
ORIGINAL ARTICLE

Immunology knowledge as one of the basic sciences that forms the foundations to developing sound clinicians

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Objective: The aim of this study was to (1) generate a valid questionnaire to determine immunology knowledge, (2) compare immunology knowledge across 3 different cohorts of chiropractic students that had already studied immunology, (3) examine the attitudes of chiropractic students to the study of immunology, and (4) examine whether students' attitudes affected their knowledge levels.

Methods: Factor analysis was used to refine an immunology knowledge and perceptions questionnaire that was generated by a group of experts that was then completed by 90 students. Immunology knowledge level of each of the cohorts was compared using a 1-way analysis of variance. Kappa statistics were used to measure agreement between 2 statements, and logistic regression was used to determine whether students' attitudes were associated with their knowledge levels.

Results: There was a significant difference in the immunology knowledge levels across the 3 year groups ($F[2, 87] = 4.78$, $p = .011$). Fifth-year students ($n = 26$) demonstrated 25% less immunology knowledge than third-year students ($n = 35$; $p = .005$). Of 90 students, 64 agreed that immunology knowledge was important to chiropractors, and 53 agreed that immunology knowledge was important for the average person. No relationship existed between their value of immunology knowledge and their score on the multiple-choice questions.

Conclusion: Third-year students' immunology knowledge was significantly higher than that of the fifth-year students. Students value immunology knowledge, but this does not translate to retention of this knowledge. The validated questionnaire is a useful tool for assessing immunology knowledge retention for undergraduate students.

Key Indexing Terms: Attitude; Chiropractic; Education; Knowledge; Students

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INTRODUCTION

The Council on Chiropractic Education Australasia requires chiropractic students to meet minimum competencies to achieve accreditation. Basic science knowledge must be of sufficient depth and scope for graduates to apply advances in health care to clinical practice.¹ Basic science instruction in chiropractic education “must ensure an in-depth understanding of basic biological principles, consisting of a core of information on the fundamental structures, functions and interrelationships of the body systems.”¹ The basic sciences include anatomy, biochemistry, physiology, neurology, microbiology, histology, embryology, pathology, biophysics, molecular and cell biology, genetics, immunology, and other appropriate subjects. In-depth information on abnormal biological conditions must be provided to support a high level of understanding of the etiology, epidemiology, differential diagnosis, pathogenesis, prevention, treatment, and prog-

nosis of conditions relevant to primary health care practice.

There have been positive changes regarding the role of basic science research within the chiropractic profession since the 1990s.² The importance of the basic sciences for novice and very experienced clinicians has been demonstrated, particularly for clinical problem solving.^{3,4} Understanding based on the basic sciences enhances long-term recall of clinical information with students who had been provided with a basic science explanation for diagnostic categories better able to accurately diagnose a case.⁵

Two possible mechanisms whereby basic sciences knowledge enhances clinical performance have been proposed. One is that the basic sciences may provide a framework of understanding on which clinical knowledge is developed.^{6,7} Second, the basic sciences provide a framework for organizing information allowing material to be learned in an organized fashion.² It has been

demonstrated that information that is learned in an organized manner is often easier to recall.⁸ However, recent research would suggest that basic sciences do more than simply provide an organized framework for clinicians to learn and recall information. In order to build on foundations of basic science knowledge, students must retain basic science concepts. Repeated testing and rehearsal of knowledge has been shown to reduce the normal attrition of knowledge over time.^{3,9} A standardized method for testing the retention or loss of knowledge would be advantageous. For anatomy, a short carpal bone test requires students to identify all 8 carpal bones on a diagram of the human skeletal wrist. Carpal bones are easily and objectively examined and have clinical relevance in a number of disciplines, which is why they have been used as a benchmark of anatomy knowledge.^{8,10-15} While Custers and ten Cate³ list other tests used for measuring long-term retention of basic sciences, there do not appear to be any standards similar to the carpal bone test.

The aims of this study were to (1) generate a validated questionnaire to determine retained immunology knowledge; (2) compare the retained immunology knowledge levels of a cross section of chiropractic students 2 weeks (third-year students), 1 year (fourth-year students), and 2 years (fifth-year students) after studying immunology; (3) examine the attitudes of chiropractic students to the study of immunology; and (4) determine whether students' attitudes to immunology knowledge affected their knowledge levels.

