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ORIGINAL ARTICLE

Making a case for genomics in chiropractic education

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Objective: To determine if an existing course in genetics should be revised to refocus on the topic of genomics and its impact on health and primary care, a survey of chiropractors was conducted regarding genomics and patient care.
Methods: A short survey was designed to ascertain chiropractors' knowledge and use of genomics in their practices, particularly regarding direct to consumer genetic testing. Nine closed-ended questions and 2 open-ended questions were included. Pearson correlation was used to evaluate relationships between close-ended responses. Content analysis was conducted on the final open-ended question that queried respondents for further comments.
Results: There were 181 completed surveys returned. Patients do ask chiropractors about their own direct to consumer genetic testing results—42% indicated that they are approached by patients 1–3 times per month to discuss genetics/genomics. Knowledge of genomics varies among chiropractors, yet 51% feel that teaching genomics is moderately (31%) or extremely (20%) important.
Conclusion: An introductory course in clinical genomics is necessary to prepare a chiropractor for patient care.

Key Indexing Terms: Chiropractic; Education; Teaching; Genomics

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INTRODUCTION

Personal genetic information is becoming increasingly available to patients. By February of 2019 more than 26 million individuals had added their DNA to 1 of 4 leading direct to consumer (DTC) genetic testing companies.[1] Patients can utilize DTC genetic testing kits to access their genetic information without the involvement of a physician. The changes in both the knowledge that the public has regarding genomics and more so the changes genomics is impressing on routine clinical care means that all clinicians in the health care environment need to be conversant in genomics, including chiropractors.

The discipline of genetics dates back to Gregor Mendel when he first deciphered the patterns of inheritance in the 1860s using pea plants.[2] The term "genome" was first proposed by Hans Winkler in 1920 to mean the complete genetic complement of an organism.[3] It would then be several decades before DNA was confirmed to be the molecule of inheritance through the work of Rosalind Franklin, Maurice Wilkins, James Watson, and Francis Crick in the 1950s.[4] From this point forward, the interest in deciphering the messages held by DNA was underway beginning with the development of Sanger sequencing in 1977.[5] This technology eventually allowed for the sequencing of the entire human genome.[6] This massive-decade long project was the beginning of a new era in science and medicine.[7] Following Sanger sequencing, high-throughput next generation sequencing (NGS) has allowed sequencing to be carried out at a rate that can produce over 100 times more data.[8] Using NGS, an individual's genome can be sequenced in a single day and as such, NGS has revolutionized genomic research to allow for the acquisition of information that is being translated into routine clinical care.[9]

Using genomics in the clinic, clinical genomics, is common in some areas of health care. Cancer and rare diseases are 2 of the areas of patient care that have benefited most from the application of study of the entirety of our DNA.[9] Yet, the expectation is that all areas of health will be touched by genomics.[10] The field of allopathic medicine is calling for more genetics and genomics education in medical schools to prepare physicians for this reality.[7,11,12] Although chiropractors may not be faced with treating cancer or deciphering rare disease, it is not uncommon for a patient to seek personalized nutritional advice from their chiropractor.[13] In a study conducted in New York, 80% of chiropractors responding to a survey indicated that they used nutritional counseling in their practices.[14] Chiropractic educational curriculums emphasize wellness and prevention, which includes substantial training in nutrition. Two or more nutrition

courses are offered in most chiropractic core curricula, and some programs support additional training with electives.[14] With this in mind, the developing discipline of nutrigenomics, which is the study of the interaction between genes and food, holds promise for application by chiropractors and other health care providers. This nutritional interface will eventually allow for customized diet plans for patients to be developed.[13] Recently, a model for developing these personalized plans has been proposed. The model includes items such as past medical history, individual preferences, habitat/climate, DNA studies, and database analysis. All these together can create a functional diet plan.[15] Although personalized plans have not yet been realized, the value of nutrigenomics in several noncommunicable diseases has been recognized. These include obesity, cardiovascular disease, and cancer.[16] One example is the use of nutrigenomics to inform the diets of patients with breast cancer, such as increasing flaxseed for a particular tumor signature to assist in treatment.[17]

The DTC testing kit so readily available to consumers creates circumstances where the results can be challenging for patients, due to the lack of involvement of a health care professional. Other than providing information regarding an individual's ancestry and heritage, the report that is provided to a customer shows predicted health risks based on a large database of individuals who have previously submitted their DNA for analysis. If the DTC report contains worrisome or ambiguous results, the individual may turn to a health care provider for assistance interpreting the report or for advice on how to proceed.[7] One of the questions this study addresses is, "Is that health care provider a chiropractor?" In other words, are patients asking their chiropractor about their DTC testing results?

