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# ORIGINAL ARTICLE

## Chiropractic student diagnosis and management of headache disorders: A survey examining self-perceived preparedness and clinical proficiency

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**Objective:** To explore the self-perceived preparedness and clinical proficiency in headache diagnosis and management of Australian chiropractic students in senior years of study.

**Methods:** Australian chiropractic students in the 4th ($n = 134$) and 5th year ($n = 122$) of 2 chiropractic university programs were invited to participate in an online cross-sectional survey. Descriptive analyses were conducted for all variables. Post hoc analyses were performed using simple linear regression to evaluate the relationship between self-perceived preparedness and correctness of headache diagnosis and management scores.

**Results:** Australian chiropractic students in senior years demonstrated moderate overall levels of self-perceived preparedness and proficiency in their ability to diagnose and manage headache disorders. Final-year students had a slightly higher self-perceived preparedness and proficiency in headache diagnosis and management compared to those students in the 4th year of study. There was no relationship between self-perceived preparedness and correctness of headache diagnosis and management for either 4th- or 5th-year chiropractic students.

**Conclusion:** Our findings suggest that there may be gaps in graduate chiropractic student confidence and proficiency in headache diagnosis and management. These findings call for further research to explore graduate chiropractic student preparedness and proficiency in the diagnosis and management of headache disorders.

**Key Indexing Terms:** Chiropractic; Curriculum; Education; Evidence-Based Practice; Preparedness; Headache

## INTRODUCTION

Headache disorders remain the second-leading cause of years lived with disability in people of all ages, behind low back pain.[1] In 2016, almost 3 billion people globally were estimated to experience migraine and tension-type headache alone, migraine being most burdensome for women between 15 and 49 years of age.[2] Given the high primary care-seeking behavior of those with headache disorders[3,4] it is vital that providers are skilled in the diagnosis and management of this patient population.

Chiropractors in Australia are regulated primary care health professionals, and their education is provided by universities through 5-year degree programs.[5,6] During the first 3 years of undergraduate chiropractic education, Australian chiropractic students are introduced to pathology and differential diagnosis in addition to their training in basic sciences. Student training in the final 2 years further builds student clinical knowledge and skills, including in the diagnosis and management of headache disorders. Students learn to classify headaches according

to the International Headache Society's International Classification of Headache Disorders,[7] including for common recurrent headaches and for red flag headaches associated with serious underlying pathology. All knowledge is formally assessed as part of the end of semester written examination. These chiropractic programs are accredited to ensure that graduates are competent to deliver safe and effective health care in the community. Among the competency standards, graduating chiropractors must be able to (1) critically analyze information to generate a clinical impression, such as a working diagnosis, and (2) formulate a management care plan.[8] These professional skills are included in the clinical teaching units and internship training during the final 2 years of Australian university chiropractic education.[9,10]

Internationally, headache disorders rank in the top 5 conditions for which people seek help from chiropractors,[11] and 1 in 5 new patients seeking help from Australian chiropractors are reported to have a chief complaint of headache.[12] Accordingly, it is vital that chiropractic students learn to generate a headache

diagnoses following internationally recognized classification of criteria[7] and learn to develop a management care plan for those with headaches following an evidence-based rationale.[8]

Previous international studies have identified that chiropractic graduate students can perceive themselves to be unprepared within certain clinical competencies, raising concerns about gaps that may exist between student education and practice-ready practitioners.[13–15] To date, little research has specifically examined chiropractic students' perceived preparedness and ability to diagnose and manage headache disorders. In direct response to this research gap, the primary aim of this study was to assess 4th- and 5th-year Australian chiropractic students' self-perceived preparedness for headache disorder diagnosis and management, as well as their performance (correctness) in headache diagnosis and management decision making. The secondary aim was to assess whether there was a relationship between self-perceived preparedness and correctness of headache diagnosis and management scores.

## METHODS

### Ethical Considerations

Ethical review for this study was approved by the Human Research Ethics Committee (HREC [Medical Sciences]) of Macquarie University, Australia (Ethics approval number: 5201834214672) and with permission from the head of department (Chiropractic) at Murdoch University. The study purpose and research methods were not concealed from the participants. Participation in this study was voluntary in nature. Consent was implied by completing the survey, and participants had the right to withdraw consent at any time without reason. Survey data were exported and stored as an Excel file, and no personal identifiers, such as name of consenting participant or IP address, were retained. Participants' privacy and rights were protected throughout the study.

### Study Design, Setting, and Participants

The chiropractic program at Macquarie University (Sydney, New South Wales) includes a 3-year undergraduate bachelor's degree followed by a 2-year postgraduate master's degree. The chiropractic program at Murdoch University (Perth, Western Australia) includes a 3-year bachelor of chiropractic science followed by 2-year bachelor of clinical science degree. Students in their second to the last ($n = 134$) and final year ($n = 122$) of these 5-year programs were invited to participate in an online cross-sectional survey.

It is in the final 2 years of each these programs where students are most exposed to educational units that develop their clinical decision-making skills for primary contact health care. For this study, these students are hereby described as 4th- and 5th-year cohorts. Eligible students were informed of the study via announcements from lecturers responsible for the relevant teaching units from each program and via the student university online portal. The survey was conducted between October 17 and November 11, 2018 via the Qualtrics (Provo, UT)

electronic data capture platform. The survey contained 2 questionnaires that needed to be completed by all participants. The first examined student perceptions about their preparedness for headache patient diagnosis and management, and the second examined student decision making in headache diagnosis and management.

### Survey Instrument

The questionnaire introduction explained the approximate duration, contents, and purpose of the study; that survey completion was voluntary; and that participant information was anonymous. Consent was implied by completing the survey. The preparedness questionnaire's design, organization, and items were drawn from a tool previously devised and employed for undergraduate medical training[16] that has been similarly adapted and used in previous studies.[17,18] The headache case vignettes employed in our study were developed after a review of the literature and consideration of similar research previously conducted.[19–21] When doing so, we assessed the level of clinical information, including history and examination findings, considered sufficient within case vignettes for primary care students to make appropriate decisions about headache patient diagnosis and management. Face validity of the survey tool was assessed by the relevant lecturers in neurological diagnosis and management from both participating universities. Both lecturers have a background of many years of teaching and conducting education-based research, including within the neurological sciences, to ensure overall case content appropriately matched student headache education at both institutions. Headache features described in the case vignettes followed formal International Classification of Headache Disorders criteria.[22]

### Variables and Measurements

Students first completed the self-perceived preparedness questionnaire on headache diagnosis and management (Appendix A available at www.journalchiroed.com: Preparedness questionnaire). Students were requested to select responses for each question from an ordinal rating scale (1, not at all prepared; 2, underprepared; 3, mostly prepared; 4, highly prepared). Aggregated scales (0–100) were created whereby 0 = not prepared and 100 = fully prepared.

