A COMPARISON OF THE ATTITUDES, BELIEFS, AND KNOWLEDGE OF NUTRIGENOMICS BETWEEN DIETETIC STUDENTS IN THE USA AND MEXICO

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DEDICATION

For my mother, Linda Hartwig, who was my greatest cheerleader and friend.
I will miss you always.

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ABSTRACT

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A COMPARISON OF THE ATTITUDES, BELIEFS, AND KNOWLEDGE OF NUTRIGENOMICS BETWEEN DIETETIC STUDENTS IN THE USA AND MEXICO

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The purpose of this study was to compare nutrition/dietetic students from Texas Woman's University (TWU) and Universidad Autónoma de Nuevo León (UANL) in respect to their perceived need, interest, and knowledge of different topics within nutritional genomics. A nutritional genomics survey was administered to students at UANL and compared to students at TWU that had taken the survey as part of a previous study. The data was analyzed using chi-square test of homogeneity and Fisher's exact test. The results showed that students from TWU and UANL differed from each other in their knowledge level, desire to learn more, and perceived need for 'omic' technologies. Both TWU and UANL students lack a high level of knowledge about different 'omic' topics but recognize the important role that 'omics' will play in their future careers as dietitians.

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CHAPTER I

INTRODUCTION

Food has long been recognized as a significant predictor and mediator of human health. Hippocrates, considered the father of medicine, famously stated “Let food be thy medicine and medicine be thy food.” Many diseases that have plagued mankind in the recent past had their origins in poor nutrition. Scurvy, first reported in the Papyrus of Ebers (1550 BC), was known to sailors as the “curse of the mouth” and was associated with exhaustion, spontaneous bleeding, and muscle pain [1]. It was noted in that papyrus that onions and vegetables could be used to treat it. However, it was not understood until the discovery of vitamin C that scurvy was a disease caused by vitamin C deficiency. Similarly, berberi is a disease characterized with memory problems, poor muscle function, tingling in the hands and feet, and paralysis. The discovery of thiamin greatly reduced the incidence of this disease, which was caused by thiamin deficiency [2-3]. With the discovery of vitamins and their functions in the human body, the concept of nutrition as a treatment for disease gained ascendance. Unfortunately, over time it was noted that there were variations in how individuals responded to different foods and vitamins. Thus, the concept of “let food be thy medicine” fell to the wayside until the discovery of DNA and its sequencing [4].

With the completion of the Human Genome Project in 2001, personalized nutrition is rapidly becoming a possibility through the explosion of knowledge brought about through the study of genetics, genomics, and other 'omic' disciplines. 'Omic' technologies use a global, systematic approach to examine the molecules of cell, tissue, or organism, defining its functionality. Their purpose is to investigate these molecules within a biological system in a non-biased and non-targeted manner through comprehensive, hypothesis-generating studies [5]. These 'omic' technologies are used in nutritional science to search for diet-gene interactions and to propose possible mechanisms through which those interactions work. Nutritional genomics is an umbrella term comprising nutrigenetics, nutrigenomics, and nutritional epigenomics [6-7]. Other 'omics' technologies currently seen in nutritional science include transcriptomics, proteomics, metabolomics, lipidomics, foodomics, and metagenomics [5-6,8].

The emergence of genetic and 'omic' technologies has driven consumers to seek data about their own genome through direct-to-consumer (DTC) genetic testing services. These companies promise, for a fee, to analyze the consumer's genetic information for susceptibilities for disease and propose lifestyle modifications and personalized nutrition advice tailored to reduce the consumer's disease risk [9]. These companies can also prey on the consumer, selling them supplements at exorbitant prices to mitigate their genetic risk. This is a serious problem for several reasons. First, diagnosing disease or disease-risk is the purview of the physician. DTC companies are not qualified to speak to a patient's genetic risk for a disease and offer lifestyle modifications to treat that risk.

Second, offering personalized nutrition advice is the purview of the registered dietitian, who has the training in nutritional science and medical nutrition therapy necessary to address nutrition concerns in health or disease.

An interesting conundrum appears, however, when considering who will offer personalized nutrition based on genetics to treat disease or disease risk. Physicians, nurses, and members of the allied healthcare team generally lack training in both genetics and nutrition. For most, nutrition and genetics fall outside their scope of practice. The registered dietitian is weak in genetics, but strong in nutritional science. Therefore, it follows that this role in the future will fall to the registered dietitian. Since most registered dietitians are weak in genetics, it will be necessary to train current registered dietitians and dietetic students in these new ‘omic’ technologies for their emerging role within the healthcare team.

CHAPTER II

REVIEW OF LITERATURE

CURRENT STATE OF GENETIC KNOWLEDGE AMONG HEALTH PROFESSIONALS AND STUDENTS

Health professionals routinely manage patients with complex diseases, such as diabetes and cardiovascular disease. These diseases generally have genetic (epigenetic) and lifestyle components in their manifestation, yet most of these professionals lack formal education in nutritional genomics and genetics in general [1]. Many of them already perform genetic-related services when they obtain a historical, familial record of disease from the patient and discuss the ramifications of those diseases with them. Unfortunately, many health care professionals do not feel confident in their knowledge or ability to discuss genetics with their patients [2]. This lack of knowledge represents a major barrier to offering nutrigenomic services to the public.

Physicians

It is now imperative that physicians have or acquire a basic knowledge of genetics and understand how to apply these concepts within their scope of clinical practice [2]. Physicians that have not acquired competencies in genetic knowledge put their patients at risk of not receiving the best available standard of care and open themselves up to malpractice lawsuits [3]. Additionally, studies have shown that patients will approach their primary care physician initially for information regarding a genetic-related concern and that primary care physicians are highly interested in receiving more education in genetics [4]. In a systematic review of the barriers facing primary care physicians in offering genetic services, Suther and Goodson identified lack of genetic knowledge as the primary barrier to offering those services, followed by a deficient family history, a scarcity of referral guidelines, and lack of confidence [5]. Baars and associates also pointed to the lack of genetic knowledge in general practitioners, pediatricians, and gynecologists as a worldwide problem and cited the number of years since the physician graduated from medical school as a key factor tied to a lower genetic knowledge score [6].

Nursing

Genetic education in the nursing profession is not adequate to ensure that an appropriate standard of care is being met. A systematic review by Burke and Kirk revealed that there are widespread deficiencies in genetic education among nurses and midwives and that these professionals have low confidence levels in their ability to provide genetic-related services [7]. The delivery of genetic education to nurses is sporadic and weak across different countries, including the United States and the United Kingdom. In a review by Kirk, Tonkin, and Skirton, the authors mentioned one of their previous studies that examined the confidence level of nurses providing genetic education in the United Kingdom across seven different competencies [8]. The highest level of confidence among all the competencies was only 48%, while those who expressed that they were “not at all competent” ranged from 13-63%. In a recent review by Barr et al., it was found that current education levels were still not adequate, that there was a need for continued education, and that there is uncertainty about what the genetic scope of practice for nurses should be in the future [9].

Dietitians

Lack of genetic knowledge is not limited to primary care physicians or nurses. In 1998, the Human Genome Education Model Project surveyed dietitians, psychologists, social workers, speech-language-hearing specialists, occupational therapists and physical therapists to identify the outcomes of genetics education on the clinician’s confidence level in providing genetic services [10]. In this survey, Lapham et al. found that 70% of allied health professionals conversed with their clients about the genetic components of their health issues and 30% provided counseling regarding genetic concerns. The study found that the more education that a clinician had in genetics, the more confident they were in providing genetic services.

