“Omics” Education in Dietetic Curricula: A Comparison between Two Institutions in the USA and Mexico

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Abstract

Background/Aims: The completion of sequencing of the human genome and a better understanding of epigenomic regulation of gene expression have opened the possibility of personalized nutrition in the near future. This has also created an immediate need for trained personnel qualified to administer personalized nutrition education. Of all the allied healthcare personnel, dietitians are the most likely to undertake this role. However, dietitians and dietetic students are still deficient in their knowledge of nutrigenomics and other “omics” 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. In this study, we compared nutrition and dietetic students from Texas Woman’s University (TWU) and the Universidad Autónoma de Nuevo León (UANL) for their perceived need for, interest in, and knowledge of different topics within nutritional genomics.

Methods: Students from both universities were sent an e-mail link to the survey which was located at psychdata.com. One hundred twenty-seven students completed the survey. The survey assessed the students’ knowledge of, perceived need for, and interest in different omics technologies, as well as their basic knowledge of basic nutrition and genetic topics. Differences were assessed using the χ² test for homogeneity and Fisher’s exact test.

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

Conclusions: Undergraduate nutrition students from both the USA and Mexico lack a high level of knowledge in different omics topics but recognize the role that omics will play in their future as dietitians. There were differences between the 2 universities in terms...
of the desire to learn more about different omics technologies and to take more classes covering different topics with nutritional genomic components. In order to make personalized nutrition a reality, future dietitians will need to become fluent in different omics technologies.

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Introduction

Traditionally, information for nutrition education regarding 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. [3] and Lander et al. [4] simultaneously published the sequence of the human genome. This major breakthrough in genetics, coupled with a steady progress towards a better understanding of gene-nutrient interactions, is making personalized nutrition education a possibility for the near future. Therefore, we need to prepare trained personnel to be 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]. Therefore, 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 need evaluation to help 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 surveyed students majoring in Nutrition and Dietetics at 2 similar institutions in the USA and Mexico to evaluate and compare their knowledge level, attitude, and perceived need for omics education in their future careers.

Materials and Methods

Study Participants and Recruitment

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

Experimental Procedure

The survey consisted of 90 questions formulated to assess the respondent’s knowledge of metabolomics, proteomics, foodomics, and nutrigenomics. The respondents indicated their level of knowledge on a specific omics topic using a 4-point Likert scale (1 = none, 2 = little, 3 = some, and 4 = high). Additional questions to evaluate (1) their desire to learn more about the above topics and (2) their perception of the need for such knowledge for their respective professions were also included. The validity of the survey was reviewed by a 5-member panel of nutrition experts. This resulted in a set of 75 questions that were ready to be administered to a small group of students for validation. Next, a pilot test was conducted with 10 students mostly majoring in nutrition. Based on the pilot study feedback, the survey was shortened to 59 questions and a few adjustments were made to the wording of the questions (Table 1).

The survey was uploaded to the website PsychData, which allowed for the questionnaire to be answered online. The survey was distributed to the entire TWU student body via an e-mail link provided by the PsychData software. The students were given 3 weeks to complete the survey. Five hundred eighty students started the survey but only 190 completed the survey. The data from 54 of these students majoring in nutrition and dietetics were included in the analysis and for comparison with UANL students. Prior to administration of the survey to UANL students, we translated the omics survey into Spanish, retranslated it back into English, and then examined the survey critically to ensure that the meaning of the questions had not changed in 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 TWU was comprised of 83 participants, 25 of whom were excluded due to incomplete responses, for a final sample size of 54. UANL had 111 respondents, 38 of whom did not complete the survey, for a total of 73 respondents. Descriptive statistics were produced and a $\chi^2$ test for homogeneity was used for comparisons between groups. $\alpha < 0.05$ was considered statistically significant.