METHODS

Participants

This project was approved by the Murdoch University Human Ethics Committee (number 2014/116). The immunology component forms roughly half of the Immunology, Genetics, and Microbiology unit (CHI305) in the 5-year chiropractic program at Murdoch University. Chiropractic students complete this unit in the second semester of their third year of study. One hundred and forty-nine chiropractic students enrolled in the third, fourth, and fifth years of study in the chiropractic program were asked if they would voluntarily complete an immunology knowledge and attitude questionnaire. Third-year students had completed the immunology component of the unit CHI305 2 weeks prior to completing the questionnaire, whereas the fourth-year students and the fifth-year students had completed this unit 1 and 2 years previously, respectively. Students were not forewarned about the questionnaire in order to measure only current unrehearsed immunology knowledge levels. The research was conducted in an ethical manner as approved by the Murdoch Human Research Ethics Committee.

Development of the Instrument of Measurement

A brief questionnaire was designed and consisted of 11 questions that tested students' immunology knowledge (7 questions) and attitudes toward the value of immunology knowledge (3 questions) for chiropractors and the general population. One last question asked the student when he

or she last studied immunology. The questionnaire was reviewed for validity and accuracy by a panel of 6 experts (5 academics teaching and researching in the area of immunology and 1 chiropractor). These experienced academics have a combined research output of 265 publications.

Content Validity

The lead author drafted 7 questions to measure immunological knowledge of students in alignment with the specific learning objectives of the unit. The content validity of the preliminary questionnaire was assessed by a panel of immunologists and a chiropractor. Each panel member assessed each scale item using 4 categories: "not relevant," "unable to assess relevance without major revision," "relevant but needs minor alteration," and "very relevant." Using the established method of Polit and Beck,¹¹ a value of 1 was assigned to the "very relevant" and "relevant but needs minor alteration" categories, and the remaining categories were assigned a value of 0. The content validity index (CVI) for each item was derived by summing the values for each expert and dividing by the number of experts. Items with CVI in excess of 0.79 were retained for the final version of the questionnaire.¹¹

Factor Analysis and Internal Consistency

Factor analysis was used to explore the dimensionality of the questionnaire and reduce the data to extract the principal components. A scree plot was generated and revealed 1 component with an eigenvalue of 1.75. Six out of 7 items strongly loaded on this component. This component explained 25% of the variance in the test scores. Items with correlations greater than 0.3 were retained, resulting in the removal of 1 question with a correlation of 0.2. Therefore, data from 6 multiple-choice questions (MCQ) were used in the analysis of immunology knowledge levels. Internal consistency was measured using Cronbach's alpha measurement.

Use of the Instrument of Measurement

The validated questionnaire (Appendix A) was comprised of 6 MCQs to test students' retained knowledge and 3 questions on students' perceptions of the value of immunology knowledge. Students were given 10 minutes to complete the questionnaire. Question 10 asking "when the student last studied immunology" was added to identify any students who had studied immunology at a time other than with their year cohort.

Statistical Analysis

Descriptive statistics were used to quantitate the mean scores of immunology knowledge and the level of agreement with statements regarding the value of immunology in chiropractic and the general population. Inferential statistics were performed using the statistical package IBM SPSS Statistics version 21 (IBM Corporation, Armonk, NY, USA) to ascertain if differences existed between levels of immunology knowledge across years (analysis of variance [ANOVA]) and the proportion of