In a follow-up study to the Human Genome Education Model Project, Gilbride and Camp surveyed dietitians to determine their knowledge of the human genome project and identify the educational needs of dietitians regarding genetics [11]. Gilbride and Camp found that more than a third of respondents had no genetics education at all in their dietetics training and that only 45% had some genetics content in their coursework.

Continuing education options were even less utilized by dietitians, with only 12.9% attending a workshop or seminar on human genetics. Most of the respondents (87.1%) had not attended a non-credit course, workshop, or seminar in genetics. Many of these dietitians, however, discussed the genetic features of a disease with their clients (67.7%) and/or provided advice on genetic concerns (24.1%).

Other Allied Health Professionals

Christianson, McWalter, and Warren conducted a study to discover how prepared graduates from a midwestern college of allied health sciences were when they entered their field of choice to provide genetic-related services [12]. The specialties that were evaluated included speech-language pathology, physical therapy, audiology, nutrition sciences, dietetics, advanced medical imaging technology and clinical laboratory services. Christianson, McWalter, and Warren created a survey by combining the HuGEM survey with questions from the National Coalition of Health Professional Education in Genetics guidelines. Respondents were asked which genetic-related services they performed. Eliciting the family history of disease from a client was the most commonly performed genetic-related service in communication sciences and disorders (73%), nutrition education and dietetics (63%), and physical therapy programs (44%). Less commonly performed genetic services included discussing a genetic basis of a condition, identifying patients with a genetic condition, or referring patients to genetic counseling. Between 77% and 88% of respondents had a low level of confidence in their aptitude to perform genetic-related services except to elicit a genetic family history.

Ultimately, the study found that the subjects' confidence was based on their training and the number of years of experience they had.

In a qualitative study by Weir, Morin, Ries, and Castle, healthcare professionals were invited to participate in focus groups discussing direct-to-consumer testing and their knowledge, attitudes and perception of nutritional genomics [13]. These groups were composed of pharmacists, physicians, dietitians, naturopaths, and nutritionists. These professionals felt that they had a lack of competency in nutritional genomics and raised concerns that nutritional genomics, as an emerging field, did not have a strong evidence base. The participants also expressed concern that nutrigenomic tests were sold to consumers without a health care professional acting as an intermediary to interpret results, even as they admitted that they were not confident in their own ability to interpret those results.

CURRENT STATE OF NUTRITION KNOWLEDGE AMONG HEALTH PROFESSIONALS AND STUDENTS

Many healthcare professionals do not feel confident in their ability to provide genetic-related services due to lack of education and experience. Unfortunately, these same professionals are also deficient in nutrition knowledge and counseling skills, making it difficult for them to provide services in nutritional genomics.

Physicians

Most physicians lack training and knowledge in providing nutrition-related services. It is recommended by the National Academy of Sciences that medical schools provide at least 25 hours of nutrition education to their students, but most medical schools provide far less than that [14]. In a national survey in 2010 by Adams et al., it was found that while most medical schools require some education in nutrition, only 25% of the schools surveyed required a course in nutrition [15]. The average amount of hours given to nutrition instruction was 19.6, which falls below the 25-hour recommendation from the National Academy of Sciences. It is important to note that this represents a decrease from 2004 when the average amount of education hours was 22.3. Only 27% of the schools surveyed achieved the 25-hour minimum recommended hours. The lack of nutrition education at medical school may directly translate to how doctors interact with their patients in their practice. Eaton and associates studied community family practice physicians and found that nutrition education happened in only 24% of all patient visits and that in these visits the average amount of time spent discussing nutrition was 55 seconds (range: <20 seconds to >6 minutes) [16]. These physicians spent more time discussing nutrition concerns with patients with chronic illnesses, such as diabetes and cardiovascular disease and less time discussing preventative nutrition with their healthy patients.

Physicians and medical students perceive that their education in nutrition is weak, eroding their confidence to provide nutrition-related services. Danek et al. performed a qualitative study at Indiana University School of Medicine to explore medical students', residents', and physicians' experience with nutrition education while attending the university [14]. The perceptions of these students were revealing. The students felt that nutrition was poorly assimilated into their program, noting that most of the nutrition education they received was in basic science courses, that it was weak and almost useless, and that it would not be helpful in their practice. They did not get to view nutrition counseling performed by a physician or registered dietitian during their shadowing experiences and struggled with frustration at not having the nutrition knowledge needed to effectively counsel patients. Physicians in the focus groups candidly admitted that they did not remember receiving any education in providing nutrition counseling at all.

In a similar study by Vetter et al. examining the nutrition knowledge of resident physicians, they found that only 14% of resident physicians felt adequately prepared to offer nutrition counseling to their patients [17]. These residents, when given a nutrition knowledge test, answered only 66% of the questions correctly with particular deficits in nutrition assessment, obesity, cardiovascular nutrition, and endocrine diseases. Many of these interns felt strongly that nutrition assessment should be utilized during primary care visits (77%) and that it was their responsibility to provide these services (94%), but also felt inadequately prepared to discuss nutrition issues with patients (86%).

Nursing

Nursing has a long history of providing nutrition care, starting from its inception, and continuing into the current era [18]. As dietetics evolved into a profession, however, nursing reduced its involvement in providing nutritional services to those under their care. Currently, nurses provide nutrition screening for malnutrition, initiate/monitor enteral and parenteral feeding, and offer nutrition counseling to patients under their care [19]. Reflecting this reduced role in the provision of nutrition, many universities ended the compulsory nutrition coursework requirements. The registration exam for nursing still asks questions about nutrition therapy, enteral and parenteral feeding, and assessment/monitoring [19]. A survey by Stotts et al. evaluating 264 nursing schools found that all programs included nutrition content, but only 54% included a separate nutrition course, which provided 32 ± 21.5 hours of nutrition training [20]. Nutritional biochemistry was taught by only 70% of the programs surveyed [18]. Most of the programs instructed nurses in nutrition assessment, enteral and parenteral feeding, and nutrition assessment [18]. In nursing schools that offer nutrition as a standalone course, nutritional knowledge may still be insufficient in those students that complete it. In a survey of undergraduate nursing students where the majority (92.8%) had completed one standalone nutrition course, Buxton and Davies found that the mean score on a nutrition questionnaire was only 8.95 out of a possible 20 [19].

Mowe et al. found that the primary determinant of poor nutritional practice by physicians and nurses in Denmark, Sweden, and Norway was insufficient nutritional knowledge followed by an absence of interest and lack of responsibility [21]. Mowe et al. reported that 25% of physicians and nurses found it hard to recognize undernourished patients, 53% found it challenging to determine the patient's energy needs, and 40% lacked procedures to determine if a patient was malnourished. The authors of this paper note that this lack of knowledge is commonly seen across hospital settings and is reflective of the low priority that nutrition education has in both Europe and the United States. Similarly, Park et al. assessed the nutrition knowledge of Korean nurses responsible for implementing therapeutic dietary regimens in their hospitals [22]. Park et al. found that these nurses answered only 58.4% of the questions correctly, reflecting limited knowledge and experience in applying nutritional principles to complex issues such as obesity and cardiovascular disease.