Given all the above reasons, the decision was made to revise a University of Western States (UWS) genetics course that had been part of the curriculum for decades. The new course would be called clinical genomics and would introduce how genomics is finding its way into the primary care clinic. The purpose of this study is to inform course revision and to determine if and how genomics is entering into the chiropractic practices of UWS graduates. To accomplish this, a survey was created that was distributed by email to graduates from the last 3 decades.

METHODS

Participants

UWS graduates from 1980 to 2018 were contacted via email. The alumni office contacted those who graduated after 1979 with a DC degree. Additionally, the graduates contacted had identified themselves as available for email correspondence from the university, as opposed to traditional mail only. The survey, created with the SurveyMonkey (San Mateo, CA; www.surveymonkey.com) software, was sent to 2053 individuals with a 2-week open window for response. A reminder email to complete the survey was sent 1 week after the initial email.

This study, with the alumni survey included, was identified as exempt by the UWS institutional review board (IORG 0001188).

Survey Instrument

The survey instrument was designed to discover if patients are asking their chiropractors about DTC testing and to measure the attitudes of practicing chiropractors with regard to clinical genomics. The face validity of the survey was established by presenting the survey to the UWS community of research. To evaluate the survey for internal consistency and scale reliability, a Cronbach α was conducted using IBM SPSS Statistics for Windows, version 23.0 (IBM Corp, Armonk, NY). Reliability analysis produced a Cronbach's α of .70. Members from the faculty body reviewed the survey in winter of 2019 prior to distribution. This review occurred during a community of research meeting in which faculty provided feedback to help clarify the questions in the study.

The survey consisted of 11 items, 9 closed-ended and 2 open-ended. The first item asked the respondent to identify year of graduation by selecting the 5-year interval in which they graduated. Item #2 similarly asked the respondent to select the appropriate 5-year interval for how many years they have been in practice. The third item was an open-ended question that asked the respondent to indicate their type of chiropractic practice or focus of their practice. The fourth item asked the respondent to select the number of times patients have asked about DTC genomic testing results. Item #5 used a Likert scale from "not confident at all" to "extremely confident" to ask how confident the respondent felt in their own understanding of genomics. The sixth item also used a Likert scale and asked respondents to indicate if they were aware of the developing discipline of nutrigenomics. The response choices ranged from "not at all aware" to "extremely aware." The seventh item asked respondents how often patients request nutrition advice, with options from "patients do not request" to "more than 10 times per month." Item #8 asked if respondents were aware of significant developments in cancer or cancer treatment due to genomics. This item used the Likert scale "not at all aware" to "extremely aware." Item #9 asked the respondent to rank the importance of understanding genomics to them and their practice on a Likert scaled from "not at all important" to "extremely important." Item #10 used the same Likert scale in #9 to ask if "teaching chiropractic students introductory clinical genomics is important to their future as integrated care doctors." The final question, #11, was an open-ended question prompting the respondent to add any additional comments regarding the teaching of clinical genomics at our institution.

Analysis

Statistical and content analyses were performed after the surveys were completed. Pearson correlation was conducted to determine if a relationship existed between year of graduation and years in practice and to search for a relationship between year of graduation and opinions on genetics education.

