

9. Certain components of the NFPE seem too complex for routine use in my work setting to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

10. Using the NFPE to identify MNDs is safe, and is associated with few risks.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

11. I feel adequately trained to conduct the NFPE to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

12. Using the NFPE to detect signs and symptoms of MNDs is especially relevant in settings where medical infrastructure is lacking.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

13. I predict that using the NFPE to identify MNDs will be associated with risks in my workplace.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

14. I feel confident in my ability to conduct the NFPE to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

15. Using the NFPE to detect signs and symptoms of MNDs is especially relevant in the setting of inflammation when the accuracy of biochemical markers of nutrition status may be compromised.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

16. Potential risks associated with use of the NFPE in my workplace will limit my use of the NFPE to identify MNDs.

1. Strongly disagree

2. Disagree
3. Neutral
4. Agree
5. Strongly agree

17. I feel comfortable with the aspects of the NFPE that require me to touch the patient.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

18. Using the NFPE to detect signs and symptoms of MNDs is especially relevant when cost prohibits the use of biochemical markers of nutrition status.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

Appendix D: Test Questions Outlined by Theoretical Construct

Construct-Specific Questions Highlighted on Pre/Posttest

Please choose one response to each question below by using the bold function.

1. The nutrition focused physical exam (NFPE) can be used to detect signs and symptoms of micronutrient deficiencies (MNDs).

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

2. I have adequate time during my work day to incorporate the NFPE into practice.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

3. MNDs that are common in the U.S. can be detected by using the NFPE.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

4. I have adequate resources at work to incorporate the NFPE into practice.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

5. Using the NFPE to detect signs and symptoms of MNDs is challenging.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree

5. Strongly agree

6. Identification of MNDs using the NFPE and subsequent treatment of MNDs promotes positive clinical outcomes.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

7. The complexity of the NFPE will limit my use of the NFPE to detect MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

8. MNDs are common in my workplace, and utilizing the NFPE will help me better identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

9. Certain components of the NFPE seem too complex for routine use in my work setting to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

10. Using the NFPE to identify MNDs is safe, and is associated with few risks.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

11. I feel adequately trained to conduct the NFPE to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

12. Using the NFPE to detect signs and symptoms of MNDs is especially relevant in settings where medical infrastructure is lacking.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

13. I predict that using the NFPE to identify MNDs will be associated with risks in my workplace.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

14. I feel confident in my ability to conduct the NFPE to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

15. Using the NFPE to detect signs and symptoms of MNDs is especially relevant in the setting of inflammation when the accuracy of biochemical markers of nutrition status may be compromised.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

16. Potential risks associated with use of the NFPE in my workplace will limit my use of the NFPE to identify MNDs.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

17. I feel comfortable with the aspects of the NFPE that require me to touch the patient.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

18. Using the NFPE to detect signs and symptoms of MNDs is especially relevant when cost prohibits the use of biochemical markers of nutrition status.

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

Construct Key:

Observability (1)= Purple

Compatibility (2)=Blue

Complexity (3) =Green

Trialability (4) =Yellow

Self-Efficacy (5) =Grey

Relative Advantage (6)= Red

Appendix E: Focus Group Guide

Focus Group Guide

Introduction

Thank you for taking the time to meet with us today. My name is Leah Qubty. I'm a Registered Dietitian and current Doctorate of Clinical Nutrition student at the University of North Florida (Feel free to introduce yourself and your professional role here). As part of this project, we are gathering qualitative data to assess nutrition professionals' perceptions of using the nutrition-focused physical exam (NFPE) to identify micronutrient deficiencies. The purpose of this break out room is to encourage open discussion about use of the NFPE in various settings in Ghana. We'll be in this breakout room for about 45 minutes, and when we rejoin the large group a spokesperson from each breakout room will share highlights from their group discussion. Would someone like to be the spokesperson for our group? Great thank you.

Does anyone have any questions before we start? Ok, let's get started.

Opening Question

1. Let's start by having you describe how common micronutrient deficiencies are among your client or patient population.

Introductory Question

2. Please discuss how micronutrient deficiencies are identified in your workplace.

Transition Question

3. Now that we've discussed how common micronutrient deficiencies are in your workplace and how they are identified, let's begin discussing the role of the NFPE in identifying micronutrient deficiencies. How do you foresee the NFPE fitting into current practices?