Results

Demographics

The demographic characteristics of the sample are shown in Table 2. The respondents of the survey were predominantly female (92.9%), which reflects the gender distribution generally seen in the dietetic/nutrition profession. There were significant differences in age between students attending TWU and UANL $(\chi^2[4, n = 127] = $
| Question                                                                 | Possible answers |
|-------------------------------------------------------------------------|------------------|
| Metabolomics is the study of the set of metabolites present in an organism, tissue, or cell. What is your level of knowledge of metabolomics? | None Little Some High |
| Would you like to learn more about the topic of metabolomics? Do you see a need for this information in your profession? | Yes No |
| Proteomics is the study of the expression pattern of proteomes, the complete set of native and modified proteins expressed by an organism, tissue, or cell. What is your level of knowledge of proteomics? | None Little Some High |
| Would you like to learn more about the topic of proteomics? Do you see a need for this information in your profession? | Yes No |
| Foodomics is the study of the food and nutrition domains through the application and integration of advanced omics technologies to improve consumers’ well-being, health, and knowledge. What is your level of knowledge of foodomics? | None Little Some High |
| Would you like to learn more about the topic of foodomics? Do you see a need for this information in your profession? | Yes No |
| Nutrigenomics is the study of the effect of nutrients and bioactive components on gene expression. What is your level of knowledge of nutrigenomics? | None Little Some High |
| Would you like to learn more about the topic of nutrigenomics? Do you see a need for this information in your profession? | Yes No |
| 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 level of knowledge of transcriptomics? | None Little Some High |
| Would you like to learn more about the topic of transcriptomics? Do you see a need for this information in your profession? | Yes No |
| 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 level of knowledge of lipidomics? | None Little Some High |
| Would you like to learn more about the topic of lipidomics? Do you see a need for this information in your profession? | Yes No |
| Nutrigenetics is the study of the effect of genetic variations on our response to dietary components (fat, carbohydrate, vitamins, minerals, etc.). What is your level of knowledge of nutrigenetics? | None Little Some High |
| Would you like to learn more about the topic of nutrigenetics? Do you see a need for this information in your profession? | Yes No |
| Epigenetics/epigenomics is the study of heritable changes in gene expression that do not involve changes to the underlying DNA sequence. What is your level of knowledge of epigenomics/epigenetics? | None Little Some High |
| Would you like to learn more about the topic of epigenomics/epigenetics? Do you see a need for this information in your profession? | Yes No |
Table 1 (continued)

| Question                                                                                                                                                                                                 | Possible answers                  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| GMO are genetically modified organisms (plants, animals, and microbes) whose genome has been altered by the techniques of genetic engineering so that their DNA contains one or more genes not normally found there. What is your level of knowledge of GMO? | None     | Little  | Some    | High    |
| Would you like to learn more about the topic of GMO? Do you see a need for this information in your profession?                                                                                         | Yes      | No      |          |         |
| Would you like to take a course on diabetes and other noncommunicable diseases?                                                                                                                              | Yes      | No      |          |         |
| Genes are on chromosomes that reside in the cytoplasm of mammalian cells.                                                                                                                                    | Agree    | Disagree| I do not know/I am not sure |
| Would you like to take a course on genes and chromosomes?                                                                                                                                                    | Yes      | No      |          |         |
| Individuals within a race exhibit wide variations in response to diet or dietary components.                                                                                                                                 | Agree    | Disagree| I do not know/I am not sure |
| Would you like to take a course on genes and chromosomes?                                                                                                                                                    | Yes      | No      |          |         |
| 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    | Disagree| I do not know/I am not sure |
| Between 1985 and 2010, there was 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    | Disagree| I do not know/I am not sure |
| Would you like to take a course on epigenetics?                                                                                                                                                           | Yes      | No      |          |         |
| Almost all (99.9%) nucleotide bases are exactly the same in all people within a race but differ between races.                                                                                                                                                         | Agree    | Disagree| I do not know/I am not sure |
| Would you like to take a course that includes the topic of nucleotide bases?                                                                                                                                 | Yes      | No      |          |         |
| Some individuals, who consume a high-fat diet, show no evidence of atherosclerotic disease like most others. This can be explained by the dependence of the physiologic response based on gene-diet interactions. | Agree    | Disagree| I do not know/I am not sure |
| Would you like to take a course that includes the topic of gene/diet interaction?                                                                                                                                 | Yes      | No      |          |         |
| A mutation becomes a single-nucleotide polymorphism with time when the rare allele is fixed in a population.                                                                                                                                                  | Agree    | Disagree| I do not know/I am not sure |
| Almost all (99.9%) nucleotide bases are exactly the same in all people within a race, but differ between races.                                                                                                                                                     | Agree    | Disagree| I do not know/I am not sure |
| Would you like to take a course that includes the topic of nucleotide bases?                                                                                                                                 | Yes      | No      |          |         |
| Some individuals, who consume a high-fat diet, show no evidence of atherosclerotic disease like most others. This can be explained by the dependence of the physiologic response based on gene-diet interactions. | Agree    | Disagree| I do not know/I am not sure |
| Would you like to take a course that includes the topic of gene/diet interactions?                                                                                                                                 | Yes      | No      |          |         |
| A mutation becomes a single-nucleotide polymorphism with time when the rare allele is fixed in a population.                                                                                                                                                  | Agree    | Disagree| I do not know/I am not sure |
This difference was explored using adjusted standardized residuals, which showed that the differences were in the age ranges of 18–24 years (38.9 vs. 95.9%, ±7.0) and 25–29 years (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 of the age groups between the universities. Similarly, there were also meaningful differences in student classification between TWU and UANL among students who took the survey (χ² [4, n = 127] = 83.31; p = 0.000, Cramér’s V = 0.810). The classifications of “freshman” (3.7 vs. 60.3%, ±6.6), “senior” (31.5 vs. 0.0%, ±5.2), and “postbaccalaureate” (44.4 vs. 1.4%, ±6.0) had elevated adjusted standardized residuals, showing significant differences between the 2 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 (GMO) in university students at TWU and UANL. These results are shown in Table 3. Students indicated their level of knowledge by