Students then completed the second questionnaire to assess student decision making in headache diagnosis and management by reviewing 10 headache patient vignettes and providing a headache diagnosis and management decision for each vignette. The headache types selected for the vignettes were those that commonly present to chiropractic clinical settings, namely migraine, tension headache, cervicogenic headache,[23] as well medication-overuse headache (MOH) and red flag headache presentations (vertebral artery dissection, meningitis, and cerebellar tumor). Vignette information included descriptions of symptoms, previous treatment history, relevant diagnostic test results, and physical findings to allow for considered responses to the questions.

For each case study, students were requested to provide the headache diagnosis via a free text response box and to

give an opinion on the approach they would recommend for clinical management by selecting from a range of clinical management options provided. These included (1) patient self-care only; (2) chiropractic management (patient education/advice and/or manual therapies); (3) chiropractic and allied health comanagement, for example, psychologist, counselor, exercise physiologist, physiotherapist, dietician; (4) chiropractic and medical comanagement; (5) do not provide care and first refer for medical and/or neurologist assessment; and (6) refer for urgent medical attention and evaluation. Student answers for each of the 10 case vignette diagnoses were scored 1 = correct, 0.5 = partially correct, and 0 = incorrect. A partially correct score was applied when responses failed to include the headache subtype (chronic/acute, migraine with/without aura) or where only 1 headache type was correct for vignettes with more than 1 headache type, or where answers provided insufficient detail to fully identify the specific type of red flag headache.

For each participant, a correct diagnosis total score (0–100) was created from the aggregated responses to all the vignettes. Similarly, management decisions were scored as either 1 = correct or 0 = incorrect. Scoring for headache management allowed for more than 1 correct answer in some circumstances. Correct management decisions were assessed based upon answers that were consistent with current best evidence that would address the presenting headache type and recognition of the individual circumstances presented in each case vignette. For each participant, a correct management total score (0–100) was created from the aggregated responses to the vignettes. After discussion with educators from both institutions, it was agreed that student overall scores would be described within a score range (<50 = fail, 50–60 = borderline, 61–70 = moderate, 71–80 = good, >80 = highly proficient). Two separate authors (CM and SW) independently scored student answers, scores were compared, and any differences were discussed and resolved between the authors.

The last section of the survey collected information on student sociodemographic and related characteristics. The questionnaire was pilot tested with 5 senior-year chiropractic students from different sociodemographic backgrounds who provided feedback to assist with improving survey content, length, and wording.

### Statistical Analysis

Data were inspected, cleaned, and prepared for analysis. Participants were described by demographic characteristics (age and sex), type of student enrollment (local vs international), English as first language, year of enrollment, and chiropractic institution (Macquarie University or Murdoch University). Descriptive analyses were conducted for all variables. Items using a 4-point Likert scale were reported as frequency distributions (counts and proportions). Scale variables were described via means and standard deviations or 95% confidence intervals (CIs).

Differences between the 4th- and 5th-year cohorts and the summary scores (preparedness and correctness) were tested using the independent samples $t$ test, with effect estimates expressed as mean differences (95% CI). Differ-

**Table 1 - Sociodemographic Characteristics of Student Participants**

| | 4th-Year Students, 119 (58.6%) | 5th-Year Students, 84 (41.4%) |
|---|---|---|
| Age: (Mean ± SD) | 24.2 ± 3.6 | 25.5 ± 4.5 |
| Sex | | |
| Male | 58 (48.7%) | 49 (58.3%) |
| Female | 61 (51.3%) | 35 (41.7%) |
| Enrollment type | | |
| Local (domestic) student | 110 (92.4%) | 78 (92.9%) |
| International student | 9 (7.6%) | 6 (7.1%) |
| English first language | | |
| Yes | 95 (79.8%) | 59 (70.2%) |
| No | 24 (20.2%) | 25 (29.8%) |
| University | | |
| A (Macquarie) | 50 (42%) | 58 (69%) |
| B (Murdoch) | 69 (58%) | 26 (31%) |

ences between chiropractic program year and categorical item responses were tested using the $\chi^2$ test, and effect estimates were expressed as association coefficients (Kendall's τ-b, Cramér's V and φ) with bias-corrected and accelerated bootstrap (1000 replications) CI (95% CI).

Post hoc analyses were performed using simple linear regression to evaluate the relationship between self-perceived preparedness and correctness of headache diagnosis and management scores. Linear regression models were stratified by the student's year of study. All analyses and graphical illustrations were conducted using statistical software (SPSS Statistics for Windows, Ver. 25.0; IBM Corp, Armonk, NY).

## RESULTS

A total of 203 chiropractic students completed the survey (79% response rate). Participants were in the 4th (58.6%) and 5th year (41.4%) of a 5-year chiropractic program at Macquarie University (53.2%) and Murdoch University (46.8%) in Australia (Table 1). The mean age of participants was 24.7 ± 4.0 years (range 21–50 years), and 52.7% were male. Most participants were local (domestic) (92.6%) and spoke English as their first language (75.9%). The combined mean score (out of 100) for students' self-perceived preparedness for headache diagnosis was 64.1 (95% CI, 62.1–66.1) and for self-perceived preparedness for headache management was 63.4 (95% CI, 61.1–65.6) (Table 2).

### Primary Analyses: Difference Between 4th- and 5th-Year Chiropractic Students' Self-Perceived Preparedness for Headache Diagnosis and Management

There was a small difference between 4th- and 5th-year chiropractic students in the mean self-perceived preparedness score for headache diagnosis (mean difference 5.7 [95% CI, 1.8–9.7], $t = 2.8$, $df = 201$, $p = .005$). The mean self-perceived preparedness score for headache diagnosis was 61.7 (95% CI, 59.2–64.3) ($n = 119$) compared to 67.5