Allied health

Allied health professionals are essential providers of nutrition recommendations, but their roles are specialized to their field. Speech-language pathologists, occupational therapists, and physical therapists monitor and treat conditions such as dysphagia and eating disorders, and work to help rehabilitate individuals struggling with the mechanics of eating [18]. However, their scope of practice in nutrition is very specialized and their education does not provide a breadth of nutritional knowledge that would allow them to make nutrition recommendations with confidence. Registered dietitians, however, are food and nutrition experts that have completed at least a bachelor's degree in nutrition/dietetics in a program accredited through the Academy of Nutrition and

Dietetics, finished a 1200-hour supervised internship, and passed the registration exam [18]. They routinely make nutrition assessments, diagnose nutrition-related concerns, and plan nutritional interventions to help their clients. They possess confidence in offering nutrition-related recommendations.

Given that physicians, nurses, and allied health professionals generally lack confidence in both nutrition and genetics, registered dietitian nutritionists are uniquely positioned to offer educational and interventional services in nutrigenetics and nutrigenomics.

CURRENT STATE OF NUTRIGENOMIC KNOWLEDGE AMONG NUTRITION PROFESSIONALS AND STUDENTS

Nutrition professionals use conventional, evidence-based guidelines for population groups based on lifecycle stage, gender, disease state, and environmental/social factors to provide nutrition therapy to their patients/clients [23]. These general guidelines are further tailored to the individual using anthropometrics, laboratory data, and current dietary intake information. As personalized as this is, however, it does not take into account the individual genetic variations that influence nutrient requirements and the impact that has on health and wellness [24]. By incorporating “omics” research into nutrition therapy, it may be possible to improve health outcomes for clients as well as reduce disease progression. However, dietitians lack confidence and knowledge to implement ‘omics’ technologies in current dietetic practice.

Confidence levels in providing nutrigenomic services are associated with participation in clinical and educational activities involving genetic components. In 2013, Collins et al. administered a questionnaire to dietitians in the United Kingdom, Australia, and the United States assessing their involvement, knowledge and confidence level in performing activities related to genetics and nutrigenomics [25]. They observed that the dietitian’s level of confidence was positively associated with their participation in clinical or educational activities involving nutritional genomics. They also found that less than 50% of clinical dietitians surveyed even discussed the dietary and genetic basis of disease with their patients. Similarly, Whelan and associates found that the lack of involvement with nutrigenomics was associated with low levels of confidence [26].

Lack of knowledge was a key factor limiting the integration of nutritional genomics into dietetic practice [25-27]. The total knowledge scores for genetics and nutritional genomics in tests taken by dietitians for studies were low and ranged from 41% to 56.3% correct [25-25,28]. Interestingly, these same studies found that dietitians performed better on the genetic portion of the test versus the nutrigenomic part, suggesting that dietitians may be better informed about genetics than diet-gene interactions [26,28]. For example, Oosthuizen found that, in a survey of dietitians from South Africa, the mean knowledge score on the genetics portion of the exam was 58.5 (±24%), compared to the nutritional genomics section which was 31.2% (±23%) [28].

Collins et al. noted that the best predictor of higher knowledge scores involved participation in educational activities, less years of experience, and understanding the relevance of genetics to their careers [25]. Other factors limiting the integration of nutritional genomics into dietetic practice were concerns about lack of evidence for its utility in clinical practice, negative attitudes about direct-to-consumer genetic testing, perceived lack of role in a therapeutic setting, and a lack of confidence in the science of genetics and nutritional genomics [27].

Acknowledging the need for increased nutrigenomic education, the Accreditation Council for Education in Nutrition and Dietetics (ACEND) put forth a mandate for genetic education to be added to the curriculum for students in DPD (Didactic Programs in Dietetics) accredited academic institutions [29]. Despite this mandate, however, a study by Beretich and associates in 2017 found that the amount of genetic education offered in DPD programs in the United States remained low, consisting of only 1-10 clock hours of genetic education [29]. Interestingly, dietetic students do show an increased level of nutritional genomic knowledge when compared to their professional counterparts. A study by Joseph (2016) showed that dietetic students performed higher than practicing dietitians and other students in the allied health professions when asked knowledge-based questions about nutrigenomics [30]. As with dietitians, it was found that students with previous exposure to nutritional genomics had higher knowledge of genetics than those with no exposure [29-30].

In a qualitative study by Horne et al., the researchers explored the attitudes, beliefs, and knowledge of personal nutrigenomics testing among dietetic students [31]. Horne et al. found that dietetic students had little knowledge of nutritional genomics, but were interested in taking a class to learn more. The students believed that nutrigenomics was an important part of their future practice and that it could improve credibility for dietetics within the healthcare team. Students also found it frustrating, however, that they were not currently being taught about nutrigenomics in their current undergraduate program.

The purpose of the present study was to survey nutrition/dietetic students at Texas Woman's University and Universidad Autónoma de Nuevo León to determine their attitudes, knowledge level, and beliefs regarding nutritional genomics. Specifically, this study examined the following.

1) The age, gender and university classification of the student.
2) The perceived need, interest, and knowledge of different topics within nutritional genomics including metabolomics, proteomics, nutrigenomics, transcriptomics, lipidomics, nutrigenetics, epigenetics, genetically modified organisms (GMOs).
3) Basic nutritional and genetic knowledge of dietetic/nutrition students.

Although this study is mainly a descriptive study, three hypotheses were posited and tested.

1) The proportion of nutrition majors regarding ‘omics’ knowledge level is not the same between students attending Texas Woman’s University and Universidad Autónoma de Nuevo León.

2) The proportion of nutrition majors will not be the same regarding ‘omics’ attitudes at both Texas Woman’s University and Universidad Autónoma de Nuevo León.

3) The proportion of nutrition majors is not the same regarding the perception of need for ‘omic’ education between Texas Woman’s University and Universidad Autónoma de Nuevo León.

CHAPTER III

METHODOLOGY

STUDY PARTICIPANTS AND RECRUITMENT

One hundred twenty-seven undergraduate nutrition and dietetic students from Texas Woman's University and Universidad Autónoma de Nuevo León were recruited through campus email to participate in an anonymous online survey through PsychData (www.psychdata.com) examining attitudes and beliefs towards 'omics' education at the university setting. Participants were 18 years of age or older and primarily female (92.9% vs. 7.1% males). Participants included 54 students from Texas Woman's University and 73 students from Universidad Autónoma de Nuevo León. Participants received no compensation for participation in this survey. This study was approved by the Institutional Review Board at Texas Woman's University and Universidad Autónoma de Nuevo León. Informed consent was obtained before the survey was launched.

EXPERIMENTAL PROCEDURE

The questionnaire was created and validated in a previous study in our laboratory assessing knowledge, attitude and perceived future need for 'omics' education among allied health students at Texas Woman's University. Survey questions assessed demographics, knowledge level, interest level and perceived future professional need for 'omics' education. Knowledge level questions were based on a 4-point Likert scale

(1=none, 2=little, 3=some, 4=high), where interest and future need questions were based on yes/no responses.