| Question                                                                 | Possible answers                  |
|--------------------------------------------------------------------------|-----------------------------------|
| Single-nucleotide polymorphisms occur exclusively in the coding (gene) region of the genome | Agree | Disagree | I do not know/I am not sure |
| Would you like to take a course that includes the topic of single-nucleotide polymorphisms? | Yes | No |
| miRNA are involved in posttranscriptional regulation of gene expression | Agree | Disagree | I do not know/I am not sure |
| Would you like to take a course that includes the topic of posttranscriptional regulation? | Yes | No |
| Bioactive food components and exercise play a role directly or indirectly in the modulation of miRNA expression | Agree | Disagree | I do not know/I am not sure |
| A change in dietary pattern may change circulating miRNA levels | Agree | Disagree | I do not know/I am not sure |
| Would you like to take a course that includes the topic of miRNA expression? | Yes | No |
| The redundancy of the genetic code is responsible for the fact that most mutations have no consequences | Agree | Disagree | I do not know/I am not sure |
| Would you like to take a course that examines the consequences of mutations? | Yes | No |
| Methylation of DNA may physically impede the binding of transcription proteins to the gene and thus transcription | Agree | Disagree | I do not know/I am not sure |
| One of the mechanisms of health benefits of spinach consumption is associated with a change in the methylation pattern | Agree | Disagree | I do not know/I am not sure |
| Lysine and arginine methylations are examples of DNA methylation | Agree | Disagree | I do not know/I am not sure |
| Would you like to take a course that examines the effects of methylation? | Yes | No |

The following answers were assigned a value of 1: none, yes, and agree. The following answers were assigned a value of 2: little, no, and disagree. The following answers were assigned a value of 3: some and I do not know/I am not sure. The following answer was assigned a value of 4: high.