**Table 2 - Combined 4th-Year and 5th-Year Students' Self-perceived Preparedness to Diagnose and Manage Headache**

| | Not at all Prepared | Underprepared | Mostly Prepared | Highly Prepared | Summary Score (0–100) |
|---|---|---|---|---|---|
| **Preparedness for diagnosis** | | | | | Mean 64.1 SD 14.4 $n = 203$ |
| Ask appropriate questions to evaluate and record a headache patient history | 2 (1%) | 30 (14.8%) | 141 (69.5%) | 30 (14.8%) | |
| Administer and evaluate a headache patient diary | 22 (10.8%) | 95 (46.8%) | 69 (34%) | 17 (8.4%) | |
| Ask appropriate questions to evaluate and record headache patient red flags | 0 (0%) | 17 (8.4%) | 127 (62.6%) | 59 (29.1%) | |
| Ask appropriate questions to evaluate and record the mental state of the headache patient when necessary, eg, signs of anxiety or depression | 4 (2%) | 55 (27.1%) | 118 (58.1%) | 26 (12.8%) | |
| Perform a physical examination of a headache patient | 1 (0.5%) | 44 (21.7%) | 107 (52.7%) | 51 (25.1%) | |
| Perform a neurological examination of a headache patient | 0 (0%) | 23 (11.3%) | 123 (60.6%) | 57 (28.1%) | |
| Formulate a differential diagnosis of the headache type | 3 (1.5%) | 40 (19.7%) | 119 (58.6%) | 41 (20.2%) | |
| Formulate a differential diagnosis of the headache subtype, eg, with or without aura, chronic/episodic | 4 (2%) | 61 (30%) | 107 (52.7%) | 31 (15.3%) | |
| **Preparedness for management** | | | | | Mean 63.4 SD 16.4, $n = 203$ |
| Evaluate the patient's response to previous headache treatments (efficacy and side effects) | 5 (2.5%) | 62 (30.5%) | 109 (53.7%) | 27 (13.3%) | |
| Make clinical judgments based on the research evidence for headache treatment | 6 (3%) | 60 (29.6%) | 111 (54.7%) | 26 (12.8%) | |
| Respond to patient questions including those related to their values and preferences regarding headache treatment options | 7 (3.4%) | 69 (34%) | 102 (50.2%) | 25 (12.3%) | |
| *Consider any relevant personal, social, family or work issues that may contribute to some headache types | 0 (0%) | 33 (16.3%) | 123 (60.9%) | 46 (22.8%) | |
| Explore and discuss possible headache triggers with patients | 0 (0%) | 32 (15.8%) | 114 (56.2%) | 57 (28.1%) | |
| Recognize when urgent medical care, including further clinical or diagnostic investigations, may be needed for a headache patient | 1 (0.5%) | 31 (15.3%) | 113 (55.7%) | 58 (28.6%) | |
| [a]Recognize when to work with other headache-related health care providers as appropriate (medical and/or allied and/or complementary) | 4 (2%) | 53 (26.2%) | 108 (53.5%) | 37 (18.3%) | |
| Formulate a treatment and management plan for a headache patient | 4 (2%) | 71 (35%) | 100 (49.3%) | 28 (13.8%) | |

[a] 1 missing response ($N = 202$)

(95% CI, 64.4–70.5) ($n = 84$) for 4th- and 5th-year students, respectively (Fig. 1). The difference was mostly explained by students' perceived ability to ask appropriate questions to evaluate and record a patient history ($T_b = 0.23$ [95% CI, 0.09–0.35]) and perceived ability to formulate a differential diagnosis of headache subtypes ($T_b = 0.16$ [95% CI, 0.3–0.28]) (Table 3).

Similarly, there was a small difference between 4th- and 5th-year chiropractic students in the mean self-perceived preparedness score for headache patient management (mean difference 5.9 [95% CI, 1.3–10.4], $t = 2.5$, $df =$ 201, $p = .01$). The mean self-perceived preparedness score for headache management was 60.9 (95% CI, 57.9–64.0) ($n = 119$) compared to 66.8 (95% CI, 63.6–70.1) ($n = 84$) for 4th- and 5th-year students, respectively (Fig. 1). The difference was mostly explained by students' perception of their ability to formulate a headache patient treatment and management plan ($T_b = 0.32$ [95% CI, 0.20–0.43]) (Table 4). The overall student mean score for correct diagnoses was 63.2 (95% CI, 60.7–65.7) and for correct management decisions was 70.2 (68.3–72.2) (Table 5). Case 1, cervicogenic headache, was the headache type for which students
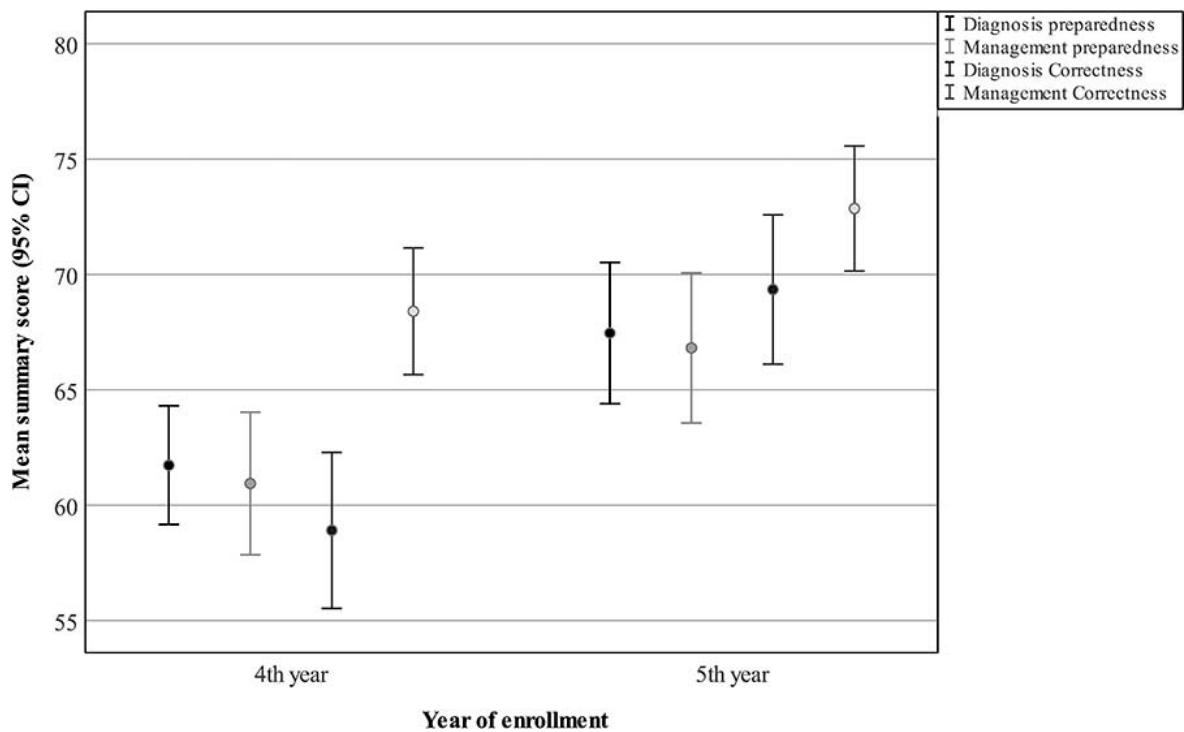
**Figure 1** - Mean summary score (95% CI) for preparedness and correctness of headache diagnosis and management.