The current study used the subset of 54 nutrition students from the previous study and compared their responses to those from Universidad Autónoma de Nuevo León in Mexico. Prior to administration of the survey in Mexico, we translated the ‘omics’ survey into Spanish, retranslated it back into English, and then examined the survey critically to ensure that questions did not change their meaning through translation. Any questions regarding translation were discussed with bilingual nutrition faculty from UANL. After administration of the survey via PsychData, the data was extracted and analyzed using SPSS version 25. The original survey sample for Texas Woman’s University had 83 participants, 29 of which were deleted due to incomplete responses, for a final sample size of 54. Universidad Autónoma de Nuevo León had 111 respondents, of which 38 did not complete the survey for a total of 73 respondents. Descriptive statistics were produced and chi-square test for homogeneity was used for comparisons between groups. Significance was set at $\alpha < 0.05$.

CHAPTER IV

CHAPTER SUBMITTED FOR PUBLICATION

A Paper To Be Submitted For Publication in the

Lifestyle Genomics Journal

‘Omics’ Education in Dietetic Curricula: A Comparison Between Two Institutions in USA and Mexico

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Short Title: Comparison of ‘omics’ education at TWU and UANL

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Keywords

Nutritional genomics, Nutrigenomics, Proteomics, Transcriptomics, Epigenetics, Epigenomics, Nutrition education, Dietetic students, Dietitians

1. Abstract

Background/Aims: The complete sequencing of the human genome and a better understanding of epigenomic regulation of gene expression has opened the possibility for personalized nutrition in the near future. This also created an immediate need for trained personnel qualified to administer personalized nutrition education. Of all the allied healthcare personnel, dietitians are more likely to undertake this role. However, dietitians and dietetic students are still deficient in their knowledge of nutrigenomics and other ‘omic’ technologies. Therefore, with the eventual goal of dietetic curriculum reorganization, the International Society of Nutrigenetics/Nutrigenomics (ISNN) has set out to evaluate nutrigenomic knowledge among dietetic students from different countries. Here we compare nutrition and dietetic students from Texas Woman's University (TWU) and Universidad Autónoma de Nuevo León (UANL) for their perceived need, interest, and knowledge of different topics within nutritional genomics.

Method: Students from both universities were sent an email link to a survey located at psychdata.com. One hundred twenty-seven students completed the survey. The survey assessed the student’s knowledge, perceived need and interest of different ‘omic’ technologies, as well as basic knowledge of basic nutrition and genetic topics. Differences were assessed using Chi-Square test of homogeneity and Fisher’s Exact Test.

Results: Students from TWU and UANL exhibited differences in their knowledge, desire to learn more, and perceived need of ‘omic’ science in some but not all categories.

Conclusions: Undergraduate nutrition students from both the United States and Mexico lack a high level of knowledge in different ‘omic’ topics, but recognize the need that ‘omics’ will play in their future as dietitians. There were differences between the two universities in the desire to learn more about different ‘omic’ technologies and to take more classes covering different topics that included nutritional genomic components. In order to make personalized nutrition a reality, future dietitians will need to become fluent in different ‘omic’ technologies.

2. Introduction

Traditionally, nutrition education for health maintenance and disease prevention has come from epidemiologic data [1]. Over the years, we have learned that individuals respond differently to diet and nutrition education recommendations suggesting a possible involvement of genetics [2]. In 2001, Venter et al. and Lander et al. [3-4] simultaneously published the sequence of human genome. This major breakthrough in genetics opened the possibility of personalized nutrition education. Steady progress towards a better understanding of gene-nutrient interactions is making personalized nutrition education a possibility in the near future. Therefore, we need to prepare trained personnel capable of delivering nutrigenomic education to the public. Due to the changing nature of healthcare delivery structures, it is certain that the burden of nutrigenomic education will rest on allied health professionals particularly dietitians and nurses [5]. There is a need to prepare allied health professionals as educators trained in nutrigenomics and other "omics" principles and their application. With this goal in mind, the International Society for Nutrigenetics and Nutrigenomics has recommended a needed evaluation to determine how to promote nutrigenomics education for allied health students globally. "The purpose of the International Society of Nutrigenetics/Nutrigenomics (ISNN) is to increase through research the understanding of the role of genetic variation and dietary response and the role of nutrients in gene expression among both professionals and the general public [6]."

To this end, we have surveyed students majoring in Nutrition & Dietetics at two similar institutions in the USA and Mexico to evaluate and compare their knowledge level, their attitude and perceived need for "omics" education in their future careers.

3. Materials and Methods

Study participants and recruitment

One hundred twenty-seven undergraduate nutrition and dietetic students from Texas Woman's University and Universidad Autónoma de Nuevo León were recruited through campus email to participate in an anonymous online survey through Psychdata (www.psychdata.com) examining attitudes and beliefs towards 'omics' education at the university setting. Participants were 18 years of age or older and primarily female (92.9% vs. 7.1% males). Participants included 54 students from Texas Woman's University and 73 students from Universidad Autónoma de Nuevo León. Participants received no compensation for participation in this survey. This study was approved by the Institutional Review Boards at Texas Woman's University and Universidad Autónoma de Nuevo León. Informed consent was obtained before administration of the survey.

Experimental Procedure

The questionnaire was created and previously validated in another study that assessed knowledge, attitude and perceived future need for 'omics' education among allied health students at Texas Woman's University (Table 1). Survey questions assessed demographics, knowledge level, interest level and perceived future professional need for ‘omics’ education. Knowledge level questions were based on a 4-point Likert scale (1=none, 2=little, 3=some, 4=high), where interest and future need questions were based on yes/no responses.

The current study used the subset of 54 nutrition students from the previous study and compared their responses to those from Universidad Autónoma de Nuevo León in Mexico. Prior to administration of the survey in Mexico, ‘omics’ survey was translated into Spanish, retranslated back into English, and then examined to ensure that questions did not change their meaning through translation. Any questions regarding translation were discussed with bilingual nutrition faculty from UANL. After administration of the survey via Psychdata, the data was extracted and analyzed using SPSS version 25. The original survey sample for Texas Woman’s University had 83 participants, 29 of which were deleted due to incomplete responses, for a final sample size of 54. Universidad Autónoma de Nuevo León had 111 respondents, of which 38 did not complete the survey for a total of 73 respondents. Descriptive statistics were produced and chi-square test for homogeneity was used for comparisons between groups. Significance was set at $\alpha < 0.05$.

4. Results

Demographics

Demographic characteristics for the study participants are shown in Table 2. The respondents to survey were predominantly female (92.9%), reflecting the gender distribution generally seen in the dietetic/nutrition profession. There were significant differences in age between students attending Texas Woman’s University and the Universidad Autónoma de Nuevo León ($\chi^2(4, N = 127) = 49.96$, $p = .000$, Cramér’s $V = .627$). This difference was explored using adjusted standardized residuals, showing that differences existed in the 18-24 year old age range (38.9% vs. 95.9%, ± 7.0) and the 25-29 year old group (24.1% vs. 1.4%, ± 4.0). Of interest, however, is that all of the age groups had an adjusted standardized residual of ± 2.4 or higher suggesting that there were meaningful differences in the composition of all the age groups between the universities. Similarly, there were also meaningful differences in student classification between TWU and UANL among students that took the survey ($\chi^2(4, \text{N} = 127) = 83.31$, $p = .000$, Cramér’s $V = .810$). The classifications of “freshman” (3.7% vs. 60.3%, ± 6.6), “senior” (31.5% vs. 0.0%, ± 5.2), and “post-baccalaureate” (44.4% vs. 1.4%, ± 6.0) had elevated adjusted standardized residuals showing significant differences between the two universities. The differences between the university attended and the sophomore and junior classifications were insignificant.