Key Questions

4. Please share your thoughts on the role of the NFPE in identifying micronutrient deficiencies in your workplace.

5. Do you think there may be anything that limits use of the NFPE to identify micronutrient deficiencies in your workplace?

- If an affirmative answer is given, follow up with: if so, what might that/those be?

6. Do you think there may be anything that makes it easier to use the NFPE to identify micronutrient deficiencies in your workplace?

- If an affirmative answer is given, follow up with: if so, what might that/those be?

7. How do you feel this webinar has impacted your view of using the NFPE to identify micronutrient deficiencies in your workplace?

8. How do you feel this webinar has impacted your confidence or comfort level with using the NFPE to identify micronutrient deficiencies in your workplace?

Closing Question

9. On the topic of using the NFPE to identify micronutrient deficiencies in Ghana, is there anything else you would like to add?

Closing Remarks

Thank you for your participation. We'll rejoin the large group now, where a spokesperson from each group will take 2-3 minutes to share key points from our discussion with the large group. I believe_____ volunteered as our spokesperson, is that correct? Now, we'll return to the large group setting for discussion and concluding remarks.

Note to focus group leaders: If there is extra time at the end of the discussion, here are some suggestions:

1. Revisit former questions that you feel that might encourage further discussion i.e. "it seemed like there was a lot of good discussion happening when we were talking about things that might help remove barriers to using the NFPE in the community setting. Now that we've finished our discussion, did anything else come to mind for anyone about this?"

2. Ask the participants what they thought of the online webinar format. Are there things we could have done better? Are there things that they appreciated?

3. Discuss how the current COVID-19 pandemic might impact use of the NFPE to identify micronutrient deficiencies.

Appendix F: Qualitative Data Codebook

Qualitative Data Codebook

Code	Type	Description	Example from Data	Highlight color used to identify code in the transcript
Micronutrient Deficiencies	Deductive	The participant mentions deficiencies occur in the participants' workplace or discusses which micronutrient deficiencies occur in the participants' workplace	"So I think most of the micronutrient deficiencies will be iron."	Color
Laboratory tests	Deductive	The participant mentions that biochemical markers of nutrition status (laboratory tests) are used to identify micronutrient deficiencies	"So normally, when someone comes to the hospital in Ghana, it's a baseline—they do a baseline test, they kind of like run tests. And through that, you are able to pick out what has fallen below the normal range, and all that. So, when a patient comes to, for example, myself for consultation I would look out for the labs first."	Color
Community Application	Deductive	The NFPE is relied on in the community setting to identify micronutrient deficiencies, or the participant mentions that it might have high utility in the community/rural setting to identify MNDs	"When it comes to detecting micronutrient deficiencies and less commonly detected in the urban hospital setting and more commonly detected in the rural setting. In fact, one of our group members is doing a form of a nutrition focus physical exam now. A short form where she's checking for physical signs of Vitamin	Color

			A deficiency and iron deficiency."	
Compatibility	Deductive	The participant speaks to how compatible or incompatible using the NFPE to identify micronutrient deficiencies is with their work life.	"And then barriers. There were three that came up, one in the hospital settings is that RD to patient ratio."	Color
Trialability	Deductive	Participants indicate current use or intended future use of NFPE in clinical practice (indicates trialability).	"We can work on it because it's a vital tool, and we are ready to use it, and as I heard from one of our other groups: are we using it already? Yes, to a lesser extent, because it's not a conscious effort."	Color
Relative Advantage	Deductive	The participant speaks to whether using the NFPE to identify micronutrient deficiencies will or will not be advantageous in some way to alternative forms of micronutrient assessment (i.e. using biochemical markers of micronutrient status, or not assessing micronutrient status).	"And also, it's costly to do labs so even in terms of monitoring your patient, if the patient has the initial labs or baseline labs, what are you going to do when the patient can't afford to continually do the labs for you to monitor. So then our NFPE plays a very vital role in the absence of our labs, and then we are able to monitor or screen."	Color
Observability	Deductive	The participant speaks to whether using the NFPE to identify micronutrient deficiencies in their workplace will yield observable results	"And then, the impact of this webinar on our view of using the NFPE. It was awesome for us, it has opened our eyes to possibilities, because we think we all agree that we're not using it as much as we should, because it opens doors to actually doing very good assessments, and we could maximize our assessments of the patient using these	Color