**Table 3 - Students' Self-perceived Preparedness to Diagnose Headache in 4th and 5th Years**

| | Not at All Prepared | Underprepared | Mostly Prepared | Highly Prepared | $\chi^2$ | Kendall's tau-b (95% CI) |
|---|---|---|---|---|---|---|
| Ask appropriate questions to evaluate and record a headache patient history | | | | | | |
| 4th year | 2 (1.7%) | 24 (20.2%) | 81 (68.1%) | 12 (10.1%) | $\chi^2 = 11.43, df = 3, p = 0.01$ | $T_b = 0.23$ (0.09 to 0.35) |
| 5th year | 0 (0%) | 6 (7.1%) | 60 (71.4%) | 18 (21.4%) | | |
| Administer and evaluate a headache patient diary | | | | | | |
| 4th year | 16 (13.4%) | 56 (47.1%) | 41 (34.5%) | 6 (5%) | $\chi^2 = 5.64, df = 3, p = 0.13$ | $T_b = 0.11$ (−0.01 to 0.23) |
| 5th year | 6 (7.1%) | 39 (46.4%) | 28 (33.3%) | 11 (13.1%) | | |
| Ask appropriate questions to evaluate and record headache patient red flags | | | | | | |
| 4th year | 0 (0%) | 11 (9.2%) | 80 (67.2%) | 28 (23.5%) | $\chi^2 = 4.29, df = 2, p = 0.12$ | $T_b = 0.13$ (−0.002 to 0.07) |
| 5th year | 0 (0%) | 6 (7.1%) | 47 (56%) | 31 (36.9%) | | |
| Ask appropriate questions to evaluate and record the mental state of the headache patient when necessary, eg, signs of anxiety or depression | | | | | | |
| 4th year | 2 (1.7%) | 27 (22.7%) | 76 (63.9%) | 14 (11.8%) | $\chi^2 = 4.06, df = 3, p = 0.26$ | $T_b = -0.07$ (−0.01 to 0.8) |
| 5th year | 2 (2.4%) | 28 (33.3%) | 42 (50%) | 12 (14.3%) | | |
| Perform a physical examination of a headache patient | | | | | | |
| 4th year | 1 (0.8%) | 32 (26.9%) | 61 (51.3%) | 25 (21%) | $\chi^2 = 6.37, df = 3, p = 0.95$ | $T_b = 0.16$ (0.02 to 0.28) |
| 5th year | 0 (0%) | 12 (14.3%) | 46 (54.8%) | 26 (31%) | | |
| Perform a neurological examination of a headache patient | | | | | | |
| 4th year | 0 (0%) | 13 (10.9%) | 73 (61.3%) | 33 (27.7%) | $\chi^2 = 0.08, df = 2, p = 0.96$ | $T_b = 0$ (−0.14 to 0.13) |
| 5th year | 0 (0%) | 10 (11.9%) | 50 (59.5%) | 24 (28.6%) | | |
| Formulate a differential diagnosis of the headache type | | | | | | |
| 4th year | 3 (2.5%) | 28 (23.5%) | 73 (61.3%) | 15 (12.6%) | $\chi^2 = 12.82, df = 3, p = 0.05$ | $T_b = 0.22$ (0.1 to 0.34) |
| 5th year | 0 (0%) | 12 (14.3%) | 46 (54.8%) | 26 (31%) | | |
| Formulate a differential diagnosis of the headache subtype, eg, with or without aura | | | | | | |
| 4th year | 4 (3.4%) | 39 (32.8%) | 64 (53.8%) | 12 (10.1%) | $\chi^2 = 8.66, df = 3, p = 0.03$ | $T_b = 0.16$ (0.3 to 0.28) |
| 5th year | 0 (0%) | 22 (26.2%) | 43 (51.2%) | 19 (22.6%) | | |

**Table 4 - Students' Self-perceived Preparedness to Manage Headache in 4th and 5th Years**

| | Not at All Prepared | Underprepared | Mostly Prepared | Highly Prepared | $\chi^2$ | Kendall's tau-b (95%CI) |
|---|---|---|---|---|---|---|
| Evaluate the patient's response to previous headache treatments (efficacy and side effects) | | | | | | |
| 4th year | 4 (3.4%) | 43 (36.1%) | 59 (49.6%) | 13 (10.9%) | $\chi^2 = 6.02, df = 3, p = .11$ | $T_b = 0.16\ (-0.002\text{ to }0.07)$ |
| 5th year | 1 (1.2%) | 19 (22.6%) | 50 (59.5%) | 14 (16.7%) | | |
| Make clinical judgments based on the available research evidence for headache treatment | | | | | | |
| 4th year | 6 (5%) | 36 (30.3%) | 65 (54.6%) | 12 (10.1%) | $\chi^2 = 5.95, df = 3, p = .11$ | $T_b = 0.11\ (-0.04\text{ to }0.21)$ |
| 5th year | 0 (0%) | 24 (28.6%) | 46 (54.8%) | 14 (16.7%) | | |
| Respond to patient questions including those related to their values and preferences regarding headache treatment options | | | | | | |
| 4th year | 7 (5.9%) | 40 (33.6%) | 60 (50.4%) | 12 (10.1%) | $\chi^2 = 6.12, df = 3, p = .11$ | $T_b = 0.09\ (-0.04\text{ to }0.21)$ |
| 5th year | 0 (0%) | 29 (34.5%) | 42 (50%) | 13 (15.5%) | | |
| Consider any relevant personal, social, family, or work issues that may contribute to some headache types | | | | | | |
| 4th year | 0 (0%) | 18 (15.3%) | 77 (65.3%) | 23 (19.5%) | $\chi^2 = 2.43, df = 2, p = .30$ | $T_b = 0.04\ (-0.10\text{ to }0.18)$ |
| 5th year | 0 (0%) | 15 (17.9%) | 46 (54.8%) | 23 (27.4%) | | |
| Explore and discuss possible headache triggers with patients | | | | | | |
| 4th year | 14 (11.8%) | 75 (63%) | 30 (25.2%) | 0 (0%) | $\chi^2 = 6.18, df = 2, p = .05$ | $T_b = -0.01\ (-0.14\text{ to}$ |
| 5th year | 18 (21.4%) | 39 (46.4%) | 27 (32.1%) | 0 (0%) | | |
| Recognize when urgent medical care, including further clinical or diagnostic investigations, may be needed for a headache patient | | | | | | |
| 4th year | 1 (0.8%) | 20 (16.8%) | 66 (55.5%) | 32 (26.9%) | $\chi^2 = 1.44, df = 3, p = .70$ | $T_b = 0.06\ (-0.067\text{ to }0.19)$ |
| 5th year | 0 (0%) | 11 (13.1%) | 47 (56%) | 26 (31%) | | |
| Recognize when to work with other headache-related health care providers as appropriate (medical and/or allied and/or complementary) | | | | | | |
| 4th year | 4 (3.4%) | 37 (31.4%) | 58 (49.2%) | 19 (16.1%) | $\chi^2 = 7.43, df = 3, p = .06$ | $T_b = 0.15\ (0.02\text{ to }0.28)$ |
| 5th year | 0 (0%) | 16 (19%) | 50 (59.5%) | 18 (21.4%) | | |
| Formulate a treatment and management plan for a headache patient | | | | | | |
| 4th year | 4 (3.4%) | 57 (47.9%) | 46 (38.7%) | 12 (10.1%) | $\chi^2 = 25.99, df = 3, p < .001$ | $T_b = 0.32\ (0.20\text{ to }0.43)$ |
| 5th year | 0 (0%) | 14 (16.7%) | 54 (64.3%) | 16 (19%) | | |