The final open-ended survey question asked the respondents if they had any further comments regarding teaching genomics in the chiropractic curriculum. Content analysis was conducted by reviewing each response and

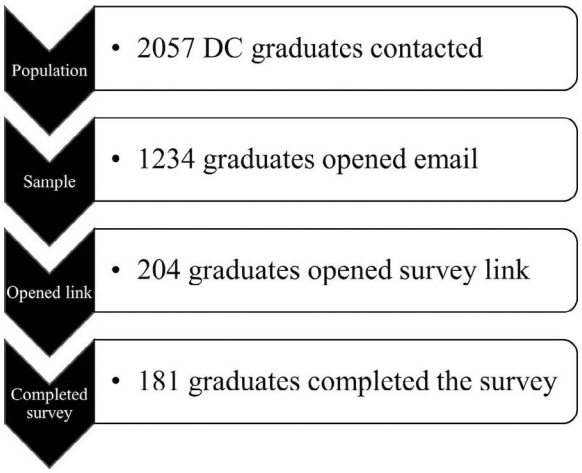

Figure 1 - Flowchart representing the survey process. A large population was identified, within that population a sample of individuals engaged with the email, and within the sample, a number of respondents emerged.

establishing a code based on key words or phrases. Codes were grouped into categories and lastly categories were grouped into overarching themes.[18]

RESULTS

Survey Results

SurveyMonkey collects data on the number of individuals that open the email, and the number of individuals that open the survey link. This allows the calculation of respondent rate based on the number of individuals that accessed the link (Fig. 1). Two hundred four graduates accessed the survey by opening the survey link; 181 completed the survey. These individuals were distributed throughout the identified time frame from 1980 to 2018 (Table 1). In addition to capturing respondents from all years requested, respondents indicated years of practice ranging from 36–40 years to 1–5 years (Table 2). The types of chiropractic practice or main focus of the practice were indicated to be general (58.9%), sports (14.3%), specialized (eg, pediatrics) (18.8%), and multidisciplined (8%).

The fourth item in the survey asked respondents to indicate how often patients mentioned or asked to discuss their own results from DTC genomic testing kits such as 23andMe or Ancestry. Over 50% of respondents indicated

Table 1 - Survey Respondents' Year of Graduation

Graduation Year	N (%)
1980–1985	24 (13.3)
1986–1990	25 (13.9)
1991–1995	14 (7.8)
1996–2000	24 (13.3)
2001–2005	16 (8.9)
2006–2010	20 (11.1)
2011–2015	31 (17.2)
2016–2018	26 (14.4)

Table 2 - Survey Respondents' Number of Years in Practice

Years in Practice	N (%)
1–5	46 (25.6)
6–10	21 (11.7)
11–15	22 (12.2)
16–20	16 (8.9)
21–25	22 (12.2)
26–30	25 (13.9)
31–35	17 (9.4)
36–40	11 (6.1)

that patients have never mentioned personal DNA test results. The survey found that 42% of respondents have had patients engage with them regarding their own personal DNA test results 1–3 times per month. The remainder of the respondents indicated patients discussed personal DNA results between 4–6 times per month (3.3%) and 10 times per month (1.1%).

Survey item #5 requested that the respondent reflect on their own confidence regarding genomics. The largest percentage, 34% indicated "not confident at all", whereas only 5% indicated "extremely confident." The other categories of "slightly confident," "somewhat confident," and "moderately confident" garnered responses of 21%, 24%, and 16%, respectively.

Items #6 and #8 utilized the same Likert scale of "not at all aware" to "extremely aware." Item #6 asked about awareness around the developing field of nutrigenomics. The majority of respondents expressed some level of awareness. In item #8, 8.4% indicated that they were extremely aware of the developments in cancer/cancer treatment as a result of genomics (Fig. 2).

The results of survey item #7 show that 14.7% of respondents indicated that patients do not request nutrition advice from them in their chiropractic practices. On the other end of the continuum, 13% indicated that patients request personal nutrition advice more than 10 times per month. The intermediate responses of 1–3 per month, 4–6 times per month, and 7–10 times per month showed 35.3%, 22.0%, and 15.1%, respectively.