Level of knowledge in ‘omics’ technologies

We measured knowledge levels in metabolomics, proteomics, foodomics, nutrigenomics, transcriptomics, lipidomics, nutrigenetics, epigenetics/epigenomics, and genetically modified organisms (GMOs) in university students at TWU and UANL. These results are shown in Table 3. Students indicated their level of knowledge by choosing one of four options: none, little, some, and high. Significant differences were observed between TWU and UANL in foodomics ($\chi^2(3, N = 127) = 16.42$, $p = .001$, Cramér's $V = .360$), nutrigenomics ($\chi^2(3, N = 127) = 9.56$, $p = .023$, Cramér's $V = .274$), and GMOs ($\chi^2(3, N = 127) = 24.59$, $p = .000$, Cramér's $V = .440$). We then used adjusted standardized residuals for each significant 'omics' technology to explore where the levels of knowledge differed between TWU and UANL. In foodomics, students from TWU and UANL differed in none (22.2% vs. 49.3%), some (33.3% vs. 16.4%) and high (13.0% vs. 1.4%) knowledge levels; adjusted standardized residuals were none (± 3.1), some (± 2.2), and high (± 2.7) respectively. Nutrigenomics was found to be significantly different between the two universities in the "little" knowledge level only (50% vs. 24.7%; adjusted standardized residual ± 3.0). In GMOs, students differed in none (3.7% vs. 37.0%), some (51.9% vs. 26.0%) and high (16.7% vs. 5.5%) knowledge levels; adjusted standardized residuals were none (± 4.4), some (± 3.0) and high (± 2.1) respectively. No significant differences were seen between TWU and UANL in metabolomics, proteomics, transcriptomics, lipidomics, nutrigenetics, and epigenetics/epigenomics. Overall, very few students indicated a high knowledge of any of the 'omic' technologies. In the total sample, only 0.8% of students stated that they had a high knowledge of transcriptomics and 10.2% stated that they had a high amount of knowledge of genetically modified organisms, which was the highest percentage of all the 'omic' technologies.

Attitudes (the desire to learn more about omics)

The students from Texas Woman's University and Universidad Autónoma de Nuevo León were compared on their desire to learn more about 'omics' technologies and their willingness to take classes addressing different genetic concepts commonly seen in the study of 'omics'. These results are listed in Tables 4 and 5. Students' desire to learn about different 'omics' technologies was only significant for two 'omics' technologies: proteomics ($p = .008$, Fisher's exact test) and transcriptomics ($p = .000$, Fisher's exact test). The desire to learn proteomics was higher in students from the Universidad Autónoma de Nuevo León (95.9%) compared to Texas Woman's University (79.6%). Similarly, the desire to learn more about transcriptomics was higher in students from UANL (84.9%) compared to students from TWU (50%).

Additional survey questions assessed whether students desired to take classes addressing different genetic concepts commonly seen in the study of 'omics'. These topics included diabetes and non-communicable diseases, genes and chromosomes, genetic response to diet, epigenetics, nucleotide bases, gene-diet interactions, single nucleotide polymorphisms (SNPs), post-translational regulation, miRNA expression, mutations, and methylation. The percentages of students from TWU and UANL differed significantly in their desire to take classes in seven of these concepts. A greater percentage of students from UANL compared to TWU wished to take classes in diabetes and non-communicable diseases (91.3 vs. 83.3; $p = .009$, Fisher's exact test), genes and chromosomes (82.2 vs.

59.3; *p* = .005, Fisher's exact test), nucleotide bases (76.7 vs. 40.7; *p* = .000, Fisher's exact test), and single nucleotide polymorphisms (72.6 vs. 38.9; *p* = .000, Fisher's exact test). Similarly, UANL was also higher in post-transcriptional regulation (68.5 vs. 38.9; *p* = .001, Fisher's exact test), miRNA expression (84.9 vs. 59.3; *p* = .002, Fisher's exact test), and methylation (79.5 vs 61.1; *p* = .029, Fisher's exact test).

Perceived need for 'omics' knowledge in future profession

We assessed students from Texas Woman's University and Universidad Autónoma de Nuevo León to determine the perceived need for 'omics' knowledge in their future profession. These results are listed in Table 6. We found that there were significant differences in perceived need in three 'omics' technologies: metabolomics (90.7% vs. 100%; *p* = .012, Fisher's exact test), proteomics (88.9% vs. 100%; *p* = .005, Fisher's exact test), and transcriptomics (53.7% vs. 82.2%; *p* = .001, Fisher's exact test). GMOs approached significance (94.4% vs. 82.2%; *p* = .057, Fisher's exact test.) The differences in the perceived need for 'omics' technologies were not significant between the universities for foodomics (94.4% vs. 97.3%), nutrigenomics (96.3% vs. 98.6%), lipidomics (94.4% vs. 98.6%), nutrigenetics (96.3% vs. 100%), and epigenetics/epigenomics (77.8% vs. 86.3%).

5. Discussion

This survey endeavored to measure the differences in knowledge, desire to learn, and perceived future need of 'omics' technologies between students from the United States and Mexico. Although there was considerable variation between students from the two countries in their desire to learn and take classes about 'omics,' the overall knowledge level of 'omics' was low, with very few students indicating a high level of 'omics' knowledge. However, the perceived need to learn about 'omics' as part of their future profession was high in both groups, with a few exceptions.

Knowledge levels

The perceived differences in knowledge levels between the students from the USA and Mexico were different in three 'omics:' foodomics, nutrigenomics, and GMOs. This could be due to a variety of factors. At TWU, nutritional genomics is a required one-credit course taken during the junior or senior year. Additionally, genetic topics are woven into nutrition classes whenever they are relevant. UANL has no similar course requirement, although nutrigenetics/nutrigenomics is offered as an optional course that students could take if desired. Nutritional genomics is mainly taught within classes at UANL throughout their nutrition program. The requirement of a course in nutritional genomics at TWU could possibly explain the higher knowledge level scores in the three nutritional genomics topics. Note, however, that the low level of hours dedicated to nutritional genomics is still normal in dietetic programs. Beretich et al. found that 88.7% of the didactic programs in dietetics surveyed offered 1-10 clock hours dedicated to genetics education, which is insufficient to adequately explain and educate 'omic' topics at the university setting [7]. Reasons cited for this inadequacy include a curricula already 'bursting at the seams' with educational requirements, lack of time, low instructor knowledge levels of genetics and insufficient resources [8].

Overall, the number of students that could endorse a "high' level of 'omic' knowledge was low. This is comparable to those that have already earned the dietitian credential [9-12]. Collins et al. found that dietitians had a lower knowledge test score on nutritional genomics compared to genetics, which may reflect that 'omic' technologies are developing concepts within the field of nutrition [13]. Since knowledge of nutritional genomics has been shown to impact the confidence of dietitians when offering services that have a genetic component, priority should be given to genetics and nutritional genomics education at the university level [9,13-14].