**Table 5 - Combined 4th- and 5th-Year Students' Correctness in Headache Diagnosis and Management Decisions**

| | Incorrect | Partially Correct | Correct | Summary score (0–100) |
|---|---|---|---|---|
| **Correct diagnosis** | | | | |
| Case 1 (Cervicogenic headache) | 16 (7.9%) | 0 (0%) | 186 (92.1%) | $63.2 \pm 17.9$ |
| Case 2 (Tension-type headache) | 37 (18.2%) | 0 (0%) | 166 (81.8%) | $n = 203$ |
| Case 3 (Migraine with aura) | 7 (3.4%) | 62 (30.5%) | 134 (66%) | |
| Case 4 (Tension headache + migraine) | 21 (10.3%) | 127 (62.6%) | 55 (27.1%) | |
| Case 5 (Chronic tension headache) | 56 (27.6%) | 109 (53.7%) | 38 (18.7%) | |
| Case 6 (Migraine without aura) | 62 (30.5%) | 36 (17.7%) | 105 (51.7%) | |
| Case 7 (MOH) | 134 (66%) | 6 (3%) | 63 (31%) | |
| Case 8 (Vertebral artery dissection) | 88 (43.3%) | 39 (19.2%) | 76 (37.4%) | |
| Case 9 (Meningitis) | 57 (28.1%) | 9 (4.4%) | 137 (67.5%) | |
| Case 10 (Cerebellar tumor) | 67 (33.2%) | 11 (5.4%) | 124 (61.4%) | |
| **Correct management** | | | | |
| Case 1 (Cervicogenic headache) | 5 (2.5%) | | 198 (97.5%) | $70.2 \pm 14.2$ |
| Case 2 (Tension-type headache) | 33 (16.3%) | | 170 (83.7%) | $n = 203$ |
| Case 3 (Migraine with aura) | 183 (90.1%) | | 20 (9.9%) | |
| Case 4 (Tension headache + migraine) | 28 (13.8%) | | 175 (86.2%) | |
| Case 5 (Chronic tension headache) | 27 (13.3%) | | 176 (86.7%) | |
| Case 6 (Migraine without aura) | 24 (11.8%) | | 179 (88.2%) | |
| Case 7 (MOH) | 162 (79.8%) | | 41 (20.2%) | |
| Case 8 (Vertebral artery dissection) | 28 (13.8%) | | 175 (86.2%) | |
| Case 9 (Meningitis) | 56 (27.6%) | | 147 (72.4%) | |
| Case 10 (Cerebellar tumor) | 58 (28.6%) | | 145 (71.4%) | |

**Table 6 - Student's Correctness in Headache Diagnosis in 4th and 5th Years**

| | Year | Incorrect | Partially Correct | Correct | $\chi^2$ | Cramér's V (95% CI) |
|---|---|---|---|---|---|---|
| Case 1 | 4 | 14 (11.9%) | 0 (0%) | 10 (88.1%) | $\chi^2 = 6.05$, $df = 1$, $p = .014$ | $\varphi_c = 0.17$ (0.50 to 0.27) |
| | 5 | 2 (2.4%) | 0 (0%) | 82 (97.6%) | | |
| Case 2 | 4 | 31 (26.1%) | 0 (0%) | 88 (73.9%) | $\chi^2 = 11.81$, $df = 1$, $p = .001$ | $\varphi_c = 0.24$ (0.12 to 0.35) |
| | 5 | 6 (7.1%) | 0 (0%) | 78 (92.9%) | | |
| Case 3 | 4 | 4 (3.4%) | 40 (33.6%) | 75 (63%) | $\chi^2 = 1.28$, $df = 2$, $p = .53$ | $\varphi_c = 0.08$ (−0.08 to 0.20) |
| | 5 | 3 (3.6%) | 22 (26.2%) | 59 (70.2%) | | |
| Case 4 | 4 | 16 (13.4%) | 77 (64.7%) | 26 (21.8%) | $\chi^2 = 5.80$, $df = 2$, $p = .06$ | $\varphi_c = 0.17$ (0.03 to 0.30) |
| | 5 | 5 (6%) | 50 (59.5%) | 29 (34.5%) | | |
| Case 5 | 4 | 45 (37.8%) | 62 (52.1%) | 12 (10.1%) | $\chi^2 = 22.5$, $df = 2$, $P < 0.001$ | $\varphi_c = 0.33$ (0.17 to 0.44) |
| | 5 | 11 (13.1%) | 47 (56%) | 26 (31%) | | |
| Case 6 | 4 | 35 (29.4%) | 19 (16%) | 65 (54.6%) | $\chi^2 = 1.09$, $df = 2$, $p = .58$ | $\varphi_c = 0.07$ (−0.18 to 0.08) |
| | 5 | 27 (32.1%) | 17 (20.2%) | 40 (47.6%) | | |
| Case 7 | 4 | 78 (65.5%) | 5 (4.2%) | 36 (30.3%) | $\chi^2 = 1.58$, $df = 2$, $p = .46$ | $\varphi_c = 0.09$ (−0.14 to 0.14) |
| | 5 | 56 (66.7%) | 1 (1.2%) | 27 (32.1%) | | |
| Case 8 | 4 | 54 (45.4%) | 23 (19.3%) | 42 (35.3%) | $\chi^2 = 0.63$, $df = 2$, $p = .73$ | $\varphi_c = 0.06$ (−0.80 to 0.18) |
| | 5 | 34 (40.5%) | 16 (19%) | 34 (40.5%) | | |
| Case 9 | 4 | 41 (34.5%) | 5 (4.2%) | 73 (61.3%) | $\chi^2 = 5.81$, $df = 2$, $p = .06$ | $\varphi_c = 0.17$ (0.03 to 0.30) |
| | 5 | 16 (19%) | 4 (4.8%) | 64 (76.2%) | | |
| Case 10 | 4 | 50 (42%) | 9 (7.6%) | 60 (50.4%) | $\chi^2 = 14.9$, $df = 2$, $p = .001$ | $\varphi_c = 0.27$ (0.14 to 0.038) |
| | 5 | 17 (20.5%) | 2 (2.4%) | 64 (77.1%) | | |

most frequently reported a fully correct headache diagnosis (92.1%) and management decision (97.5%). Students most frequently reported an incorrect diagnosis for case 7, MOH (66%), and an incorrect patient management decision for case 3, migraine with aura (90.1%).