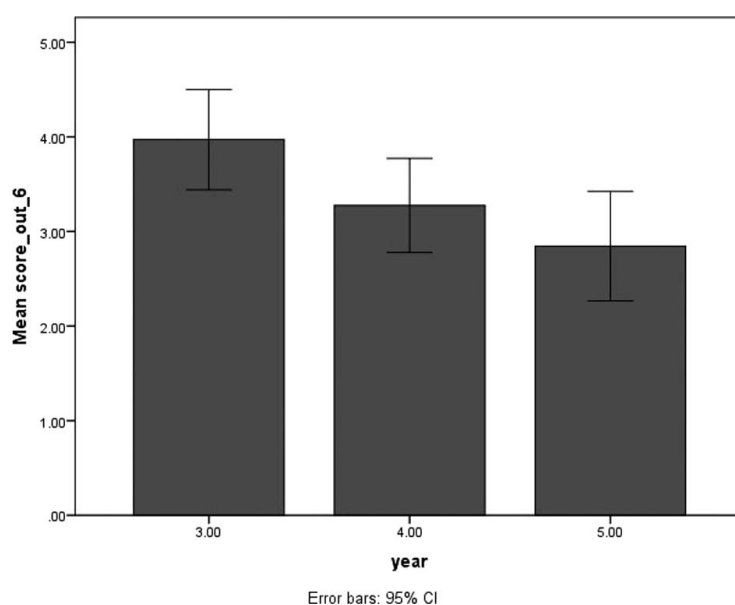


Figure 1 - Mean score on the immunology knowledge test of chiropractic students in years 3, 4, or 5 of the Chiropractic Program at Murdoch University. Error bars show the 95% confidence interval of the mean.

student agreement with statements regarding the value of immunology in chiropractic and the general population (kappa). Logistic regression was used to examine the association between the students' level of immunology knowledge and their perceptions of immunology.

The 1-way ANOVA measuring the variance in knowledge levels across the year groups was performed using data from 90 students (third-year, $n = 35$; fourth-year, $n = 29$; fifth-year, $n = 26$) on 6 MCQs with 5 response options.

Binary logistic regression was performed with the dependent variable being the students' scores dichotomized into pass (score of 3 or above out of 6) or fail (score below 3). If the confidence interval of exponential β crosses 1, the association is not significant. The covariate was dichotomized data from a Likert scale question asking if students thought immunology knowledge was important to chiropractors. If students agreed or strongly agreed, data were coded to a number 1. If students were neutral, disagreed, or strongly disagreed, the data were coded to a zero.

RESULTS

Of the 149 students eligible to participate, 90 students (60%) completed the questionnaire (third-year, $n = 35$; fourth-year, $n = 29$; fifth-year, $n = 26$) students).

Internal consistency of the 6-question MCQ questionnaire was measured with Cronbach's alpha equal to .49. Data were collected from all available students and were normally distributed (skewness = -0.18 ; kurtosis = -0.54). However, post hoc power analysis revealed that with 90 participants in 3 groups, the study was underpowered at .54.

Cross-Sectional Evaluation of Immunology Knowledge

Immunology knowledge was 25% lower in fifth-year compared to third-year students (Fig. 1). There was a significant difference in the immunology knowledge levels across the 3 year groups ($F[2, 87] = 4.78, p = .011$). The immunology knowledge level of the fourth-year students was not significantly different from third- or fifth-year students.

Students' perceptions of the value of immunology knowledge to the chiropractic and general populations were examined (Table 1). There was moderate agreement ($\kappa = .45$) with 52% (47/90) of students agreeing that immunology knowledge was important for chiropractors and the general population. Twenty-two percent (20/90) of students proclaimed that immunology knowledge was not important for chiropractors or the general population. Nineteen percent (17/90) of students agreed that immu-

Table 1 - Students' Perception of the Value of Immunology Knowledge for Chiropractic and General Populations

Number of Students Who Agree Immunology Knowledge Is Important for General Population	Number of Students Who Agree Immunology Knowledge Is Important for Chiropractors		
	No	Yes	Total
No	20	17	37
Yes	6	47	53
Total	26	64	90

Table 2 - Students' Perceptions of Whether They Clinically Applied Their Immunology Knowledge

	Agree, Strongly Agree n (%)	Neutral, Disagree, Strongly Disagree n (%)
Third-year (n = 35)	13 (37)	22 (63)
Fourth-year (n = 29)	9 (31)	20 (69)
Fifth-year (n = 26)	6 (23)	20 (77)
Combined (n = 90)	28 (31)	62 (69)

nology knowledge was important only to chiropractors. Interestingly, 6 students believed that immunology knowledge is important for the general population but not for chiropractors.

There was no association between students' attitude to the importance of immunology knowledge for chiropractors and whether they passed or failed the immunology knowledge test ($\beta = 1.02 \pm 0.525$, 95% confidence interval [CI], 0.364–2.85, $p = .972$). Over two-thirds (69%; Table 2) of the chiropractic students in years 3 to 5 were neutral/disagreed or strongly disagreed with the statement that they clinically applied their immunology knowledge. There was no association between students' perceptions of whether they clinically applied their immunology knowledge and their score on the immunological knowledge test ($\beta = 1.17$, 95% CI, 0.87–1.58, $p = .30$).