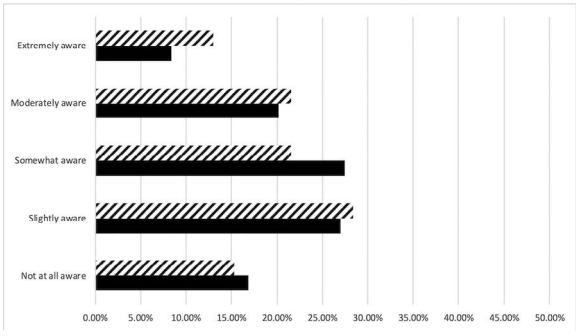

Figure 2 - Responses to items #6 and #8. Item #6: Knowledge of the developing discipline called nutrigenomics. Item #8: Developments in cancer due to genomics.

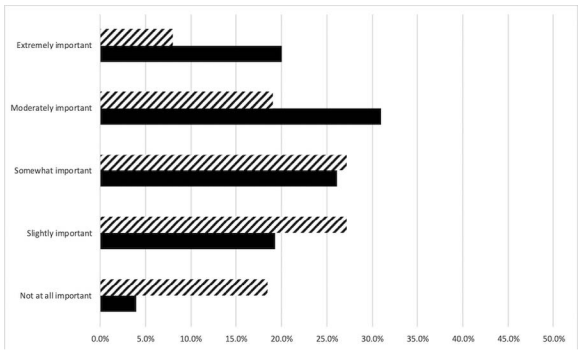

Figure 3 - Responses to items #9 and #10. Item #9: Understanding genomics is important to my practice. Item #10: Teaching genomics to chiropractors is important.

The final 2 Likert items #9 and #10 shared the same scale. The results of item #9 showed that 8% of respondents felt that understanding genomics is extremely important to their chiropractic practice. Item #10 showed that only 4% felt teaching genomics was not at all important, at the other end of the continuum, 20% felt it was extremely important (Fig. 3).

Pearson Correlation

Results of the correlational analysis indicated that there was a significant positive association between years in practice and awareness of the significant developments in cancer and/or cancer treatment due to genomics ($r_s(177) = .20$, $p = .008$), as well as the importance of teaching chiropractic students introductory clinical genomics to their future as integrated care doctors ($r_s(175) = .17$, $p = .03$). The same was found for year of graduation and awareness of the significant developments in cancer and/or cancer treatment due to genomics ($r_s(177) = .21$, $p = .005$), as well as year of graduation and the importance of teaching chiropractic students introductory clinical genomics to their future as integrated care doctors ($r_s(175) = .17$, $p = .2$) (Table 3).

Content Analysis

The open-ended question that asked if survey respondents had further comments regarding teaching genomics in the chiropractic curriculum generated a variety of responses. Not all respondents answered the question, whereas some simply answered "no." The 38 substantive responses were reviewed to find words and phrases that were identified as codes. The codes were grouped by common features into categories. Lastly, categories were grouped into 2 themes, "genomics is important in chiropractic education" and "genomics is not important in chiropractic education." The number of occurrences of each category was recorded by reviewing all codes derived from the responses (Table 4). A comment that illustrates the category of preparing for the future included "the importance of understanding and being knowledgeable in this area is only going to continue to increase, maintaining a curriculum that prepares DCs for new trends in healthcare is wise." On the other hand, a comment from 1 graduate, "UWS should focus on chiropractic technique, not genomics" demonstrates the category that education should focus on chiropractic techniques.

DISCUSSION

The advent of DTC has given individuals unprecedented access to their own DNA and all the data that can be extracted from that important molecule. Unfortunately, the very nature of direct consumer testing, which does not often involve a health care professional creates a frequently frustrating, sometimes scary lack of understanding on the part of the consumer. Additionally, DTC testing can identify false positives, that require clinical confirmation.[19] When faced with uncertainty of testing results, many

Table 3 - Results of Pearson Correlation

Question 1: Year of Graduation	Correlation Coefficient	Significance (*p*)
DTC DNA Testing Kits (Q4)	0.08	.314
Confidence in understanding genomics (Q5)	0.15	.13
Aware of nutrigenomic development (Q6)	0.10	.195
Requested personal nutrition advice (Q7)	0.10	.19
Aware of cancer developments due to genomics (Q8)	0.21[a]	.005
Understanding genomics is important to my practice (Q9)	0.14	.06
Teaching intro clinical genomics is important (Q10)	0.17[a]	.02
Question 2: Years in Practice	**Correlation Coefficient**	**Significance**
DTC DNA Testing Kits (Q4)	0.098	.19
Confidence in understanding genomics (Q5)	0.08	.30
Aware of nutrigenomic development (Q6)	0.12	.11
Requested personal nutrition advice (Q7)	0.11	.13
Aware of cancer developments due to genomics (Q8)	0.20[a]	.008
Understanding genomics is important to my practice (Q9)	0.15	.06
Teaching intro clinical genomics is important (Q10)	0.17[a]	.03

DTC, direct to consumer.
[a] Significant positive correlation.