### *Primary Analyses: Difference Between 4th- and 5th-Year Chiropractic Students' Correctness for Headache Diagnosis and Management*

There was a moderate difference between 4th- and 5th-year chiropractic students in the mean correct diagnosis score (mean difference 10.4 [95% CI, 5.6–15.3], $t = 4.3$, $df = 201$, $p < .001$). The mean correct diagnosis score for 4th-year students was 58.9 (95% CI, 55.5–62.3) ($n = 119$) compared to 69.3 (95% CI, 66.1–72.3) ($n = 84$) in 5th-year students (Fig. 1). The difference was mostly explained by students' diagnosis in case 5, chronic tension headache ($\varphi_c = 0.33$ [95% CI, 0.17–0.44]) (Table 6).

There was a small statistically significant difference between 4th and 5th-year chiropractic students in the mean score for correct headache management (mean difference 4.5 [95% CI, 0.5–8.4], $t = 2.2$, $df = 201$, $p = .03$). The mean score for headache management in 4th-year students was 68.4 (95% CI, 65.7–71.1) ($n = 119$) compared to 72.9 (95% CI, 70.2–75.6) ($n = 84$) in 5th-years students (Fig. 1). The difference was mostly explained by students' performance in case 6, migraine without aura ($\varphi_c = 0.18$ [95% CI, 0.07–0.28]), followed by case 3, migraine with aura ($\varphi_c = −0.14$ 18 [95% CI, −0.26 to −0.02]) (Table 7).

### *Secondary and Post Hoc Analyses: Relationship Between Perceived Preparedness and Correctness of Headache Diagnosis and Management*

Post hoc analyses were conducted to evaluate the relationships between perceived preparedness and correctness of headache diagnosis and management. Simple linear regression models were stratified by the students' year of study. There was no relationship between student perception of their diagnosis preparedness and correctness of diagnosis for either 4th-year ($R^2 = 0.03$, $F(1, 117) = 3.57$, $p = .06$) or 5th-year ($R^2 = 0.016$, $F(1,82) = 1.31$, $p = .26$) chiropractic students. The effect size of the prediction model in 4th-year students was $\beta = 0.23$ (95% CI, −0.01 to 0.46) and for 5th-year students was $\beta = 0.13$ (95% CI, −0.1 to 0.36) (Fig. 2). Similarly, there was no relationship between student perception of their management preparedness and correctness of headache management for either 4th-year ($R^2 = 0.003$, $F(1, 117) = 0.38$, $p = .54$) or 5th-year ($R^2 = 0.029$, $F(1,82) = 2.42$, $p = .12$) chiropractic students. The effect size of the prediction model in 4th-year students was $\beta = 0.05$ (95% CI, −0.11 to 0.21) and 5th-year students was $\beta = 0.14$ (95% CI, −0.04 to 0.32) (Fig. 3).

### DISCUSSION

Findings from this study suggest Australian chiropractic students in the final 2 years of study (when combined) demonstrate moderate overall levels of self-perceived preparedness and proficiency in their ability to diagnose and manage headache disorders. Overall estimates suggest that final-year students have a slightly higher self-perceived preparedness and a slightly higher proficiency in headache diagnosis and management compared to those students in the 4th year of study. Since headache patient caseload is substantial within Australian chiropractic clinical practice,[12,24] it is important to better understand graduate student confidence and proficiency in headache patient care.

Our findings suggest that, when combined, 4th- and 5th-year chiropractic students report moderate levels of self-perceived preparedness for headache diagnosis and management. Previous research has found that improve-

**Table 7 - Student's Correctness in Headache Management in 4th and 5th Years**

| | Year | Incorrect | Correct | $\chi^2$ | $\varphi$ (95%CI) |
|---|---|---|---|---|---|
| Case 1 | 4 | 5 (4.2%) | 114 (95.8%) | $\chi^2 = 3.62$, $df = 1$, $p = .06$ | $\varphi = 0.13$ (0.08 to 0.18) |
| | 5 | 0 (0%) | 84 (100%) | | |
| Case 2 | 4 | 21 (17.6%) | 98 (82.4%) | $\chi^2 = .41$, $df = 1$, $p = .52$ | $\varphi = 0.05$ (−0.11 to 0.17) |
| | 5 | 12 (14.3%) | 72 (85.7%) | | |
| Case 3 | 4 | 103 (86.6%) | 16 (13.4%) | $\chi^2 = 4.18$, $df = 1$, $p = .04$ | $\varphi = -0.14$ (−0.26 to −0.02) |
| | 5 | 80 (95.2%) | 4 (4.8%) | | |
| Case 4 | 4 | 21 (17.6%) | 98 (82.4%) | $\chi^2 = 3.59$, $df = 1$, $p = .06$ | $\varphi = 0.13$ (−0.001 to 0.26) |
| | 5 | 7 (8.3%) | 77 (91.7%) | | |
| Case 5 | 4 | 16 (13.4%) | 103 (86.6%) | $\chi^2 = .01$, $df = 1$, $p = .94$ | $\varphi = 0.005$ (−0.12 to 0.14) |
| | 5 | 11 (13.1%) | 73 (86.9%) | | |
| Case 6 | 4 | 20 (16.8%) | 99 (83.2%) | $\chi^2 = 6.85$, $df = 1$, $p = .01$ | $\varphi = 0.18$ (0.07 to 0.28) |
| | 5 | 4 (4.8%) | 80 (95.2%) | | |
| Case 7 | 4 | 96 (80.7%) | 23 (19.3%) | $\chi^2 = .14$, $df = 1$, $p = .71$ | $\varphi = 0.03$ (−0.11 to 0.16) |
| | 5 | 66 (78.6%) | 18 (21.4%) | | |
| Case 8 | 4 | 18 (15.1%) | 101 (84.9%) | $\chi^2 = .43$, $df = 1$, $p = .51$ | $\varphi = 0.05$ (−0.09 to 0.18) |
| | 5 | 10 (11.9%) | 74 (88.1%) | | |
| Case 9 | 4 | 38 (31.9%) | 81 (68.1%) | $\chi^2 = 2.72$, $df = 1$, $p = .1$ | $\varphi = 0.12$ (−0.03 to 0.26) |
| | 5 | 18 (21.4%) | 66 (78.6%) | | |
| Case 10 | 4 | 38 (31.9%) | 81 (68.1%) | $\chi^2 = 1.59$, $df = 1$, $p = .21$ | $\varphi = 0.09$ (−0.05 to 0.23) |
| | 5 | 20 (23.8%) | 64 (76.2%) | | |