Desire to learn

Students from UANL expressed a greater desire to learn more about proteomics and transcriptomics than students at TWU. In all other 'omic' technologies, however, there were no significant differences between UANL and TWU. UANL students also were more interested in learning about diabetes and non-communicable diseases, genes and chromosomes, nucleotide bases, single nucleotide polymorphisms, post-transcriptional regulation, miRNA expression and methylation. On why dietetic students might prefer learning about one 'omic' technology over another, the literature is silent. One possible reason could be the differences in demographics in our sample of students from TWU and UANL. The TWU sample is highly skewed toward juniors, seniors, and post-baccalaureate students, while the UANL sample was comprised primarily of freshmen and juniors. It is possible that the closer students get to completing their degree in dietetics, the more likely it is that the students do not want to add more topics to their curricula, irrespective of topic.

Perceived future need of 'omics' technologies in the profession

Overall, students expressed a high perceived need to learn more about 'omic' technologies (70.1% to 98.4%) in relation to their future work in the dietetics profession. The three 'omics' that were different between TWU and UANL were in metabolomics, proteomics, and transcriptomics. In these three 'omics,' UANL students had a much higher perceived future need than TWU students. This high overall perceived need for nutritional genomic knowledge was also found in a qualitative study by Horne and associates [15]. In these focus groups, it was noted that students were well aware of their low levels of knowledge in omics technologies, but that their perceived need of the nutritional genomic knowledge was high due to the perception that it would be part of their future careers.

Conclusion

The results of this study indicate that undergraduate dietetic students from both the United States and Mexico lack a high level of knowledge in nutritional genomics, but recognize that this knowledge will be an important part of their future careers as dietitians. There were differences between the two universities in the desire to learn more about different ‘omic’ technologies and to take more classes covering different topics with nutritional genomic components to them. As advances in nutritional genomics progress, future dietitians will need to be proficient in understanding and utilizing different ‘omic’ technologies to make personalized nutrition a reality.

8. Statements

All papers must contain the following statements after the main body of the text and before the reference list:

8.1. Acknowledgement

The authors would like to thank Antonio Miranda for his contribution in translating the Spanish survey back to English and for helping create the Spanish email script.

8.2. Statement of Ethics

All subjects have given their informed consent for the survey and the study protocol was approved by the Institutional Review Boards of both Texas Woman's University and Universidad Autónoma de Nuevo León.

8.3. Disclosure Statement

The authors have no conflicts of interest to declare.

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10. Table Legends

Table 1. Questionnaire

Table 2. Demographics

Table 3. Frequencies (%), chi-square results, and adjusted standardized residuals for different levels of ‘omics’ knowledge, divided by Texas Woman’s University (TWU), Universidad Autónoma de Nuevo León (UANL), and total.

Table 4. Frequencies (%) of the desire to learn ‘omics’ technologies compared by university group.

Table 5. Frequencies (%) of the desire to take classes pertaining to different ‘omics’ topics compared by university group

Table 6. Frequencies (%) of the perceived need to learn ‘omics’ technologies for future work in their profession compared by university.

Table 1

A questionnaire for the assessment of metabolomics, proteomics, foodomics, and nutrigenomics knowledge

Questions	Possible answers and assigned values
Metabolomics is the study of the set of metabolites present in an organism, tissue, or cell. What is your knowledge level of Metabolomics?	None [Value=1] Little [Value=2] Some [Value=3] High [Value=4]
Would you like to learn more about the topic of Metabolomics? Do you see a need for this information in your profession?	Yes [Value=1] No [Value=2]
Proteomics is the study of the expression pattern of proteome, the complete set of native and modified proteins expressed by an organism, tissue, or cell. What is your knowledge level of Proteomics?	None [Value=1] Little [Value=2] Some [Value=3] High [Value=4]
Would you like to learn more about the topic of Proteomics? Do you see a need for this information in your profession?	Yes [Value=1] No [Value=2]
Foodomics is the study of the Food and Nutrition domains through application and integration of advanced omics technologies to improve consumer's well-being, health, and knowledge. What is your knowledge level of Foodomics?	None [Value=1] Little [Value=2] Some [Value=3] High [Value=4]
Would you like to learn more about the topic of Foodomics? Do you see a need for this information in your profession?	Yes [Value=1] No [Value=2]
Nutrigenomics is the study of the effect of nutrients and bioactive components on gene expression. What is your knowledge level of Nutrigenomics?	None [Value=1] Little [Value=2] Some [Value=3] High [Value=4]
Would you like to learn more about the topic of Nutrigenomics? Do you see a need for this information in your profession?	Yes [Value=1] No [Value=2]
Transcriptomics is the study of the transcriptome - the complete set of RNA transcripts that are produced by the genome, under specific circumstances or in a specific cell - using high-throughput methods, such as microarray analysis. What is your knowledge level of Transcriptomics?	None [Value=1] Little [Value=2] Some [Value=3] High [Value=4]

Would you like to learn more about the topic of Transcriptomics? Do you see a need for this information in your profession?	Yes [Value=1] No [Value=2]
Lipidomics is the study of the structure and function of the complete set of lipids (the lipidome) produced in a given cell or organism as well as their interactions with other lipids, proteins and metabolites. What is your knowledge level of Lipidomics?	None [Value=1] Little [Value=2] Some [Value=3] High [Value=4]
Would you like to learn more about the topic of Lipidomics? Do you see a need for this information in your profession?	Yes [Value=1] No [Value=2]
Nutrigenetics is the study of the effect of genetic variations on our response to dietary components (fat, carbohydrate, vitamins, minerals etc.). What is your knowledge level of Nutrigenetics?	None [Value=1] Little [Value=2] Some [Value=3] High [Value=4]
Would you like to learn more about the topic of Nutrigenetics? Do you see a need for this information in your profession?	Yes [Value=1] No [Value=2]
Epigenetics/Epigenomics is the study of heritable changes in gene expression that does not involve changes to the underlying DNA sequence. What is your knowledge level of Epigenomics/Epigenetics?	None [Value=1] Little [Value=2] Some [Value=3] High [Value=4]
Would you like to learn more about the topic of Epigenomics/Epigenetics? Do you see a need for this information in your profession?	Yes [Value=1] No [Value=2]
GMOs are genetically modified organisms (plants, animals, microbes) whose genome has been altered by the techniques of genetic engineering so that its DNA contains one or more genes not normally found there. What is your knowledge level of GMOs?	None [Value=1] Little [Value=2] Some [Value=3] High [Value=4]
Would you like to learn more about the topic of GMOs? Do you see a need for this information in your profession?	Yes [Value=1] No [Value=2]
Diabetes is characterized by dark urine, dark pigmentation of cartilage and other connective	Agree Disagree Do not know/

tissue, and arthritis. It was the first genetic disease described in human.	[Value=1]	[Value=2]	I'm not sure [Value=3]
Would you like to take a course on diabetes and other non-communicable diseases?	Yes [Value=1]	No [Value=2]	
Genes lay on chromosomes that reside in the cytoplasm of mammalian cells.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course on genes and chromosomes?	Yes [Value=1]	No [Value=2]	
Individuals within a race exhibit wide variations in response to diet or dietary components.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course on genes and chromosomes?	Yes [Value=1]	No [Value=2]	
Epigenetics refers to changes in gene expression that are not heritable and do not involve changes to the underlying DNA sequence; a change in phenotype without a change in genotype.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Between 1985 and 2010, there has been a precipitous increase in obesity in every state of this country as well as worldwide. The most plausible explanation for this phenomenon is epigenetics.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course on epigenetics?	Yes [Value=1]	No [Value=2]	
Almost all (99.9%) nucleotide bases are exactly the same in all people within a race, but differ between races.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course that includes the topic of nucleotide bases?	Yes [Value=1]	No [Value=2]	
Some individuals, who consume high fat diet, show no evidence of atherosclerotic disease like most others. This can be explained by the dependence of physiologic response based on gene-diet interaction.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]