49.96; p = 0.000, Cramér’s V = 0.627).
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choosing 1 of the following 4 options: none, little, some, and high. Significant differences were observed between TWU and UANL in foodomics ($\chi^2 [3, n = 127] = 16.42; p = 0.001, Cramér’s V = 0.360$), nutrigenomics ($\chi^2 [3, n = 127] = 9.56; p = 0.023, Cramér’s V = 0.274$), and GMO ($\chi^2 [3, n = 127] = 24.59; p = 0.000, Cramér’s V = 0.440$). However, the level of knowledge of the remainder of the omics technologies (proteomics, nutrigenomics, transcriptomics, metabolomics, epigenetics/epigenomics, and lipidomics) was not significantly different between the 2 institutions. 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 2 universities in the “little” knowledge level only (50 vs. 24.7%; adjusted standardized residual: ±3.0). In GMO, 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, or epigenetics/epigenomics. Overall, very few students endorsed a high knowledge of any of the omics technologies. In the total sample, only 0.8% of the students stated that they had a high knowledge of transcriptomics and 10.2% stated that they had a high knowledge of GMO, which was the highest percentage among all of the omics technologies.

**Attitudes (Desire to Learn More about Omics)**

Students from TWU and UANL were compared based on their desire to learn more about omics technologies (Table 4) and their willingness to take classes addressing different genetic concepts commonly seen in the study of omics (Table 5). Students’ desire to learn about different omics technologies was only significant for 2 omics technologies, i.e., proteomics ($p = 0.008$, Fisher’s exact test) and transcriptomics ($p = 0.000$, Fisher’s exact test). The desire to learn about proteomics was higher in students from UANL (95.9%) compared to TWU (79.6%). Similarly, the desire to learn about transcriptomics was higher in students from UANL (84.9%) compared to students from TWU (50%).

Additional survey questions assessed whether students wished to take classes addressing different genetic concepts commonly seen in the study of omics. These topics included diabetes and noncommunicable diseases, genes and chromosomes, genetic response to diet, epigenetics, nucleotide bases, gene-diet interactions, single-nucleotide polymorphisms, posttranslational regulation, miRNA expression, mutations, and methylation. The percentages of students from TWU and UANL differed significantly in terms of their desire to take classes in 7 of these concepts. A greater percentage of students from UANL compared to TWU wished to take classes in diabetes and noncommunicable diseases (91.3 vs. 83.3%; $p = 0.029$, Fisher’s exact test), and single-nucleotide polymorphisms (72.6 vs. 38.9%; $p = 0.002$, Fisher’s exact test), and methylation (79.5 vs. 61.1%; $p = 0.029$, Fisher’s exact test).

**Perceived Need for Omics Knowledge in Future Profession**

We assessed students from TWU and UANL to determine their 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 for the following 3 omics technologies: metabolomics (90.7 vs. 100%; $p = 0.012$, Fisher’s exact test), proteomics

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**Table 2. Demographics of the students participated in the survey**

| Classification          | 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 (years)             |                |                 |                   |
| 18–24                   | 21 (38.9)      | 70 (95.9)       | 91 (71.7)         |
| 25–29                   | 13 (24.1)      | 1 (1.4)         | 14 (11.0)         |
| 30–34                   | 6 (11.1)       | 1 (1.4)         | 7 (5.5)           |
| 35–40                   | 6 (11.1)       | 0 (0.0)         | 6 (4.7)           |
| >40                     | 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)         |
| Postbaccalaureate       | 24 (44.4)      | 1 (1.4)         | 25 (19.7)         |

Values are presented as numbers (%).

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Table 3. Frequencies, χ² results, and adjusted standardized residuals for different levels of omics knowledge

| Subjects, n (%)          | TWU     | UANL    | total    | p         | Adjusted standardized residual |
|--------------------------|---------|---------|----------|-----------|---------------------------------|
| What is your level of knowledge of metabolomics? |         |         |          | χ² = 4.878, p = 0.181          |
| 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 (7.9)   | 1 (1.4)   | 5 (3.9)   | 1.7       |                                 |
| What is your level of knowledge of proteomics? |         |         |          | χ² = 3.934, p = 0.269          |
| 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 level of knowledge of foodomics? |         |         |          | χ² = 16.420, p = 0.001         |
| 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 level of knowledge of nutrigenomics? |         |         |          | χ² = 9.565, p = 0.023          |
| 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 level of knowledge of transcriptomics? |         |         |          | χ² = 1.625, p = 0.654          |
| 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 (0.08)  | 1.2       |                                 |
| What is your level of knowledge of lipidomics? |         |         |          | χ² = 2.602, p = 0.457          |
| 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 level of knowledge of nutrigenetics? |         |         |          | χ² = 0.737, p = 0.865          |
| 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 level of knowledge of epigenetics/epigenomics? |         |         |          | χ² = 6.174, p = 0.103          |
| 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 level of knowledge of GMO? |         |         |          | χ² = 24.590, p = 0.000         |
| 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       |                                 |

Significant associations are in bold.