ments in perceived preparedness among graduate medical students is positively influenced both by the relevance of undergraduate teaching to real life clinical practice and the level of exposure (hands-on experience) students have to specific clinical cases.[17,25] For headache diagnosis, our study found there was a small (mean 5.7 point) yet statistically significant difference between 4th- and 5th-year chiropractic students in their mean scores for self-perceived preparedness. This difference was mostly ex-plained by students' perceived ability to ask appropriate questions to evaluate and record a patient history and students' perceptions of their ability to formulate a differential diagnosis of headache subtypes. For headache patient management, our study found there was also a small (mean 5.9 point) yet statistically significant difference between 4th- and 5th-year chiropractic students regarding self-perceived mean preparedness, which was mostly explained by 5th-year students feeling more prepared
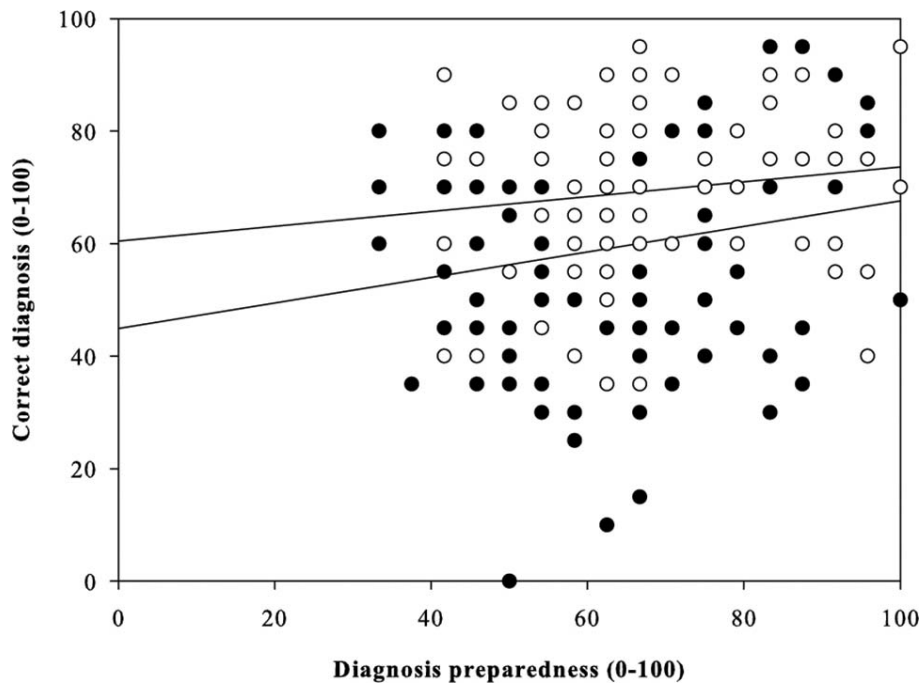


**Figure 2** - Prediction model effect size for 4th- and 5th-year students' perception of their preparedness and correctness of headache diagnosis.
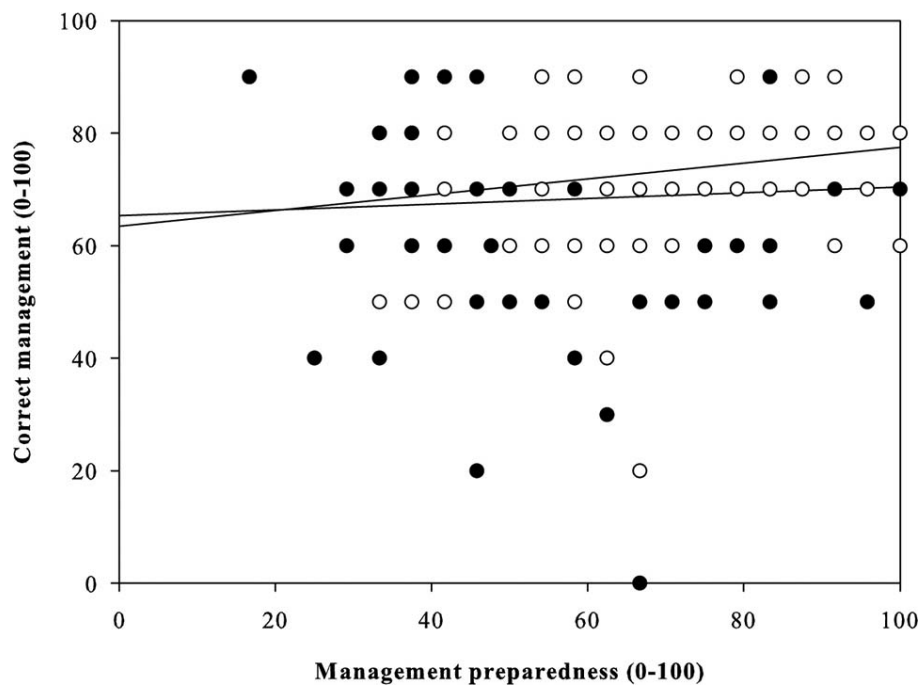
**Figure 3** - Prediction model effect size for 4th- and 5th-year students' perception of their preparedness and correctness of headache management.

regarding their ability to formulate a headache patient treatment and management plan. While the additional training and exposure to headache patients during the final year of clinical internship training may be 1 factor that contributes to the improvement in perceived preparedness of final-year chiropractic students overall, the absence of a larger difference in self-perception scores between 4th-year and final-year students may suggest the potential for overconfidence in self-perceived preparedness among 4th-year students. Previous studies have identified the Dunning-Kruger effect in which those with a poorer academic performance have a cognitive bias toward assessing their ability to be greater than it truly is.[26] While there may be other explanations, the Dunning-Kruger effect may be 1 explanation for why the self-perceived preparedness of 4th-year students was only slightly less than final year students in our study. However, it is important to note that the lack of correlation between student self-perceived preparedness and correctness of headache diagnosis and headache patient management for either 4th- or final-year students could suggest that student participants generally had a realistically adjusted overall understanding of their confidence and abilities in headache diagnosis and management. While such a finding may broadly reflect the positive impact of the current headache-related study unit content within the final years for these Australian chiropractic schools, more research is required.