There was a positive correlation between students' perception of whether immunology knowledge was important to chiropractic students/chiropractors and whether they clinically applied their immunology knowledge ($\beta = 0.055$, 95% CI, 0.007–0.43, $p = .006$). Only 1 student (out of 28; 3.5%) who clinically applied immunology knowledge did not believe it was important for chiropractic students or chiropractors. The other 27 (out of 28; 96.5%) students who applied their immunology clinically agreed that immunology knowledge was important to chiropractic students and chiropractors. Less than half of the students (27/64; 42%) who agreed that immunology knowledge was important in chiropractic perceived that they applied it in their clinical practice.

DISCUSSION

This is the first study to design a validated questionnaire to measure and compare the level of immunology knowledge in a population of chiropractic students 2 weeks, 1 year, and 2 years after completion of an immunology unit. The study found that there was a significant difference of immunological knowledge between third- and fifth-year chiropractic students. While the immunology content taught to all 3 groups of students was identical, it must be acknowledged that the assumption being made is that immunology knowledge for all students started at a similar base immediately after completing the unit. Interestingly, the inferred attrition rate ("negative forgetting curve")

was linear and showed a difference in knowledge retention of 25% between years 3 and 5. This is similar to the findings of Lazic and colleagues¹² showing a 30% difference in knowledge retention by medical students between years 2 and 5 where they spoke about a disconnection between basic science knowledge and clinical skills. The findings of the current study are similar to another study where medical students loss of immunology knowledge over 1 year was 17.6% and this was found to be unrelated to student perception of the quality of the course.¹⁶ This was opposite to the findings of Meyer and colleagues,¹⁵ where basic knowledge of anatomy was greater in the clinically active fifth-year students than in the preclinical second-year chiropractic students who had just completed their first year of anatomy studies. The difference in retained knowledge between third- and fifth-year students is possibly due to the absence of rehearsal or direct application of the knowledge. Unlike the carpal bone study,¹⁵ where initial learning was reinforced by clinical experience, there would have been little opportunity for the students in the current study to directly revisit the immunology knowledge they possess.

The majority of students valued immunology knowledge and agreed or strongly agreed that it was important for the chiropractic and general populations. The proportion of students valuing immunology knowledge in the chiropractic population was significantly higher than the proportion of students valuing immunology knowledge in the general population. Strength of agreement that immunology was important for chiropractors was not related to a high score on the immunology knowledge test. This is in contrast to the close association of immunology interest and knowledge proposed by Alexander and colleagues.¹⁷

Limitations

The present study was cross sectional in nature and therefore did not measure the retention levels longitudinally in the same group of students. Increasing the number of MCQs would have increased the internal consistency (measured by Cronbach's alpha) of the questionnaire. In addition, an exploration of the students' reasons for valuing immunology knowledge by using open-ended questions would have been an interesting addition. The study used a convenience sample limited by the total number of students able to participate (enrolled in the unit and in attendance on the day the study was implemented). Ideally, a larger cohort might be used in future studies. Also, as previously, stated there is an assumption that all students start at a similar knowledge baseline. This may be determined using a prestudy test.

CONCLUSION

The average immunology knowledge levels of students in their fifth and final year of chiropractic study were 25% lower than that of third-year students who had recently completed their immunology study. Perceptions of chiro-

practic students did not affect their score on the immunology knowledge test but did affect whether they applied their knowledge clinically. Chiropractic students value the importance of immunology knowledge in chiropractic and general populations.

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This work was funded internally. The authors have no conflicts of interest to declare relevant to this work.