(88.9 vs. 100%; p = 0.005, Fisher’s exact test), and transcriptomics (53.7 vs. 82.2%; p = 0.001, Fisher’s exact test). GMO approached significance (94.4 vs. 82.2%; p = 0.057, 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%).
Discussion

This survey endeavored to measure the differences in knowledge, desire to learn, and perceived future need for omics technologies between students from the USA and Mexico. Although there was considerable variation between students from the 2 countries in terms of the desire to learn and to take classes about omics, the overall knowledge level of omics was low, with very few students endorsing 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 the following 3 omics: foodomics, nutrigenomics, and GMO. This could be due to a variety of factors including the fact that a large proportion of UANL students were freshmen and juniors whereas all of the TWU students were juniors and seniors (Table 1). At TWU, nutritional genomics is a required 1-credit course taken during 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 may 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 3 nutritional genomics topics. Note, however, that the low number of hours dedicated to nutritional genomics is still normal in dietetic programs. Beretich et al. [7] found that 88.7% of the didactic programs in dietetics surveyed offered 1–10 clock hours dedicated to genetics education, which is insuffi-

Table 4. Desire to learn about omics technologies

| Subjects, n (%) | TWU | UANL | total | $p^a$ |
|----------------|-----|------|-------|------|
| Metabolomics   |     |      |       |      |
| Yes            | 48  | 71   | 119   | 0.071|
| No             | 6   | 2    | 8     |      |
| Proteomics     |     |      |       |      |
| Yes            | 43  | 70   | 113   | 0.008|
| No             | 11  | 3    | 14    |      |
| Foodomics      |     |      |       | 0.650|
| Yes            | 51  | 71   | 122   |      |
| No             | 3   | 2    | 5     |      |
| Nutrigenomics  |     |      |       | 1.000|
| Yes            | 53  | 72   | 125   |      |
| No             | 1   | 1    | 2     |      |
| Transcriptomics|     |      |       | 0.000|
| Yes            | 27  | 62   | 89    |      |
| No             | 27  | 11   | 38    |      |
| Lipidomics     |     |      |       | 0.162|
| Yes            | 50  | 72   | 122   |      |
| No             | 4   | 1    | 5     |      |
| Nutrigenetics  |     |      |       | 1.000|
| Yes            | 52  | 70   | 122   |      |
| No             | 2   | 3    | 5     |      |
| Epigenetics/Epigenomics | | | | 1.000|
| Yes            | 48  | 65   | 113   |      |
| No             | 6   | 8    | 14    |      |
| GMOs           |     |      |       | 0.150|
| Yes            | 51  | 62   | 113   |      |
| No             | 3   | 11   | 14    |      |

$^a$Fisher’s exact test. $p < 0.05$ was considered statistically significant. Significant associations are in bold.
cient to adequately explain omics topics in the university setting. The reasons cited for this inadequacy include curricula already “bursting at the seams” with educational requirements, a lack of time, low instructor knowledge levels of genetics, and insufficient resources [8]. Overall, the number of students who could endorse a high level of omics knowledge was low. This is comparable to that rate in those who have already earned the dietitian credential [9–12]. Collins et al. [13] found that dietitians had a lower knowledge test score on nutritional genomics compared to genetics, which may reflect that omics technologies are developing concepts within the field of nutrition. 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 omics technologies, however, there were no significant differences between UANL and TWU. UANL students were also more interested in learning about diabetes and noncommunicable

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

^a Fisher’s exact test. p < 0.05 was considered statistically significant. Significant associations are in bold.
diseases, genes and chromosomes, nucleotide bases, single-nucleotide polymorphisms, posttranscriptional regulation, miRNA expression, and methylation. There is no literature on why dietetic students might prefer learning about one omics technology over another. One possible reason could be the differences in demographics in our sample of students from TWU and UANL. The TWU sample was highly skewed toward juniors, seniors, and postbaccalaureate 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, irrespectively of topic.