Would you like to take a course that includes the topic of gene/diet interaction?	Yes [Value=1]	No [Value=2]	
A mutation becomes a SNP with time when the rare allele is fixed in a population.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Almost all (99.9%) nucleotide bases are exactly the same in all people within a race, but differ between races.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course that includes the topic of nucleotide bases?	Yes [Value=1]	No [Value=2]	
Some individuals, who consume high fat diet, show no evidence of atherosclerotic disease like most others. This can be explained by the dependence of physiologic response based on gene-diet interaction.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course that includes the topic of gene/diet interaction?	Yes [Value=1]	No [Value=2]	
A mutation becomes a SNP with time when the rare allele is fixed in a population.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
SNPs occur exclusively in the coding (gene) region of the genome.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course that includes the topic of SNPs?	Yes [Value=1]	No [Value=2]	
miRNAs are involved in the post-transcriptional regulation of gene expression.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course that includes the topic of post-transcriptional regulation?	Yes [Value=1]	No [Value=2]	
Bioactive food components and exercise, play a role directly or indirectly in the modulation of miRNA expression.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure

			[Value=3]
A change in dietary pattern may change circulating miRNA levels.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course that includes the topic of miRNA expression?	Yes [Value=1]	No [Value=2]	
The redundancy of the genetic code is responsible for the fact that most mutations have no consequences.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course that examines the consequences of mutations?	Yes [Value=1]	No [Value=2]	
Methylation of DNA may physically impede the binding of transcription proteins to the gene and thus transcription.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
One of the mechanisms of health benefits of spinach consumption is associated with change in methylation pattern.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Lysine and arginine methylations are examples of DNA methylation.	Agree [Value=1]	Disagree [Value=2]	Do not know/ I'm not sure [Value=3]
Would you like to take a course that examines the effects of methylation?	Yes [Value=1]	No [Value=2]	

Table 2

Demographics

	TWU (*n* = 54)	**UANL (*n* = 73)**	**Total (*n* = 127)**
Gender			
Male	1 (1.9)	8 (11.0)	9 (7.1)
Female	53 (98.1)	65 (89.0)	118 (92.9)
Age			
18-24 years	21 (38.9)	70 (95.9)	91 (71.7)
25-29 years	13 (24.1)	1 (1.4)	14 (11.0)
30-34 years	6 (11.1)	1 (1.4)	7 (5.5)
35-40 years	6 (11.1)	0 (0.0)	6 (4.7)
>40 years	8 (14.8)	1 (1.4)	9 (7.1)
Classification			
Freshman	2 (3.7)	44 (60.3)	46 (36.2)
Sophomore	1 (1.9)	5 (6.8)	6 (4.7)
Junior	10 (18.5)	23 (31.5)	33 (26.0)
Senior	17 (31.5)	0 (0.0)	17 (13.4)
Post-Baccalaureate	24 (44.4)	1 (1.4)	25 (19.7)

Abbreviations – Texas Woman's University (TWU) and Universidad Autónoma de Nuevo León (UANL).

Table 3

Frequencies (%), chi-square results, and adjusted standardized residuals for different levels of ‘omics’ knowledge, divided by Texas Woman’s University (TWU), Universidad Autónoma de Nuevo León (UANL), and total.

	Frequencies (%) by university group				
	TWU	**UANL**	**Total**	**Adj. Std. Res.**	**P**
Knowledge level of 'omics'					
What is your knowledge level of Metabolomics?					$\chi2$ = 4.878, p = .181
None	14 (25.9)	23 (31.5)	37 (29.1)	0.7	
Little	22 (40.7)	23 (31.5)	45 (35.4)	1.1	
Some	14 (25.9)	26 (35.6)	40 (31.5)	1.2	
High	4 (7.4)	1 (1.4)	5 (3.9)	1.7	
What is your knowledge level of Proteomics?					$\chi2$ = 3.934, p = .269
None	17 (31.5)	34 (46.6)	51 (40.2)	1.7	
Little	26 (48.1)	31 (42.5)	57 (44.9)	0.6	
Some	9 (16.7)	7 (9.6)	16 (12.6)	1.2	
High	2 (3.7)	1 (1.4)	3 (2.4)	0.9	
What is your knowledge level of Foodomics?					**$\chi2$ =16.420, p= 001**
None	12 (22.2)	36 (49.3)	48 (37.8)	3.1	
Little	17 (31.5)	24 (32.9)	41 (32.3)	0.2	
Some	18 (33.3)	12 (16.4)	30 (23.6)	2.2	
High	7 (13.0)	1 (1.4)	8 (6.3)	2.7	
What is your knowledge level of Nutrigenomics?					**$\chi2$ = 9.565, p= .023**
None	8 (14.8)	21 (28.8)	29 (22.8)	1.9	
Little	15 (27.8)	29 (39.7)	44 (34.6)	1.4	
Some	27 (50.0)	18 (24.7)	45 (35.4)	3	
High	4 (7.4)	5 (6.8)	9 (7.1)	0.1	
What is your knowledge level of Transcriptomics?					$\chi2$ = 1.625, p = .654
None	28 (51.9)	37 (50.7)	65 (51.2)	0.1	
Little	20 (37.0)	27 (37.0)	47 (37.0)	0	
Some	5 (9.3)	9 (12.3)	14 (11.0)	0.5	
High	1 (1.9)	0 (0.0)	1 (0.8)	1.2	
What is your knowledge level of Lipidomics?					$\chi2$ = 2.602, p = .457
None	17 (31.5)	22 (30.1)	39 (30.7)	0.2	
Little	18 (33.3)	33 (45.2)	51 (40.2)	1.3	
Some	17 (31.5)	17 (23.3)	34 (26.8)	1	
High	2 (3.7)	1 (1.4)	3 (2.4)	0.9	
What is your knowledge level of Nutrigenetics?					$\chi2$ = .737, p = .865
None	7 (13.0)	13 (17.8)	20 (15.7)	0.7	
Little	20 (37.0)	27 (37.0)	47 (37.0)	0	
Some	23 (42.6)	27 (37.0)	50 (39.4)	0.6	
High	4 (7.4)	6 (8.2)	10 (7.9)	0.2	
What is your knowledge level of Epigenetics/Epigenomics?					$\chi2$ = 6.174, p = .103
None	17 (31.5)	27 (37.0)	44 (34.6)	0.6	
Little	17 (31.5)	33 (45.2)	50 (39.4)	1.6	
Some	17 (31.5)	11 (15.1)	28 (22.0)	2.2	
High	3 (5.6)	2 (2.7)	5 (3.9)	0.8	
What is your knowledge level of GMOs?					**$\chi2$ = 24.590, p= .000**
None	2 (3.7)	27 (37.0)	29 (22.8)	4.4	
Little	15 (27.8)	23 (31.5)	38 (29.9)	0.5	
Some	28 (51.9)	19 (26.0)	47 (37.0)	3	
High	9 (16.7)	4 (5.5)	13 (10.2)	2.1	

Table 4

Frequencies (%) of the desire to learn ‘omics’ technologies compared by university group.