Our findings also suggest chiropractic students in senior years (4th and final years combined) report moderate levels of correctness in their headache diagnosis and management, although overall student proficiency scores were lower for headache diagnosis than for headache management. Previous studies have identified the variable reliability of headache diagnosis within primary care settings,[27–29] despite headache diagnosis being the principle foundation for providing effective headache patient management.[7] It is therefore vital that chiropractors receive high-quality training in headache diagnosis in order to provide optimal patient care for this patient population. There was a moderate (mean 10.4 point) difference between 4th- and final-year chiropractic students in their mean scores for correct diagnosis. This difference was mostly explained by final-year students' improved diagnosis of chronic tension-type headache. Identification of chronic headache subtypes, such as chronic tension-type headache, may help chiropractors to better identify headache features where psychobehavioral treatment may be valuable for the management of headache pain[30] and associated psychiatric comorbidities.[31] The smaller (mean 4.5 point) difference between 4th- and final-year chiropractic students' mean score for correct headache management was mostly explained by final year students' improved correctness in the management of migraine with and without aura. It may be that this difference is explained by the hands-on exposure to headache patients that is likely to occur during student clinical internship training as part of their final year of chiropractic education. The importance of chiropractic student exposure to a broad patient case mix during student residencies has been previously discussed.[14,32] While accreditation standards for Australian chiropractic training programs do not mandate specific requirements around patient case mix,[8] it is expected that by graduation students will be exposed to a sufficiently broad patient case load during their clinical internship to provide safe and effective patient care across different patient populations. Uncertainty therefore remains as to whether chiropractic graduate students are sufficiently exposed to a broad range of headache types during their

clinical internship training in order to be adequately prepared for effective headache patient management.

When combined, our study found a substantial percentage of student participants self-reported feeling mostly or highly prepared to ask appropriate questions to evaluate and record headache patient red flags. However, our findings also show that student correctness in the diagnosis of headache red flag case presentations was generally lower than their correctness in the diagnosis of common recurrent headache case presentations. In addition, with the exception of vertebral artery dissection, more than 1 in 4 students reported an incorrect clinical management decision for headache red flag case presentations such as meningitis and cerebellar tumor. Uncertainty remains regarding how often primary care providers fail to identify and appropriately manage headache-related red flag signs within primary care practice settings.[33,34] While those with headache red flags are more likely to present to hospital emergency departments than to primary care settings,[35] such findings could suggest chiropractic graduate students may not be sufficiently exposed to headache red flag cases during their senior years and clinical internship training. Hospital-based student residency training has been included within a limited number of chiropractic institutions internationally, and preliminary findings suggest hospital-based student residency training may be valuable in improving the clinical education of graduate chiropractic students.[14] While further research is required, there may be a need for Australian chiropractic training programs to provide students with greater exposure to headache red flag cases through hospital-based clinical training. While there remains little hospital access for chiropractic students in Australia, such experience, including through student participation in neurology rounds in hospitals, may help to improve student clinical decision making in this area. While serious headache red flag presentations are likely to be rare in chiropractic settings, it is essential that graduate chiropractic students achieve a satisfactory level of competency in the diagnosis and management of those who present with headache red flags in order to correctly identify circumstances where headache patients need urgent medical attention.

Our study found the largest percentage of incorrect diagnosis and management decisions was in regard to MOH. While the percentage of those with MOH in chiropractic settings remains unknown, it has been reported that around a third of adults with headache who present for medical management have MOH.[36] MOH—a headache occurring on 15 or more days per month for more than 3 months in those with a preexisting primary headache disorder resulting from the overuse of acute or symptomatic headache medications[7]—has been identified as the 18th leading cause of disability worldwide.[37] With headache medications being the most common frontline treatment utilized for headache management, it is vital that chiropractors are able to recognize the clinical signs of those with MOH during the history and systems review of presenting patients and to provide appropriate advice and referral in order to help with reducing the burden of this substantial public health issue.

Previous research has also identified that MOH can often go unrecognized within medical primary care settings.[38,39] While further research is required, it may be that further chiropractic student training in MOH is needed, including via student lectures or through student supervision during their clinical internship training with the use of additional diagnostic aids.[40] In addition, only 10% of student participants identified the need to first refer those with migraine with aura for medical and/or neurologist assessment in a case vignette that described the patient having not previously consulted a medical doctor for a headache diagnosis or management. It is not clear from our findings if this small percentage is because some participants overlooked such details within this particular vignette or if there are similar teaching/learning gaps in this area. Given the stronger evidence for the effectiveness of pharmaceutical migraine treatments[41] and the limited, preliminary evidence for the effectiveness of migraine treatment methods typically utilized by chiropractors,[42] graduating chiropractors need to carefully consider the strength of the clinical evidence for headache treatments found both inside and outside of chiropractic clinical settings when making patient management decisions in order to provide effective headache management.

In comparison, findings from this study suggest that chiropractic students in senior years show a generally higher level of proficiency in their headache diagnosis and clinical management of the most common headache types. For example, a substantial percentage of study participants reported the correct diagnosis (partially or fully) and management decisions for case studies associated with common recurrent headaches such as migraine without aura, tension-type headache, and cervicogenic headache. Previous research suggests it is those with common recurrent headaches that most often present to chiropractors for headache-related care.[23] The higher student proficiency in the diagnosis and management of common recurrent headaches suggested by the findings from this study may indicate that graduating chiropractors are better prepared for the diagnosis and management of the headache types most common to chiropractic clinical practice.

### Limitations

This study presents some limitations. First, the results of this study are not generalizable beyond the Australian training institutions where the study data were collected. Second, while the preparedness questionnaire used in this study has been similarly adapted from past research,[17,18] both instruments used for this study have not been validated. Therefore, the results and study interpretations presented should be approached with some caution. Third, while the headache case vignettes questionnaire was developed by the appropriate lecturers in neurological diagnosis and management to improve face validity, matching vignette content to student educational levels, written clinical vignettes may not provide students with all of the necessary information needed when making clinical decisions about headache patient diagnosis and management. While clinical vignettes are commonly utilized in primary care education and assessment,[20,43] they cannot

substitute for face-to-face headache patient consultation. In addition, while cutoff points can be arbitrary, we have reported mean differences (95% CI) between 4th-and 5th-year students as "small" but significant differences in scores. For these analyses (*t* tests), our description of "small" and "moderate" effects for the differences in the mean scores are congruent with the magnitudes of Cohen's *d*. While recognizing these limitations, it is hoped that this cross-sectional survey provides valuable insights into graduate student preparedness and clinical decision making associated with headache patient management, helps to advance educational strategies within this field of chiropractic education, and assists with identifying key questions for future research on this topic.

## CONCLUSION

It is important that clinical education programs optimize chiropractic student learning in preparation for clinical practice. Our findings suggest that there may be gaps in the self-perceived preparedness and proficiency in the diagnosis and management of headache disorders. These findings may be useful to educators when considering approaches that can improve chiropractic student education in headache diagnosis and management. Future work needs to further explore graduate chiropractic student preparedness and proficiency in the diagnosis and management of headache disorders. Graduate chiropractic clinicians need to be mindful of areas of uncertainty in headache patient management in order to ensure better quality and safety in chiropractic patient care.

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