Perceived Future Need for Omics Technologies in the Profession

Overall, students expressed a high perceived need to learn more about omics technologies (70.1 to 98.4%) in relation to their future work in the dietetics profession. The 3 omics that were different between TWU and UANL were: metabolomics, proteomics, and transcriptomics. In these 3 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 et al. [15]. In these focus groups, it was noted that students were well aware of their low levels of knowledge in omics technologies but their perceived need for nutritional genomic knowledge was high due to the perception that it would be a part of their future career.

| Table 6. Perceived need to learn omics technologies for future professional work |
|---------------------------------------------------------------|
| Subjects, n (%) | TWU | UANL | total | p<sup>a</sup> |
| Metabolomics |
| Yes | 49 (90.7) | 73 (100) | 122 (96.1) | 0.012 |
| No | 5 (9.3) | 0 (0.0) | 5 (3.9) | |
| Proteomics |
| Yes | 48 (88.9) | 73 (100.00) | 121 (95.3) | 0.005 |
| No | 6 (11.1) | 0 (0.0) | 6 (4.7) | |
| Foodomics |
| Yes | 51 (94.4) | 71 (97.3) | 122 (96.1) | 0.650 |
| No | 3 (5.6) | 2 (2.7) | 5 (3.9) | |
| Nutrigenomics |
| Yes | 52 (96.3) | 72 (98.6) | 124 (97.6) | 0.574 |
| No | 2 (3.7) | 1 (1.4) | 3 (2.4) | |
| Transcriptomics |
| Yes | 29 (53.7) | 60 (82.2) | 89 (70.1) | 0.001 |
| No | 25 (46.3) | 13 (17.8) | 38 (29.9) | |
| Lipidomics |
| Yes | 51 (94.4) | 72 (98.6) | 123 (96.9) | 0.311 |
| No | 3 (5.6) | 1 (1.4) | 4 (3.1) | |
| Nutrigenetics |
| Yes | 52 (96.3) | 73 (100.0) | 125 (98.4) | 0.179 |
| No | 2 (3.7) | 0 (0.0) | 2 (1.6) | |
| Epigenetics/epigenomics |
| Yes | 42 (77.8) | 63 (86.3) | 105 (82.7) | 0.241 |
| No | 12 (22.2) | 10 (13.7) | 22 (17.3) | |
| GMOs |
| Yes | 51 (94.4) | 60 (82.2) | 111 (87.4) | 0.057 |
| No | 3 (5.6) | 13 (17.8) | 16 (12.6) | |

<sup>a</sup>Fisher’s exact test. p < 0.05 was considered statistically significant. Significant associations are in bold.
Conclusion

The results of this study indicate that undergraduate dietetic students from both the USA and Mexico lack a high level of knowledge in nutritional genomics but recognize that this knowledge will be an important part of their future career as dietitians. There were differences between the 2 universities in the desire to learn more about different omics technologies and to take more classes covering different topics with nutritional genomic components. As our understanding of nutrigenomics, nutrigenetics, and other omics progresses, future dietitians will need to develop proficiency in understanding and utilizing different omics technologies to make personalized nutrition education a reality in the very near future [16]. Although we have been aware of the deficiency in genetic education in dietetic programs for over a decade [7–9, 11, 13, 15, 17], we have not done much in the way of making recommendations for correcting this deficiency [18]. In the USA, the Academy of Nutrition and Dietetics is the largest organization of food and nutrition professionals. This organization advances the profession by providing reliable nutrition information to its members and the public. Therefore, we recommend that the Academy of Nutrition and Dietetics release a position paper on genetic education for all of its programs.

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Statement of Ethics

All of the subjects gave informed consent for taking part in the survey, and the study protocol was approved by the Institutional Review Boards of both TWU and UANL.

Disclosure Statement

The authors have no conflict of interests to declare.

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