	Frequency (%) by university group[a]			
	TWU	**UANL**	**Total**	***P*[b]**
Desire to learn more about 'omics'				
Metabolomics				0.071
Yes	48 (88.9)	71 (97.3)	119 (93.7)	
No	6 (11.7	2 (2.7)	8 (6.3)	
Proteomics				**0.008**
Yes	43 (79.6)	70 (95.3)	113 (89.0)	
No	11 (20.4)	3 (4.1)	14 (11.0)	
Foodomics				0.650
Yes	51 (94.4)	71 (97.3)	122 (96.1)	
No	3 (5.6)	2 (3.9)	5 (3.9)	
Nutrigenomics				1.000
Yes	53 (98.1)	72 (98.6)	125 (98.4)	
No	1 (1.9)	1 (1.4)	2 (1.6)	
Transcriptomics				**0.000**
Yes	27 (50.0)	62 (84.9)	89 (70.1)	
No	27 (50.0)	11 (15.1)	38 (29.9)	
Lipidomics				0.162
Yes	50 (92.6)	72 (98.6)	122 (96.1)	
No	4 (7.4)	1 (1.4)	5 (3.9)	
Nutrigenetics				1.000
Yes	52 (96.3)	70 (95.9)	122 (96.1)	
No	2 (3.7)	3 (4.1)	5 (3.9)	
Epigenetics/Epigenomics				1.000
Yes	48 (88.9)	65 (89.0)	113 (89.0)	
No	6 (11.1)	8 (11.0)	14 (11.0)	
GMOs				0.150
Yes	51 (94.4)	62 (84.9)	113 (89.0)	
No	3 (5.6)	11 (15.1)	14 (11.0	

[a] University groups include Texas Woman's University (TWU) and Universidad Autónoma de Nuevo León (UANL).
[b] Results are based on Fisher's exact test. Significance was set at P <. 05. Significant associations are highlighted in boldface.

Table 5

Frequencies (%) of the desire to take classes pertaining to different 'omics' topics compared by university group.

	Frequency (%) by university group[a]			
	TWU	UANL	Total	P[b]
Desire to take a class to learn about:				
Diabetes and non-communicable diseases				**0.009**
Yes	45 (83.3)	71 (97.3)	116 (91.3)	
No	9 (16.7)	2 (2.7)	11 (8.7)	
Genes and chromosomes				**0.005**
Yes	32 (59.3)	60 (82.2)	92 (72.4)	
No	22 (40.7)	13 (17.8)	35 (27.6)	
Human response to diet				1.000
Yes	51 (94.4)	69 (94.5)	120 (94.5)	
No	3 (5.6)	4 (5.5)	7 (5.5)	
Epigenetics				0.625
Yes	47 (87.0)	61 (83.6)	108 (85.0)	
No	7 (13.0)	12 (16.4)	19 (15.0)	
Nucleotide bases				**0.000**
Yes	22 (40.7)	56 (76.7)	78 (61.4)	
No	32 (59.3)	17 (23.3)	49 (38.6)	
Gene-diet interactions				0.758
Yes	50 (92.6)	66 (90.4)	116 (91.3)	
No	4 (7.4)	7 (9.6)	11 (8.7)	
Single nucleotide polymorphisms				**0.000**
Yes	21 (38.9)	53 (72.6)	74 (58.3)	
No	33 (61.1)	20 (27.4)	53 (41.7)	
Post-transcriptional regulation				**0.001**
Yes	21 (38.9)	50 (68.5)	71 (55.9)	
No	33 (61.1)	23 (31.5)	56 (44.1)	
miRNA expression				**0.002**
Yes	32 (59.3)	62 (84.9)	94 (74.0)	
No	22 (40.7)	11 (15.1)	33 (26.0)	
Mutations				0.253
Yes	41 (75.9)	62 (84.9)	103 (81.1)	
No	13 (24.1)	11 (15.1)	24 (18.9)	
Methylation				**0.029**
Yes	33 (61.1)	58 (79.5)	91 (71.7)	
No	21 (38.9)	15 (20.5	36 (28.3)	

[a] University groups include Texas Woman's University (TWU) and Universidad Autónoma de Nuevo León (UANL).
[b] Results are based on Fisher's exact test. Significance was set at P <. 05. Significant associations are highlighted in boldface.

Table 6

Frequencies (%) of the perceived need to learn ‘omics’ technologies for future work in their profession compared by university.

	Frequency (%) by university group[a]			
	TWU	**UANL**	**Total**	***P*[b]**
Perceived need to learn more about 'omics'				
Metabolomics				**0.012**
Yes	49 (90.7)	73 (100.0)	122 (96.1)	
No	5 (9.3)	0 (0.0)	5 (3.9)	
Proteomics				**0.005**
Yes	48 (88.9)	73 (100.0)	121 (95.3)	
No	6 (11.1)	0 (0.0)	6 (4.7)	
Foodomics				0.650
Yes	51 (94.4)	71 (97.3)	122 (96.1)	
No	3 (5.6)	2 (2.7)	5 (3.9)	
Nutrigenomics				0.574
Yes	52 (96.3)	72 (98.6)	124 (97.6)	
No	2 (3.7)	1 (1.4)	3 (2.4)	
Transcriptomics				**0.001**
Yes	29 (53.7)	60 (82.2)	89 (70.1)	
No	25 (46.3)	13 (17.8)	38 (29.9)	
Lipidomics				0.311
Yes	51 (94.4)	72 (98.6)	123 (96.9)	
No	3 (5.6)	1 (1.4)	4 (3.1)	
Nutrigenetics				0.179
Yes	52 (96.3)	73 (100.0)	125 (98.4)	
No	2 (3.7)	0 (0.0)	2 (1.6)	
Epigenetics/Epigenomics				0.241
Yes	42 (77.8)	63 (86.3)	105 (82.7)	
No	12 (22.2)	10 (13.7)	22 (17.3)	
GMOs				0.057
Yes	51 (94.4)	60 (82.2)	111 (87.4)	
No	3 (5.6)	13 (17.8)	16 (12.6)	

[a] University groups include Texas Woman's University (TWU) and Universidad Autónoma de Nuevo León (UANL).
[b] Results are based on Fisher's exact test. Significance was set at P <. 05. Significant associations are highlighted in boldface.

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APPENDIX A

Institutional Review Board
Office of Research and Sponsored Programs
P.O. Box 425619, Denton, TX 76204-5619
940-898-3378
email: IRB@twu.edu
https://www.twu.edu/institutional-review-board-irb/

DATE: September 17, 2018

TO: Dr. Vicky Imrhan
Nutrition & Food Sciences

FROM: Institutional Review Board - Denton

Re: Notification of Approval for Modification for Should 'Omics' Education be a Part of Undergraduate Allied Health Profession Curricula? (Protocol #: 19193)

The following modification(s) have been approved by the IRB:

1. La Universidad Autonoma de Nuevo Leon (UANL) has been added as a data collection site. The recruitment script, consent form, and survey have been translated into Spanish, as the participants from UANL will predominantly be Spanish-speaking.