Table 4 - Categories and Themes From Content Analysis of Open-Ended Questions

Theme	Important to Chiropractic Education	Number of Responses
Categories	Makes chiropractors relevant	10
	Genomics addressing life style and diet may benefit practice	9
	Knowledge of genomics will prepare chiropractors for the future	8
Theme	**Not Important to Chiropractic Education**	**Number of Responses**
Categories	Education should focus on chiropractic technique	4
	Genomics should not be part of the required curriculum, possible elective	5
	Genomics is too futuristic/not enough evidence	2

individuals turn to their health care providers.[7] Allopathic medicine has identified a gap in its educational curriculum with regard to genomics. Primary care providers need to have a background to prepare them for the rapidly changing landscape of genomic data.

The chiropractic profession does not have a single identity, particularly in the United States. Some have a practice style that is subluxation based, whereas others define themselves as primary care physicians. Some chiropractors are certified in internal medicine, diagnostic imaging, or a variety of other areas.[20] As a result, it is possible that only those chiropractors that have a particular identity or practice style may be approached by patients to discuss DTC genomics results. This study found that graduates of the university also have a variety of practice styles consistent with what is known throughout the profession. However, the study did not show a relationship between the type of practice and the attitude toward genomic education. A correlation was detected between year of graduation and awareness of genomic discoveries about cancer and cancer treatment. Additionally, graduates with longer practice time supported genomic education in the chiropractic curriculum. Graduates with more work experience may be more likely to be aware of trends in genetics and genomics because of their experiences with patients.

This study found that 42% of chiropractors who responded indicated that patients discussed DNA results with them 1 to 3 times per month. This finding, more so than any other finding in the study shows strong support for the inclusion of genomic education in chiropractic curricula. An introductory course in genomics, as opposed to traditional genetics, will provide the foundation for helping patients navigate the complexities of DTC results. This may include helping patients manage expectations, helping patients access clinical confirmation, and reassuring patients who may have received worrisome results. This study helped inform revision of a genetics course formerly focused on inheritance, to make it more reflective of how genomics impacts health care.

Limitations

This study was limited to a convenience sample of graduates of the UWS, expanding the study to graduates of other colleges would provide a more expansive view of chiropractors' experience with patients and genomic data. Additionally, as graduates from 1980 to 2018 were surveyed, these individuals would have had different educational experiences and different curricula.

The response rate to the survey, although sufficient based on number of individuals that opened the survey email, is lower than is desirable overall. The limitation of 204 individuals opening the survey link, when it was sent to 2057 individuals, is difficult to overcome with the study being limited by the willingness of graduates to engage in the survey process. The overall low response rate and the homogenous UWS alumni population introduces bias into the results, as only those individuals associated with UWS and with a previous interest in genomics may have completed the survey.

Content analysis of the open-ended question revealed that chiropractors' have opinions regarding genomics that may reflect their own chiropractic identity. In follow-up surveys, it may be beneficial to ask respondents about their identity in addition to their style of practice.

CONCLUSION

This study demonstrated that a significant number of graduates are engaging with their patients about DTC DNA testing results. This finding indicates that an introductory genomics course may be useful in providing care to patients.

FUNDING AND CONFLICTS OF INTEREST

No funding was provided to perform this project, and the authors declare that there are no conflicts of interest.

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Author Contributions

Concept development: KB. Design: KB, LT. Supervision: KB. Data collection/processing: KB, LT. Analysis/interpretation: KB, LT. Literature search: KB. Writing: KB, LT. Critical review: KB, LT.

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