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Author Contributions

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References

1. Council on Chiropractic Education Australasia. *Educational Standards for First Professional Award Programs in Chiropractic*. Armadale: Council on Chiropractic Education Australasia; 2009.
2. Shields RF. The self-concept of chiropractic students as science students. *J Chiropr Med*. 2005;4(2): 70–75.
3. Custers EJJ, ten Cate OT. Very long-term retention of basic science knowledge in doctors after graduation. *Med Educ*. 2011;45:422–430.
4. Woods N. Science is fundamental: the role of biomedical knowledge in clinical reasoning. *Med Educ*. 2007;41:1173–1177.
5. Woods N, Brooks L, Norman G. The value of basic science in clinical diagnosis: creating coherence among signs and symptoms. *Med Educ*. 2005;39: 107–12.
6. de Bruin A, Schmidt H, Rikers R. the role of basic science knowledge and clinical knowledge in diagnostic reasoning: a structural equation modeling approach. *Acad Med*. 2005;80(8):765–773.
7. Baghdady M, Pharoah M, Regehr G, Lam E, Woods N. The role of basic sciences in diagnostic oral radiology. *J Dent Educ*. 2009;73(10):1187–1193.
8. Varela F, Thompson E, Rosch E. *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge: Cambridge University Press; 1991.
9. Roediger HL III, Butler A. The critical role of retrieval practice in long-term retention. *Trends Cogn Sci*. 2010; 15(1):20–27.
10. Spielmann P, Oliver C. The carpal bones: A basic test of medical students' and junior doctors' knowledge of anatomy. *Surgeon*. 2005;3(4):257–259.
11. Polit D, Beck C. The content validity index: are you sure you know what's being reported? Critique and recommendations. *Res Nurs Health*. 2006;29:489–497.
12. Lazic E, Dujmovic J, Hren D. Retention of basic sciences knowledge at clinical years of medical curriculum. *Croat Med J*. 2006;47:882–887.
13. Strkalj G, Schroder T, Pather N, Solyali V. A preliminary assessment of the fifth-year chiropractic students' knowledge of anatomy. *J Altern Complement Med*. 2011;17(1):63–66.
14. Valenza M, Castro-Martin E, Valenza G, Guirao-Pineiro M, De-la-Llave-Rincon A, Fernandez-de-las-Penas C. Comparison of third year medical and physical therapy students' knowledge of anatomy using the carpal bone test. *J Manipulative Physiol Ther*. 2012; 35(2):121–126.
15. Meyer AJ, Armson A, Losco CD, Losco B, Walker BF. factors influencing student performance on the carpal bone test as a preliminary evaluation of the anatomical knowledge retention. *Anat Sci Educ*. 2015:1–7.
16. D'Eon M. Knowledge loss of medical students on first year basic science courses at the university of Saskatchewan. *BMC Med Educ*. 2006;6(5):1–5.
17. Alexander P, Jetton T, Kulikowich J. Interrelationship of knowledge, interest, and recall: assessing a model of domain learning. *J Educ Psychol*. 1995; 87(4):559–575.

APPENDIX A

Validated Immunology Knowledge, Perceptions, and Value Questionnaire

- ☐ I give consent to participate in this research
☐ I *do not* give consent to participate in this study

Retained Immunology Knowledge

Please circle the one correct answer for each question.

Question 1: Which of the following is a member of innate immunity?

- a. T-cell
- b. B-cell
- c. Natural killer cell
- d. Memory lymphocyte

Question 2: Which of the following is part of the humoral branch of the immune system?

- a. T-cell
- b. B-cell
- c. Natural killer cell
- d. Macrophage

Question 3: Which of the following is of the cell-mediated branch of the immune system?

- a. T-cell
- b. Antibody
- c. Natural killer cell
- d. Macrophage

Question 4: Plasma cells produce

- a. Opsins
- b. Antibodies
- c. Actin
- d. Interferon

Question 5: HIV infection directly targets CD4⁺ T cells in the immune system. Which type of cells are CD4⁺ cells?

- a. Antibody producing cells

- b. T helper cells
- c. B cells
- d. Natural killer cells

Question 6: Inducing a CD4⁺ T cell to start proliferating first requires binding of antigen in which of the following classes of molecule?

- a. MHC class I
- b. MHC class II
- c. MHC class III
- d. equally to MHC class I and class II

Question 7: Knowledge of the immune system is important for the average person?

I _____ I _____ I _____ I _____ I _____
 Strongly Agree Agree Neutral Disagree Strongly Disagree

Question 8: Knowledge of the immune system is necessary for a chiropractic student or a chiropractor?

I _____ I _____ I _____ I _____ I _____
 Strongly Agree Agree Neutral Disagree Strongly Disagree

Question 9: I clinically apply immunology knowledge?

I _____ I _____ I _____ I _____ I _____
 Strongly Agree Agree Neutral Disagree Strongly Disagree

Question 10: When did you last revise immunology (please tick appropriate box)?

- ☐ 1 week
- ☐ 1 month
- ☐ 6 months
- ☐ 1 year
- ☐ 2 years
- ☐ not at all