			tools. So, we are all for it."	
Complexity	Deductive	The participant speaks to how complex or challenging using the NFPE to identify micronutrient deficiencies is	"We got into conversations about training of how to approach someone because it is a skill that we're not always comfortable with"	Color
Knowledge	Deductive	This webinar improved the knowledge of the participant in regards to using the NFPE to identify micronutrient deficiencies.	"Even if we knew something earlier about the NFPE in terms of assessing patients using this tool, of course it's always good to learn something new. And we learned so much."	Color (underlined)
Feelings of self-efficacy	Deductive	This webinar increased the confidence (feelings of self-efficacy) of the participant in conducting the NFPE to identify micronutrient deficiencies.	"And the presentation, boosted their confidence in applying NFPE."	Color (underlined)
Dietetics leader influence	Inductive	Leaders in the Ghanaian dietetics community influence the use of the NFPE by the Ghanaian dietetics community.	"So the ways in which we thought we could overcome that barrier is if it could be incorporated more into the didactic program, um so that we get more practical training on how to use it."	Color (underlined)
Cultural leader influence	Inductive	Leaders in the Ghanaian culture influence the use of some type of physical exam to assess health status.	"So my group, we had a very nice discussion about the use of the NFPE in determining micronutrient deficiencies. And we realized that it's been used. In our setting, mostly our grandmothers—when a lady is pregnant—they will look around the eyes and the eyelids in order to check if she's pregnant. The main use is in order	Color (underlined)

			to detect pregnancy—that's according to our grandmothers. But mostly that shows if the lady is pregnant or not. So, in a way, it's being used by our grandmothers and other people."	
Religious or cultural barriers	Inductive	Religious or cultural practices are a barrier for the nutrition professional to use the NFPE to identify micronutrient deficiencies in practice.	"He couldn't even touch some of his clients, due to religious reasons because they came in gowned from head to toe, you can't even see the skin."	Color (underlined)
COVID	Deductive	COVID is a barrier to using the NFPE to identify micronutrient deficiencies due to social/physical distancing and/or telehealth services.	"So, we are in an era where touching people—getting close to someone, may be a challenge because of social or physical distancing."	Color (underlined)

Appendix G: IRB Approval Letter

UNF
UNIVERSITY of NORTH FLORIDA.

Office of Research and Sponsored Programs
1 UNF Drive
Jacksonville, FL 32224-2665
904-620-2455 FAX 904-620-2457
Equal Opportunity/Equal Access/Affirmative Action Institution

MEMORANDUM

UNF IRB Number: 1643132-1
Exemption Date: 10-26-2020
Processed on behalf of UNF's IRB EE-B

DATE: October 26, 2020

TO: Ms. Leah Qubty

VIA: Dr. Lauri Wright
Nutrition & Dietetics

FROM: Dr. Jennifer Wesely, Chairperson
On behalf of the UNF Institutional Review Board

RE: Declaration of Exempt Status for IRB#1643132-1
"A Two-Day Webinar on the Micronutrient-Directed Nutrition-Focused Physical Exam for Ghanaian Dietitians: Examining Dietitian-Perceived Self-Efficacy and Innovation"

Your research study identified above was reviewed on behalf of the UNF Institutional Review Board has been declared "Exempt" under category 2. A "limited IRB review" was conducted to confirm the safeguards in place are sufficient to protect subjects' privacy and to maintain confidentiality of the data.

Please be advised that any subject complaints, unanticipated problems, or adverse events that occur are to be reported to the IRB as soon as practicable, but no later than 3 business days following the occurrence. Please use the Event Report Form to submit information about such events.

While the exempt status is effective for the life of the study, any substantive changes must be submitted to the IRB for prospective review. In some circumstances, changes to the protocol may result in alteration of the IRB review classification.

To submit an amendment to your exempt protocol, please complete an Amendment Request Document and upload it along with any updated materials affected by the changes via a new package in IRBNet. For additional guidance on submitting an amendment, please contact the IRB administrator.

Upon completion of this study, please submit a Closing Report Form as a new package in IRBNet. Please maintain copies of all research-related materials for a minimum of 3 years following study closure. These records include the IRB-approved protocol, approval memo, questionnaires, survey instruments, consent forms, and all IRB correspondence.

Should you have questions regarding your study or any other IRB issues, please contact the Research Integrity unit of the Office of Research and Sponsored Programs by emailing IRB@unf.edu or calling (904) 620-2455.